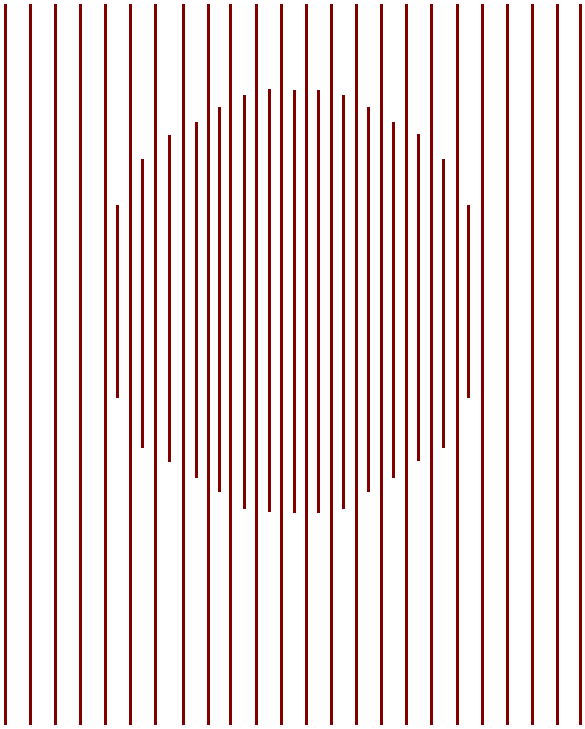
CBO PAPERS

GREENING THE NATIONAL ACCOUNTS

March 1994



CONGRESSIONAL BUDGET OFFICE

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March 1994

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PREFACE

This Congressional Budget Office (CBO) paper was prepared in response to a request from the Joint Economic Committee to discuss the information needed to revise or expand the national income accounts to reflect changes in natural resources and the environment. The paper focuses on the benefits that might be realized and major problems that will be encountered in carrying out certain suggestions that fall under the rubric of green accounting.

Raymond Prince and Patrice L. Gordon of CBO's Natural Resources and Commerce Division wrote the paper, under the supervision of Jan Paul Acton and Roger Hitchner. Heather Miller and Veronica French provided research assistance. John Peterson and Robert Dennis of CBO offered insightful comments and helpful criticism. The authors wish to thank Carol Carson, Jack E. Triplett, Steven Landefeld, Arnold Katz, and Gary Rutledge, all of the Bureau of Economic Analysis; Anne Grambsch of the Environmental Protection Agency; and Henry Peskin, Robert Repetto, and Joel Darmstadter for their constructive comments.

Sherwood Kohn edited the manuscript, and Christian Spoor provided editorial assistance. Aaron Zeisler prepared the figures. Angela Z. McCollough produced the numerous drafts and prepared the paper for publication.

Robert D. Reischauer
Director

March 1994

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SUMMARY

National income accounting is one of the most important policymaking tools to appear in the last 50 years. It contributes to policymaking by using detailed economic data to compute such summary indicators as gross domestic product (GDP). Measurements such as the percentage of GDP spent on health care often alert decisionmakers to the need for new policy initiatives. Researchers often use the data to analyze policy alternatives. The information in the national accounts supports three basic functions, namely, to provide an economic interpretation of changes in the nation's assets and national wealth, to furnish gauges of current income based on the actual or imputed market value of goods and services, and to measure financial and factor input flows in the economy.

CRITICISMS OF THE TREATMENT OF NATURAL RESOURCES AND THE ENVIRONMENT IN THE NATIONAL ACCOUNTS

Many demands for changing the accounts arise from a concern that insufficient data about natural resources and the environment restrict the accounts' potential to inform decisionmakers on important issues such as the relationship between trade, growth, and environmental policies. Three major criticisms have emerged in the debate over the national accounts' treatment of natural resources and the environment:

- Some say that the national accounts should reflect changes in environmental quality and natural resource reserves. Figures on investment and depreciation are supposed to tell decisionmakers whether productive assests are being maintained, but they ignore most changes in natural resources and the environment.

- Critics argue that summary measures of income and output in the national accounts should include the services provided by natural resources and the environment because they affect the quality of life. Such benefits as recreation on public lands, the aesthetics of a clean environment, and the preservation of biodiversity are not included; nor are the effects of pollution, which are reflected in measures of national income only if they reduce worker productivity. Proposals to include an alternative

measure of national income in the accounts in the form of a "green" GDP represent an attempt to address this criticism.

- It is said that the national accounts should identify the value added by environmental services that are implicitly included in current measures of income and should pinpoint some of the costs of reducing damages caused by pollution. The accounts ignore the capability of the environment to dispose of wastes, even though its ability to absorb pollutants is a valuable service to both producers and consumers. Money spent on avoiding damages caused by pollution--so-called defensive spending on such items as pollution abatement equipment and some prescription medicines--is included in national income but is not differentiated from other forms of investment or consumption in the national accounts.

ADDRESSING CRITICISMS OF THE ACCOUNTS' TREATMENT OF NATURAL RESOURCES AND THE ENVIRONMENT

Incorporating more information on natural resources and the environment into the accounts requires much conceptual work and data gathering. As a first step in addressing criticisms of the way in which the accounts treat natural resources and the environment, the Commerce Department's Bureau of Economic Analysis (BEA) plans to produce prototype estimates of the economic value of such nonrenewable natural resources as petroleum, gas, coal, uranium, and certain nonfuel minerals. These efforts, which BEA calls Phase I, will involve estimates made largely from available market data. The estimates could provide the basis for a measure of national income that is adjusted for the depletion of natural assets. Also, BEA has been compiling data for some time on expenditures for abatement equipment. These efforts are an important step in identifying the costs of avoiding pollution damages.

In time, BEA plans to extend its work to such renewable resources as forests and fisheries (Phase II). Building on this work, BEA intends eventually to evaluate a broader range of environmental assets, possibly based on levels of environmental quality (Phase III). Similar efforts are under way at the United Nations, which produces guidelines for the System of National Accounts (SNA) used by many member nations. To date neither BEA nor the U.N. has official plans to determine the full value of pollution damages, aesthetic effects, and the preservation of biodiversity.

BEA's attempts to address criticisms of the treatment of nonrenewable natural resources in the accounts (Phase I) will face significant measurement problems despite the general availability of market data. It is difficult when market conditions are changing to estimate changes in the reserves of nonrenewable natural resources that are economically exploitable. Moreover, the multiple-use characteristics of many items pose an important problem when estimating abatement expenditures. For example, air conditioners may reduce the effects of air pollution on sufferers of respiratory ailments but are not purchased solely for medicinal purposes. Researchers will have to determine how much of the total cost of such items should be assigned to reducing pollution damage.

Efforts to assign value to renewable resources and the environment (BEA's Phases II and III) will encounter additional measurement problems that BEA's Phase I efforts (assigning value to nonrenewable resources) will mostly avoid. The measurement of net changes in biological (renewable) resources, for example, is difficult because population growth rates are not precisely known. Furthermore, national average measures of environmental quality do not reveal regional "hot spots" where remedial actions may be necessary.

The principal problem in advancing beyond Phase I, however, will be the increasing importance of identifying reliable and consistent methods of pricing those nonmarket services that derive their value more from the benefits they yield final consumers than from their use as an input in the production of a marketed commodity. The need to identify such methods will intensify if so-called nonmarket final services prove to be a greater part of the total value of renewable measures and the environment than they are of nonrenewable resources. But it may prove more difficult to reach a consensus on the value of blue whales or clean lakes than oil deposits because the farther a resource is from the market economy--that is, the less linked a resource is to market activities--the more uncertain its monetary value becomes.

In the accounts, market prices are the basis for the value of goods and services that are bought and sold in organized markets. Assets, such as groundwater, provide goods and services that are rarely bought and sold but contribute to production. A price can be imputed indirectly for such goods and services by using information about the production process and the value of marketed output. Other assets, such as various wild species, provide services that are not sold and do not contribute directly to production. The choice of techniques for imputing a price to these services is, therefore, much more limited. The limited choice of techniques is an especially knotty

problem when attempting to place a value on the damage that pollution does to health.

CONCLUSIONS

The concept of incorporating more of the use of natural resources and the environment into the national accounts has been called green accounting. An important benefit of "greening" the national accounts would be to enhance the information available for analyzing policy issues. Among the issues are the effect of environmental protection on economic growth, the distributional impacts of environmental and natural resource policies, and the link between trade and environmental and resource policies. In addition, the process of compiling information for an integrated set of data could yield new insights into the workings of the economy.

Although natural resources and the environment are not given the same treatment as privately owned physical capital in the national accounts, some researchers would oppose green accounting. One concern is that it would be difficult to compare current and past data. Another concern is the problem of maintaining the standards of the accounts; for the most part these standards are thought to be set by applying market data. A primary advantage of using accounting systems for policy analysis is that they measure disparate goods and services with a common metric. But defining different items in economic terms rather than by some physical measurement is only worthwhile if these values are consistent and reliable.

The national accounts now record the value of some goods and services on the basis of imputed prices. Examples are limited, however, to such items as the value of services of owner-occupied housing. Can data be collected, and measures generated, to meet the standards of the accounts for reliable and consistent measures? These concerns can be addressed by separating out (in satellite accounts) the new estimates from official totals until a sufficient consensus develops around the consistency and integrity of new estimates. Revising the accounts beyond BEA's Phase I requires, however, a significantly expanded reliance on imputed prices for goods and services. Nevertheless, a gradual process of modifying measures of national economic performance is consistent with the history and development of the national accounts. It is within this context that any effort to incorporate into the national accounts more information on natural resources and the environment should be judged.

CHAPTER I
INTRODUCTION

Environmental and natural resources issues have risen to the top of the political ferment during the last two decades. Concerns about energy consumption and the degree to which national forests should be used for timber production or protected wilderness areas are examples of continuing resource policy issues. Environmental problems such as the *Exxon Valdez* oil spill, the depletion of the ozone layer, and the threat of global warming have focused national and international attention on environmental issues.

When analyzing public policy, decisionmakers often turn to the national accounts. If properly done, national accounting can be a useful instrument for economic analysis and policy evaluation. The accounts can indicate variations in economic activity, the amount of saving and investment, and the mix of industrial activities, among other patterns (see Box 1). Total indicators derived from the national accounts--such as gross domestic product (GDP), which measures the level of economic activity within the economy--shape perceptions about economic growth and well-being. Moreover, detailed data in the accounts can help to predict the effects on employment and output of actions ranging from a broad-based energy tax to restrictions on logging in national forests.

Although the national accounts provide useful information about economic activity, their ability to inform policy is limited. Total economic indicators from the accounts do not incorporate even the most basic changes in the natural environment. Ecological catastrophes can appear as short-term economic stimuli because many of the negative effects on recreation, wildlife, and future harvests of fish and timber, for example, are not recorded. The depletion of natural resources such as oil, gas, timber, and fish stocks count toward current income and profits, but the accounts do not indicate the potential loss of future income from overuse or exhaustion of these resources.

The national accounts were designed to help government understand the processes that produce current income and future wealth. It is generally acknowledged that natural systems interact with economic affairs. If the linkages between the two are not considered, the national accounts can provide distorted and potentially misleading measures of economic progress.

BOX 1.
THE BASIC FUNCTIONS OF THE U.S. NATIONAL ACCOUNTS

The U.S. government organizes its national accounting system into four major components: the national and income and product accounts (NIPAs), which record transactions involving final goods and services; the input-output (I-O) tables, which record the flow of goods and services between industry sectors (intermediate goods) and flows between industries and final consumers; the flow of funds accounts, which record transactions between financial sectors; and balance sheet and revaluation accounts (hereafter referred to as balance sheets), which record changes and sources of changes in the value of tangible reproducible assets, land, and financial assets held by the private sector from the beginning to the end of each year.[1] Some documents of the Bureau of Economic Analysis also list the balance of payments as a separate account, although its information is mostly repeated in the foreign transactions section of the NIPAs.

The basic functions of the national accounts are to provide an economic interpretation of changes in the nation's assets and wealth, to provide measures of current economic activity and income based on the actual or imputed market value of goods and services, and to measure financial and input flows in the economy.

Providing an Economic Interpretation of Changes in the Nation's Assets and Wealth: The balance sheets serve this function by recording the value of national assets at a given point in time. Changes in national wealth are evaluated by determining the change in value of assets over the accounting period. Changes in the value of assets are attributed to the combined effects of capital consumption, capital formation, and revaluation due to capital gains (each component of change in value is recorded separately in the balance sheets). Capital consumption is an estimate of depreciation of the fixed capital stock caused by age, use in production, and accidental loss. It is an estimate of that part of current output that should be set aside to replace the physical capital that has worn out or was destroyed.

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1. Department of Commerce, Bureau of Economic Analysis, *The Use of National Income and Product Accounts for Public Policy*, BEA:SP868043 (1986).

Measuring Economic Activity and Income on the Basis of the Market Value of Goods and Services: The NIPA is the most important set of accounts for this function. The most widely reported measure is gross domestic product (GDP), which measures the value of all final goods and services produced in the economy during a given period. As a rule, each product is valued at its market price and the values are added together, resulting in the total measure of GDP. Gross domestic product for 1993 totaled $6,374 billion (advanced estimates in current dollars).

The production of GDP causes wear and tear on the existing capital stock; that is, machines wear out as they are used in production. If some resources recorded in current GDP were not used to maintain or replace the existing capital, GDP could not be kept at the current level. Net domestic product (NDP), as distinct from gross domestic product, deducts from the measure of gross production the consumption of the existing capital stock (from age, use in production, and accidental loss) over the course of a given period. Accordingly, NDP is a better measure of the amount of income (or consumption) that could be maintained over long periods, given the existing capital stock and labor force. During 1993, net domestic product totaled $5,703 billion (advanced estimates in current dollars) and capital consumption was $671 billion, about 11 percent of GDP.

Measuring Financial and Input Flows in the Economy: The flow of funds accounts and I-O tables are the most important components of the national accounts for measuring financial and input flows in the economy. The flow of funds accounts record financial transactions between households, nonfinancial businesses, governments, foreigners, and financial institutions. The I-O tables trace different delivery flows between the sectors of production in the economy. These accounts measure the unfinished goods and services (intermediate products) that each industry purchases to produce output and measure the amount each industry sells to all purchasers (other industries and final consumers). Among other things, input-output tables can be used to investigate the effects of different economic policies on production and employment by industry. Many researchers use data from the I-O tables as the basis of models attempting to trace the effects of policies on employment and output in different sectors. Information from the flow of funds accounts is commonly used to investigate the financial health of economic sectors or the economy as a whole. For example, these data are used in models that evaluate a credit crunch or the effect of regulatory changes on the financial system.

Some economists would like to merge environmental and natural resource concerns with mainstream economic policies, to give these assets "a seat at the table." The Congress's Joint Economic Committee held hearings in September 1991 on ways in which the accounts could be used to "shape effective and sustainable economic policies."[1] As a result of those hearings, the committee concluded that measures of national income produced by the national income accounts "are not a good measure of sustainable income." During his Earth Day speech in April 1993, President Clinton called for the Bureau of Economic Analysis to produce " 'Green GDP' measures [that] would incorporate changes in the natural environment into the calculations of national income and wealth."[2] International agencies have also responded to demands that the national accounts incorporate more information on natural resources and the environment. In 1989 the World Bank published an influential work entitled *Environmental Accounting for Sustainable Development.* The United Nations is currently trying to upgrade and standardize the guidelines for its widely used System of National Accounts (SNA). And as part of this effort, the U.N. is developing methods of incorporating nature into the SNA by using a separate System of Integrated Environmental-Economic Accounts.

