Natural Resource Accounting (II): Toward the Development of a Regional Model

William S. Prudham and Steve Lonergan
Centre for Sustainable Regional Development
University of Victoria
Victoria, BC V8W 2Y2

In a separate paper in this issue, we have discussed natural resource accounting methodology. Resource accounting systems fit into the growing literature on environmental information systems, the distinguishing feature of resource accounting systems being that they are designed with the adjustment of macro-economic income and wealth tables in mind. These adjustments reflect changes in the status of environmental resources. Adjusting the economic aggregates and providing environmental statistics can both be achieved in the use of a single system, but not by accident; both objectives must be explicit in the design process.

One way to expand the scope of resource accounting is through the design of regional systems. Though difficult to define, one may think of a region as being an area linked by a set of common attributes, such that the area in question forms a relatively homogeneous spatial unit. While resource accounting systems designed strictly to augment economic accounts may best be applied at the national level, this is not the case if resource accounting systems are to act as environmental information systems, since sensible national scale spatial units do not exist for most environmental variables. Environmental monitoring systems must contain some explicit recognition of spatial heterogeneity in ecosystems. In addition, sustainable development clearly has a spatial component in that: 1. equity considerations require that some measure of socio-economic distributions over space be considered and 2. local initiatives and empowerment are crucial elements of a more environmentally benign economic development strategy.
Regional Analysis

There has been little consideration in the literature given to resource accounting at the regional, that is, sub-provincial or sub-territorial level. This is probably due to the fact that most research in this area has focused on supplementing the System of National Accounts (SNA) and/or other existing macro-level statistical databases (see Friend 1986). Gilbert and Hafkamp (1986) do mention the possibility for regional applications of resource accounting as part of their multi-objective approach. Nijkamp et al. (1991) outline some considerations for the analysis of resource use and sustainability at the regional level and recognize the critical role that resource accounting could play in facilitating this analysis. The draft System for Integrated Economic and Environmental Accounting [SEEA (UNSO 1990: 43-45)] includes reference to the regionalization of certain tables as a future objective, thereby acknowledging that spatial aspects of socio-economic and environmental relationships are critical to comprehensive, integrated environmental accounting. The most advanced effort to develop accounts along spatial themes has emerged from the French system which contains provisions for the compilation of territorial accounts and ecosystem accounts (Weber 1983). The lack of empirical work makes evaluation of the success - or failure - of these provisions difficult.

Specific impediments to a regional accounting system take one of two forms. The first of these includes the problem of spatial delineation. Geographers, in particular, are familiar with the modifiable areal unit problem and the associated concept of ecological fallacy. The modifiable areal unit problem refers to two related phenomena, namely the scale and zoning problems. The scale problem is witnessed in the statistical analysis of the same data at different spatial scales, with different results associated with different resolutions. The zoning problem occurs when different results arise from the same data set assessed at the same scale, but organized in different spatial configurations. It is well known that the absolute magnitude of aggregate correlation results will tend to exceed those measured at a more disaggregate scale. But the influence of scale on spatial process is not well understood. Further, the division of space into discrete units is a critical factor in determining group level spatial distributions. In the absence of processes for eliminating the inherent ambiguity of these problems, it is important to select agglomerations in a coherent spatial context, that is, one that makes some intuitive sense given a knowledge of relevant spatial processes. Ultimately, this entails ranking the spatial processes in order of their perceived importance. It is fundamental that the modifiable areal unit issue is explicitly acknowledged within the accounting system and that analysis on system data that involves aggregation is not performed in a naive and superficial fashion.

