Integrated Economic and Environmental Satellite Accounts

The existing systems of national economic accounts—including national income and product accounts, input-output accounts, and balance sheets—are without question premier tools for analysis and decisionmaking. Since their origins over 50 years ago, they have been refined, extended, and updated to reflect changes in the economy and to respond to changing analytical and policy concerns. Continuing this evolution, this article and its companion "Accounting for Mineral Resources: Issues and BEA's Initial Estimates," beginning on page 50, present new work by BEA on an accounting framework that covers the interactions of the economy and the environment. To do so, this framework provides new breakdowns that are relevant to the analysis of these interactions and extends the existing accounts' definition of capital to cover natural and environmental resources. The framework takes the form of a satellite account—an account that supplements, rather than replaces, the existing accounts.

This article presents the analytical and economic accounting background for the new work, an overview of the satellite accounting framework, and a long-term plan to implement the framework. Because it introduces a topic that has both economic and environmental dimensions, some parts of the article may appear elementary—perhaps even oversimplified—to readers familiar with the economic (and economic accounting) dimensions, while other parts may appear elementary to those familiar with the environmental dimensions.

The second article discusses the conceptual and methodological issues in mineral resource accounting and presents estimates of mineral stocks and changes in those stocks for the past several decades. It is a technically oriented article that describes in some detail the alternative valuation methods and the source data and estimating procedures used to prepare the new estimates.

Over the years, the national economic accounts have benefited from discussion and critique of concepts, source data, and estimating methods. The same is to be expected for the IEESA's, as BEA's new integrated economic and environmental satellite accounts are being called. I invite your comments.

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THE ECONOMY and the natural environment interact at many points, and these interactions raise analytical questions.

- The Nation's wealth includes natural resources, such as oil and gas reserves and timber, that are used in production. At what rate are these resources being used?
- The income of producers in the mineral industries includes a return to the drilling rigs, mining equipment, and other structures and equipment engaged in them and a return to the mineral. What share is attributable to the mineral?
- Economic activity adds to the proved stock of natural resources by exploration and technological innovation. How much of the use of natural resources in production has been offset by these additions?
- Households, governments, and business all make expenditures to maintain or restore the environment. What share of their spending is for the environment?
- The economy disposes of wastes into the air and water, and the resulting degradation of the environment imposes costs, such as lower timber yields and fish harvests and higher cleaning costs. What are these costs? Which sectors bear them?

The answers to questions such as these about the interaction of the economy and the environment are often based on partial and sometimes even inconsistent information, suggesting the need to identify and quantify the interactions within a systematic framework as a basis for more informed analysis and decisionmaking. This article introduces the integrated economic and environmental satellite accounts (IEESA's), which are meant to help fill that need. The IEESA's are a supplementary set of accounts structured to show the interactions of the economy and the environment more fully than the existing economic accounts. While the IEESA's build on the existing economic accounts, they do not replace them; likewise, IEESA measures do not replace measures, such as gross domestic product (GDP), from the existing accounts.

The Bureau of Economic Analysis (BEA) began work leading to this article—and to the companion article about mineral resources, which begins on page 50—in 1992. At that time, as part of a long-term program to modernize its economic accounts, BEA began research on two sets of accounts to supplement the existing national accounts. One of these sets of supplementary accounts, called satellite accounts, focused on the stock, and changes in the stock, of natural resources.[1] (The roles that satellite accounts can serve and their general structure are introduced in the accompanying box.) Work on the natural resources satellite accounts was given added impetus and extended in scope in 1993 when President Clinton, as part of his April 21 Earth Day address, gave high priority to the development of "Green GDP measures [that] would incorporate changes in the natural environment into the calculations of national income and wealth." At that time, BEA committed to producing initial estimates of natural resource depletion within a year.

1. The other set, on research and development, will be introduced in an upcoming issue of the SURVEY OF CURRENT BUSINESS.

The first section of this article discusses the analytical and economic accounting background of the IEESA's and concludes with a summary of a United Nations system of satellite accounts for the environment, after which BEA's accounts are fashioned. The second section introduces the main features of the IEESA's, presents an inventory of available data sources, and considers uses of the new accounts. The final section describes BEA's long-term work plan for developing the satellite accounts, the first phase of which is completed with the presentation of the two articles in this issue of the SURVEY OF CURRENT BUSINESS. Bibliographic references for both articles begin on page 62.

Satellite Accounts: What Are They?

Satellite accounts are frameworks designed to expand the analytical capacity of the national accounts without overburdening them or interfering with their general-purpose orientation. In this role, satellite accounts organize information in an internally consistent way that suits the particular analytical focus at hand, yet they maintain links to the existing national accounts. Further, because they supplement, rather than replace, the existing accounts, they can be a laboratory for economic accounting in that they provide room for conceptual development and methodological refinement.

In their most flexible applications, satellite accounts may use definitions and concepts that differ from the existing accounts. For example, a satellite account may be built around a broader concept of capital formation than the existing accounts. This flexibility is being used in BEA's work on integrated economic and environmental accounts and on research and development accounts. Satellite accounts such as these use different concepts and definitions by design; in other respects, they retain consistency with the existing accounts.

Satellite accounts can add detail or other information about a particular aspect of the economy to that in the existing accounts; for instance, they can integrate monetary and physical data. They can arrange information differently, perhaps by cutting across sectors to assemble information on both intermediate and final consumption. For example, a satellite account can assemble business expenditures on training—treated as intermediate consumption in the existing accounts—and education-related expenditures by households and government to analyze the role of education in the economy. They can use a classification other than the primary one. For example, they can identify expenditures on "research in education" as part of research expenditures even though they are included in education expenditures in the existing accounts.

The terminology and concepts associated with satellite accounts reflect the experiences of several countries that have constructed them, largely on an ad hoc basis, for fields such as health, education, agriculture, research and development, and the environment. The *System of National Accounts 1993*, the newly revised international guidelines, includes a chapter that provides a general framework for satellite accounts and demonstrates how that framework can be used for some of the fields in which such accounts would be most useful. This chapter represents, in a real sense, the coming of age of satellite accounts as an analytical tool.

The Background for Integrated Economic and Environmental Accounting

The analytical background

It is, of course, a simplification to speak of the economy and the environment as two distinct realms. It can be argued, for example, that the economy is part of nature because the economic activity of human beings in producing food and shelter parallels the similar activity of animals. In this simplification, the economy is defined as the human activities relating to income, production, consumption, accumulation, and wealth (although there is a continuing discussion about the scope to be given, for example, to the term "production"). The term "environment" refers to the environment of human beings, which is made up of the biological resources, subsoil resources, land and related ecosystem resources, water, and air. From the standpoint of the economy, the environment can be thought of as consisting of a range of natural resource and environmental assets that provide an identifiable and significant flow of goods and services to the economy.

The economy uses these productive natural assets in a wide range of ways. Crude oil pumped from proved reserves, for example, is used in the production of petroleum products, while clean water in lakes and oceans is used in the production of fish, paper products, and electric power. The economy's uses of the goods and services provided by these environmental assets can be grouped into two general classes. When use of the natural asset permanently or temporarily reduces its quantity, the use is viewed as involving a flow of a good or service, and the quantitative reduction in the asset is called depletion. In that class of uses, biological resources, for example, are used as food, as raw materials for clothing, and as building materials and fuel. Water is used for drinking, cooling, processing, and irrigation.

When use of the natural asset reduces its quality, the qualitative reduction in the asset is called degradation. These qualitative uses include the conversion of land from one use to another, such as the partial development of forestland. The development of forestland results in a reduction in the economic value of the land as forestland because of the reduction in the flow of recreational services associated with its degradation as a wildlife area and tourist destination. In another kind of qualitative use, natural assets are used as a sink for the disposal of residual pollutants that are byproducts of production.

The use of natural assets describes only part of the interaction between the economy and the environment. There are also feedback effects. Materials balance and energy accounting highlight both the use of the natural assets and the feedback effects from the use; thus, they capture the full interaction between the economy and the environment.[2] In the case of natural resources, oil pumped from reserves today reduces the quantities that can be extracted from existing fields in the future; similarly, overharvesting of fish stocks today reduces yields in the future.