IS THE TREATMENT OF NATURAL RESOURCES AND THE ENVIRONMENT IN THE NATIONAL ACCOUNTS MISLEADING?

Measures of economic activity in the national accounts can be misleading when important information about natural resources and the environment is either missing or mislabeled. First, the national accounts do not reflect changes in environmental quality and natural resource reserves. When compared, investment and depreciation data are supposed to tell decisionmakers whether the nation is maintaining its productive assets, but the data ignore most changes in natural resources and the environment. Second, summary measures of income and output in the national accounts exclude many of the services provided by natural resources and the environment, even though they have an impact on the quality of life. Interest in having the accounts produce an alternative measure of national income in the form of a "green" GDP represents an attempt to address these omissions.

1. Joint Economic Committee of Congress, "Making the Environment Count" (press release, September 11, 1991).

2. White House, "Earth Day Address" (press release, April 21, 1993).

Third, some important effects of natural resources and the environment on gross domestic product are hidden. The national accounts do not identify environmental services that are included in current measures or certain costs that are related to the reductions of damage by pollution.

The Accounts Do Not Record Changes in Environmental Quality or Most Natural Resource Reserves

The desire to improve measurement of the effects of economic policies is responsible for much of the interest in adding more information to the accounts about natural resources and the environment. The growing interest in policies that promote "sustainable development," for example, has led to suggestions that natural resources and the environment be treated as capital assets providing services to the economy--so-called natural capital.

Natural capital contributes to production just as physical capital does. The absorptive capacity of the environment or the wood from harvested timber can contribute to production just as machines contribute to the manufacture of goods. Similarly, the environment or natural resources can depreciate just as machines do from wear and tear. Also, as with physical capital, investment can be made in some forms of natural capital as a means of maintaining or increasing its stock; for example, expenditures to maintain levels of environmental quality or to expand the stock of timber. Investment in either physical or natural capital requires that current consumption be sacrificed in expectation of a flow of income in the future.

GDP measures the value of nearly all marketed final goods and services produced in the economy, plus a few nonmarketed goods. Certain marketed goods and services--mostly illegal activities--are excluded, and the value of certain nonmarketed services--most notably the services of owner-occupied housing and financial institutions--are included. The price of nonmarketed services is based on imputed, or estimated, fair market prices.

Currently, such items as machinery and equipment are assigned value in the accounts as productive capital. The value of the change in the stock of these items, caused by use and accidental loss, is recorded as capital consumption and subtracted from gross domestic product in order to measure net domestic product (NDP).

NDP is what remains after enough has been set aside to maintain the capital stock; it constitutes a recognition that one cannot maintain a consumption level by drawing down the stock of capital. The accounts do not,

however, allow for the impact of output on the condition of mines, forests, soil, air, and water quality. The accounts are less reliable, therefore, for alerting decisionmakers to changes in these assets that may require new policy initiatives.

If changes in environmental quality and natural resource stocks were recorded, they could help the national accounts provide an economic interpretation of changes in the nation's assets. The balance sheets serve this function by recording the value of national assets at a given point in time. Many of the changes necessary to record changes in environmental quality and natural resources would appear in the balance sheets, although many changes would also appear in the national income and product accounts (NIPAs).

Current Measures of National Income Exclude Many of the Services Provided by Natural Resources and the Environment

Demands that the accounts measure a green GDP reflect a desire to include more of the final nonmarket services provided by natural resources and the environment in measures of national income. These items include non-health-related services such as recreation on public lands and aesthetic benefits, nonuse benefits (the benefit derived from knowing an amenity is available), and the potential benefits of biological diversity. Inclusion of these services in national income would increase both GDP and the contribution to GDP by natural resources and the environment. Those who advocate including these services argue that current GDP, by ignoring them, gives a misleading impression of the importance of natural resources and the environment to the standard of living.

Measuring a green GDP could also mean including the damage that pollution causes to human health that is not already measured through its effect on worker productivity. Thus, the effects of pollution-induced respiratory ailments on absenteeism are already counted to some extent in GDP, but the pain and suffering from these ailments are not. Such damages could be treated as health-related services that, if included as negative values, would reduce GDP.

Some proponents justify the inclusion of these services as a step toward a measure of national welfare. This goal is probably unattainable because assigning values to losses resulting from sickness and death and weighing such factors as literacy rates or the distribution of income (which many would argue should be evaluated as a part of national welfare) would be difficult to incorporate into the framework of the national accounts. Incorporating such

considerations would probably involve changing the metric of the accounts from an objective value measure to a subjective index of well-being, thereby detracting from the usefulness of summary measures.

Including more of the services of natural resources and the environment, however, could enhance the ability of the accounts to provide a measure of income that might indicate changes in the quality of life more accurately than conventional GDP. Measures such as a green GDP would be reported in the national income and product accounts. The NIPAs are the component in which most of the changes necessary to measure final services of natural resources and the environment would appear, although adjustments to the input-output (I-O) accounts could be made to correspond to changes made in the NIPAs.

The Accounts Do Not Identify Environmental Services Included in Current Measures of National Income or the Costs of Reducing Pollution Damages

The ability of models based on the I-O tables to predict the impact of environmental and natural resource policies on employment, output, and trade--or the impact of trade and employment policies on the environment--is limited by the information in the national accounts. The accounts do not show the value of either the environment's waste disposal services or of defensive expenditures to counter pollution. The environment disposes of waste by absorbing by-products of output and consumption. Because there are no market transactions in payment for these services, the accounts do not treat the environment as a factor of production. They implicitly assign a value of zero to these services. Actually, the value of environmental waste disposal services is currently subsumed under profits and rents in the accounts. Firms and households spend a lot to prevent, reverse, or avoid the effects of pollution. The so-called defensive expenditures against pollution are lumped together with other investments, such as pollution abatement equipment, or consumption expenditures, such as prescription medicines, air filters in the home, and so on.

If waste disposal services were separated from profits, and rents and defensive expenditures were also separated from investment and consumption expenditures, the ability of the national accounts to measure the effects of changing allowable emission levels on production could be enhanced. The separation would also make the benefits of improving environmental quality clearer. Many of the changes would appear in the input-output tables, which measure the flow of expenditures between individual industries and sectors.

GREEN ACCOUNTING COULD BENEFIT DECISIONMAKERS

The notion of more fully incorporating the use of natural resources and the environment into the national accounts has been called "green accounting." An important benefit of this approach would be to increase the information available for analyzing policy issues. Among the key issues are the effect of environmental protection on economic growth, the distributional impacts of environmental and natural resource policies, and the link between trade and environmental and resource policies.

There are at least two more good reasons for incorporating environmental and natural resources into the national accounts. First, incorporating such information would result in a more comprehensive source of data for identifying the causes of economic problems related to the environment and natural resource management. Second, the process of compiling information for a single integrated data set could yield new and important insights.

Environmental Protection and Economic Growth

The impact of environmental protection on the economy and employment is a matter of much debate. In the 1992 Presidential campaign, for example, efforts to preserve flora and fauna in the Pacific Northwest potentially affected loggers' jobs and became a matter of public debate. Supporters on both sides cited much anecdotal evidence concerning the impact of environmental protection on the employment and the economy.

Researchers also disagree about the effect of environmental policies on the economy. Since the extensive environmental legislation of the 1970s, interest has arisen in evaluating the economic and employment effects of environmental regulations. Many of the studies of the effects of environmental protection conclude that statutory limits on pollution reduce economic growth. For example, economist Edward Denison--whose model relied extensively on data from the national accounts--estimated that for the 1973-1982 period U.S. government regulations for pollution abatement reduced measured national output growth by 0.09 percent a year.[3] In 1990, Dale Jorgenson and Peter Wilcoxen used a general-equilibrium model to estimate the impact of environmental regulation on the economy by

3. Edward F. Denison, *Trends in American Economic Growth 1929-1982* (Washington, D.C.: Brookings Institution, 1985), p. 111.

simulating its growth between 1973 and 1985 with and without regulation.[4] The results indicate that environmental regulation reduced the annual growth rate of GNP by 0.19 percent a year from 1973 through 1985. Jorgenson's and Wilcoxen's estimates indicate that GNP was about 2.5 percent lower in 1985 than it would have been otherwise.

Rather than employing simulation models, some researchers use statistical methods on historical data to assess the effects of regulation. A 1992 study finds empirical evidence to indicate a positive relationship between environmental protection and economic growth. This study, conducted by economist Stephen Meyer, examines such a positive relationship at the state level.[5] Meyer statistically tested the hypothesis that undertaking policies to protect the environment hinders economic growth and job creation. His data cover the period between 1973 and 1989. He finds no evidence to support a negative relationship between environmental regulation and economic growth. In fact, his results showed just the opposite: states with ambitious programs to protect the environment had the highest levels of economic growth and job creation over the period. Meyer's results do not, however, prove a causal relationship between environmental regulations and economic growth.

Both simulation and statistical models can be based on relationships derived from national accounting data. But the accounts do not link environmental quality to output. Unless obtained independently, models based on data from the accounts will not have any of the feedback effects of environmental changes on productivity. In essence these models assume that environmental quality would be the same without federal legislation. Very different answers could be produced if the feedback effects of the environment on output were included in such models.

Given current models, it is not clear what the net impact of such programs might be and whether significant differences in growth rates exist in the relative impact of one program over another. It is clear, however, that more detailed information is needed about the relationship between policy, expenditures on final and intermediate products, and environmental and natural resources. Information generated by an expanded set of accounts could provide important pieces of the puzzle.

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4. Dale W. Jorgenson and Peter J. Wilcoxen, "Environmental Regulation and U.S. Economic Growth," *Rand Journal*, vol. 21, no. 2 (Summer 1990), pp. 315 and 327.

5. Stephen Meyer, "Environmentalism and Economic Prosperity: Testing the Environmental Impact Hypothesis" (working paper, Massachusetts Institute of Technology, Project on Environmental Politics and Policy, Cambridge, Mass., October 1992).

Distributional Impacts of Environmental and Natural Resource Policies

The benefits and costs of environmental and resources policies fall more heavily on some industries or income groups than on others. Improved water quality especially seems to favor higher income groups since most of the improvement is in nonurban recreation sites. Employment in industries that pollute more, such as chemical and paper manufacturing, could be most affected by tighter air quality standards.[6] Such a perception--whether correct or not--can cause political resistance to new initiatives that might result in policy improvements.

The input-output accounts can be especially useful for analyzing the impact of legislation on different industries. Detailed models of the payments sector in I-O tables have also been developed to predict the effect of policies on income distribution. The Forest Service has incorporated one such simulation in its regional planning model, IMPLAN (Impact Analysis System for Planning).[7] One way of improving information about the distributional effects of environmental and natural resource policies is to incorporate data on environmental and natural resources service flows into the accounts.

Links Between Trade and Environmental and Natural Resource Policies

Policymakers have come to appreciate the notion that nations cannot make policy without considering what is happening in other countries. Concern about the effects of the North American Free Trade Agreement on the environment, for example, was an important consideration during negotiations and required working out a separate side agreement on environmental issues before the Administration was willing to submit the final agreement to the Congress. National accounting systems that include environmental and natural resources could provide useful information during negotiations over the nation's commitments to restore or maintain natural capital.

A traditional justification for trade measures and sanctions is that they retaliate for activities that place the United States at a competitive disadvantage. A case could be made that pollutants that cross boundaries have this effect. Discharges of pollutants by other countries may not only affect production costs in the United States, but could affect them differently

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6. William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy* (New York: Cambridge University Press, 1988), pp. 245-253.

7. For a description, see Adam Rose, Brandt Stevens, and Gregg Davis, *Natural Resource Policy and Income Distribution* (Baltimore: Johns Hopkins Press, 1988).

than in the home country. For example, the effects of greenhouse gases on local climate patterns vary depending on latitude, size of land mass, and so on.

Trade restrictions have not been used when a country's production and processing methods result in excessive discharges of pollutants such as carbon, sulfur or nitrogen oxides, or chlorofluorocarbons across national boundaries. One reason is the difficulty of determining the effect of transboundary pollutants on industry costs. Expanding the input-output tables to include the use of waste disposal services and identify abatement costs could help in identifying primary and secondary costs of transboundary pollutants.

The Clinton Administration has recently expressed an interest in assessing the effect of environmental policies on trade.[8] The intent is to give decisionmakers a sense of the trade impacts of an environmental policy before it is carried out. Some researchers have expressed concern over ways in which such assessments would be conducted because there is currently no effective way of measuring the myriad trade impacts of environmental policies. Incorporating information on natural resources and the environment into the national accounts could provide useful information for models assessing these impacts.

PRICE AND QUANTITY DATA ON ENVIRONMENTAL AND NATURAL RESOURCES ARE DIFFICULT TO DETERMINE

Is it possible to incorporate the value of natural resources and the environment into measures of income and wealth so that the information could contribute to policy analysis? A primary advantage of using accounting systems for policy decisions is that they measure disparate goods and services with a common metric. But defining different items in economic terms rather than by some physical measurement is only worthwhile if these values are consistent and reliable.

Uncertainties and Problems in Valuing Nonmarketed Flows

As a rule, a value is assigned to each product in the accounts by multiplying its market price by the quantity produced. Goods or services that do not pass from seller to buyer in a legitimate market are difficult to price. For example,

8. "Administration to Assess Trade Impact on All Environmental Policies," *Environmental Policy Alert* (Inside Washington Publishers, Washington, D.C., September 29, 1993), pp. 41-42.

there is no single way of placing a value on the services of a stay-at-home spouse, or the services of the police force and the government. Conventional accounts currently include some of these services. In some cases, cost or some imputed measure is used as a proxy for price. Government services are priced at cost, so the wages of government employees are taken to represent their contribution to GDP. The price of services from owner-occupied housing (which does not involve direct market transactions) is imputed from rates on rental housing. Others of these hard-to-measure activities, such as the services of a stay-at-home spouse, are omitted from GDP.

The issue of valuation is especially important in incorporating environmental and natural resources because so many of the goods and services of these assets are not traded in markets. The principal problems of measurement are (1) identifying the most appropriate way of gauging physical changes in environmental and natural resource reserves; and (2) identifying reliable and consistent methods of estimating value and depreciation. Measuring environmental quality is difficult because the effects of pollution on health, recreation, and ecosystems are uncertain. Measuring resource availability is difficult because future demand is uncertain and existing supplies are hard to determine. Questions about the accuracy and precision of these measurements raise doubts about the usefulness of information from the accounts in guiding public policy.

Many of the goods and services of natural capital are either not sold in markets or are sold under conditions that make market-generated values inappropriate for estimating depreciation. The lack of organized markets is especially problematic in pricing service flows associated with the effects of changes in environmental quality on health. Techniques for imputing prices are at an early stage of development and in some cases, such as the assignment of value to human life, there may never be agreement.

Conclusions

Green accounting includes all or some part of the following: expanding the set of assets, expanding the set of services derived from those assets, and reclassifying the current set of services included in the accounts. If green accounting is to be useful for the analysis of policy issues, techniques that are used to incorporate natural resources and the environment into the accounts must be consistent with current accounting procedures. The basic accounting and economic identities underlying the accounts should be preserved wherever possible.

CHAPTER II

UNDERSTANDING THE KINDS OF REVISIONS NECESSARY FOR ADDRESSING CRITICISMS OF THE NATIONAL ACCOUNTS

National accounting systems serve as an information framework for analyzing the economy. They are designed to perform many of the same functions for the economy that private accounting does for individual business enterprises. Business managers use accounting methods to help in managing their day-to-day operations and assessing long-term practicability. Policymakers examine quarterly changes in national income totals to guide stabilization policies aimed at dampening swings in the business cycle. Policymakers also use such measures as the saving rate and the amount of capital formation recorded in the accounts to guide their assessment of the long-term performance of the economy.