The second impediment to regional accounting involves pre-existing divergence between independent databases. Biophysical databases, recognizing different spatial processes, tend to be organized using different areal divisions than do socio-economic databases. For example, the biogeoclimatic zones of British Columbia (BC Ministry of Forests 1988) show little correspondence with the political districts along which socio-economic data are commonly gathered. Selection of regions by socio-political or biophysical criteria, and the integration of the system with other databases organized in different spatial configurations, must be considered. Manning (1988) favours a biophysical orientation in regional sustainability analysis because this conforms with existing landscape features and is more congruent with the natural system, the management of which is a key goal of any sustainability framework. The disadvantage of choosing either orientation over the other is that hybridization of databases with different spatial divisions is difficult and imprecise. A partial solution to this dilemma may lie in the development of a geocoding component to resource accounting which would allow different spatial allocations to fit the needs of data users. At the macro-level, the United Nations Environment Program (UNEP) has initiated a geocoding program for its global resources database (Mooneyhan 1988). Geocoding is no panacea, however. Not only do the modifiable areal unit and aggregation problems still exist, but digitizing is time consuming and expensive. In addition, interpolation techniques used to combine databases and increase resolution introduce new sources of error.

Despite the paucity of literature on the design and implementation of regional resource accounting structures, one might expect that some of the generic principles of more macro-level accounting apply. Specifically, regional systems should cater to recognized, immediate user needs. This should be reflected in both the scope of the system as a whole and in the integration of system constituents. As well, specific provisions need to be built into the design of the framework to facilitate the achievement of meaningful results from incremental implementation. Wherever possible, existing databases should be utilized to make efficient use of available finances and time.

We identify three main considerations in formulating a regional system design. These include:

1. the orientation of the system;
2. design efficacy; and
3. the choice of metrics in individual accounts.

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1. Ecological fallacy occurs when data are available only at the group level, but the subject of interest is at the individual level. Because of the scale problem, aggregate data are not used for assessing these individual relationships.

2. The use of existing databases has been identified as a vital design criterion by Hamilton (1991) and by the IREE (1990).
A variety of choices vis-à-vis orientation are available for structuring a regional accounting system. At one extreme, accounting frameworks can be limited to market resources; at the opposite extreme is a more ecological approach to the accounts. The choice is a function of how human interaction with the environment is perceived. This relationship has been described as a system of inputs and outputs, with resources forming inputs to human welfare and economic production, and with residuals forming outputs to the environment from the productive sectors of the economy (Bartelmus 1990; Pearce and Turner, 1990). This can be further differentiated to identify separately the provision of tangible, market resources to economic production and the provision of non-market, often intangible environmental services. A central purpose of the resource accounting framework is to supply information on the flows of environmental services, and the depletion and degradation of the environment which can result.

The critical issue is where economics ends and ecology begins, if such a barrier exists. Odum (1989: 271) has written that "...when the study of the household (ecology) and the management of the household (economics) can be merged, and when ethics can be extended to include environmental as well as human values, then we can be optimistic about the future of humankind." Friend (1990) has expanded upon this overlap in the literal interpretations of the terms "ecology" and "economics". Any resource accounting system is inevitably directed at this interface, the perception of which influences the system design. Our model is comparatively broad in its ecological scope. This stems from our belief that resource accounting frameworks can act as environmental information systems and that exclusive coverage of market resources does not adequately describe the intricate, coupled economic-ecological relationship. Further, one of the main reasons for undertaking a regional design is to facilitate better environmental monitoring, as outlined above.

Balancing the need for broad coverage of ecological functions, however, is the equally important need for an efficacious model, useful from a planning and policy standpoint. Two aspects of the model are critical in this regard: 1. the provision of a sufficiently small number of indicators or aggregates for digestion by policy-makers; and 2. the design of the model such that implementation and derivation of information could take place by increments. The first of these concerns is addressed through the compilation of central accounts consisting of aggregate measures of change in resource stocks and/or quality over the accounting interval, as well as aggregate resource flow totals, all measured in physical units. Further aggregation is possible through the synthesis of monetary data from valuation accounts into grouped monetary indices of depletion and degradation. The second concern is addressed implicitly in the

design in that account users can determine on a subjective basis which resources will be the subject of initial account compilation. Since individual resource records and accounts are largely distinct, information can be compiled account-by-account, resource-by-resource, or record-by-record.