In the case of environmental assets, the feedback is more complicated, with effects that often fall on other industries and consumers. For example, when businesses use environmental goods and services along with labor and capital in production, residuals—such as lead and cadmium, or carbon monoxide and sulfur oxides—are also produced and are then disposed of into the environment. Up to a point, the environment is able to assimilate these residuals; beyond that point, however, significant environmental degradation affects the ability of the environment to provide

2. Materials balance and energy accounting, developed in the late 1960's, is based on the first law of thermodynamics—that matter can neither be created nor destroyed. The accounts therefore describe a circular flow process: A raw material input is transformed by the processes of the economy, this transformation results in a new product and in residuals, and those residuals are transformed in the natural environment into raw materials.

Acknowledgments

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raw materials to the economy (and to assimilate residuals). Degradation of air and water quality, for example, may lead to economic feedback—for example, lower timber yields and fish harvests, higher rates of depreciation in plant and equipment, additional cleaning costs, and increased health expenditures. In addition, either because of governmental regulations or the need to dispose of residuals that the environment can no longer handle, businesses and others may need to make expenditures for pollution abatement and control.

Integrated economic and environmental accounting aims to provide a picture of these interactions between the economy and the environment. Although this picture, as already noted, has numerous elements and is complex, by definition it does not cover many of the transformations and interactions within the environment itself—for example, the disposal of waste products from wild fish and mammals or the conversion of natural carbon dioxide into oxygen by plant matter on land and in the oceans. The accounts highlight the fact that economic sustainability depends on environmental sustainability, and they provide data to help analyze the costs and benefits for the careful stewardship of our economic and environmental assets. Consistent and detailed accounting of the interactions between the economy and the environment provides a common framework for integrating the work of environmental specialists, economists, and other analysts from a wide range of disciplines.

The economic accounting background

Economic accountants have long been aware of the issues that arise with respect to natural resources and the environment. One of the issues, which is also reviewed in the companion article, is whether the economic accounts should reflect the parallelism that is apparent in business accounting between depreciation, a charge for the using up of plant and equipment in production, and depletion, a charge for the using up of natural resources in production. In particular, because depletion of mineral resources has long been chargeable against profits in the U.S. tax code and because tax return tabulations have been used as source data for profits and other property income components of the national income and product accounts (NIPA's), explicit decisions were required on the treatment of depletion in the accounts. Initially, depletion was treated symmetrically with depreciation, but no entry was made for additions to the stock of mineral resources parallel to the treatment of investments in structures and equipment. As a result of dissatisfaction with this asymmetric treatment, the entry for depletion was removed beginning in 1947.

In the late 1960's and early 1970's, environmental accounting issues came up as part of a broader interest in social accounting. Work by James Tobin and William Nordhaus, among others, on adjusting traditional economic accounts for changes in leisure time, disamenities of urbanization, exhaustion of natural resources, population growth, and other aspects of welfare produced indicators of economic well-being. However, the seemingly limitless scope, the range of uncertainty, and the degree of subjectivity involved in such measures of nonmarket activities limited the usefulness of, and interest in, these social indicators. It was felt that inclusion of such measures would sharply diminish the usefulness of traditional economic accounts for analyzing market activities. Attention subsequently focused on more readily identifiable and directly relevant market issues, such as the extent to which expenditures that relate to the protection and restoration of the environment (and other so-called defensive expenditures) are identifiable in the economic accounts.

In response to this interest in environmental protection, in the mid-1970's, BEA was a pioneer in the development of estimates of pollution abatement and control (PAC) expenditures in a national accounting framework. Further, presaging what was to come, the framework for these estimates can be viewed as an early form of a satellite account. The PAC estimates focus on an area of interest and provide detail that would have burdened presentation of the more general NIPA estimates.

The steps in the evolution of natural resource and environmental accounting since the early 1980's can be summarized in terms of international efforts, in which there was active U.S. participation, and the literature related to these effects. For this purpose, 1982 is a reasonable place to start. In that year, the United Nations Environment Program (UNEP) was given the mandate to develop methodological guidelines on environmental accounting. In its earlier work, UNEP had tried to clarify the linkages between economic development and the environment to help integrate issues of environmental and resource management into the framework of economic decisionmaking. To follow up on the mandate, UNEP and the World Bank sponsored a series of workshops in 1983–86 to explore the current state of environmental and natural resource accounting. The general thinking was that although economists had long considered the "external effects" of production and consumption, they had not taken into account the effects on the resource system as a whole and the consequence that eventually someone was going to have to bear the "external costs." A broader view would internalize environmental costs in the production process, for which it would be essential to calculate costs and benefits properly and to distinguish clearly between true income and the drawing down of assets by depletion or degradation. Accordingly, the workshops focused on the shortcomings of traditional economic accounting: GDP does not adequately represent true income because environmental protection costs are treated as generating income and because depletion and degradation of natural resources are not charged against current income. A number of remedies for these shortcomings were proposed, but workable methodologies and good data were lacking, and some of the proposals were conflicting.[3]

Although the empirical foundations for integrating environmental and economic accounting estimates were lacking in the mid-1980's, a growing body of research and information was accumulating.[4] France, Norway, and the Netherlands were working toward physical accounting matrices, which they have integrated into cost-benefit and cost-effectiveness work in the environmental policy field. Subsequently, Canada, the United Kingdom, Japan, and Australia all did preliminary work toward supplementing their traditional accounts. The United Nations and the World Bank jointly sponsored pilot studies with statisticians in Mexico and Papua New Guinea. In addition to these country efforts, researchers—such as Henry Peskin, working with the Environmental Protection Agency in a study of the Chesapeake Bay region, and Robert Repetto and his associates at the World Resources Institute, in their studies of China, Costa Rica, and the Philippines—have added significantly to the growing literature on environmental accounting.

In the meantime, a revision of the System of National Accounts (SNA), the international guidelines followed by most countries in preparing their economic accounts, was undertaken. A major issue was the extent to which the revised SNA would remedy the perceived shortcomings of traditional national accounts.

The discussion stimulated by the 1987 report of the World Commission on Environment and Development, *Our Common Future*, gave added reason to explore statistical measures that would provide appropriate tools to guide policy and decisionmaking.[34] This report focused on sustainable development—that is, development that meets the needs of the present without compromising the ability to meet the needs of the future. According to the report, the Commission had been established by the United Nations General Assembly because of the growing realization that it is impossible to separate economic development issues from environmental issues—the realization, in other words, that many forms of development erode the environmental resources upon which they are based, and that such environmental degradation can undermine economic development.

By 1989, it became clear that, given the divergent views on a number of conceptual and practical issues in natural resource and environmental accounting, international consensus in time for a fundamental change in the SNA as part of the ongoing revision was not possible. Therefore, it was agreed that the revised SNA would address links to environmental concerns, such as the definition and boundary for assets, and that a satellite account for integrated economic and environmental accounting would be pursued. The United Nations undertook the preparation of a handbook to provide guidance on the construction of the satellite account.

Subsequently, this approach found support in several forums. In May 1991, a Special Conference of the International Association for Research in Income and Wealth brought together economic accountants and environmental specialists to discuss a preliminary version of the United Nations handbook. In June 1992, the United Nations Conference on Environment and Development (the "Earth Summit") in Rio de Janeiro included a program for establishing systems of integrated accounts as a complement to the existing system in its Agenda 21.[29] Agenda 21 urged national offices that prepare economic accounts to undertake the work and urged the United Nations to distribute widely, and then refine, its handbook. In October 1992, economic accountants, in a seminar held to review the revised SNA, generally welcomed the features that link to the environment and the section of the revised SNA's chapter

3. See Salah El Serafy and Ernst Lutz [7].

4. See, for example, Henry M. Peskin and Ernst Lutz [17].

on satellite accounts that discusses integrated economic and environmental accounts based on the United Nations handbook. In February 1993, the Statistical Commission of the United Nations endorsed the revised SNA.[5] The Commission, in highlighting the important features of the revised SNA, noted that it laid the groundwork for dealing with the interaction between the economy and the environment.

The United Nations System of Environmental and Economic Accounting

The United Nations System of Environmental and Economic Accounting (SEEA), as described in the handbook, is a flexible, expandable satellite system.[30] It draws on the materials balance approach to present the full range of interactions between the economy and the environment. The SEEA builds on, and is designed to be used with, the *System of National Accounts 1993* (hereafter *SNA 1993*) [31]. Like the SNA, the SEEA is primarily concerned with the implications of the environment for production, income, consumption, and wealth.