Even though natural resources and the environment are not given the same treatment as privately owned physical capital in the current accounts, some economists would not advocate green accounting. There are at least two practical reasons for this resistance. One concern is maintaining consistency with historical time series from the national accounts. Another is maintaining the standards of the accounts; in large part these standards are thought to be upheld by using mostly market data. Can data be collected and measurements devised so that they meet the standards of the accounts for reliable and consistent assessments? These concerns are satisfied by separating out (in satellite accounts) the new estimates from official reported totals until a sufficient consensus develops around the consistency and integrity of new estimates. The United Nations is using this approach in its satellite system for integrated environmental and economic accounting as it begins green accounting efforts. The Bureau of Economic Analysis plans to build upon the work of the United Nations in developing an accounting framework that is consistent with the national accounts.

Given a decision to carry out some form of green accounting, the initial hurdle is determining just how to proceed. Which nonmarket services should be measured and which forms of natural capital (or other kinds of capital) should be depreciated? An important guiding principle is whether there are data and techniques available that make some revisions easier to carry out than others. Applying the analyses necessary to carry out some of the easier kinds of revisions could help inform decisionmakers about the impacts of some policies and lay a basis for more extensive revisions of the accounts.

In addition to addressing specific criticisms, revising the accounts to broaden the set of covered assets would allow for measures of sustainable income. In particular, such a revision would involve expanding the asset boundary to include every type of reproducible and natural capital. Within the framework of the national accounts, sustainability is related to maintaining wealth for the purpose of ensuring future income and consumption.

Basic accounting and economic concepts underlie the construction of the accounts that make them a powerful tool in economic analysis. Because it is important to continue to perform these traditional functions, any attempt to revise the accounts to measure changes in natural resources and the environment better should be attempted without upsetting the underlying framework. In order to understand the revisions involved in changing the national accounts, one must understand how they represent economic activity.

HOW THE NATIONAL ACCOUNTS REPRESENT ECONOMIC ACTIVITY

The national income and product accounts measure the flow of products and income in the U.S. economy. The *product side* of the national accounts measures the flow of goods and services produced in the economy. The *income side* of the accounts measures the income earned by factors (inputs) contributing to the production of these outputs. The two sides of the accounts represent two different measures of the same continuous flow.

The product side measures expenditures on output. The receipts from the sale of output then become payments compensating the factors that produced the output. For example, the amount spent on a loaf of bread at the supermarket becomes payment to the farmer, miller, baker, and supermarket owner for the labor and capital used in the production of the bread and their profits. Since the value of output equals income (a national accounting identity), gross domestic product can be viewed either as total expenditures on final output or as total income generated in production.

Intermediate Goods, Factor Services, and Final Goods and Services

A national accounting system must first measure the economic activity involved in the production of goods and services. Some products are sold to the final user. These products are called *final goods and services*. Other products are sold to be used in the production of other goods and services (that is, to be transformed and resold). These products are called *intermediate*

goods. Thus, wheat is an intermediate good used to produce flour, which in turn is used to produce bread. Here, bread is a final good because it is consumed rather than resold. In the case of natural resources and the environment, some of the goods and services may be intermediate and some may be final. For example, timber from forests, agricultural land, or minerals are sold and used in the production of other goods such as boards, agricultural commodities, or gasoline. They are intermediate goods. Drinking water, however, is a final good because it is sold to the final consumer.

The issue of double counting is critical to an accurate measure of national income. Clearly, GDP is not meant to include the value of the flour, yeast, milk, and other ingredients in a loaf of bread as well as the value of the loaf itself. Value added is another term for total input measured by total factor income for service provided.[1] Double counting is avoided in the accounts by working with value added. At each stage of manufacture of a good, only the value added to the good at that stage of production is counted as a part of GDP. The value of wheat (above the costs of purchased intermediate goods) sold by the farmer is counted as part of GDP. Then the value of flour sold by the miller minus the cost of the wheat is the miller's value added. Following the process along to the final good, the value of the bread is equal to the sum of value added at each stage.

Stocks and Flows in the Economy

An asset is any material or process that has the potential to generate a continuing flow of income.[2] A *stock* represents an asset at a particular point in time. Stocks generate flows as assets are used in the economy. *Flows* are the services generated by a stock during an accounting period (usually a year). The economic value of an asset is equal to the expected net present value of the flow of future services generated by the asset.

The Flow of Factor Services from Capital Stocks. The accounts assume that the production of any good or service can be linked to the flow of factor services provided by capital assets. Currently, the accounts recognize that the value of goods and services sold in the market includes the capital services of the plant and equipment used in their manufacture.

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1. GDP measured by final output should be equal to GDP measured by value added.

2. Irving Fischer, *The Nature of Capital and Income* (New York: Macmillan, 1906).

In a modern economy there are two general types of capital stock: reproducible and natural capital (see Table 1). Reproducible capital stock would not exist if humans did not inhabit the earth; in general, natural capital stock would anyway. Reproducible capital is subdivided into privately owned and publicly owned tangible and human capital.

Tangible reproducible capital includes computers, cranes, steel mills, textile plants, roads, and bridges. This form of capital stock is used by companies to manufacture such goods as automobiles and cookware, by governments and universities to provide medical and educational services, and by people for their personal housing.

Much publicly owned reproducible capital stock adds value to GDP. Human capital contributes to GDP as well. Human capital is a function of the total number of workers plus their skills and knowledge.

Natural capital consists of the environment and natural resource reserves. The environment as natural capital is made up of air (the atmosphere), water (the hydrosphere), and land (the lithosphere). The atmosphere absorbs greenhouse gases (carbon dioxide, methane, hydrofluorocarbons, and so on); ozone-depleting substances, including chlorofluorocarbons; emissions of particulate matter, nitrous oxides and sulphur oxides; and volatile organic compounds that contribute to atmospheric ozone. The hydrosphere absorbs such pollutants as heavy metals, chlorides, plastics, acid rain, pesticides, organic wastes, and chemical fertilizers. Paper, glass, metals, rubber products, plastics, pesticides, and chemical fertilizers are also deposited in the lithosphere. These waste disposal services directly affect the production of marketed goods and, therefore, affect GDP.

Natural capital provides marketed environmental waste disposal services and nonmarketed environmental waste disposal services. It is generally thought that the value added by environmental waste disposal services that are not marketed greatly exceeds the value added by marketed services.

Natural resources are a type of natural capital. Natural resources are divided into renewable and nonrenewable stocks. Renewable resources include agricultural lands, recreational areas, forests, lakes, streams, grasslands, wetlands, fisheries, and wildlife. These resources provide marketed factor services that serve as inputs for the production of final goods and services such as food, wood products, and drinking water and recreation.

TABLE 1. MAJOR SERVICE FLOWS FROM VARIOUS TYPES OF ASSETS AND CURRENT TREATMENT IN THE NATIONAL ACCOUNTS

	Category of Service Flow		
Type of Asset	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

SOURCE: Congressional Budget Office.

a. Underground market activities, such as illegal drug sales, are not included in gross domestic product (GDP) and are not represented. Marketed factor services add value to GDP, which is recorded in the accounts.

b. The value added to GDP by nonmarketed factor services is not identified separately in the accounts.

c. Nonmarketed final services are not included in GDP except for housing, which is assigned an imputed value.

Nonrenewable natural resource stocks include reserves of mineral fuels (petroleum, natural gas, coal, and uranium), nonfuel minerals (namely lead, copper, and gold), and groundwater. Nonrenewable resources provide inputs for the production of energy and metal products.

Capital services provided by environmental and natural resource assets also contribute to the production of goods. The current accounts, however, do not contain separate accounting entries for the value of these flows.

The Flow of Final Services from Capital Stocks. Assets can also generate service flows that go to households (final users) rather than to businesses as primary inputs to production. The services of these assets are labeled nonmarketed because they are not usually bought and sold in established markets and are not included in GDP. Owner-occupied housing and financial services are the only final service flows from capital that are currently recorded in the accounts. Including other final services of capital would require expanding the definition of GDP.

The Golden Gate Bridge and Empire State Building, for example, contribute to the ambience of San Francisco and New York in ways that differ from their services as contributions to the production of other goods and services. The final services of education, such as informing the citizenry and heightening people's appreciation of historical sights, are also nonpecuniary.

Natural resources and the environment derive much of their social value from the aesthetic, recreation, and health benefits they provide--for example, the Grand Canyon and clean water. The fact that people appreciate clean air and water and unspoiled land is demonstrated by the recreational choices they make. The benefits of beaches and mountains are examples of final services to households. Many natural resources also provide nonmarketed final services known as nonuse benefits. The willingness of individuals who may never actually see a blue whale to spend money to protect them is evidence that these services are considered valuable to the final user.

Investment and Depreciation

One of the fundamental principals of national accounting is that income and capital must be measured separately. The flow of capital services from capital stock generates income. If you liquidate your capital assets and use the proceeds for consumption, you are living beyond your means, thereby undermining your ability to create future income.

In accounting for capital assets, the accounts record changes in the stock of capital. Changes in the stock of capital are affected by investment and depreciation (among other things). Investment represents expenditures for augmenting the capital stock and is made at the expense of current consumption to ensure future income. The use of capital to generate output causes wear and tear, and hence depreciation from use of the capital stock. Therefore, the entire total of the factor incomes of all capital services (recorded as GDP) cannot be used for current consumption. Some gross income must be set aside to restore the stock of capital. As a result, the current accounts depreciate physical capital assets--equipment, machines, buildings, and so on--in the accounts. Net domestic product (NDP), calculated by subtracting capital consumption (an estimate of the amount needed to maintain the stock of capital) is an attempt to separate out income that can be used for current consumption.

The term "fixed capital" is used in the accounts to represent a depreciable capital asset, the service flows of which add value to GDP. One method of revising the accounts requires an analogous treatment for natural resource and environmental assets. Some analysts have suggested that certain forms of natural resources and the environment be treated as inventories rather than fixed capital (see Appendix C). There may be some differences in measurement techniques because of the special nature of various forms of natural capital assets. For example, no amount of investment will increase the amount of a finite (nonrenewable) resource; however, money can be spent to discover additional supplies. In the case of renewable resources such as forests, regeneration must be accounted for in assessing the size of the stock.

Asset and Production Boundaries

Asset and production "boundaries" define the set of goods and services that are included in the national accounts. The asset boundary contains real assets that include fixed capital.[3] An asset must be included in the asset boundary if it is to be assigned a value in the balance sheets. It must also be designated as fixed capital if its depreciation from use and accidental loss is to be subtracted from GDP. The production boundary delineates the set of goods and services that are treated as either intermediate or final products. Only final products in the production boundary are counted toward GDP.

3. Inventories and financial assets (stocks, bonds, and so on) are also recorded in the balance sheets of the accounts.

Current Production and Asset Boundaries of U.S. Accounts

The gross domestic product includes most final goods and services involving an exchange of money (a market transaction). A number of marketed activities are not reflected in the present taxonomy because they are a part of the underground economy. Examples include illegal activities such as drugs, prostitution, and gambling; but underground transactions also include payments "under the table" such as paying baby sitters and home health care workers in cash. These are market activities that some estimate to be as much as 13 percent of GDP. Few advocate incorporating such illegal activities in GDP.

The GDP also equals the income earned from all the factor services used in the production of these final goods and services. These services are also included in the production boundary. Some factor services that add value to GDP are, however, nonmarketed. These services have no market price and are not recorded in the accounts. Nevertheless, they do affect GDP through productivity.[4] Nonmarketed factor services that affect the value of GDP and are therefore inside the production boundary include the services of publicly owned reproducible capital; the factor services--human capital--of volunteers; environmental waste disposal factor services; and the factor services from natural resources.

Finally, most final services of capital are not included in the production boundary and are therefore not counted in GDP. The major exceptions are services of owner-occupied housing and services of financial institutions whose value equals 9 percent of GDP. These final services are assigned a value in the accounts based on imputed prices.

The current asset boundary shows that the accounts only recognize privately owned capital that is tangible and reproducible, including housing (see Table 2 on page 22). Other forms of capital--publicly owned reproducible, human, and natural--are not included in the asset boundary. This means that the current asset and production boundaries are inconsistent because the current production boundary implicitly or explicitly counts the factor services of publicly owned, human, and natural capital. This inconsistency means that the balance sheets do not record investment or depreciation for some kinds of capital stock whose factor services affect GDP.

4. For further explanation, see Jan Bojo and others, *Environment and Development: An Economic Approach* (Dordrecht, Netherlands: Kluwer Academic Publishers, 1992), pp. 40-53.

ADDRESSING CRITICISMS OF THE TREATMENT OF NATURAL RESOURCES AND THE ENVIRONMENT

The current treatment of natural resources and the environment within the framework of the asset and production boundaries of the accounts has been criticized as misleading. Three general kinds of revisions are possible to address the perceived problems. The first would expand the set of goods treated as national assets to include valuable--but now uncounted--environmental and natural resources. In the parlance of the national accounts, this is *expanding the asset boundary*. The second kind of revision would expand the set of goods and services included in the measure of national income to encompass final services flowing from the environment and the nation's natural resources that are now unacknowledged (*expanding the production boundary*). The third kind of revision would reclassify some of the economic activities measured in the accounts by (1) identifying activities that counteract or protect against deteriorating environmental conditions and (2) identifying the contribution of the waste disposal services of the environment to income. This kind of revision to the accounts is called *reorganizing the production boundary*. These types of revisions fall under the rubric of green accounting because they more clearly identify the links between nature and the economy in the accounts.

Expanding the Asset Boundary

Expanding the asset boundary to record changes in natural resources and the environment implies that values for depletion and degradation would be computed for these natural capital assets, along with capital consumption for tangible reproducible capital. For conventional GDP (that is, using the current production boundary), the asset boundary would have to be expanded to include factor services generated by natural capital (see Table 3 on page 24). That is, values for depletion and degradation could be estimated for natural assets such as forests, mineral reserves, and the quality and quantity of agricultural lands. Values for degradation could also be calculated for changes in the environment's waste disposal services that are available without exceeding ambient quality standards as set by regulation. Of course, changing the production boundary would imply a different set of services as a basis for valuing capital assets.

If capital consumption for the expanded set of assets were subtracted from GDP, the results could be used to produce what might be termed an environmentally adjusted NDP measure. That is, environmentally adjusted

TABLE 2. CURRENT ASSET AND PRODUCTION BOUNDARIES IN THE NATIONAL ACCOUNTS

Type of Asset	Asset Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

(Continued)

SOURCE: Congressional Budget Office.

NOTE: Shaded services not included in boundaries.

TABLE 2. CONTINUED

Type of Asset	Production Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

a. Underground market activities are not included in gross domestic product (GDP) and are not represented Marketed factor services add value to GDP, which is recorded in the accounts.

b. The value added to GDP by nonmarketed factor services is not identified separately in the accounts.

c. Nonmarketed final services are not included in GDP except for housing, which is assigned an imputed value.

TABLE 3. EXPANDED ASSET AND CURRENT PRODUCTION BOUNDARIES FOR COMPUTING ENVIRONMENTALLY ADJUSTED NET DOMESTIC PRODUCT

Type of Asset	Expanded Asset Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other non-pecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

(Continued)

SOURCE: Congressional Budget Office.

NOTE: Shaded services not included in boundaries.

TABLE 3. CONTINUED

Type of Asset	Current Production Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

a. Underground market activities are not included in gross domestic product (GDP) and are not represented. Marketed factor services add value to GDP, which is recorded in the accounts.

b. The value added to GDP by nonmarketed factor services is not identified separately in the accounts.

c. Nonmarketed final services are not included in GDP except for housing, which is assigned an imputed value.