The third major consideration in the design of the model is the choice of a suitable mix of metrics. Choices range from entirely physical units, as in the Norwegian accounts, to the predominantly monetary accounts espoused by Repetto et al. (1989) and Peskin (1989a and 1989b). Despite the concentration on monetary accounting, physical accounts are the backbone of any resource accounting system. This is because compilation of the accounts requires that physical data be initially collected and because physical accounts are a basis upon which alternative analyses can be performed (Bartelmus 1990; Hamilton 1991).

There have been efforts to develop alternative homogeneous units of measure for use in the place of monetary units, entropy being a prominent example (Daly 1977; Odum 1983; Amir 1989; Judson 1989). However, the use of embodied energy or entropy increase through economic production as a measure of value does not exhaust all sources of value. As Georgescu-Roegen (1971) and Judson (1989) have pointed out, Einstein's theory establishing the relationship between mass and energy is of questionable relevance in the analysis of low temperature processes such as those that predominate in biotic systems. Also, it is difficult to envisage an entropy theory of value that would be sensitive to the value that humans place on natural aesthetics, especially in a comparative, qualitative sense. In our model, we have elected to utilize a variety of valuation techniques for the sake of pluralism, but we employ only dollars as units in valuation.

Specific aspects of the accounting system are described in the following sections. These include a set of resource records, compiled by components (biotic and abiotic), as well as by ecosystem. Each of these records consists of a central account (the core of the record), optional user and valuation accounts, and a provision for component linkage analysis. In addition, the framework includes an aggregate monetary account of region-wide depletion and degradation indicators, as well as an aggregate input-output table showing the flows of ecological components to sectors of the regional economy and the flows of economic residuals from the economy to the environment. The overall spatial resolution of the model is intended to be flexible, with regional delineation potentially following existing socio-political boundaries. However, the use of watersheds to form regions is forwarded as a possible alternative. Several advantages exist in the use of watersheds. First, there is an extensive literature on the use of watersheds as planning units (Pereira 1973; Tate, 1981). Second, watersheds are spatially consistent aggregations, allowing analytical flexibility. And third, the watershed provides a common biophysical thread over a defined and relatively static geographical area, in the form of a common catchment area.

3. Weber (1983) mentions the critical nature of this consideration in the design of the French system.
Although emphasis in the design process was placed upon the application of the framework in regions of Vancouver Island, on the west coast of Canada (Figure 1), the basic structures could conceivably form the core for other regional systems. The Provincial Blueline System (BC Ministry of the Environment and Parks 1988) is one possible framework for watershed identification and classification.

**System Design**

The core of the regional resource accounting system is composed of resource records, each of which contains resource accounts. Resource records are the set of all resource accounts compiled for a given facet of the natural patrimony. In each resource record there are three resource accounts (see Figure 2)

![Figure 2 Resource Records](image)

*Note: Each resource record is devoted to a single resource. Thus, records 'A' through 'E' above represent five distinct records compiled for five resources. The image is meant to denote a database linkage in which resource records are ordered and linked. Each individual record has potentially three types of accounts, namely central, user and evaluation accounts, along with an additional provision for component linkage analysis.*

and an analysis of component linkage. Central accounts are the principle resource account of each record and are comprised of measures of the changes in resource stocks and/or health over the accounting period. User accounts describe the destination resource flows as well as any identified stock functions of the resource in contributing to human welfare (for example, forest functions – see de Groot (1986) regarding functional ecosystem evaluation). Valuation accounts employ various methods to assign monetary values to resource functions. A final facet of each record involves component linkage analysis, where connections between distinct resource records, that is, separate facets of the patrimony, are explored. While central accounts form the core of all resource records, the other accounts are largely independent of each other and may be completed on a priority basis as a function of user need.

Resource records are organised according to two major divisions (see Figure 3): components and ecosystems. Component accounts are compiled for individual resources, or single component species or substances. Components are further divided by abiotic resources and biotic resources, the biotic subdivision including all those living organisms which can be classified as
Abiotic components are the non-living resources and are split into two classes, environmental resources (for example, air and water) and non-renewable resources (for example, natural gas and mineral deposits).