The SEEA has four stages, each successively providing a more comprehensive accounting for the interaction between the economy and the environment. The four-stage presentation recognizes the need to develop concepts, to inventory and augment source data, and to adapt the implementation to differing analytical needs. The starting point is the *SNA 1993*, which incorporated several features that anticipated the needs of environmental accounting.[6] Stage A disaggregates, or provides additional detail on, environmentally related economic activities and assets. This stage, for example, focuses on actual expenditures intended to prevent or repair the degradation of the environment. It includes a detailed breakdown of the stocks of natural resource assets and changes in these stocks. Finally, it includes sector links to show the supply and uses of natural resources. The use of natural resources—depletion and degradation—can be broken down into intermediate inputs by industry, investment, final consumption by households and government, and imports and exports.

Stage B begins with the physical counterpart of stage A. It maps, in physical terms, the interaction between the environment and the economy. It provides the physical quantities to which prices are applied to derive the economic values included in the economic accounts. These physical accounts also provide a bridge to natural resource accounting and to materials and energy balances accounting. Stage B then links the physical quantities to monetary values.

Stage C provides far more comprehensive and explicit measures of the interaction between the economy and the environment. It does so, first, by the use of alternative valuation techniques—that is, alternatives to the use of values tied to the market, the valuation used in the *SNA 1993* and in traditional accounting systems. The alternative valuation techniques include estimates based on maintenance costs, or the costs necessary to maintain at least the present level of environmental assets, and estimates based on contingent valuation, or the willingness to pay for reductions in depletion or degradation of natural assets. Second, it does so by the more explicit introduction of environmental effects on the measures of national production, investment, income, and wealth. Stages A and B of the SEEA (as well as the *SNA 1993*) record environmental effects either as changes in the value of assets or as changes in the distribution of income among the factors of production; these changes do not explicitly affect gross domestic product, final demand, or net domestic product.

Stage D consists of further extensions of the SEEA. These extensions are provided for the purpose of "opening a window on further analytical applications," and they will require further research. They include household production and the use of recreational and other unpriced environmental services in household production.

Framework for the IEESA's

BEA's IEESA's build on the accumulating experience represented in the SEEA. This experience is consistent with two lessons from social accounting in the 1970's. First, such accounts should be focused on a specific set of issues. Second, given the kind of uses to which the estimates would be put, the early stage of conceptual develop-

5. For a summary of the SNA, the revision process, and the new features, see [30].

6. The two main features that anticipated the needs of environmental accounting dealt with the coverage of assets and the recording of changes in them. First, the SNA 1993 includes within the boundary of economic assets all assets over which ownership rights can be established and enforced and that provide economic benefits to their owners. This boundary explicitly includes natural assets, both those whose growth is the result of human cultivation (for example, vineyards and livestock) and those that, although not cultivated, are under control of an owner (for example, land, subsoil assets, and water resources). Second, it records all changes in the value of assets from one balance sheet to another. As part of doing this, there is an account to record certain changes in assets not recorded as production or as costs of production; this account records, for example, the additions to, and depletion of, subsoil assets and the natural growth of uncultivated forests. Another account records changes in the value of assets due to price change. Further, the *SNA 1993* describes how to use these and other features as a point of departure for an environmental satellite account.

ment, and the statistical uncertainties (even if the estimates are limited to the effect on market activities), such estimates should be developed in a supplemental, or satellite, framework.

Structural features

The IEESA's are structured to focus on the interaction of the economy and the environment. The interactions covered are those that can be tied to market activities and thus valued in market prices or proxies thereof. They are shown as effects on production, income, consumption and wealth.

The accounts have two main structural features. First, natural resources and environmental resources are treated like productive assets. These resources, along with structures and equipment, are treated as part of the Nation's wealth, and the flow of goods and services from them are identified and their contribution to production measured. Second, the accounts provide substantial detail on expenditures and assets that are relevant to understanding and analyzing the interaction. Fully implemented IEESA's would permit identification of the economic contribution of natural and environmental resources by industry, by type of income, and by product. Ultimately, accounts by region would add an important analytical dimension.

Natural and environmental resources as productive assets.—An example helps to explain the reasoning behind treating natural and environmental resources like productive assets in the economic accounts. This example is much simplified, notably in that it shows only one side of an account, focuses on aggregates, and uses descriptive rather than technically precise terminology. In this example, all income from production goes to either "wages" or "profits." Wages are recorded as earned; however, profits—that is, total revenues less labor and other operating expenditures—are reduced by an entry for "depreciation," where depreciation is the amount that must be set aside to cover the using up of capital in production. Thus, for an industry and for all industries combined, wages plus profits and depreciation equals gross domestic product (GDP).

In the traditional accounts, the economy would be pictured as follows:

Wages	6,000
Plus: Profits	3,000
Depreciation	1,000
Gross domestic product	**10,000**

Because depreciation is included in GDP, GDP is not a measure of sustainable income; that is, if a nation consumed all of its GDP, it would reduce the productive capacity available to future generations because it had consumed the amount it should have set aside to cover the using up of capital. In fact, the "gross" in the name, gross domestic product, refers to that feature. As a better measure of sustainable income, the traditional accounts provide net domestic product (NDP), which is calculated as GDP less depreciation.

Gross domestic product	**10,000**
Less: Depreciation	1,000
Net domestic product	**9,000**

Capital in the traditional accounts is limited to structures and equipment. In the IEESA's, natural and environmental resources are viewed as having characteristics similar to structures and equipment: Labor and materials are devoted to producing them, and they then yield a flow of services over time. For that reason, the IEESA's include these resources, along with structures and equipment, as part of the Nation's wealth and give them the same treatment as structures and equipment in the traditional accounts. The IEESA's deal with three points of asymmetry between the treatment of natural resources—for example, mineral reserves—and of structures and equipment encountered in traditional accounts. In traditional accounts: (1) depreciation is subtracted from profits to determine true, or sustainable, profits, but depletion is not; (2) depreciation is subtracted from GDP to estimate NDP, but depletion is not; and (3) additions to the stock of plant and equipment are added to GDP as capital formation, but additions to mineral reserves are not.

The depletion of mineral reserves is like the depreciation of plant and equipment: It is the amount that must be set aside to cover the cost of using up mineral resources in production. If an oil company earns $3,000 in profits but depletes its mineral reserves by $100, then its true economic profits are only $2,900, the amount over and above its depletion of assets. In the IEESA's, therefore, an estimate is made of the amount of profits that should be recognized as depletion. This amount is subtracted from profits and entered, like depreciation, as a separate component, thereby dealing with the first point of asymmetry. Further, depletion, like depreciation, must be subtracted from GDP to arrive at NDP. Doing so deals with the second point of asymmetry.

Wages	6,000
Plus: Profits (IEESA)	2,900
Depreciation	1,000
Depletion	100
Gross domestic product (IEESA)	**10,000**
Less: Depreciation	1,000
Depletion	100
Net domestic product (IEESA)	**8,900**

Note that recognizing depletion lowers profits and changes the composition of GDP, but the level of GDP itself is not reduced; recognizing depletion reduces NDP in comparison with the traditional accounts' NDP.

In the IEESA's, additions to mineral reserves (for example, extensions as a result of investments in improved technology or additions as a result of exploration) are treated like additions to the stock of structures and equipment—that is, as capital formation. Additions to reserves do not appear in the traditional accounts; therefore, to treat them as capital formation, they are added to GDP. In the IEESA's, additions to reserves raise capital formation, profits, GDP, and NDP. Recognizing the additions to reserves thus deals with the third point of asymmetry. If the additions amounted to 150, the economy would be pictured as follows:

Wages	6,000
Plus: Profits (IEESA)	3,050
Of which: Capital formation in mineral reserves	150
Depreciation	1,000
Depletion	100
Gross domestic product (IEESA)	**10,150**
Less: Depreciation	1,000
Depletion	100
Net domestic product (IEESA)	**9,050**

Compared with the traditional accounts, both the composition and level of GDP differ. Thus, the IEESA's give a view of an industry's production that reflects changes in its resource base. The IEESA's measure of NDP, therefore, is a better measure of sustainable income than the traditional accounts' measure because it incorporates changes in mineral wealth as well as structures and equipment. Whether the IEESA's measure of NDP is higher or lower than in the traditional accounts depends on whether depletion or additions is larger, and this will vary from resource to resource and from period to period. Estimates of this kind for all natural and environmental resources would help gauge whether the current level of GDP can be maintained by the Nation's natural resource base.