NDP would be modified for depreciation as a result of the use of tangible capital, depletion of natural resources, and degradation of environmental assets.

Changes in the value of tangible reproducible assets--whether from use, capital gains and losses, or investment--are currently recorded in the balance sheet. Similar types of entries could be made to account for changes in natural capital assets that occur over the accounting period. Resulting measures of depreciation from use (depletion and degradation) could be linked to the NIPA accounts to calculate an environmentally adjusted NDP.

Expanding the Production Boundary

Expanding the production boundary to include more services of natural resources and the environment would mean that broadened definitions of national income could be calculated. Measurement of a green GDP, for example, could count the final services of natural resources and the environment (see Table 4 on page 28). That is, the value of non-health-related services--recreation, biodiversity, aesthetic and nonuse benefits--as well as pollution damages (treated as health-related services that have been assigned negative values) would be included in national income.

Carrying out this kind of revision would require estimating imputed prices for final services of natural resources and the environment since they are not marketed. The product side of the accounts would record expenditures for marketed goods plus the imputed values for the set of final services of natural capital. The income side of the accounts would record payments to factors for their value added to both marketed and nonmarketed goods. In some cases the nonmarketed final services are difficult to evaluate because they are not related to the production process or to any market transaction. A lack of market data limits the choice of techniques for imputing a price for the assets generating these services.

Reorganizing Items Included in the Production Boundary

One way of reorganizing items that are included in the production boundary would be to identify service flows from the environment. This revision would recognize the flow of waste disposal services from the environment to businesses as a contribution to production. As is the case for other kinds of factor services in production, there is an associated return (income). Since waste disposal services are not marketed, a price would have to be assigned

to them on the basis of this factor's contribution to output. This information could be estimated by sector, recorded in the input-output tables, and used in analyzing the impacts of environmental policies. For example, the economic impact on production of an environmental policy changing allowable emission levels could then be traced through the I-O tables on an industry-by-industry level.

The identification of waste services is described as a reorganization rather than a redefinition of the production boundary, since it need not change GDP.[5] Instead, it would involve assigning some of the value added that is now recorded as profits, rents, and so forth to imputed factor payments for the environment. Under this revision, the product side of the accounts would not have to change; that is, expenditures would remain the same. The income side of the accounts--which records payments to factors--would be affected, however, since income would be reallocated among the factors of production. No one explicitly receives the return (factor payments) from the use of waste disposal services because there are virtually no established property rights for the services of the environment.[6] Since these factor payments are not paid out (as are wages), they are implicitly recorded as a part of profits or other factor income. (Some researchers suggest that the factor payments for use of the environment could be recorded separately in the accounts as a subsidy to producers who use these services.) Reorganizing the production boundary would, therefore, result in changes to the I-O table more than to other components of the accounts.

Many proponents of changing the accounts are concerned that gross domestic product is not a good measure of productive activity because it includes spending on pollution prevention. Some advocate circumventing this anomaly but subtracting so-called defensive expenditures from GDP. The production boundary would not change if this were done but GDP would decrease as a result of the reclassification of expenditures for restoring environmental degradation from final to intermediate.

The problem with this approach is that it also yields unexpected results. Countries that ignore pollution problems and spend money on other types of goods and services might appear to be better off than countries that spend money on preventing pollution. In addition, by taking expenditures on

5. Identifying the contribution to production of the waste disposal services of the environment would involve estimating a production relationship given the other factors of production. There are established methods of estimating returns on factors of production that may be applied in this circumstance.

6. The obvious exception is the ownership implied by the sale of marketable pollution permits.

TABLE 4. EXPANDED ASSET AND PRODUCTION BOUNDARIES FOR COMPUTING GREEN GROSS DOMESTIC PRODUCT AND ITS NET DOMESTIC PRODUCT

	GDP Asset Boundary: Category of Service Flow		
Type of Asset	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

(Continued)

SOURCE: Congressional Budget Office.

NOTE: Shaded services not included in boundaries.

TABLE 4. CONTINUED

Type of Asset	Production Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

a. Underground market activities are not included in gross domestic product (GDP) and are not represented. Marketed factor services add value to GDP, which is recorded in the accounts.

b. The value added to GDP by nonmarketed factor services is not identified separately in the accounts.

c. Nonmarketed final services are not included in GDP except for housing, which is assigned an imputed value.

environmental protection out of GDP, the effects of increased environmental protection on jobs and incomes could not be as easily measured. The reason is that any relationship between expenditures on environmental protection and output or income would be removed from the accounts (conforming to the identity of income and expenditure).

Instead of subtracting expenditures on environmental protection, items included in the current production boundary could be reorganized to identify more clearly the costs of reducing the risks of pollution-caused damages to health. Reclassifying these items would mean that some of the expenditures now listed as investment and consumption would be listed as defensive expenditures. These would include expenses for ameliorating health problems related to the environment and for abatement equipment. Reclassifying these costs as a part of reorganizing the accounts would also help to identify the benefits and costs of changing emission levels at the industry level. This type of revision is also classified as a reorganization because it would not have to result in a change in the measure of national income.

USING THE NATIONAL ACCOUNTS TO MEASURE SUSTAINABLE INCOME

The desire that economic growth not be accomplished at the expense of environmental quality or an excessive depletion of natural resources has focused attention on the concept of sustainable development. The World Commission on Environment and Development (the Brundtland Commission) introduced the idea to policymakers in its seminal 1987 report, *Our Common Future*. The commission defined the concept as "meeting the needs of the present generation without compromising the needs of future generations."[7] It has proved difficult to carry out the concept of sustainability with any precision, however. Among the many definitions of sustainability, the notions of "weak" and "strong" sustainability provide a useful framework for analysis. Strong sustainability implies that natural resources should be preserved at levels consistent with some minimum ecological criteria. The notion suggests that no further substitution of one type of capital with another should be permitted beyond a certain point. Weak sustainability suggests that the total value of capital should be preserved where losses in one asset can be

7. There are problems with this general definition of sustainable development in that it implicitly assumes that the economy (and national government) meet(s) "needs" as opposed to "wants." For developed nations in particular, many would agree that these economies meet a lot of wants while failing to meet some important needs. The many interpretations of this general definition take on subjective valuations of "needs" versus "wants." Although there are problems with this definition, it remains the generally accepted broad basis from which more specific definitions are derived.

compensated for by gains in others. Incorporating natural resources and the environment into the accounts, in particular by expanding the asset boundary, implicitly adopts a framework in which trade-offs between different types of capital are possible. At any rate, the Brundtland Commission's general definition can and has been interpreted in many ways, including the notion that the assets of ecological systems must be kept physically intact, or that wealth (the total value of all assets) must not be allowed to decline.[8]

The general concept of sustainability originates in the study of nature, where predators are often observed avoiding the overexploitation of their supply of prey in order to ensure a sustained yield. In economics, the concept of income (introduced by John Hicks) serves as a guide for "prudent conduct" in deciding how much to consume from current monetary receipts.[9] Hicksian income is defined as the maximum amount that a person or organization can consume during a specific period and still have as much wealth at the end as at the beginning. It is based on the idea that if you liquidate your assets and use the proceeds for consumption, you are living beyond your means, and thereby undermining your ability to sustain your current standard of living. Hicksian income is increasingly referred to as sustainable income because it could be used to indicate whether the total value of a nation's assets are being maintained.[10]

Using the information in the national accounts to generate a measure of sustainable income is consistent with the idea of meeting present needs without compromising the needs of future generations. Sustainable income is calculated by adjusting GDP for the net change in the value of all assets that contribute to national wealth. Using the current production boundary to measure sustainable income would require accounting for changes in all forms of capital that generate factor services. This total measure could serve as an indicator of whether the economy was accumulating or expending wealth. Measuring sustainable income would help the accounts provide assessments of the nation's assets and national wealth.

One benefit of measuring sustainable income is that data necessary for such an effort would enhance the usefulness of the accounts for policy analysis. The more detailed information about the flow of goods and services

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8. Tom Tietenberg, *Environmental and Natural Resource Economics* (New York: Harper Collins Publishers, 1992), Chapter 20.

9. John Hicks, *Value and Capital* (London: Oxford Press, 1936).

10. S.E. Serafy and Ernst Lutz, "Environmental and Resource Accounting: An Overview," in Yusuf Ahmad, Salah El Serafy, and Ernst Lutz, eds., *Environmental Accounting for Sustainable Development* (Washington, D.C.: World Bank, 1989), p. 2.

from publicly owned and human capital in the I-O tables and balance sheets would be helpful in analyzing links between investments in education and transportation systems and the performance of the economy. Moreover, it would provide policymakers with a general measure of national wealth incorporating the effects of changes in international terms of trade. The benefits are, therefore, similar to those derived from the additional data needed to incorporate natural capital into the accounts; that is, helping to analyze the ties between environmental and natural resource policies and economic performance.

Understanding Sustainable Income

Gross domestic product, net domestic product, and sustainable income represent different ways of representing the nation's capital. GDP measures gross income but ignores the fact that a part of that income may be generated by drawing down capital assets. As currently measured in the accounts, NDP estimates the income remaining after adjusting for the change in the tangible capital stock caused by use and accidental loss (capital consumption). Sustainable income is the amount of income that would be left over after calculating the change in the full value (as it affects national wealth) of all assets. Calculating the changes in value of capital imparts additional information about national wealth. On an international basis, human capital makes an important contribution to sustainability. Hence, it is important that any treatment of sustainable income be truly comprehensive by accounting for the change in value of the full set of assets contributing to the economy. To do otherwise could bias the results because the value of these assets may move in different directions. A decrease in the value of natural assets could be more than offset by an increase in the value of reproducible assets. These implicit trade-offs are consistent with the notion of "weak" sustainability.

Net domestic product is not a good measure of sustainable income, for two reasons. First, as currently calculated, NDP is not adjusted for the depreciation of all forms of capital that contribute to final goods and services counted in GDP. Second, capital consumption does not measure the net change in the value of assets. Rather, it is an estimate of the loss of value caused by use and accidental loss. In some cases, with no change in prices, the two methods of calculating depreciation are equivalent.

A measure of sustainable income using the current definition of GDP would keep the production boundary unchanged but expand the asset boundary. The asset boundary would be expanded to include the discounted income from the factor service flows of tangible, publicly owned, human, and

natural capital. The reason for expanding the boundary would be to record changes in value for capital that provide factor service flows that are counted in the current measure of national income (see Table 5). Measuring the sustainability of conventional GDP requires that net changes in the value of all forms of capital be subtracted from GDP. This measure of sustainable income, although based on the current definition of GDP, would still be laborious because the value of nontraditional forms of capital (natural, human, and publicly owned) would have to be computed along with reproducible capital that is tangible and privately owned.

Measuring sustainable income on the basis of a green GDP would entail expanding the definition of GDP to include a "fair" market value for all current service flows from natural capital. Measuring the sustainability of this more broadly defined GDP requires that the changes in the value of capital in the accounts be based on changes in the future flows of all factor services from publicly owned tangible, reproducible, and human capital, and both the factor service and final flows of natural capital that are counted in the expanded measure of GDP (see Table 6). Thus, the flows from natural capital would have to include not only factor services, but health benefits, recreation services, and nonuse benefits, since the asset and production boundaries must coincide in order to measure sustainable income.

Measuring Sustainable Income

There are two important issues connected with deciding to measure sustainable income as a part of revising the accounts, namely whether one can justify the additional efforts required to (1) expand the asset boundary beyond natural resources and the environment and (2) compute a second (broader) measure of depreciation.

In order to obtain a consistent measure of sustainable income, one must measure the change in value of all assets in the asset boundary. One of the greatest challenges in the task of expanding the asset boundary to measure sustainable income is assessing value and the change in it for a broader set of assets. The difference between the change in value and capital consumption is approximately equivalent to the amount of capital gains and losses resulting from price changes in the economy.

The net change in the value of an asset is caused by physical changes in the stock--through use and accidental loss--and unanticipated changes in general market conditions. Improvements in technology, other changes in the production process (including capacity utilization), changes in market

TABLE 5. ASSET AND PRODUCTION BOUNDARIES FOR COMPUTING SUSTAINABLE INCOME BASED ON CONVENTIONAL GROSS DOMESTIC PRODUCT

	Expanded Asset Boundary: Category of Service Flow		
Type of Asset	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

(Continued)

SOURCE: Congressional Budget Office.

NOTE: Shaded services not included in boundaries.

TABLE 5. CONTINUED

Type of Asset	Current Production Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, Non-use benefits

a. Underground market activities are not included in gross domestic product (GDP) and are not represented. Marketed factor services add value to GDP, which is recorded in the accounts.

b. The value added to GDP by nonmarketed factor services is not identified separately in the accounts.

c. Nonmarketed final services are not included in GDP except for housing, which is assigned an imputed value.

TABLE 6. EXPANDED ASSET AND PRODUCTION BOUNDARIES FOR COMPUTING SUSTAINABLE INCOME BASED ON GREEN GROSS DOMESTIC PRODUCT

	Expanded Asset Boundary: Category of Service Flow		
Type of Asset	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

(Continued)

SOURCE: Congressional Budget Office.

NOTE: Shaded services not included in boundaries.

TABLE 6. CONTINUED

Type of Asset	Expanded Production Boundary: Category of Service Flow		
	Marketed Factor Services[a]	Nonmarketed Factor Services[b]	Nonmarketed Final Services[c]
	Reproducible Capital		
Tangible, Privately Owned	Services of business-owned plant and equipment to industry and commerce	Major service flows not identifiable	Owner-occupied housing
			Services of business-owned capital
Tangible, Publicly Owned	Services paid for through user fees	Factor services of infrastructure to industry and commerce	Services of infrastructure to households
Human	Services of labor paid for by wages and salaries	Volunteer services	Other nonpecuniary services of education
	Natural Capital		
Environmental	Marketable permits for use of the waste disposal services of the environment	Waste disposal and other services of air, land, and water	Effects on health, aesthetics
Renewable Natural Resource	Food, lumber, water, and recreation paid for by user fees	Major service flows not identifiable	Other recreation services, biodiversity, nonuse benefits
Nonrenewable Natural Resource	Energy, minerals, water, and recreation paid for by user fees	Major service flows not identifiable	Recreation services, nonuse benefits

a. Underground market activities are not included in gross domestic product (GDP) and are not represented. Marketed factor services add value to GDP, which is recorded in the accounts.

b. The value added to GDP by nonmarketed factor services is not identified separately in the accounts.

c. Nonmarketed final services are not included in GDP except for housing, which is assigned an imputed value.

concentration, new discoveries, and changes in consumer tastes can all affect asset markets. When changes in market conditions affect prices and interest rates, the value of an asset can show capital gains (with a price increase) or losses (with a price decrease). In some cases, the physical quantity of assets may change only slightly but prices may fluctuate widely. Nevertheless, sustainable income must account for changes in the value of capital associated with its contribution of service flows to future GDP. This may necessitate the use of statistical smoothing methods to net out transitory capital gains and losses.

HOW DO WE PROCEED?

Green accounting is usually interpreted to mean adding more information about natural resources and the environment to the national accounts. If a decision is made to adopt some level of green accounting, the most immediate concern will be how to proceed with the three general types of revisions. Some or all of these approaches to revising the accounts could be applied. Should all three kinds be undertaken simultaneously or in sequence? Should the easiest aspects of each kind of revision be completed--either simultaneously or sequentially--before the more difficult are attempted?