In addition to the resource records, there are two accounts which draw input from region-wide multiple resource information. The first of these is an input-output table describing the flows between sectors of the economy and the environment. This table draws information from the user accounts in the individual resource records. The second multiple-resource account is the aggregation table, which summarises information from the various valuation accounts to produce aggregate indices of the monetary value of depletion and degradation for the region.

Individual facets of the regional system are described in detail in the subsequent sections. The overall structure of the system with system linkages and information flows is shown in Figure 4.

Central Accounts

The central accounts form the core of each resource record, containing physical measures of opening and closing stocks and/or health, together with identification of various flows. Although the French patrimonial system also contains central accounts, the central accounts of the regional model developed here actually correspond more closely with the French equilibrium accounts. These are the accounts which contain core physical information on the stocks and flows of resources (Weber 1983), and are the crucial base upon which other accounts may be constructed.

The generic structure of the central resource accounts is quite simple and is similar to raw physical accounts in other systems. The resource is first divided into sub-classes by row. For example, in a central account for a species of wildlife, subclasses might be broken down by age, gender or other demographic divisions, as well as by economic status; that is, economic versus non-economic. Any attempt at geocoding in the implementation of the regional framework would likely take place at this point, dividing the resource classes further by some locational classification system. The last row contains column entries which are the sums of the rows above. Reading across the columns, there are entries for opening stocks, recruitment (additions to stocks through revised estimates of size or imports), other additions, harvesting, other losses and closing stocks. The identity in each row is that the sum of the entries in the first three columns less the sum of the last two entries is equal to the closing stock.

Environmental resource central accounts will also focus on health indices, and thus the generic categories of the central account described above are inadequate. In their stead, it would be logical to set up accounts along the lines of a state of environment report database for resource quality. Thus, for air quality in the region, information could be compiled by testing location, with data organized on the basis of various quality indices. Particular indices could include nitrogen dioxide, carbon monoxide, sulphur dioxide, suspended particulates, lead particulates and ozone, as these are the six most commonly tar-

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4. This paper purposefully avoids the debate as to differentiation between resources and non-resources. From an ecological perspective, the division is somewhat artificial, a fact that emphasises the importance of considering ecosystems. For the purposes of resource management, Zimmerman (1951) has asserted that the definition of resources is entirely a subjective process, stemming from cultural desires and preferences. Weber (1983) offers an appealing definition of natural patrimony; resources as used in this paper largely coincide with this concept.
targeted air pollutants. Data recorded could track average ambient quality or, more probably, total days during the accounting period in which ambient quality fell into pre-determined classes of resource quality.

Central accounts for ecosystems also bear special mention. This is because of the need to reflect ecosystem health along with extent. Further, some system of classification is necessary.

The means by which ecosystem health can be assessed is of some debate. Holling (1986) outlines the concepts of resilience - the flexibility of ecosystems in their ability to absorb disturbance while maintaining distinctive functional and structural attributes - and stability - the tendency of ecosystems to maintain low amplitude fluctuations. Holling maintains that understanding the importance of these principles is critical to unravelling the mysteries of ecosystem organization and function, especially in the face of anthropogenic disturbances. The difficulty in translating this approach into prescriptions for ecosystem accounting structures stems from the potentially chaotic behaviour of dynamic natural systems (Holling 1986; Gleick 1987).