Detail that highlights the interaction.—In the IEESA's, the standard economic accounting categories are disaggregated to show detail that highlights the interaction of the economy and the environment. For example, the expenditures detail shows spending by households, government, and business to maintain or restore the environment. The asset detail shows environmental management (conservation and development, and water supply) and waste-management projects (sanitary services, air and water pollution abatement and control) within the standard category of nonresidential fixed capital.

The estimating requirements underlying these two main structural features of the IEESA's are apparent in the IEESA tables, even when, as shown in this article, they are in skeleton form. Table 1, an asset account, and table 2, a production account, use modified forms of tables presented in the SEEA.

Asset accounts

Integrated economic and environmental accounting requires the measurement of stocks and flows related to assets, which are presented in an asset account. An asset account is like a balance sheet in that it presents stocks, or holdings, at a point in time. (Because an asset account is limited to nonfinancial assets, it does not include liabilities and net worth, as would a balance sheet.) However, an asset account also presents flows related to the assets during a period of time.

The IEESA's provide a complete accounting for the relevant assets—that is, they show both stocks and flows associated with changes in those stocks. Column 1 in table 1 provides for estimates of opening stocks. Columns 2–5 provide for estimates of the flows that represent different kinds of changes in the stock: First, a net total and then three flows: The decrease in stocks due to depreciation (or more formally, in economic accounting terms, consumption of fixed capital), depletion, or degradation; the increase in stocks due to capital formation in the form of new structures and equipment, additions to inventories, additions to the stock of natural and environmental assets; and changes in value due to price changes and to changes in the volume of assets other than those due to economic activity (for example, natural disasters). Column 6 provides for estimates of closing stocks.

Table 1 presents the nonfinancial assets that BEA would try to include in IEESA asset accounts. The table's rows generally follow the subcategories of the *SNA 1993* and the SEEA, but some of the subcategories are regrouped to broaden both the production boundary and the definition of assets. Nonfinancial assets are divided into made assets, developed natural assets, and environmental assets. Made assets, which largely replicate the scope of nonfinancial assets in traditional income and wealth accounts, are subdivided into fixed assets and inventories. Developed natural assets are

Table 1.—IEESA Asset Account, 1987

[Billions of dollars]

This table can serve as an inventory of the estimates currently available for the IEESA's. In decreasing order of quality, the estimates that have been filled in are as follows: For made assets, estimates of fixed reproducible tangible stock and inventories, from BEA's national income and product accounts or based on them, and pollution abatement stock, from BEA estimates (rows 1–21); for subsoil assets, the highs and lows of the range based on alternative valuation methods, from the companion article (rows 36–41); and best-available, or rough-order-of-magnitude, estimates for some other developed natural assets (selected rows 23–35 and 42–47) and some environmental assets (selected rows 48–55) prepared by BEA based on a wide range of source data described in this article. The "n.a."—not available—entries represent a research agenda.

	Row	Opening stocks	Change				Closing stocks (1+2)
			Total, net (3+4+5)	Depreciation, depletion, degradation	Capital formation	Revaluation and other changes	
		(1)	(2)	(3)	(4)	(5)	(6)
PRODUCED ASSETS							
Made assets	**1**	**11,565.9**	**667.4**	**–607.9**	**905.8**	**369.4**	**12,233.3**
Fixed assets	2	10,535.2	608.2	–607.9	875.8	340.2	11,143.4
Residential structures and equipment, private and government	3	4,001.6	318.1	–109.8	230.5	197.4	4,319.7
Fixed nonresidential structures and equipment, private and government	4	6,533.6	290.1	–498.1	645.3	142.9	6,823.7
Natural resource related	5	503.7	23.1	–19.2	30.3	12.0	526.8
Environmental management	6	241.3	8.4	–7.0	10.6	4.7	249.6
Conservation and development	7	152.7	3.6	–4.4	5.3	2.7	156.4
Water supply facilities	8	88.5	4.8	–2.5	5.3	2.0	93.3
Pollution abatement and control	9	262.4	14.7	–12.2	19.7	7.3	277.1
Sanitary services	10	172.9	12.8	–5.6	13.7	4.8	185.8
Air pollution abatement and control	11	45.3	.6	–4.1	3.5	1.3	45.9
Water pollution abatement and control	12	44.2	1.3	–2.5	2.6	1.2	45.5
Other	13	6,029.9	267.0	–478.9	615.0	130.9	6,296.9
Inventories [1]	14	1,030.7	59.3	....	30.1	29.2	1,090.0
Government	15	184.9	6.8	....	2.9	3.8	191.7
Nonfarm	16	797.3	62.4	....	32.7	29.7	859.7
Farm (harvested crops, and livestock other than cattle and calves)	17	48.5	–9.9	....	–5.5	–4.4	38.6
Corn	18	10.2	.3	....	–1.1	1.4	10.5
Soybeans	19	5.0	–.1	....	–1.0	.9	4.9
All wheat	20	2.6	0	....	–.2	.2	2.6
Other	21	30.7	–10.1	....	–3.2	–6.9	20.6
Developed natural assets	**22**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Cultivated biological resources	23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cultivated fixed natural growth assets	24	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Livestock for breeding, dairy, draught, etc	25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cattle	26	12.9	2.0	n.a.	–.3	2.3	14.9
Fish stock	27	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Vineyards, orchards	28	2.0	.2	n.a.	0	.2	2.2
Trees on timberland	29	288.8	47.0	–6.9	9.0	44.9	335.7
Work-in-progress on natural growth products	30	n.a.	n.a.	....	n.a.	n.a.	n.a.
Livestock raised for slaughter	31	n.a.	n.a.	....	n.a.	n.a.	n.a.
Cattle	32	24.1	7.5	....	0	7.5	31.6
Fish stock	33	n.a.	n.a.	....	n.a.	n.a.	n.a.
Calves	34	5.0	.9	....	–.5	1.4	5.9
Crops and other produced plants, not yet harvested	35	1.8	.3	....	.1	.2	2.1
Proved subsoil assets [2]	36	270.0 ↔ 1066.9	57.8 ↔ –116.6	–16.7 ↔ –61.6	16.6 ↔ 64.6	58 ↔ –119.6	299.4 ↔ 950.3
Oil (including natural gas liquids)	37	58.2 ↔ 325.9	–22.5 ↔ –84.7	–5.1 ↔ –30.6	5.8 ↔ 34.2	–23.1 ↔ –88.3	35.7 ↔ 241.2
Gas (including natural gas liquids)	38	42.7 ↔ 259.3	6.6 ↔ –57.2	–5.6 ↔ –20.3	4.1 ↔ 14.9	8.1 ↔ –51.8	49.4 ↔ 202.2
Coal	39	140.7 ↔ 207.7	2.2 ↔ –3.4	–5.4 ↔ –7.6	4.4 ↔ 6.3	3.2 ↔ –2.1	143.0 ↔ 204.2
Metals	40	(*) ↔ 215.3	67.2 ↔ 29.5	–.2 ↔ –2.2	2.2 ↔ 9.2	65.2 ↔ 22.5	38.5 ↔ 244.8
Other minerals	41	28.4 ↔ 58.7	4.3 ↔ –.8	–.4 ↔ –.9	.1 ↔ 0	4.6 ↔ .1	32.8 ↔ 57.9
Developed land	42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Land underlying structures (private)	43	4,053.3	253.0	n.a.	n.a.	n.a.	4,306.3
Agricultural land (excluding vineyards, orchards)	44	441.3	42.4	n.a.	–2.8	45.2	483.7
Soil	45	n.a.	n.a.	–.5	n.a.	n.a.	n.a.
Recreational land and water (public)	46	n.a.	n.a.	–.9	.9	n.a.	n.a.
Forests and other wooded land	47	285.8	28.8	n.a.	–.6	29.4	314.6
NONPRODUCED/ENVIRONMENTAL ASSETS							
Uncultivated biological resources	48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Wild fish	49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Timber and other plants of uncultivated forests	50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Other uncultivated biological resources	51	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Unproved subsoil assets	52	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Undeveloped land	53	n.a.	n.a.	–19.9	19.9	n.a.	n.a.
Water (economic effects of changes in the stock)	54	....	n.a.	–38.7	38.7	n.a.	....
Air (economic effects of changes in the stock)	55	....	n.a.	–27.1	27.1	n.a.	....

n.a. Not available.