These questions reflect a dilemma. The Bureau of Economic Analysis has for some time been working on measuring depletion of natural resources (oil, gas, and forests) and expenditures on abatement equipment. This activity is most applicable to the work of expanding the asset boundary to record changes in environmental quality and natural resource stocks and reorganizing the production boundary to identify more clearly the costs of avoiding damage by pollution. There are no estimates comparing the costs of these research activities.

Expanding the production boundary, however, will probably be more expensive and time-consuming than expanding the asset or reorganizing the production boundaries. Any expansion of the production boundary will require imputation of prices because the services that are included are not marketed. The nonmarketed final services, such as the benefits of recreation and biodiversity, are especially difficult to price because fewer techniques are available and because many would involve the assignment of value to human life. Environmental waste disposal services--which would have to be priced as part of a reorganization of the production boundary--are also nonmarketed services, but there is a greater variety of techniques for pricing them because they are inputs for the production of marketed outputs.

It might be argued that it is premature to work toward expanding the asset boundary to include natural assets in the accounts without first deciding exactly what should be in the production boundary. After all, the value of any capital stock in the accounts is based on the discounted returns from the future flow of goods and services included in GDP. A lack of agreement on the definition of GDP means that it is unclear what set of service flows to use as a basis for valuating the nation's assets. Nevertheless, any change from the current definition of GDP will probably expand, rather than contract, the types of goods and services counted. Data collected on the service flows from natural capital counted in current GDP are likely, therefore, to remain valuable, even if GDP is eventually redefined.

Efforts by the Bureau of Economic Analysis and the United Nations' Office of Statistics are consistent with expansion of the asset boundary and reorganization of the production boundary. This makes sense as a first step because many of the flows from natural resources are bought and sold in established markets. But the next step cannot be determined until the eventual goal is identified. In part, this will be a political decision but should be influenced by the degree of uncertainty concerning available data and methods of valuing stocks and flows.

CHAPTER III

MEASUREMENT ISSUES WHEN INCLUDING MORE INFORMATION ON NATURAL RESOURCES AND THE ENVIRONMENT IN THE NATIONAL ACCOUNTS

A substantial amount of conceptual work and data gathering will be necessary to incorporate more information on natural resources and the environment into the national accounts. And in order to revise the accounts to incorporate such "green" information, decisionmakers must ultimately address the practical issues of measurement.

Even apparently straightforward revisions can pose knotty problems. One important challenge will be to put a dollar value on natural resources and the environment where there are no reliable market data on prices and quantities. Reliable market data are lacking for many types of natural capital assets, because either the asset itself or the asset's service flows are not bought and sold as distinct commodities. It is likely that expanding the asset boundary to record degradation in environmental assets will be difficult because, with few exceptions, environmental services are not marketed.

It will be especially difficult to expand the production boundary to include the final services of natural capital because virtually none of these services are marketed. This will create more of a problem for some services than for others, depending on whether the services can be indirectly linked to market activities. For example, the use of the final services of nonmarketed recreation is tied to related market expenditures on food, transportation, and special clothing. Thus, a price for recreation services can be imputed indirectly from market data. Fewer techniques are available, however, for pricing such services as the benefits of biodiversity because they are remote from market activities. Nonuse benefits can only be measured by surveys designed to show the public's willingness to pay for the possible use of these services.

It is also likely to be difficult to identify the costs of reducing pollution risks because some items are purchased for multiple uses. Therefore, the market price indicates a value for the set of services that the purchased item provides. For example, when market data indicate the price of an air conditioner, information on the market price alone does not indicate how much of that price can be attributed to the service of cleaning the air as opposed to the service of cooling it.

Even when data are available for marketed service flows, it may be difficult to identify the net change in the stock of natural capital assets. The

task of determining asset value, depletion, or degradation also requires an assessment of how best to quantify changes in natural resources and the environment. Examples of physical measurements include board feet (forests); tons (iron ore); barrels (petroleum); and parts per million, deaths per thousand, and morbidity rates (environmental quality). For biological resources, it is important to account for regeneration of the physical stock; for nonrenewable natural resources, accounting for discoveries is an issue in evaluating reserves; and for the environment, the issue is accounting for natural regeneration and degradation.

QUANTIFYING ENVIRONMENTAL AND NATURAL RESOURCE ASSETS

Questions about the accuracy and precision of estimated changes in environmental quality and natural resource stocks raise doubts about the usefulness of incorporating such data in the national accounts. Environmental quality can be described in numerous ways--for example, by average pollutant concentrations, by frequency of violations of regulated standards, and by incidents that pose catastrophic risk to living organisms. In general these measures move together, but it is possible for improvements to be made in one area and not in another. Observations of biological populations are difficult, and hence, estimates for these resources are usually based on mathematical models. Estimates of existing supplies of economically exploitable reserves are constantly being revised (by adjusting estimates of the existing stock and adding discoveries) based on information gathered during production and exploration. Quantification of these natural capital stocks is subject to gross errors because of the uncertainty involved.

Measuring Environmental Quality

Environmental pollution is often described in terms of the quantity of toxins that are being released into the air, water, or land. Most environmental regulations are based on the same emissions metric. But any attempt physically to measure the quality of the environment on a national basis will be very difficult. Two important problems that have to be identified are risk assessment and aggregation.

The primary reason for restricting the release of toxins is the risk they pose to the health of humans and other living organisms. There is increasing interest, therefore, in developing a risk-based approach to environmental policy. This approach consists of estimating and ranking the probability of

actual exposure and harm that people or other living organisms will be subjected to during the life cycle of a pollutant. But it is difficult to determine how pollution affects organisms, especially when more than one toxin is present. In other words, it is not possible to assume a one-to-one relationship between any measure of emissions and environmental quality that is defined in terms of human health.

Physical measures such as the level of emissions by pollutant and region may also be poor indicators of pollution problems because they do not reveal information about the risk of exposure. For example, data on the total weight of oxide pollutants can disguise the fact that one ton of sulfur oxides poses a far greater risk to human health than a ton of carbon monoxide. Moreover, totaling physical measurements over several regions may result in misleading information. National statistics may not reveal severe problems with water quality in local streams or high levels of ozone in a particular area. For example, the implications would be different if the total amount of emissions into the atmosphere during a period were not released in various concentrations at the local level but were spread over the entire United States. Air quality as measured by total emissions would be the same but a wider area of dispersion could positively affect human health because both population and pollution tend to be concentrated in urban areas.

There are also measurement problems associated with specific media. Air quality in a region at any specific time depends on several conditions, including the rate at which pollutants are discharged in the region, the air temperature, wind conditions, humidity, cloud cover, and other weather conditions. Each of these factors can change markedly over time. For some pollutants such as smog, there are well-defined daily cycles that can be traced to peaks in auto traffic (a direct source of emissions) and the noonday sun. For other air pollutants, cycles are not pronounced and concentrations tend to vary as randomly as the weather.

Monitoring stations throughout the United States collect data on water quality. Although the monitoring stations are placed so as to gather a broad sampling of the nation's water quality, the collected data do not necessarily measure quality where it is most likely to affect people. The collection stations are further limited because they do not measure all pollutants (including potentially toxic organic chemicals) and may not measure low concentrations of pollutants that are nonetheless significant.

Available Data on Environmental Quality

Available data on air, water, and land quality has increased in both quantity and quality over the last two decades. Further improvements are probable.

Air Quality. Since 1970, efforts to control air pollution have been focused on limiting the emissions of six common pollutants: total suspended particulates, sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, and the organic compounds that contribute to the formation of ozone in the lowest layers of the atmosphere. The U.S. Environmental Protection Agency (EPA) has established national ambient air quality standards for these pollutants to be applied uniformly throughout the country. The idea behind ambient air quality standards is that they are to be based on scientific determinations of the levels of air pollution below which humans or the environment will not be affected adversely.

Statements about air quality, whether they pertain to individual communities or national averages, rely on monitors placed in a few locations. Unfortunately, the monitors collect data on only a limited number of places, and often the locations of the monitors do not indicate actual human exposure. Furthermore, data from monitors usually are not weighted by population concentrations to account for exposure.

Water Quality. The U.S. Geological Survey (USGS) provides trend information about specific water contaminants through its National Ambient Stream Quality Accounting Network (NASQAN). Ambient monitoring stations in river basins and sub-basins throughout the country have collected information on the same pollutants since 1974. Technicians adjust these data to reflect annual variations in stream flow and statistically analyze the results to observe trends in pollution concentration levels. Indicators of pollution include concentrations of dissolved oxygen, nutrients, metals, and toxic substances such as lead, arsenic, and cadmium. Surface waters have been monitored for decades for a number of conventional water quality parameters, but the USGS only began checking in the 1980s for toxic contaminants as a contribution to the EPA's Toxic Release Inventory data base.

Because NASQAN does not monitor estuarine waters, it cannot assess the quality of water affecting large coastal population centers. Information on groundwater quality is also very limited. Even the data that are collected are unsatisfactory for some purposes. They suffer from many of the same problems as those indicated for air quality data. They often come from widely separated, fixed stations and do not adequately represent water quality in the intervening reaches. The stations are often located without regard to human

or ecological exposure so that the data provide little information on how seriously the water quality affects people or ecosystems. Only a few conventional contaminants are commonly monitored, leaving substantial gaps in our knowledge of other pollutants that may present greater risks.

Another problem with data about water quality is that consistent indicators are simply not available nationally over contiguous time periods. The EPA has recently made available national data on loadings of biochemical oxygen demand (BOD) for selected years between 1950 and 1988. BOD measures the amount of oxygen-demanding wastes in a body of water. Dissolved oxygen is necessary to sustain fish and other aquatic life. Decomposition of organic pollutants, such as those in municipal sewage, or of chemicals, such as those in industrial wastes, depletes the natural oxygen level. Other common measures of water quality include fecal coliform--a bacteria that in large concentrations may harm humans; total suspended solids--a comprehensive measure of concentrations of particles including sand, silt, and other materials that cloud the waters and may have other effects; and nutrients--including nitrogen and phosphorus--that increase the growth of plants and require oxygen when they decompose, depleting the amount of oxygen available to sustain fish. These measures all gauge various aspects of water pollution, but BOD is a fairly comprehensive indicator and is the only measure available for several contiguous years.

Land Quality. The disposal of solid wastes, which renders sites unsuitable for alternative uses, or the dumping of hazardous and toxic wastes, which results in soil contamination, pollutes the land. Some solid wastes, such as batteries, florescent bulbs, thermometers, mirrors, plastics, and tires, are also hazardous. These wastes are carcinogenic, corrosive, ignitable, toxic, or reactive. The Environmental Protection Agency regulates about 500 chemicals and substances that are subject to federal regulations. The list includes toxic chemicals, such as trichlorethylene, benzene, dioxin, and polychlorinated biphenyls (PCBs); heavy metals, such as cadmium and lead; industrial by-products, such as fuels, oils, solvents, paints, and sludge; and pesticides, explosives, and asbestos.

The large number of contaminants and the wide variety of soil conditions make it difficult to define a standard for land quality. Moreover, collecting data on the volume of waste generated is a formidable task. Most estimates of municipal solid waste are based on extrapolations from small samples or estimated from mathematical models. Estimates derived from these methods vary widely. Information on industrial, agricultural, and mining wastes is even less certain. In most cases these by-products are disposed of

on-site by the generator, who produces no data assessing the amount or characteristics of the wastes generated.

Measuring Natural Resource Stocks

The availability of the stock of natural resources is measured in terms of resources and reserves. A resource measurement is an estimate of the total stock in existence. Reserves are that part of any resource stock that is believed to be exploitable, given today's technology, prices, and costs. Most experts agree that some definition of reserves should serve as the basis of any estimate of the availability of a natural resource. The reasoning behind this position is that any estimate of an asset should be based on resources that might actually be used in current or future production.

A great deal of controversy exists, however, over an appropriate definition of reserves. Reserves are currently classified according to the degree of certainty attached to the estimates. The most conservative estimates are known as "proved" reserves. These estimates are assumed to be highly accurate, since they are based on the output of sources (forests, fields, mines, and so on) that are currently being exploited. Other known reserves that are less certain to be recovered at current prices and costs are classified as either "probable" or "possible." The broadest category, "economically recoverable undiscovered" reserves, includes both known and speculative quantities. Estimates of reserves based on more restrictive definitions, such as proved reserves, are more likely to be precise and less likely to fluctuate from one year to the next.

However reserves are defined as a basis for asset value, the way in which discoveries are to be handled remains at issue. A discovery of new reserves could be treated as gross capital formation, which increases both net and gross domestic product. Similarly, the sale of mineral rights on lands not included on the list of proved reserves could be treated as an increase in government receipts and wealth rather than the sale of assets. Other methods evaluate the net change in the stock (including use and additions) to determine asset changes over the period. This approach smooths some of the possible fluctuations in the NIPA accounts that could be caused by accounting for discoveries. This information could also be used to help reconcile value changes in the balance sheets.

Finally, the task of estimating the net change in the stock of renewable resources requires biological models in order to estimate the natural regenerative patterns of renewable resources. To obtain accurate estimates

of changes in stocks it is necessary to take into account special patterns of growth for the several varieties of timber and fish and other valuable renewable resources.

Available Data on Natural Resource Stocks

The stocks of natural resources are important economic assets. Information about each of these resources--including measurements of reserves and their value--is issued by agencies with responsibility for their management.

The Department of Agriculture (USDA) publishes a series of data on the market value of agricultural land resources.[1] Values in the series are based on actual purchase prices. USDA also provides data on assets and returns to farm assets.[2] The Forest Service (a part of USDA) collects data on the stock of timber, the amount of timber harvested and sold, the costs of the timber sale program, and the average price per unit of timber.[3] The Bureau of Mines and the Department of the Interior (DOI) publish estimates of the domestic and international demand for mineral resources and the quantities of identified supplies of these resources. Estimates of the ratio of identified stocks of resources to their expected demand are available through the year 2000. As an indicator of scarcity, this ratio measures the adequacy of known supplies and varies considerably among different resources.[4] Finally, both the DOI and the Department of Energy publish information on oil and gas reserves and royalties and bonuses paid for federal leases.[5]

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1. Department of Agriculture, Economic Research Service, *Agricultural Resources, Agricultural Land Values and Markets*, Situation and Outlook Report (June 1991). These data report land value, including value of buildings on the land. The Economic Research Service provides historical data on the market value of farm land.

2. Department of Agriculture, Economic Research Service, *Economic Indicators of the Farm Sector, National Financial Summary, 1990.*

3. Department of Agriculture, Forest Service, Timber Management, *Timber Sale Program Annual Report*, various years since 1987. These reports include data on the revenues and expenses of the timber sale program. The Forest Service also provides other unpublished data on the number of sales, value, price, and cost.

4. Department of the Interior and Bureau of Mines, *Minerals Yearbook*, vol. 1, *Metals and Minerals* (1989).

5. Department of the Interior, Minerals Management Service, Royalty Management Program, *Mineral Revenues 1990: Report on Receipts from Federal and Indian Leases*; Department of the Interior, U.S. Geological Survey, Minerals Management Service, *Estimates of Undiscovered Conventional Oil and Gas Resources in the United States--A Part of the Nation's Energy Endowment* (1989); Department of Energy, Energy Information Administration, *Annual Energy Review 1990* (May 1991).

MEASURING PRICES OF ASSET FLOWS AND STOCKS

Policymakers may be encouraged by statistics based on physical measurement to consider the impacts of policies on natural resources and the environment. But accounting for changes in natural capital on the basis of physical changes in stocks has at least two shortcomings: it does not lend itself to useful summation and it can disguise economic consequences. The act of totaling physical units of differing types or qualities can obscure wide differences in economic value--for example, physically adding up mineral reserves will not reveal vast differences in the values of different deposits, caused by variations in recovery costs and quality. Second, summaries expressed in physical units do not enable policymakers to understand the impact of economic policies on natural resources and the environment or the impact on the economy of standards based on physical measures.