Alternatively, Friend and Rapport (1991) have examined the nature of ecosystem process according to an analysis of ecosystems as complex systems by Steedman and Regier (1987). Steedman and Regier assert that ecosystems are analogous to other complex systems in that they exhibit four processes: increasing integration, increasing specialization, increasing mechanization and increasing centralization. According to Friend and Rapport (1991), there are four main approaches to indicators of ecosystem status which are sensitive to these processes. The first of these is the indicator organism approach, stemming from the theory that certain organisms, usually those in the upper echelons of the food web, exhibit broad but refined sensitivity to environmental change. Secondly, there is the biotic size spectra approach which dictates that pathologic ecosystems will exhibit a tendency toward growth in population size for small organisms mirrored by a decline in large organism biomass. The third approach is termed the ecosystem distress syndrome (EDS) and draws influence from the notion that ecosystems of a similar nature can be compared and inference regarding the symptoms of stress can be drawn based on the characteristics of stressed versus undisturbed ecosystems. The fourth system mentioned by Friend and Rapport is the indices of biotic integrity approach, comprised of a series of indicators which combine to yield an aggregate. Of these four systems, the indicator organism approach rates highest in the discussion by Friend and Rapport.

5. These are the six pollutants which form the main targets of the US Clean Air Act (US Government 1989) and are identified as key indicators of air quality by Bird and Rapport (1986).

6. "Ecosystem" has been defined as "...a unit or portion of the landscape and the life on it and in it. It is a landscape segment relatively uniform in the composition, structure and properties of both the biotic and abiotic environments, and in their interactions" (Meidinger and Pojar 1991: 11).
It is beyond the scope of this paper to differentiate between these systems for indicating ecosystem status, nor is it possible to propose alternative strategies. However, the compilation of ecosystem accounts, beginning with the central accounts, must be a priority for the development of ecologically sensitive natural resource accounting structures. Further work toward the development of some system for reflecting the status of ecosystems in an accounting format is pre-requisite to the full implementation of the regional model.

The completion of ecosystem accounts for the regional model also requires that a classification system be used for ecosystem identification and for the description of ecosystem extent. Although several possible systems exist - including the Ecological Land Survey Method (Wickware and Rubec 1989a, b) and the Canadian Vegetation Classification System (Strong et al. 1990) - two systems are of special interest. These are the Biophysical Habitat classification system, developed by the British Columbia Ministry of the Environment (Demarchi and Lea 1989), and the Biogeoclimatic Ecosystem Classification (BEC) system used by the BC Ministry of Forests (Meidinger and Pojar 1991). Both of these systems have been applied to BC. The two systems actually share certain attributes, including their common use of the biogeoclimatic subzone as a fundamental spatial unit. Also, there has been some effort to integrate the two for the purposes of resource analysis and management in BC (Demarchi and Lea 1989). However, at present, the BEC is better suited to the purposes of the regional model's ecosystem accounts.

The limitations of the Biophysical Habitat classification for exclusive use in the ecosystem accounts stems largely from its orientation toward wildlife management. Specifically, Demarchi and Lea (1989: 275) list two objectives of the system:

1. to provide a framework to assess the suitability and capability of the land surface for supporting wild animals; and
2. to provide a framework for improving animal habitat.

A hierarchical division of the province first establishes broad ecological divisions based upon climatic, physiographic and biotic features, producing ecodomains (four in BC), ecodivisions (seven in BC), ecoprovinces (eleven in BC), and ecoregions (33 in BC) (Demarchi 1988; Demarchi and Lea 1989; Demarchi 1990; Meidinger and Pojar 1991). Further delineation takes place according to biogeoclimatic variation and biophysical habitat units (Demarchi and Lea 1989). The result is an ecologically hierarchical classification of the province within a global biogeoclimatic framework intended to achieve the objectives listed above.

The BEC system involves a more strict adherence to biogeoclimatic and ecosystem variation than the Biophysical Habitat framework. Classification is based upon the combination of climate and physiographic features which result in specific combinations of ecosystems (Pajar et al. 1987; Meidinger and Pajar 1991). The result is a system that allows for zonal variation as a function of topography in contrast to the Ministry of the Environment (MOE) system, which restricts elevational variation of ecoregions and emphasises wildlife habitat (Pajar et al. 1987; Meidinger and Pajar 1991; Demarchi 1991).