* The calculated value of the entry was negative.

1. The estimate for inventories differs from the NIPA estimate by the amount of government inventories added and cattle and calves shown separately. In full implementation of the IEESA account, farm inventories would include only harvested crops.

2. The estimates in all columns result from the valuation method (see text for further discussion of the alternative methods) that produces the low and high estimates of opening stocks.

NOTE.—Leaders indicate an entry is not applicable.

subdivided into cultivated biological resources, proved subsoil assets, and developed land. Environmental assets are subdivided into uncultivated biological resources, unproved subsoil assets, undeveloped land, water, and air (the last two in terms of the economic effects of changes in the stock).

Made and developed natural assets.—To better highlight the interaction of the economy and the environment, table 1 provides more detail on natural resource and environmentally related produced assets than the traditional income and wealth accounts. Within made assets, nonresidential fixed capital is disaggregated into environmental management (conservation and development, and water supply) and waste-management projects (sanitary services, air and water pollution abatement and control). Detail is also provided on farm inventories of finished goods.

Within cultivated biological resources, table 1 provides detail beyond that contained in the traditional accounts, such as cultivated fixed natural growth assets (for example, livestock), and categories not included in the traditional accounts (for example, trees on timberland).

The treatment of proved subsoil assets and cultivated land in table 1 differs from the SEEA treatment. Proved reserves are generally defined as those reserves that are proved to a high degree of certainty—by test wells or other test data—and are recoverable under current economic conditions and with current technology. In the SEEA, they are classified as nonproduced assets. In table 1, these assets, along with cultivated natural growth assets, are included in the category "developed natural assets." As will be illustrated in the production accounts, capital formation that adds to the stock of these assets—both by bringing undeveloped or uncultivated assets into the category of developed natural assets and by adding to their value within that category—is treated in a manner similar to capital formation that adds to the stock of structures and equipment.

This treatment was adopted because it is difficult to rationalize describing proved reserves and cultivated land as "nonproduced" natural assets when expenditures are required to prove or develop them. Agricultural land, for example, must be "produced" in that expenditures must be undertaken to convert uncultivated land areas into commercially valuable farmland, which yields a return over a number of years. Wetland areas, if they are to become farmland, must be drained and graded and vegetation cleared. Unproved mineral reserves also require expenditures for test wells, engineering studies, and other exploration and development investments before they are recorded as proved reserves.

Similar treatments of these developed natural assets and made assets facilitate consistent treatment of capital formation of natural assets and more conventional capital formation, such as investment in structures and equipment. Under this treatment, as mineral reserves, for example, are proved, the total value of the produced assets—structures and equipment as well as the proved reserve's value—is included as capital formation. Similarly, as oilfield machinery is depreciated, proved reserves associated with the machinery are depleted.

The other major difference between developed assets in table 1 and in the comparable SEEA presentation is in the treatment of soil. In the SEEA, soil—that is, productive soil on agricultural land—is treated as separate from agricultural land. In table 1, soil is a subcategory of agricultural land because the value of agricultural land is inseparable from the value of the soil. Available estimates suggest that the effect of soil erosion, or depletion, on agricultural productivity and land values in the United States is quite small. Nevertheless, though soil is not treated separately, it is shown separately because its erosion has a significant effect on environmental quality through its effect on water quality.

Environmental assets.—This grouping includes natural assets with significant economic value that differ from developed natural assets in that they are generally used as raw inputs into production in their natural state, either as intermediate products or as investments. For example, uncultivated biological resources, such as tuna harvested from the ocean, are included as environmental assets, whereas cultivated biological resources, such as rockfish raised on a fish farm, are included in developed assets. Other categories in environmental assets are uncultivated land, unproved subsoil assets, water, and air.

The inclusion of unproved subsoil assets broadens the definition of subsoil assets to include reserves that, though unproved, have an economic value over and above that of other undeveloped land because of their location or geologic characteristics. As capital expenditures are made to "prove" these properties, they move from nonproduced to produced assets. This broader definition of subsoil resources will facilitate longer term planning and analysis of the use of mineral resources. The stock of proved reserves—like the stock of drill presses—can be expanded by additional investment; hence, firms will keep on hand the stock of reserves dictated by current market prices, finding costs, and interest rates. Thus, complete analysis of mineral resources requires consideration of unproved, as well as of proved, reserves.

In a distinction similar to that between proved and unproved subsoil assets, cultivated land—such as agricultural land, parkland, and land underlying buildings—is included in developed natural assets, whereas uncultivated land—-such as wetlands and forestland (not included as timberland)—is included in environmental assets. The agricultural land must be developed before it can be used as farmland, whereas wetlands are used—for example, for their disposal services—in their natural state by the economy. Water, which is subdivided by type, and air also provide services to the economy in the form of recreational and waste disposal services.

Although these environmental assets differ from made and developed natural assets, investments that add to the stock of these assets, as noted below in the production accounts, are treated symmetrically with investments that add to the stock of structures and equipment and of developed assets. These investments, for example, include pollution abatement and control to improve the quality and waste disposal capacity of the air and water, or at least to offset the degradation/depletion (which is also recorded in the production account) occurring in the current period. These investments represent a decision by the economy to devote its resources to investments that improve air and water quality, rather than investments in structures and equipment, and investments that add to the stock of clean air and water should be counted just as investments that add to the stock of made and developed assets are counted.

Estimates: Coverage, sources, and methods.—The estimates recorded for 1987 in table 1 should be regarded as rough-order-of-magnitude, or best-available, estimates. (The estimates are for 1987 because that is the last year for which data from the quinquennial economic census—used in a number of cases as a benchmark from which to estimate forward and backward—are available.) In most cases, only one estimate, rather than a range, is available. Many of the table's cells do not contain estimates, and the quality of the estimates varies greatly. In general, the quality and availability of the estimates declines as one moves down the rows from produced to nonproduced assets, reflecting the increasing conceptual and empirical difficulties in producing such estimates. The estimates may be best regarded as a measure of the work to be undertaken; they are presented here to serve as a road map for areas in which source data and estimating methods must be developed or improved.

Within made assets, the estimates of nonresidential stocks of pollution abatement (PA) structures and equipment are constructed using the same perpetual inventory techniques used to produce BEA's exiting capital stock estimates (see the box on page 44). These stock estimates capture nonresidential investments for PA that are readily identifiable. When companies and plants change their production processes (or equipment) to embody PA features, the PA portions of these investments are included to the extent they can be identified; however, identification is difficult, and understatement of PA stocks can occur. Estimates of government inventories are from unpublished NIPA data. For inventories owned by the Federal Government, the estimates are based on information on inventories from Federal agencies. For State and local governments, the estimates are based on the level of their purchases of nondurable goods; it is assumed that they hold 1 month of these purchases in inventories. The farm inventories of finished goods for agriculture are extensions of the existing inventory data in the NIPA's (following the IEESA, crops not yet harvested are shown as work-in-progress). Stock estimates for several components that would be of interest in the household sector, such as PA equipment in consumer durables and residential capital (for example, PA equipment installed in cars and septic systems in homes), are not available.

Within developed natural assets, most of the estimates are an extension of the existing national accounts data. The existing accounts include estimates for livestock only, with no split between those raised for breeding, dairy, or draft (cultivated fixed natural growth assets) and those raised for slaughter (work in progress on natural growth products). In table 1, these splits were made using assumptions based on data from the U.S. Department of Agriculture (USDA). The estimates of the value of vineyards and orchards are based on Federal Reserve Board estimates of the value of agricultural land and estimates of the acres of land in vineyards and orchards from the Bureau of the Census. Estimates of the value of fish stocks or of changes in these stocks are not yet available (and are in phase II of BEA's plan).