If adjustments to the national accounts for changes in natural resources and the environment are to be accepted, credible techniques must be developed for pricing these assets and their service flows. The methods that are chosen should yield values that are consistent with national accounting measurements. Consistent techniques of pricing are necessary, whether the goal is to account for changes in natural capital assets within the current framework of the accounts, or the aim is to extend these totals to measure sustainable income.

The more remote a resource is from the market economy, the more uncertain is its monetary value. Generally, if all of the service flows of an asset are bought and sold in organized markets, the accounts value the services at those market prices. Other assets, such as groundwater, provide services that are rarely bought or sold, but the services of such assets are inputs to production. A price can be imputed for these services by using information about the production process and value of the marketed output. Other assets, such as noncommercial wild species, provide services that are not sold and do not contribute directly to production. Available methods used to assign value to these services are limited to information taken from consumer surveys on potential expenditures or willingness to pay.

Methods of Imputing a Price for Nonmarketed Goods and Services

The current prices of nonmarketed goods and services must be imputed because no market prices exist. The current price of services (actual or imputed) can be used with quantitative information on changes in stock to calculate depreciation of natural capital. The method of estimating prices for

nonmarketed services depends on whether these flows are (1) indirectly related to a market transaction or (2) not related in any way to market activity.

Methods Indirectly Based on Market Transactions

The *hedonic pricing method* is a statistical technique for dividing the price of a good into a series of prices for its constituent characteristics. The market price of the good is viewed as the sum of the values of all its characteristics. A house, for example, is a good whose price is determined by its many characteristics, such as the number of rooms, condition, location, and so on.

The price that people are willing to pay for an incremental improvement in air quality, for instance, can be estimated by examining housing prices in areas that have varying levels of air quality. This technique can be used, therefore, to price environmental and natural resources on the basis of market behavior, even though air quality is not bought and sold as a distinct commodity. Other market prices that have been used in hedonic studies include wages for a given occupation in different cities. The technique is limited because it requires a fairly large data set for goods with many characteristics in common and ignores institutional constraints in markets.

Another method of imputing prices uses information derived from equations that characterize the physical relationship between inputs and output. Prices of inputs can be imputed from the incremental value of output that results from adding one additional unit of input. A statistical estimate of the production equation can be derived from data about the output that is associated with various combinations of inputs. But such information is not universally available, although preliminary estimates for certain commodities such as irrigation water and agricultural soil are available.

Estimates of the incremental costs of abating pollution--called marginal abatement costs--can also be used to assign a value to the services of environmental waste disposal. The incremental cost of abating pollution represents the cost of spending money on reducing pollution versus other productive uses. Thus, it may be possible to use an estimate of marginal abatement costs as a proxy of the value of environmental waste disposal services. But abatement costs show the value of these disposal services as an input to production and do not necessarily reveal the value to society of the benefits (or damages) of using the environment. It is only when abatement activity is at a socially efficient level that marginal abatement costs will equal the marginal benefit (and hence, price) to society.

Another approach involves estimating the potential costs of either maintaining the level of environmental quality at the beginning of the accounting period or achieving a level specified by regulated environmental standards. The approach estimates the potential costs of abatement. These are the costs required to achieve either a certain level of environmental quality at the beginning of the accounting period or a level specified by environmental regulation. The Bureau of Economic Analysis (BEA) collects data on abatement expenditures. Researchers could use data about physical emissions to estimate levels of environmental quality combined with estimates of abatement costs to determine how much it would cost to maintain a certain level of environmental quality. The reliability of the results depends on how accurately the methods show interactions between expenditures, emissions, and quality; that is, how well potential abatement costs and physical degradation are measured. That kind of pricing does not necessarily reflect damage to households or the environment.

Pricing Methods with No Relation to Market Transactions

Information from interviews and questionnaires is often used to place a value on the final services of natural resources and the environment. The value of a good or service can be estimated by posing questions to ascertain the maximum that people are willing to pay for some improvement in the service flow (or minimum acceptable compensation for suffering a loss). This approach avoids the pricing problems associated with market structure, externalities, and the inability to exclude nonpayers. This technique, which is widely known as *contingent valuation*, is an acceptable method of assigning value to goods under the Comprehensive Environmental Response, Compensation, and Liability Act and the Oil Pollution Control Act.

Nonmarket measures can be inaccurate, however, because they are based on what buyers or sellers claim they are willing to do rather than on actual behavior. Distortions can occur, for example, because respondents do not reveal their true sentiments or are not used to the idea of paying for such goods as hiking and clean air. In addition, researchers have serious doubts about whether values that apply to one site can be used at others and whether values are additive. Further research must address these questions satisfactorily before values obtained from nonmarket measures can be used in the national accounts.

CONCLUSIONS

The principal problems of measurement are (1) identifying the most appropriate way of measuring physical changes in environmental quality and natural resource reserves and (2) identifying reliable and consistent methods of pricing the nonmarket services of these assets.

It is difficult to place a value on the depletion or degradation of natural capital because many of its goods and services are not sold in markets, a problem that is especially troublesome in determining the costs of service flows associated with the health effects of changes in environmental quality. Problems can also arise when estimating natural resource depletion. In particular, the measurement of the change in stock must allow for regeneration and discoveries of additional reserves.

The United Nations and the Bureau of Economic Analysis have addressed the conceptual issues and problems of data availability and quality associated with assigning value to nonmarketed service flows. First, they recommend maintaining satellite accounts to record the value of natural capital, its depletion, and flow of services while measurement issues are being addressed. These measurements could be integrated later into the main components of the accounts if problems are resolved.

Second, the initial efforts of the U.N. and BEA, which are meant to improve their understanding of how best to incorporate natural resources and the environment into the accounts, have relied to a large extent on market data. As a result, their current activities have concentrated on expanding the asset boundary. The aim is to record values and depletion or degradation of natural resources with marketed flows and identify the costs of avoiding the damages of pollution. The assets being considered include land, national forests, and oil and gas reserves. In addition to these assets, the U.N. has also estimated values for the degradation of environmental quality by monitoring the costs of abatement.

CHAPTER IV

CURRENT EFFORTS TO ESTIMATE NATURAL RESOURCE DEPLETION AND ENVIRONMENTAL DEGRADATION: SOME ILLUSTRATIVE CALCULATIONS

The Bureau of Economic Analysis and the United Nations' Statistical Office have already begun research to incorporate more information on natural resources and the environment into national accounts. These efforts concentrate on two aspects of green accounting: (1) determining the monetary value of environmental degradation and resource depletion and (2) identifying pollution abatement and control expenditures.

Determining the monetary value of environmental degradation and resource depletion addresses the concern that the national accounts do not record changes in environmental quality or most natural resource stocks. Concerns that the accounts do not identify environmental services included in measurements of national income and hide the costs of reducing pollution damages are being addressed by identifying the costs of pollution abatement and control. These initial efforts do not attempt to redefine the production boundary, an undertaking that is necessary to address the concern (described in Chapter I) that the current measures of national income exclude many of the services provided by natural resources and the environment.

The focus of these initial efforts is logical because it is possible to estimate environmental degradation and the depletion of natural resources largely on the basis of market data about the costs of maintaining environmental quality and revenues from goods and services provided by natural resources. Also, many of the costs of reducing pollution damages can be estimated on the basis of data already collected in compiling the national accounts.[1] Certain abatement and control activities are left out. For example, the accounts do not have data on plant closings, delays in plant construction, or curtailments in the use of chemicals in manufacturing and agriculture that may have been caused by efforts to reduce pollution. The costs of such activities, when related to efforts to reduce pollution, are indeed part of pollution abatement costs. Finally, the accounts do not have data for nonmarket activities such as volunteer litter removal.

Current data do not, however, include the value of final service flows from natural capital. These services are not included in the current definition of gross domestic product but could be in a definition of "green" GDP.

1. Department of Commerce, *Survey of Current Business*, vol. 71, no. 11 (November 1991), p. 46.

Expanding the production boundary to broaden the definition of GDP requires much greater reliance on imputed prices.

Both types of effort--determining from data about use and accidents the monetary value of environmental degradation and resource depletion and identifying expenditures for pollution abatement and control--are difficult. One of the more important problems in identifying pollution abatement and control expenditures has been avoiding double counting of expenditures. Companies do not always subtract purchases of equipment from the total of reported expenditures. The problems of determining the monetary value of environmental degradation and resource depletion illustrate the obstacles encountered in any effort to address the other criticisms of the accounts because assigning value to these services will also depend on accurate measurement of and changes in stocks.

VALUING DEPLETION OF NATURAL RESOURCES

Natural resource assets provide marketed flows that contribute to GDP. Although their relative contribution varies from year to year, agriculture, forests, fisheries, coal, oil, and gas sectors contribute about 4 percent to value added in the United states. One objective of expanding the accounts by widening the asset boundary is to adjust net product for the depletion of natural resource assets.

The most common approach to placing a value on the depletion of natural resource assets is the net rent method. The net rent method calculates resource depletion as the marginal rent (the difference between the current market price of the good or service produced by an asset and the marginal cost of production or extraction) times the change in the stock. Recent pilot studies conducted by the U.N. Statistical Office use the net rent method for estimating the depletion of renewable and nonrenewable resources.

In a World Bank study that examines mineral stocks, economists J.M. Hartwick and A.P. Hageman propose a method of estimating depletion that accounts for discoveries of exhaustible resources.[2] The depletion equation can be separated into two parts. The first part uses the net rent method and is equal to the current-period marginal rent (price minus marginal cost) times the amount extracted. In the second part, this estimate is corrected for

2. John M. Hartwick and A.P. Hageman, *Economic Depreciation of Mineral Stocks and the Contribution of El Serafy*, Environment Department Divisional Working Paper No. 1991-27 (Washington, D.C.: World Bank, November 1991).

discoveries by subtracting the incremental cost of discovery multiplied by the amount discovered in the accounting period. (Table 7 shows estimates of depletion for U.S. oil, using this formula to account for discoveries.) These results generally follow market conditions that reflect the changes in price over the decade. Estimates of the value of oil depletion range from about 2 percent of GDP in the early 1980s to less than 1 percent in the period from 1985 to 1990.

Estimates of the value of depletion are a function of the model assumptions used to estimate the value of the stock of reserves. In each model the underlying assumption is that the value of the stock is equal to the

TABLE 7. ILLUSTRATIVE ESTIMATES: VALUING THE DEPLETION OF OIL USING THE NET RENT APPROACH MODIFIED TO ALLOW FOR DISCOVERIES (In billions of 1987 dollars)

	U.S. Oil	
	Crude Oil Prices per Barrel	Value of Depletion Using Net Rent Method[a]
1981	40.3	63.0
1982	34.0	54.6
1983	30.0	50.9
1984	28.4	49.6
1985	25.5	45.4
1986	12.9	19.3
1987	15.4	27.4
1988	12.1	19.1
1989	14.6	23.4
1990	17.7	29.8

SOURCES: Congressional Budget Office based on data from Department of Energy, Energy Information Administration, *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves*, various years (for proven reserves, use, and discoveries), and *Performance Profiles of Major Energy Producers*, various years (for market price, lifting (extraction) costs, and cost of discovery (exploration)).

a. Depletion based on total U.S. proven reserves allowing for discoveries and use.

discounted present value of income (profits). Any estimate of this value depends on assumptions about future prices, demand, and supply. Varying the assumptions of this model or choosing another model could yield very different estimates of depletion.[3] For example, a joint study by the United Nations, the World Bank, and the Mexican Instituto Nacional de Estadistics derived estimates for the stock of oil in Mexico. The values reported varied by as much as a factor of seven under alternative modeling approaches.

VALUING ENVIRONMENTAL DEGRADATION

Emissions cannot be used to measure changes in environmental stocks because pollution is almost always associated with natural capital that has some regenerative powers. Water and air sheds are examples of resources that usually regenerate themselves. But the speed of regeneration depends upon many factors, including the rate of pollutant discharges and the chemical nature of the pollutants (radioactive material is clearly a longer lasting and more dangerous kind of discharge than smoke).

The air quality index used below is a population-weighted average of the uniform air quality index for major metropolitan areas (see Box 2). The water quality index is based on biological oxygen demand estimates for municipal waste treatment plants throughout the United States. Both indexes represent physical measurements of environmental stocks that generate flows of service in the economy (see Table 8).

In this example, degradation is based on the amount by which the quality index falls since the beginning of the year if there are no further efforts to abate pollution. The results in Table 8 assume a change equal to a 50 percent decline in the quality index without abatement activities. As a test of the sensitivity of the results to the magnitude of this rate, the rate was varied from as much as 100 percent to as little as 25 percent. (Even without abatement activities, there may be some natural regeneration.) Given such a large variance in the rate of depreciation, the resulting estimates of depreciation did not vary significantly. The average incremental abatement cost per unit is derived by taking the ratio of current abatement expenditures to the incremental change in environmental quality. The incremental change in quality is equal to the index from the end of the current period minus the expected level of quality without further pollution abatement.

3. Jan van Tongeren and others, *Integrated Environmental and Economic Accounting: A Case Study for Mexico*, Environmental Working Paper No. 50 (Washington, D.C.: World Bank, December 1991).

BOX 2.
THE UNIFORM AIR QUALITY INDEX

The uniform air quality index is based on the five pollutants for which the primary National Ambient Air Quality Standards have been established, namely, particulate matter (PM_{10}), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and nitrogen dioxide (NO_2). A separate subindex for each pollutant is calculated from a function that transforms ambient concentrations into a scale from zero through 500, where a low number means low concentrations and a high number corresponds to significant harm levels. The so-called critical pollutant is based on the pollutant that has the highest subindex within or beyond the unhealthful range.

Reporting agencies in urban areas (a Census geographic delineation) maintain a daily index report based on the uniform air quality index. The report should contain the reporting area, the reporting period, the critical pollutant, the subindex corresponding to the critical pollutant, and the category describing air quality conditions from the following system:

0 to 50	Good
51 to 100	Moderate
101 to 199	Unhealthful
200 to 299	Very Unhealthful
300 and above	Hazardous.

Generally, the zone contained within the geographic boundaries of an urban area is sufficient for purposes of calculating and reporting the index. The exception occurs in cases where there is a significant air quality problem in highly populated areas adjacent to, but outside of, the urban area. For example, ozone concentrations are often highest downwind and outside the urban area.

SOURCE: *Code of Federal Regulations*, Title 40, Parts 53-60.

TABLE 8. ILLUSTRATIVE ESTIMATES: PLACING A VALUE ON DEGRADATION OF THE ENVIRONMENT FOR AIR AND WATER QUALITY

	Air Quality			Water Quality		
	Air Index	Change in Index (r=.5)[a]	Estimated Degradation (Billions of 1987 dollars)	Water Index	Change in Index (r=.5)[a]	Estimated Degradation (Billions of 1987 dollars)
1981	27.9	b	b	17.4	b	b
1982	29.4	13.9	13.5	18.1	8.7	10.7
1983	28.7	14.7	16.9	21.1	9.0	9.1
1984	28.9	14.4	15.4	25.3	10.6	8.8
1985	30.6	14.5	14.6	25.4	12.7	13.0
1986	30.7	15.3	17.1	25.5	12.7	14.0
1987	32.5	15.4	15.3	24.2	12.8	16.3
1988	31.1	16.3	19.1	23.0	12.1	15.8
1989	34.3	15.6	13.1	24.0	11.5	13.6
1990	37.0	17.2	12.2	24.9	12.0	14.3

SOURCE: Congressional Budget Office based on data provided by the Environmental Protection Agency and the Bureau of Economic Analysis.