The objectives of the BEC are identified in Meidinger and Pajar (1991: 10) as follows:

1. to characterize, describe and map the broad biogeoclimatic units of British Columbia;  
2. to characterize and describe the major forest and range sites within each biogeoclimatic unit;  
3. to provide aids to field identification of these biogeoclimatic and site units;  
4. to develop management interpretations for the site units or for groups of similar site units (treatment units); and  
5. to promote the concept of the ecosystem as the fundamental unit of resource management.

The system is based upon the interaction of climate and physiography and the vegetational manifestations that these produce. The zonal ecosystem, the typical ecosystem for a given regional climate, is used as a guide to ecosystem classification (Meidinger and Pajar 1991).

The basic unit of the biogeoclimatic system is the biogeoclimatic subzone. This describes areas which are linked by the same or similar climax ecosystems on typical or zonal sites. It is represented by two letters in the classification system, one describing the precipitation regime, and the other describing either temperature regime in interior regions or continentality (hypermaritime, maritime or submaritime) in coastal areas. Biogeoclimatic zones are inferred from subzones on the basis of climatic and similar zonal ecosystem groupings. These zones are named according to a two to four letter code commonly derived from dominant plant species in climax zonal ecosystems (for example, Coastal Douglas-fir as CDF).

Although not described in detail here, the BEC also includes classification of local modifications of subzone climate and a nomenclature system for site or local vegetation community structures. Thus, a typical site association (the basic spatial unit of the vegetation classification system) will feature a zone code, a subzone code, possibly a variant code, a site series (a site association distinguished by its zonal classification) and possibly even a site type identifier. An example is the code for the dry maritime subzone of the Coastal Western Hemlock zone, with a site series identified as Redcedar-Lady fern. If Redcedar-Lady fern is represented by a 01 (site series and site types are identified by a two-digit code prefixed by a slash), the code would read:

CWHdm/01
The multi-objective approach of the BEC makes it well suited as an ecosystem classification system for use in the ecosystem accounts. An extensive review of the BEC can be found in Poiar et al. (1987) and in Meidinger and Poiar (1991). Prior to the actual compilation of ecosystem accounts, a more extensive review of this system would be required. In addition, ongoing efforts to integrate the BEC with the Biophysical Habitat classification may produce a hybrid system which could be of use in the accounts.

Actual use of the classification system would involve description of regional ecosystems by location and extent. The extent of ecosystems can be assessed by the area of coverage in combination with the chosen status indicator and the ecosystem classification system. Columns of ecosystem central accounts could describe opening extent, anthropogenic increases and decreases, natural increases and decreases, and closing extent, thus adhering to the generic central account format outlined above. Given the often comparatively slow rate of ecosystem change and the high costs of ecological surveying, it is recommended that the accounting period for ecosystems be extended, perhaps to five or ten year increments.

User Accounts

User accounts are the second most critical accounts within resource records, in as much as these accounts detail the connections between resources and the economy, both within the region and outside. User accounts are actually a series of tables which catalogue not only the origins and destinations of anthropogenic resource flows, but also the utilization of resource stock functions (in situ or non-extractive services). They are compiled on the basis of disaggregation of the central account columns describing anthropogenic flows, and by methodologies used to identify stock or non-harvest functions. The accounts include disaggregation of resource use by sub-classes, as in the central accounts, and by resource user, including ownership and access rights.

The format of the user accounts will vary widely depending upon the nature of the resource and the type of utilisation. However, a critical component of most resource user accounts is the compilation, where data constraints allow, of resource flow matrices. Resource flows can be described by a matrix which includes resource sub-classes and which also identifies specific destinations for flows in terms of economic sectors or users. Exports to other regions in the province, to the rest of Canada and to other nations can be specified separately. A matrix \( B \), set up to describe flows of resource \( k \), would take the form of Table 1. Each entry designates shipments \( b_{ij} \) of resource sub-class \( i \) to industry \( j \), with the export sectors included as broad industrial categories.