The values of trees on timberland were estimated based on stumpage value estimates provided by the U.S. Forest Service's Pacific Northwest Research Station. The stumpage value estimates are based on the concept of net rent to the timber stand—as distinct from the land the forest sits upon—and are derived mainly from private market data on payments for logging rights. As such, they should correspond to the present discounted value of the timber sales from the tract less the costs of logging, access, transportation, and processing. All timber on timberland in the United States—public and private—is included in this category. Timber on other forestland is included in nonproduced/environmental assets. This somewhat arbitrary distinction is made partly on conceptual grounds and partly on the availability of source data. All timber in the national forests is in a sense managed, although depending on the forest, management ranges from active, such as planting, to relatively passive, such as self-seeding, fire control, and rotational harvests. Practically, no data are available for the exact definition of "cultivated timber tracts."

Stock of Plant and Equipment for Air and Water Pollution Abatement in the United States, 1980–91

This box presents estimates of the gross and net stocks of plant and equipment (P&E) for air and water pollution abatement (PA) in the United States during 1980–91. Gross and net stocks of PA P&E help to protect air and water from degradation by stationary and point industrial sources of pollutant emissions.[1]

In 1991, the gross stock of air and water PA P&E was about $183.5 billion (table A).[2] In constant (1987) dollars, the gross stock was $165.0 billion in 1991, about 2.0 percent of the real gross stock of all fixed nonresidential nonfarm business capital. Between 1980 and 1991, the real gross stock of air and water PA P&E grew at an annual rate of 2.6 percent. Growth in nonmanufacturing stocks outpaced that in manufacturing stocks, mainly reflecting PA P&E spending by electric utilities. The real net stock of air and water PA P&E—that is, after subtracting depreciation—was $91.3 billion in 1991, up from $85.8 billion in 1980.

The PA P&E stock estimates are useful when studying market production and economic well-being. They are helpful in determining how pollution abatement spending affects prices, total capital costs, and the profitability of capital. They are also helpful in constructing rough measures of the value of the degradation in air and water quality that has been avoided through pollution abatement.[3]

The 1980–91 PA P&E estimates were prepared by the perpetual inventory method: Past PA P&E flows (capital spending) were cumulated and discards deducted, in accordance with lifespans of capital goods, to arrive at gross stocks of PA P&E. Net stocks were calculated by subtracting accumulated depreciation from gross stocks. Gross and net stock estimates for 1980–91 are valued at constant and at current cost—that is, using 1987 prices (for constant cost) and replacement or current-year prices (for current cost).

Data on an establishment basis for manufacturing PA P&E spending are mainly from the Pollution Abatement Costs and Expenditures (PACE) Survey by the Bureau of the Census. Data for electric utilities are mainly from the Pollution Abatement (PA) Supplement to the Census Bureau's P&E survey; the PA Supplement reports PA P&E spending for three industries—electric utilities, petroleum, and mining. The PA Supplement reports PA P&E on a company basis, but for electric utilities (unlike for petroleum and mining), such data approximate an establishment basis. The PA P&E spending estimates for mining and for nonmanufacturing except mining and electric utilities are prepared by indirect methods; a variety of data sources are used, including the PA Supplement, an environmental protection expenditures survey by the American Petroleum Institute, and the *Census of Mineral Industries.*

Table A.—Gross and Net Stocks of Air and Water Pollution Abatement Plant and Equipment in Nonfarm Business, by Major Industry Group, Current-Cost and Constant-Cost Valuations, 1980–91

	Gross stocks					Net stocks				
	All nonfarm industries	Manufacturing			Nonmanufacturing	All nonfarm industries	Manufacturing			Nonmanufacturing
		Total	Durables	Nondurables			Total	Durables	Nondurables	
	Billions of current dollars									
1980	103.43	58.78	24.55	34.24	44.65	71.14	37.65	15.94	21.71	33.49
1981	118.66	66.31	28.04	38.27	52.35	79.54	40.94	17.56	23.39	38.60
1982	129.00	70.16	29.72	40.43	58.84	84.46	41.76	17.80	23.95	42.70
1983	135.72	71.37	30.25	41.12	64.35	86.43	40.67	17.20	23.48	45.75
1984	142.68	72.85	31.05	41.80	69.83	88.47	39.81	16.86	22.95	48.66
1985	147.25	73.83	31.70	42.14	73.41	89.05	39.07	16.60	22.47	49.97
1986	151.04	74.05	31.96	42.08	77.00	89.49	38.24	16.26	21.99	51.24
1987	157.59	75.59	32.56	43.03	82.00	91.38	38.15	16.07	22.08	53.23
1988	165.04	77.73	33.26	44.48	87.30	93.86	38.65	15.97	22.68	55.21
1989	170.82	79.69	33.83	45.86	91.13	95.67	39.54	16.07	23.47	56.13
1990	176.91	82.83	34.28	48.55	94.07	98.19	41.75	16.25	25.49	56.44
1991	183.50	87.02	34.84	52.18	96.48	101.58	45.17	16.71	28.46	56.40
	Billions of constant (1987) dollars									
1980	124.67	71.13	29.55	41.57	53.54	85.79	45.64	19.22	26.42	40.16
1981	132.26	73.56	30.91	42.66	58.70	88.84	45.54	19.38	26.15	43.31
1982	138.61	74.96	31.59	43.36	63.66	90.92	44.71	18.95	25.76	46.22
1983	142.56	74.97	31.67	43.30	67.58	90.85	42.79	18.03	24.76	48.06
1984	146.66	74.94	31.86	43.08	71.72	90.98	41.00	17.32	23.68	49.98
1985	149.58	74.81	32.07	42.74	74.77	90.52	39.62	16.81	22.81	50.91
1986	152.08	74.53	32.16	42.37	77.55	90.12	38.50	16.36	22.14	51.61
1987	154.47	74.36	32.04	42.32	80.11	89.52	37.53	15.81	21.71	52.00
1988	155.86	73.93	31.62	42.31	81.93	88.55	36.76	15.19	21.57	51.80
1989	157.52	74.05	31.42	42.63	83.48	88.16	36.75	14.93	21.82	51.40
1990	161.03	75.76	31.31	44.45	85.27	89.36	38.20	14.86	23.35	51.15
1991	164.97	78.36	31.37	47.00	86.60	91.31	40.69	15.05	25.64	50.63

1. For air PA, the Clean Air Act classifies the sources of pollutants as mobile (for example, automobiles) or stationary (for example, factories). For water PA, the Federal Water Pollution Control Act classifies sources of pollutants as point (for example, factories) or nonpoint (for example, highway construction projects).

2. The stock estimates in table A are part of a new establishment-based series for 1960 forward. BEA is planning a SURVEY OF CURRENT BUSINESS article for later this year to present such PA P&E stock estimates for selected industries and to present their related capital flows through 1992. The new stock series replaces a series prepared on a company (or enterprise) basis.

3. Stocks other than for PA P&E also protect air and water. Examples include stocks of PA devices and systems on mobile (for example, motor vehicles) and nonindustrial pollutant sources (for example, public sewer systems and septic systems), as well as PA features of solid waste management systems. Estimates for these kinds of stocks are not available.

For proved subsoil assets, the estimates shown are the highs and lows of ranges presented, along with a description of the sources and methods used to prepare them, in the companion article beginning on page 50. The estimates represent the range of differences associated with common methods for valuing nonrenewable natural resources.

The estimates within the category "developed land" are of uneven quality. The estimates of the value of agricultural land are relatively good and are based on USDA estimates of farm real estate values less BEA estimates of the value of farm structures. Soil estimates, from the USDA, reflect the annual effect of soil depletion in terms of extra fertilizer costs and reduced productivity. The estimates of residential land, included in table 1 as part of land underlying structures, also are of reasonable quality. The estimates of the other private land underlying structures are of more uncertain quality. The Federal Reserve Board produces these estimates of land values by taking estimates of real estate values from a variety of sources and subtracting BEA's estimates of the value of nonresidential structures. The Federal Reserve's estimates of real estate values are based, in part, on less than comprehensive price indexes; they do not, for example, appear to cover adequately the value of mineral tracts, timberland, or industrial buildings and land. BEA's estimates of nonresidential structures are based on perpetual inventory methods—with assumed depreciation schedules and replacement-cost indexes—and may therefore differ from the current market value of the structures included in the real estate estimates. Although over longer periods of time the perpetual inventory estimates are of good quality, during periods of declining or rapidly increasing real estate values, they may produce unreasonable results. Also, to the extent that the value of natural resource assets are not included in the real estate price indexes, the overall value of developed land will be over- or under-stated according to the path of natural resource prices relative to commercial and other land values.