NOTES: Estimates of degradation are calculated using data on pollution abatement expenditures from the Bureau of Economic Analysis, *Survey of Current Business*, various issues. Abatement expenditures are adjusted and used to estimate annual costs of abatement per unit of quality (a proxy for marginal abatement cost).

Air and water quality indexes have not been normalized and are not comparable.

a. Results assume that the index value measured at the end of the previous period will decline by 50 percent without additional pollution abatement activities. Differences between the baseline value and the actual index in the current year are attributed to pollution abatement activities. Estimates of degradation dollar values do not vary significantly when declines in index values ranging from 100 percent to 25 percent are used.

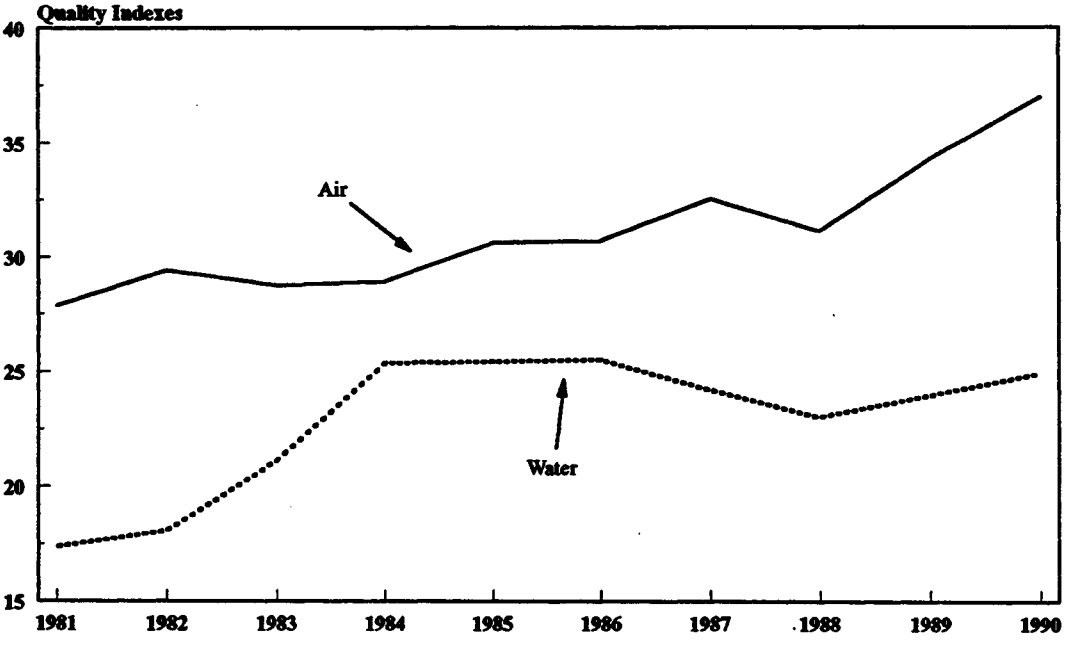
b. Not possible to compute change for the first year.

The value of environmental degradation can be expressed as an estimate of the amount that would have to be spent in the current period in order to maintain last year's level of quality. This is not an estimate of the cost of the change in the quality of the environment. It is simply an estimate of the costs associated with maintaining a level of quality. (This method is analogous to the methods used by the U.N. in pilot studies putting the System of Integrated Environmental-Economic Accounts into effect.) If expenditures in the current period are greater than the amount required to maintain last year's environmental quality, the result is additions to the stock of quality. That is, the current quality index is greater than last year's index, which implies an increase in the value of environmental stock. When environmental quality goes down, degradation figures exceed actual expenditures, reflecting a net loss in environmental quality. This happened in 1983 and 1988 for air quality and 1987 and 1988 for water quality (see Table 8).

According to this air quality index, the quality of the air increased somewhat in the 1981-1990 period. Air quality declined slightly in 1983 and 1988, bad years for ozone. Water quality, as measured by estimates of effluent discharges of BOD_5, increased significantly from 1982 to 1984, leveled off for two years, and declined somewhat from 1986 to 1988. Real abatement and control expenditures on air pollution grew from 1982 throughout the period and dropped somewhat in 1987. Real expenditures on water pollution abatement and control grew from 1982 through 1987 and fell in 1988 (see Figures 1 and 2).

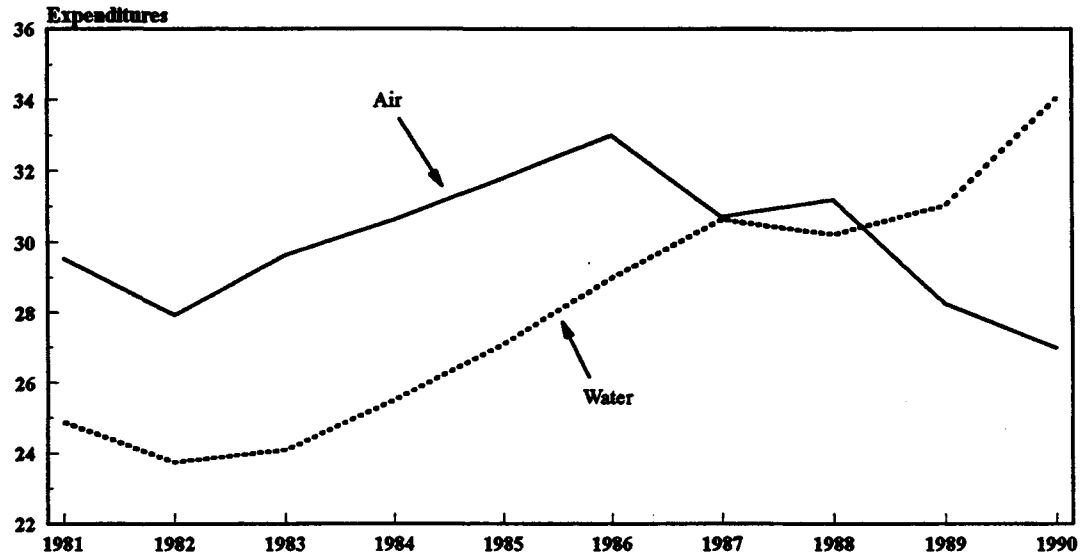
The results of this exercise highlight several interesting phenomena. First, estimates of degradation for environmental quality remain approximately constant at 1 percent of GDP during the 1980s. Environmental degradation allowances remain roughly at this level even under varying assumptions about the degradation rate--the amount by which quality would decline without any current-period expenditures on pollution abatement. The annual costs of maintaining environmental quality have been increasing during the decade--somewhat faster than GDP for water quality and slower than GDP for air quality. The upward trend in environmental costs can be attributed to the fact that the costs of maintaining a given level of quality become greater as national output and emissions increase. Moreover, the level of environmental quality was not just maintained but, according to these measures, increased over this period.

FIGURE 1. ESTIMATED AIR AND WATER QUALITY INDEXES, 1981-1990



SOURCE: Congressional Budget Office based on environmental quality data from the Environmental Protection Agency and population data from the Bureau of the Census.

FIGURE 2. EXPENDITURES FOR AIR AND WATER POLLUTION ABATEMENT AND CONTROL, 1981-1990 (In millions of 1987 dollars)



SOURCE: Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, various issues.

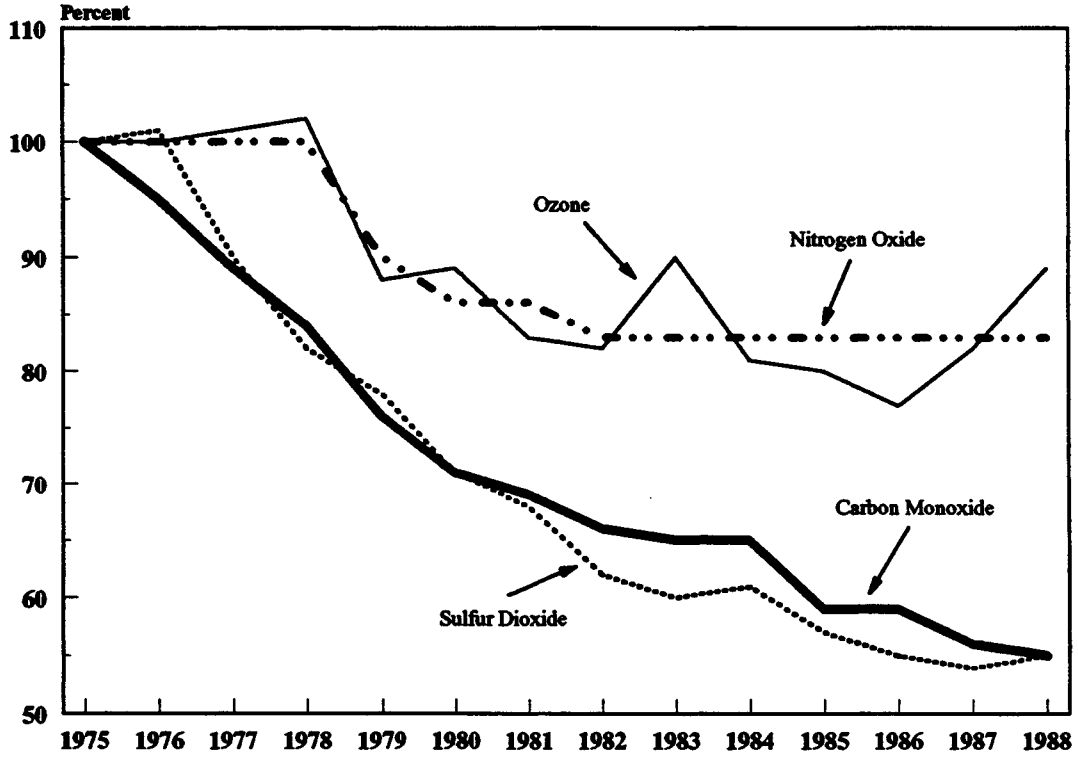
Assessing the Results

It is difficult to measure stocks or changes in stocks, regardless of whether or not market data for estimating prices exist. Better data are often available on emissions of pollutants than on changes in environmental quality. But a direct relationship does not always exist between emissions and changes in quality because there is some natural cleansing of pollutants.

Another difficulty in determining environmental degradation is that the components of a total index of environmental quality may not all move similarly (see Figure 3). Although most air pollutants show a decline, some have decreased at slower rates than others (ozone and nitrogen oxides) and some have periodically peaked upward (carbon monoxide and ozone). This difficulty may be overcome to some degree by forming several indexes based on health, ecological, and technological criteria. There are also regional differences in environmental quality that cannot be discerned from national indexes. If these differences (among various dimensions) affect estimates of degradation, they should be accounted for.

Similarly, there are no actual measurements of the physical stock of many renewable natural resources. One must rely on biological models to estimate additions to the stock. Reductions in nonrenewable natural resource stocks are the only numbers that can usually come directly from market data on how much is sold and estimates of losses resulting from natural disasters.

FIGURE 3. INDEXES OF NATIONAL AMBIENT CONCENTRATIONS FOR FOUR POLLUTANTS, 1975-1988 (1975=100)



SOURCE: Congressional Budget Office based on data from the Council on Environmental Quality, *Environmental Quality, 21st Annual Report* (1990), p. 323, Table 40.

CHAPTER V
CONCLUSIONS

The national accounts contain both summary measurements and detailed data. This information supports the three basic functions of the national accounts, namely, to provide an economic interpretation of changes in the nation's assets and national wealth, to furnish gauges of current income based on the actual or imputed market value of goods and services, and to measure financial and factor input flows in the economy.

Demands to add more information partly reflect concerns that the accounts do not adequately inform policymakers because of their limited treatment of natural resources and the environment. A comprehensive overhaul of the accounts to correct for all of those perceived deficiencies would require three kinds of revisions: (1) expanding the asset boundary to record changes in environmental quality and natural resource assets; (2) expanding the production boundary to include the services of natural resources and the environment that are not counted in measures of national income such as gross domestic product; and (3) reorganizing within the production boundary to identify more clearly the input of environmental factor service flows and the costs of reducing pollution damages counted in GDP.

Incorporating more information on natural resources and the environment into the accounts, however, requires much conceptual work and data gathering. Some or all of the three kinds of revisions to the accounts could be undertaken. An important guiding principle is whether there are data and techniques available that make some revisions easier to carry out than others. The most challenging problems that must be dealt with in incorporating more information into the accounts are (1) determining the most appropriate way of measuring physical changes in environmental quality and natural resource reserves and (2) developing reliable and consistent methods of pricing the nonmarket services of these assets.

Initial efforts by the United Nations and the Bureau of Economic Analysis, which are meant to improve understanding of how best to incorporate natural resources and the environment into the accounts, have relied to a large extent on market data. These efforts concentrate on two types of revisions of the accounts: determining the monetary value of depletion of nonrenewable resources and identifying abatement expenditures designed to reduce pollution damages.

The efforts of the U.N. and BEA are logical first steps in addressing criticisms of the accounts' treatment of natural resources and the environment. Such efforts could make the accounts more useful for analyzing the links between environmental and natural resource policies and employment, trade balances, and growth of GDP. And measurement problems associated with deriving imputed or inferred prices are not as significant for nonrenewable resources as they could be for renewable natural resources and the environment.

Efforts to go beyond the first steps, however, will involve a greater reliance on imputed prices for nonmarketed flows as well as overcoming difficulties in measuring changes in environmental quality or natural resource reserves. Such data--if accurate and consistent with other data in the accounts--could make the accounts even more useful for analyzing the links between the environment and natural resources and the economy. In addition, such data could be used to produce alternative measures of national income such as a "green" GDP and could be part of the data set necessary to measure sustainable income.

If data are not sufficiently accurate and precise, however, their incorporation could weaken rather than enhance the ability of the accounts to inform policymakers. This is an important consideration because the techniques for placing a value on nonmarket services continue to generate controversy.

Nevertheless, it may be feasible to expand the information on natural resources and the environment beyond that provided by market, especially for imputing the value of factor services such as environmental waste disposal and certain final services such as publicly provided recreation.

APPENDIX A

DEVELOPMENT OF THE NATIONAL ACCOUNTS

The first component of the national accounts to be included in government documents available to the general public was the national income and product accounts (NIPAs). NIPAs are a double-entry system that reports income on one side of the ledger (wages and salaries, capital consumption, interest, proprietor income, dividends, rents, and indirect taxes, plus some additional minor items) and expenditures on the other, or product side. The product side reports final demand for goods and services, including government spending, private investment, net exports, and consumption expenditures. These variables were first identified as part of a unified system by British economist John M. Keynes.[1] Simon Kuznets, a Ukranian-born U.S. economist, first conducted extensive measurements of these variables.[2]

Subsequent additions to the national accounts--the input-output (I-O) accounts (1947) based on the work of Wassily Leontief, the flow of funds accounts (1962), which grew out of Morris Copeland's efforts, and the balance sheets (1980) patterned after those developed by Raymond Goldsmith--adopted the same basic design of explaining economic activity on the basis of actual and imputed prices.[3]

The involvement of the federal government with national economic accounting began on a continuing basis in 1932 with S.220, which called for the Department of Commerce to prepare estimates of annual national income.[4] These estimates, most of which were made by Simon Kuznets at the National Bureau of Economic Research, were first published in *National Income, 1929-32*.[5] This work was well received and various groups, including the Committee on Government Statistics and Information Services--an

1. John M. Keynes, *General Theory of Employment, Interest and Money* (New York: Harcourt, Brace Inc., 1936).

2. Simon Kuznets, *Seasonal Variations in Industry and Trade* (New York: National Bureau of Economic Research, 1933).

3. Wassily W. Leontief, *The Structure of the American Economy, 1919-1929* (Oxford: Oxford University Press, 1941); Morris Copeland, *A Study of Money Flows in the United States* (New York: National Bureau of Economic Research, 1952); Raymond Goldsmith, *National Wealth of the United States in the Postwar Period* (Princeton, N.J.: Princeton University Press for the National Bureau of Economic Research, 1962).