The total of all resource flows to all sectors, that is, the total flow of a given resource in a region is described in equation 1, where \( T_k \) is total flow of resource \( k \) in the region.

\[
T_k = \sum_{i=1}^{n} \sum_{j=1}^{m} b_{ij}
\]  

(1)

The information in these matrices is used to produce the transaction matrix for the regional system input-output table. Each entry in the ecological commodity by economic sector transaction matrix (see below) describes the flow of a resource to a sector. Using the matrix above, a set of these can be derived for each industry \( j \) using the formula in equation 2, where \( T_{kj} \) denotes total flow of resource \( k \) to each sector \( j \).

\[
T_{kj} = \sum_{i=1}^{n} b_{ij}
\]  

(2)

Resource stock functions are also accounted for. Stock functions are those services provided by the “standing” crop or stock of the resource as opposed to those provided through extraction. The importance of distinguishing between the two has been discussed by Georgescu-Roegen (1971), who devised a flow fund model of the economy featuring flows of productive throughput and funds of relatively static infrastructure. Both are necessary in a productive economic system.

Stock functions account for three of the four generic ecosystem functions identified in de Groot’s (1986) functional ecosystem evaluation system: regulation for life support systems, carrier functions in the provision of substrates and media for settlement, and information for the provision of recreation opportunities. Examples include various functions of wetlands in providing, \textit{inter alia}, waterfowl habitat, water purification and flood control (Ferguson et al. 1989), as well as aesthetic quality afforded by pristine landscapes. Recognition of the importance of these stock functions is essential to the maintenance of a sound ecological base (International Union for the Conservation of Nature and Natural Resources [IUCNNR] 1980; de Groot 1986; Manning 1991). These functions will be identified in the user accounts separately from services which stem from resource flows. The level of services will, in many cases, be a function of the closing resource stock, and thus changing levels of functional provisions will be influenced by changes in resource stock levels over time. However, the changing socio-cultural context into which these services are introduced will play a critical role in the level of certain services. For example, it is possible that a diminished landscape could provide increased levels of service provided user populations grow sufficiently. This is an acknowledgement of the influence of cultural perception on resource and landscape values (Friend 1990). The importance of user groups is reflected in the recommended format of the account which involves a table of stock function identification by row and stock function user identification by column. A subsidiary table would ideally break down resource stocks by ownership and...
In similar fashion, estimates of the value of flows of market extractable resources can be compiled. The valuation of the total flow of a given extractable resource over the accounting period gives some indication of the direct contribution of the resource to economic production, either inside the region or elsewhere. In addition, the resource flow can be partitioned into sustainable and non-sustainable components through a combination of information from the central accounts and public policy input (for example, specific sustainability targets), and thus produce estimates of the value of so-called natural capital consumption. For renewable resources, the value of non-sustainable extraction will be assessed using the total rent deduction method recommended by, inter alia, Repetto et al. (1989) and Hamilton (1989, 1991). By contrast, non-renewable resource extraction is inherently non-sustainable. The total flow of non-renewable resources during the accounting period will be initially assessed using the average accounting period resource rent. In most cases, market rent will be derived from the operating surplus of the industry since frequent, open bidding for access rights tends to be rare. In order to maintain consistency with macro-accounting entries, rent figures should be derived from national or provincial level analysis of the appropriate resource extraction industry, however case studies using the operating surplus of the regional industry would also be useful. Deductions from current income for non-renewable resource depletion can be undertaken using either the total rent deduction method or the user-cost method devised by El Serafy (1989).

The third component of the valuation accounts involves the valuation of environmental services such as waste assimilation or the provision of recreation sites. These are not commonly market services, though they may be derived from resources which are marketed for other purposes. Thus, single resources may have valuation accounts with estimates of market value through actual and potential extraction, as well as estimates of other less direct sources of value (for example, a forest with timber and recreation values). An array of non-market valuation approaches is applicable to this facet of the valuation accounts. Guiding principles are borrowed from de Groot's functional ecosystem evaluation method for identifying and assigning values to ecological functions (de Groot 1986), as well as from Hueting (1980, 1989, 1991; Hueting and Bosch 1990) in the use of environmental quality targets for comparison with actual environmental status. In actual practise, the valuation of these services promises to be the most difficult in as much as non-market valuation is a subject of ongoing methodological debate (see, Hufschmidt et al. 1983 and Johansson 1990).