The SEEA recommends that national parks be classified as uncultivated land because their protection, and not their use, is the main function of governmental regulation. However, because these parks are extensively maintained, improved upon, and used by consumers for recreation, they are included in recreational land in table 1. The estimate of capital formation in recreational land is based on Federal Government maintenance and repair expenditures for parks; State and local expenditures are not available. It is assumed that these expenditures exactly offset the degradation/depletion of recreational land; in the case of recreational land, the only estimates available were of maintenance and repair expenditures. This assumption is made only so that both investment and degradation/depletion estimates are illustrated by the table and not to imply any judgment about the true value of degradation/depletion. (Phase II and III of BEA's work plan, described in the next section, includes work to build on the damage assessment and recreational valuation literature to construct estimates of the market value of recreational and environmental amenities.)

For environmental assets, the estimates are more uncertain than even the most uncertain estimates for developed land and proved reserves of subsoil assets. Indeed, most of this section of the table, especially that for renewable natural resources, is shown with "n.a." for "not available." No value is available for the stock of undeveloped land and its associated ecosystems, for unproved subsoil assets, and for uncultivated biological resources (wild animals and fish, plants, and forests).

Compared with the accounting for proved reserves of nonrenewable resources, where the economic literature extends back over 50 years, valuation methods and concepts for many of the renewable resources are less well developed. Renewable natural resources are inherently more difficult to value than nonrenewable natural resources for several reasons: Renewable resources, such as stocks or schools of wild fish, often have a commercial or production value as well as an amenity or a recreational value; often, ownership rights cannot be established, and they cannot be sold; and they *are* able to regenerate, so their use does not necessarily result in a net reduction in either their yield or the value of their stock.

These difficulties notwithstanding, there has been rapid progress in environmental-benefit valuation for renewable natural resources in recent years as economists have tried to keep pace with regulatory, legal, and policy needs for environmental damage and impact measures. Further work by BEA to translate these new concepts and measures into a consistent national framework would need to rely heavily on the expertise of other units within the U.S. Government—for example, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, USDA, and the Department of Interior.

The SEEA does not recommend that the stock of air—which is truly a global common—or water be valued; instead, it recommends that valuation be limited to changes in these assets—their degradation and investments in their restoration. For these assets, table 1 includes only aggregate values for the degradation of air and water and for expenditures to restore them or to prevent their degradation.

The estimates in table 1 for degradation of air and water quality—as well as for undeveloped land—are simply place markers that assume that maintenance exactly offsets degradation: They are aggregate estimates of the total costs of pollution of these media. The estimates for air, water, and undeveloped land pollution are estimates, from the Environmental Protection Agency, of the direct costs of public and private pollution control activities in the United States. Estimates of air pollution include the annualized costs of air pollution and radiation. Water pollution estimates are the annualized costs of maintaining water quality, including drinking water. Estimates of undeveloped land pollution are the annualized costs associated with Superfund, toxic chemicals, and pesticides. The estimates of costs to restore or prevent the degradation of the environment (which, as noted earlier, are treated as capital formation in that they offset degradation and depletion of air, water, and undeveloped land) are based on current PAC expenditures and the flow of services from the stock of PA equipment and structures (the estimated return on the net stock plus depreciation). (Note that these direct PAC costs differ from the environment cleanup and waste disposal service costs discussed later in the article. These costs are indirect costs imposed by pollution in the form of health costs, higher maintenance and repair expenditures, or longer trips to reach clean recreational sites.)

Production accounts

The next step in integrating economic and environmental accounting is to combine the appropriate flows from the asset account with the flows in a production account. With this integration, the production account explicitly includes the use of natural resources and environmental services in production through entries for depletion and degradation, and it explicitly includes the additions to the stock of natural and environmental assets through entries for investments that add to stocks of developed natural resources or that restore stocks of environmental assets.

Table 2 combines features of the supply and use tables in the *SNA 1993*. The table has four quadrants (one empty, except for a total), which are separated by double lines; a total column at the far right; and a total row at the bottom. The left and right upper quadrants show the use of goods and services (commodities) named at the beginning of the rows, summing to total uses as measured by total commodity output. The left-hand upper and lower quadrants show the use of intermediate inputs and factors of production by the industries named at the top of each column, summing to total supply as measured by total output.

A more typical supply and use table would show substantial industry and commodity detail—often a hundred of more industries and commodities. For the purposes at hand, this detail has been collapsed into an "other industries" column (column 3) and "Other" rows (rows 6 and 13). Detail is provided where it is especially relevant to the analysis of the environment. Such a table provides a bird's-eye view of production, income, and consumption, as highlighted in the paragraphs that follow.

Columns 1–4 in the upper left quadrant record the use of commodities by domestic industries in the *production* of other commodities—that is, intermediate use. Columns 5–9 record the use of commodities across the final demand categories that make up gross domestic product, including final *consumption* by households and government. Column 7 records the estimates in the "capital formation" column from table 1. (The made assets are recorded in rows 1–13, the developed natural and environmental assets in rows 14–24.)

In the left quadrants, rows 11–13 show the use of other commodities (that is, other than assets) as intermediate inputs. These commodities consist of expenditures for environmental cleanup and waste disposal services (row 12) and "other" (row 13). Total intermediate inputs used by industries are in row 25. Rows 26–41 record value added, or *income*. Rows 26–28 record the value added in the form of compensation of employees, indirect business taxes, and corporate profits and other property income. Rows 29–32 record, from table 1, the use of made fixed assets, including the depreciation of structures and equipment used in environmental management (row 30) and in PAC (row 31). Rows 33–41 record the use of fixed natural and environmental assets, with depletion and degradation of each of the eight categories of assets shown separately.

The estimates presented in table 2 are taken from table 1. As is indicated by the "n.a."—not available—in the table, many valuation and measurement issues remain before an IEESA production account can be completed. Further, work toward filling in the estimates would proceed in tandem with work on modernizing BEA's national accounts in line with the SNA (see the next section). For example, treating expenditures on government structures, equipment, and inventories as capital formation implements a feature of the SNA. In the table, a "Z" indicates the estimates that would reflect both work toward the IEESA's and SNA-related changes.

In addition to a production account such as table 2, the SEEA calls for parallel quantity tables. Further, because many environmental issues have their primary impact on specific regions or industries, the extension of the integrated national accounts aggregates within BEA's regional

Table 2.—IEESA Production Account, 1987

[Billions of dollars]