4. *Congressional Record*, vol. 75, 72nd Congress, 1st Session (1932), p. 12285.

5. Senate Document 124, 73rd Congress, 2nd Session (1934).

independent advisory panel sponsored by the American Statistical Association and the Social Science Research Council--urged that the Commerce Department be given responsibility for producing such information annually.

The Commerce Department developed the first versions of the NIPAs during World War II in response to Congressional and White House demands for information on how large a rearmament program the U.S. economy could support and where bottlenecks might occur. The success in providing this information firmly established national accounting as a valuable framework for analyzing the performance of the economy. Indeed, confidence in NIPA was great enough by the end of the war to make its mere existence a factor in the passage of the Employment Act of 1946. This act created the President's Council of Economic Advisors and the Joint Economic Committee of Congress to help formulate reconversion policies in the postwar period.

The United States has always been at the forefront of efforts to encourage the worldwide adoption of consistent national accounting practices. Even before the end of World War II, representatives of the British, Canadian and U.S. governments met to develop comparable concepts and modes of presentation. These discussions resulted in the first international agreement on national economic accounting practices and, in 1947, the publication of an expanded set of NIPAs. The United States was also instrumental in the formation of a national income unit at the United Nations. This unit first published the U.N.'s own System of National Accounts (SNA) in 1952, although most of the work was actually conducted under the direction of U.S. economist Richard Stone for the Organization for European Economic Cooperation.

The national economic accounts have never been--and probably never will be--a finished product. The amount of data needed to portray the economy is constantly increasing as new products and services are developed. But the main reason that the accounts will never be complete is that the number of policy issues requiring information at the macro, or national, level is constantly expanding.

When the NIPAs were first being developed in the 1940s and 1950s, policy was focused almost exclusively on short-term management of the economy. By the mid-1950s, however, policymakers were demanding better information for longer-term planning. The Bureau of Economic Analysis (BEA) responded in 1958 by expanding the data included in the input-output accounts. Equity issues became more prominent in the late 1960s, and statistics on income and wealth distribution were also added to the accounts.

In addition, by 1964 the I-O accounts introduced in the 1950s were fully integrated with NIPA.

The 1970s--a period of recession and relatively high rates of inflation--saw improvement in the Federal Reserve's flow of funds accounts and more detailed estimates of constant dollar flows. During this same period, BEA developed alternative estimates of depreciation based on uniform service life and straight-line depreciation. BEA also began reporting survey data on expenditures for pollution abatement during this decade.

A major policy concern during the 1980s and early 1990s has been the slower rate of economic growth compared with earlier postwar periods. Renewed interest in identifying the sources of national growth has resulted in improvements in the national economic accounts. Two notable changes have been the introduction of the balance sheets and BEA's switch from gross national product (GNP) to gross domestic product (GDP) as the primary measurement of national output. The first change reflected an increasing awareness of the need to keep track of the nation's assets. GDP was given an increased prominence because it is a better measurement of the national output than GNP, which includes foreign earnings of Americans and excludes earnings by foreign nationals in the United States. BEA has also developed estimates of flows, stocks, and depreciation for consumer durables and publicly owned fixed capital using alternative estimates of service life, depreciation, and valuation as well as more detailed data on foreign transactions.

APPENDIX B

THE ASSET BOUNDARY IN THE UNITED NATIONS' REVISED SYSTEM OF NATIONAL ACCOUNTS

The United Nations has redefined the asset boundary in its newly revised System of National Accounts (SNA). In addition, the U.N. will maintain a system of environmental economic accounts that contains information not included in gross domestic product (GDP) or net domestic product (NDP).

The United Nations' draft of the revised SNA classifies environmental and natural resource assets as either produced, nonproduced, or not considered in the accounts--that is, outside of the asset boundary. According to the SNA's discussion of the first two assets,

> the . . . asset boundary is determined . . . by whether the assets are subject to effective ownership and are capable of bringing economic benefits to their owners, given the existing technology, knowledge, economic opportunities, available resources and set of relative prices. Environmental assets over which ownership rights have not, or cannot, be established, such as seas or air, are excluded.[1]

Produced natural resource assets are fully integrated into the accounts. That is, the balance sheets record their market value, GDP counts the market value of their flow of services, and the difference between GDP and NDP includes the economic depreciation of these assets unless they are considered part of inventories. Cultivated biological resources, such as privately managed forests and fisheries, constitute the bulk of these assets in the United States.

Nonproduced assets consist of assets that are needed for production but have not been produced. The most important are land, mineral deposits, noncultivated biological resources, and water resources. Although they must actually be owned by institutional units, their renewal is not "under the direct control, responsibility and management of those units."[2] Nonproduced environmental and natural resource assets are not integrated fully into the accounts. The balance sheets record their market value and GDP counts the market value of their flow of services, but the consumption of fixed capital does not include the amount of their depreciation.

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1. United Nations, *Draft Revised Version of the System of National Accounts* (New York: United Nations, 1992), Chapter 13, p. 4. See also Chapter 10, pp. 2-4; Chapter 10, p. 5; and Chapter 12, p. 3.

2. Ibid., Chapter 10, p. 3.

In addition, the revised SNA eliminates losses and discoveries from consumption of fixed capital. For example, both the SNA and the U.S. national income and product accounts treat an oil spill that damages marine ecosystems differently than they do a hurricane that damages housing. Both the negative and positive effects of the hurricane are counted in conventional NDP. (Reductions in national wealth and income are negative because housing is destroyed and rental income is decreased. The increase in current income is positive because people are put to work restoring the housing.) Only the positive effects (the cleanup activity) of an oil spill are counted. Certain negative effects of an oil spill, such as a reduction of service flows because of damages to the ecosystem, are not counted in either the current SNA or the current U.S. accounts.

The U.N. proposes to correct this asymmetry by recording accidental loss of all capital in a satellite account (the "other changes" account). For the purpose of computing NDP, however, the treatment is still tantamount to assuming that the loss of national assets never happened.

Economic activity to correct this asymmetry may be better reflected by recording the loss of wealth caused by an oil spill in the same capital account where housing losses are currently recorded. If these data are used to compute a "sustainable" NDP, recording the negative effects of oil spills in the capital accounts would enable the accounts to produce a more complete picture of the relationship between current economic activity, future economic conditions, and the environment.

APPENDIX C

CHANGING THE ACCOUNTS WITHIN CURRENT PRODUCTION AND ASSET BOUNDARIES

Some proposed changes that would affect gross domestic product (GDP) and net domestic product (NDP) involve a reclassification of items within the production and asset boundaries rather than an expansion of the boundaries. Nevertheless, because these changes could affect the size of GDP or NDP they may influence perceptions about the success of public policies. Two proposals of this sort concerning environmental and natural resources are (1) to eliminate defensive expenditures on natural capital from GDP by redefining them as intermediate expenditures and (2) to treat certain environmental and natural resources as inventories rather than fixed capital.

ELIMINATING DEFENSIVE EXPENDITURES ON NATURAL CAPITAL FROM GDP

One criticism of the current method of accounting is that many of the costs of preventing, reversing, or avoiding the effects of environmental and natural resource degradation--the so-called defensive expenditures on environmental and natural resources--cause GDP to increase.[1] Pollution is a common source of degradation, but other activities--such as harvesting of timber and fish and soil depletion from farming--can also cause problems. A typical description of defensive expenditures is expenses "to compensate for, redress or guard against" degradation. Critics of the current treatment of these expenditures offer two arguments. First, the current treatment of defensive expenditures is arbitrary and inconsistent. Second, GDP should rise only when the country spends money on something good, not when it must spend money to avoid or correct for something that detracts from the nation's welfare. A frequently suggested method of handling these expenditures, originally proposed by economists Simon Kuznets and Thomas Juster, is to classify all defensive expenditures as intermediate, thus reducing GDP and

1. See Roefie Hueting, "Correcting National Income for Environmental Losses: Toward a Practical Solution," in Yusuf Ahmad, Salah El Serafy, and Ernst Lutz, eds., *Environmental Accounting for Sustainable Development* (Washington, D.C.: World Bank, 1989).

"conventional" NDP by the amount of these expenses.[2] France, Japan, and Germany have suggested such modifications in international meetings.[3]

Issues

The charge that the current treatment of defensive expenditures is arbitrary and inconsistent is part of two definitional questions that constantly arise in national income accounting: (1) the dividing line between intermediate and final goods and services and (2) the dividing line between investment and maintenance expenditures.

Intermediate Versus Final Goods Issue. The Department of Commerce's working definition of an intermediate good or service is an item that is purchased and then resold domestically by businesses (firms, nonprofit organizations, and government enterprises). Specifically, intermediate products consist of goods and services purchased by businesses on current account except for additions to inventories.

Critics of this definition for determining which expenditures to exclude from GDP point to the inconsistencies that often result. For example, under this rule, GDP is lower if an employee's business expenses are paid by the employer than if the employee pays them himself but gets a higher salary by way of compensation. The best way to think about this is to assume that the total level of economic activity--intermediate plus final goods and services--is fixed. GDP measures only final goods and services; therefore, the more of this economic activity that is classified as final, the greater GDP. GDP equals expenditures by consumers, investors, and governments or, alternatively, wages and salaries, profits, rents, interest, and indirect business taxes plus capital consumption. In this example, the reimbursed business expenses are not counted in any of these categories, but expenses paid by the employee who gets a higher salary are added to the expenditure side and salary and wages to the factor payments side. As a result, GDP is higher with the latter treatment because a greater percentage of total economic activity has been defined as expenditures on final goods and services. Eliminating all defensive expenditures on environmental and natural resources from GDP, regardless of who made them, is one way of reducing the number of inconsistencies.

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2. F.T. Juster, "A Framework for the Measurement of Economic and Social Performance," in Milton Moss, ed., *The Measurement of Economic and Social Performance*, vol. 38 of *Studies in Income and Wealth* (New York: National Bureau of Economic Research, 1973). For a good evaluation of the different approaches, see Henry Peskin and E. Lutz, *A Survey of Resource and Environmental Accounting in Industrialized Countries*, Environment Working Paper No. 37 (Washington, D.C.: World Bank, 1990).

3. Peskin and Lutz, *A Survey of Resource and Environmental Accounting*, p. 7.

Investment Versus Maintenance Expenditures. The Bureau of Economic Analysis's definition of final and intermediate products also provides an easy, if not always accurate, solution to a problem that business and tax accountants constantly face--distinguishing between investment and maintenance expenditures. Maintenance activities--such as changing the oil in an engine--are usually defined as expenditures necessary to sustain or facilitate economic activity. Since they are a precondition for production, they are considered to be intermediate rather than final products.[4] Another argument for excluding from GDP all defensive expenditures for environmental and natural resources is that they bear a closer resemblance to maintenance than to investment because a clean environment and the availability of natural resources can be considered necessary preconditions for production.

Assessment of Issues

The most frequently cited argument in favor of the defensive expenditure approach is that it eliminates the possibility that increases in pollution will raise GDP. However, GDP as it is now calculated may also rise as a result of other undesirable events such as natural disasters or war. And excluding all defensive expenditures from GDP could discourage policymakers from spending money on environmental cleanup, because GDP would end up being lower than if they had allocated resources to activities that are counted.

Another issue is concerned with how to classify consumption purchases of goods or services that can be used to protect against environmental harm but have other purposes as well. Purchases of face masks or special filtering devices on air conditioning systems are examples of defensive expenditures. These types of expenditures could be reclassified as intermediate inputs (in the production of environmental protection) and deducted from final expenditures, thereby reducing GDP. The challenge of this approach lies in deciding which kinds of purchases are mostly defensive in nature because a good is often purchased for other attributes as well as its ability to ameliorate environmental harm.

If all defensive expenditures on environmental and natural resources were excluded from GDP, it would also raise the question of whether other defensive expenditures--government outlays for national defense, fire and police protection, street cleaning, road maintenance, and a substantial part of

4. Robert Eisner, "Extended Accounts for National Income and Product," *Journal of Economic Literature*, vol. 26, no. 4 (December 1988), pp. 1611-1684.

household expenses, including commuting and health care costs--should also be excluded.

Moreover, if all defensive expenditures were eliminated from national income, it would not make GDP a better measure of welfare, but would leave it much less comprehensive and therefore less valuable for analyzing the effect of macroeconomic policies on total employment and inflation. The reason is that a smaller amount of the economic activity that ultimately determines employment levels would actually be included in the measure of national output. This view was expressed by Richard Ruggles when he argued, "We need to make gross national product even grosser than it is, and to recognize that it does not correspond to a measurement of welfare but rather provides a body of data useful to the economic analyst in understanding the behavior of the economy."[5]

The problem with the current treatment of defensive expenditures on environmental and natural resources is that its information is asymmetrical. That is, the expenditures to prevent or restore environmental and natural resource degradation are added to GDP but the decline in the value of future services is not subtracted in computing NDP.[6] The reason for the asymmetry is that the balance sheets lack any entry for consumption of natural resources and environmental services. One way to correct for this asymmetry is to treat these resources as a form of "natural" capital that is augmented by "investment" expenditures to protect and restore the asset, but diminished in the production process or by accidental losses.

TREATING ENVIRONMENTAL AND NATURAL RESOURCES AS INVENTORY

An important conceptual question in incorporating environmental and natural resources into the asset boundary is what to treat as inventory rather than fixed capital. The International Association for Research on Income and Wealth, for example, recommended the inventory approach to the Organization for Economic Cooperation and Development at its May 1992 meeting.[7] Resolution of this issue is important because it influences the size of NDP in relation to GDP and, possibly, estimates of the level of savings consistent with sustaining national income.

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5. John W. Kendrick, *Economic Accounts and Their Uses* (New York: McGraw-Hill, 1972), p. 27.

6. See Hueting, "Correcting National Income for Environmental Losses," p. 33.

7. Carol Carson, Director, Bureau of Economic Analysis, personal correspondence, January 22, 1993.

The Issue

The asset boundary includes both fixed capital and inventories. Assets are valued at the current price multiplied by quantity; the value of fixed capital is the discounted contribution to future GDP. Changes in the value of inventories are recorded in GDP; changes in the value of fixed capital due to use or accidental loss are recorded as capital consumption and used to compute NDP.

The revised guidelines for the United Nations' SNA defines a fixed asset, for example, as one that is used "repeatedly or continuously in production." They define inventories as "used up in production as intermediate consumption, sold, or otherwise disposed of." The only natural resources that the SNA currently includes as inventory are privately owned forests that are not ready to harvest, although the definition could be expanded.[8]

Assessment of the Issue

The main argument in favor of treating natural capital as an inventory is that changes in the value of inventories would affect GDP, the most widely used indicator of economic welfare. One compelling argument against classifying major categories of natural capital as inventory is that it confuses the role of GDP and NDP. GDP measures current economic activity. A $50 billion addition to oil reserves, when the oil has not actually been taken out of the ground, does not qualify as current activity, and therefore some argue that it should not be counted in current GDP. The addition to reserves does, however, qualify as an addition to wealth.

8. United Nations, *Draft Revised Version of the System of National Accounts* (New York: United Nations, 1992), Chapter 13, pp. 4 and 11; Chapter 21, p. 54.