	Row	Industries				Final uses (GDP)						Total commodity output (4+10)
		Agriculture, forestry, and fisheries	Mining, utilities, water, and sanitary services	Other industries	Total	Final consumption		Gross domestic capital formation	Exports	Imports	GDP (5+6+7+8–9)	
						Household	Government					
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
COMMODITIES												
Made	**1**	...	...	...	...	...	...	**905.8**	...	...	**(#)**	**(#)**
Assets	2	...	...	...	...	...	...	905.8	...	...	(#)	(#)
Fixed assets	3	...	...	...	...	...	...	875.8	...	...	(#)	(#)
Environmental management	4	...	...	...	...	...	...	10.6	...	...	(#)	(#)
Pollution abatement and control	5	...	...	...	...	...	...	19.7	...	...	(#)	(#)
Other	6	...	...	...	...	...	...	845.5	...	...	(#)	(#)
Inventories	7	...	...	...	...	...	...	30.1	...	...	(#)	(#)
Government	8	...	...	...	...	...	...	2.9	...	...	(#)	(#)
Nonfarm	9	...	...	...	...	...	...	32.7	...	...	(#)	(#)
Farm	10	...	...	...	...	...	...	–5.5	...	...	(#)	(#)
Other	11	(#)	(#)	(#)	(#)	(#)	(#)	...	(#)	(#)	(#)	(#)
Environmental cleanup and waste disposal services	12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	...	n.a.	n.a.	(#)	(#)
Other	13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	...	n.a.	n.a.	(#)	(#)
Natural and environmental assets	**14**	...	...	...	...	...	...	**n.a.**	...	...	**(#)**	**(#)**
Fixed	15	...	...	...	...	...	...	n.a.	...	...	(#)	(#)
Cultivated biological resources: Natural growth	16	...	...	...	...	...	...	n.a.	...	...	(#)	(#)
Proved subsoil assets	17	...	...	...	...	...	...	16.6 ↔ 64.6	...	...	(#)	(#)
Developed land	18	...	...	...	...	...	...	n.a.	...	...	(#)	(#)
Uncultivated biological resources: Natural growth	19	...	...	...	...	...	...	n.a.	...	...	(#)	(#)
Unproved subsoil assets	20	...	...	...	...	...	...	n.a.	...	...	(#)	(#)
Undeveloped land	21	...	...	...	...	...	...	19.9	...	...	(#)	(#)
Water	22	...	...	...	...	...	...	38.7	...	...	(#)	(#)
Air	23	...	...	...	...	...	...	27.1	...	...	(#)	(#)
Work-in-progress inventories (natural growth products)	24	...	...	...	...	...	...	n.a.	...	...	(#)	(#)
Total intermediate inputs	**25**	**(#)**	**(#)**	**(#)**	**(#)**	...	...	...	...	...	...	...
VALUE ADDED												
Compensation of employees	26	(#)	(#)	(#)	(#)	...	...	...	...	...	...	(#)
Indirect business taxes, etc	27	(#)	(#)	(#)	(#)	...	...	...	...	...	...	(#)
Corporate profits and other property income	28	(#)	(#)	(#)	(#)	...	...	...	...	...	...	(#)
Depreciation of fixed made assets: Structures and equipment	**29**	**n.a.**	**n.a.**	**n.a.**	**–607.9**	...	...	...	...	...	...	**(#)**
Environmental management	30	n.a.	n.a.	n.a.	–7.0	...	...	...	...	...	...	(#)
Pollution abatement and control	31	n.a.	n.a.	n.a.	–12.2	...	...	...	...	...	...	(#)
Other	32	n.a.	n.a.	n.a.	–588.7	...	...	...	...	...	...	(#)
Depletion and degradation of fixed natural and environmental assets	**33**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	...	...	...	...	...	...	**(#)**
Growth products: Fixed	34	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	...	(#)
Proved subsoil assets	35	n.a.	n.a.	n.a.	–16.7 ↔ –61.6	...	...	...	...	...	...	(#)
Developed land	36	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	...	(#)
Uncultivated biological resources	37	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	...	(#)
Unproved subsoil assets	38	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	...	(#)
Undeveloped land	39	n.a.	n.a.	n.a.	–19.9	...	...	...	...	...	...	(#)
Water	40	n.a.	n.a.	n.a.	–38.7	...	...	...	...	...	...	(#)
Air	41	n.a.	n.a.	n.a.	–27.1	...	...	...	...	...	...	(#)
Gross value added (GDP) (rows 26+27+28+29+33)	42	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	(#)	(#)
Depreciation, depletion, and degradation (rows 29+33)	43	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	...	(#)
Net value added (NDP) (rows 42–43)	44	n.a.	n.a.	n.a.	n.a.	...	...	...	...	...	...	(#)
TOTAL INDUSTRY OUTPUT	**45**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**	**(#)**

n.a. Not available.

These estimates will depend on the integration of the System of National Accounts and the System of Environmental and Economic Accounting as part of the overall modernization of BEA's economic accounts.

NOTE.—Leaders indicate that an entry is not applicable.

GDP Gross domestic product

NDP Net domestic product

and input-output programs is an important extension.

Uses of the new accounts

Integrated economic and environmental accounts are the subject of intense interest, and expectations may differ from actual results. Among some observers, especially those extrapolating from studies conducted in resource-dependent developing economies, there is an expectation that such accounts will show that U.S. economic growth as currently measured is not sustainable, because the stocks of natural and environmental resources that ultimately determine economic growth are being run down. This expectation may well stem from focusing on depletion and degradation to the exclusion of additions.

The IEESA's will help to identify the use of the various natural and environmental resources. A priori, however, it is difficult to say whether there will be a net reduction or increase in their value overall. For example, while it is almost certainly true that the economic value of the stocks of some assets, such as bluefin tuna, are declining, the stocks of other environmental assets, such as timber stocks, have been increasing as planting and growth have more than offset harvests, fire, and land conversions. Similarly, while losses of wetlands from development continue to outnumber gains from wetland restorations, increasing rates of investments in cleaner air and water since the mid-1970's appear to have resulted in net improvements in air and water quality; many of the measures of air and water quality, such as the ambient concentrations of air and water pollutants, have shown improvement.

Because of these offsetting changes, it is conceivable that when all entries in table 2—or if not all, at least enough more than at present to avoid risks of conclusions based on partial results—have been filled in, the table will show that IEESA NDP differs little from traditional NDP.[7] Nevertheless, the information about specific natural resources and specific industries, products, or regions will provide valuable insight about sustainability and the implications of different regulations, taxes, and consumption patterns. In the United States, such information should prove useful in a wide range of policy issues.

Economic accounts do not provide normative data. They either report market values or proxies for market values. If a problem with property rights leads to the undervaluation and overexploitation of a resource, a set of integrated economic accounts will not reveal the "right" price or the "correct" level of stocks. They will, however, provide the data—for example, about changes in the value of the stocks and the share of income to be attributed to the resource—needed for objective analysis of the problem.

BEA's Plan for Natural Resource and Environmental Accounting

BEA's plan calls for work on the IEESA's to be undertaken in conjunction with modernizing its economic accounts. BEA's national accounts are now undergoing the first major redesign since the 1950's. The redesign, which will be along the lines of the *SNA 1993*, will feature an integrated set of current and capital accounts, sector by sector. Fully developed capital accounts, along with balance sheets, are essential for a comprehensive set of economic accounts. The conceptual work on these accounts and the more specialized work on natural resources and the environment will be mutually supporting. Further, to make reasoned policy choices involving trade-offs among kinds of capital, one would want a view of the total capital stock—natural and made—consistently covered and appropriately valued.

BEA has developed a three-phase plan for the IEESA's. With this issue of the SURVEY, BEA has completed the first phase of work.

Phase I: Overall framework and prototype estimates.—The overall IEESA framework is designed to build upon the existing national accounts and is in line with the guidance embodied in the new international SNA about a satellite system and the companion SEEA.

In its initial work, BEA has focused on mineral resources, consisting of oil and gas, coal, metals, and other minerals with a scarcity value. As described in the companion article, the focus, in accordance with SNA recommendations, is on proved reserves, the basis for valuation is market values, and the treatment given mineral resources—which require expenditures to prove and which provide "services" over a long

7. There are also conceptual limitations to using NDP as the indicator of sustainable growth. NDP shows only the level of product, which cannot reflect much information about sustainability. The rate of change of NDP over time is more useful, but even this is not a clear indicator, because changes in NDP reflect changes in the rates of consumption, government expenditure, and net exports as well as net capital formation.

A measure that may be more useful as an indicator of sustainable growth is the net savings rate, which is affected only by changes in the rate of investment in, and the consumption of, fixed capital. If the savings rate—adjusted to reflect additions to, and subtractions from, natural as well as produced assets—is positive, then growth can be considered sustainable. (Because this assumes a high degree of substitutability between produced and natural assets, some refer to this concept as "weak sustainability.")

timespan—is similar to the treatment of fixed capital in the existing accounts.

The prototype estimates include stocks and flows in accounts that supplement BEA's national wealth accounts and NIPA's. These prototype estimates provide a comprehensive picture of the stocks of natural assets and the changes in them. They also allow an examination of the practical consequences of several alternative methods of valuing the stock of resources, additions, and depletion. The alternative methods represent the Bureau's technical assessment of the best estimates and framework that are feasible with existing sources and methods.

Phase II: Renewable natural resources.—The plan calls for work to extend the accounts to renewable natural resource assets, such as trees on timberland, fish stocks, and water resources. Development of these estimates will be more difficult than for mineral resources because they must be based on less refined concepts and less data.

Phase III: Environmental assets.—Building on this work, the plan calls for moving on to issues associated with a broader range of environmental assets, including the economic value of the degradation of clean air and water or the value of recreational assets such as lakes and national forests. Clearly, significant advances will be required in the underlying environmental and economic data, as well as in concepts and methods, and cooperative effort with the scientific, statistical, and economic communities will be needed to produce such estimates.