Component Linkage Analysis

Component linkage analysis is a provision in the system for exploring connections between distinct components, ecosystems and components, or between
distinct ecosystems. Weber (1983) outlines the purpose of the French patrimonial peripheral or linkage accounts, describing them as structures aimed at compensating for the necessarily reductionist approach of a resource accounting system. The French peripheral accounts are designed to reflect some degree of the integration of natural systems. Component linkage analysis in the regional accounting system is derived in principal directly from the French precedent in that the intent is to explore relationships involving multiple components and or ecosystems essential to the understanding of critical (as judged by resource account users) natural functions.

One facet of component linkage analysis is that it has the potential to influence the way the central accounts are compiled, as reflected by a loop connecting the two in Figure 4. This is because exploration of component and ecosystem relationships may uncover knowledge about the production of resource stocks or the allocation of resource flows, enabling more accurate estimates, especially where models are used.

Component linkage analysis establishes capacity for developing these relationships within the accounting structure. This allows for superior ecological modelling. While this facet of the system is not likely to share the profile of the central accounts or valuation accounts, it can form a vital component of long term plans for the regional model by exploring ecological relationships in a formal scientific capacity.

The Aggregation Table

The regional framework also includes an aggregation table, the purpose of which is to serve as a summary table for the economic value of all resources as calculated in the valuation accounts of the resource records. This summary includes stock and flow values for extractive resources as well as any other values that have been estimated in the environmental services component of the valuation accounts. In addition, the aggregation table provides information on regional expenditures for environmental improvement or protection. Thus the table has three sections: 1. the extraction receipts table; 2. the stock balances table; and 3. the environmental protection table.

The extraction receipts table consolidates aggregate information from the individual valuation accounts, providing a summary of the value of resource flows. Gross receipts (net of factor costs) are listed for all resources, as derived from the product of unit rent and volume extracted. Receipts from non-renewable extraction can be identified and deducted from the gross receipts to produce a corrected income figure for each resource, as in the individual records. However, the extraction receipts table will have row totals for gross receipts, non-sustainable extraction and corrected income, thus providing regional scale indicators of overall resource extraction sustainability.

The asset balance sheet similarly aggregates stock information from individual valuation accounts in a format similar to that of the Indonesian accounts (Repetto et al. 1989). However, the asset balance sheet will contain row entries for the values of opening stocks, net changes and closing stocks only. Again, total changes will be tabulated to provide very coarse indicators of whether the value of the natural resource base of the region is declining, increasing or remaining relatively constant over time. Care is necessary in interpreting results since value changes are a function of both stock fluctuations and changes in rent.

Expenditure on environmental improvement and protection has been identified elsewhere as a salient aspect of the interface between the economy and the environment (Hueting and Bosch 1990; Bartelmus et al. 1991; UNSO 1990). Normally, resource accounting frameworks which deal with expenditures on environmental improvement associate these with so-called defensive expenditures. Drehschler (1976) is among those who have pointed out the severe conceptual weaknesses of the defensive expenditure approach, most notably in that all expenditures can be treated as a defense of some sort. While expenditures for environmental improvement may also prove difficult to exclusively identify, the vagaries seem intuitively less debilitating. A reasonable alternative has been described by Hueting (1989, 1991), wherein environmental quality targets and available technological options for environmental remediation are used to place monetary values on environmental deterioration. Table 2 displays the draft classification of environmental protection activities as outlined in the SEEA (System for integrated Economic and Environmental Accounting, UNSO 1990). This classification system provides a useful starting point for the practi-
The use of data regarding expenditures of this type is of some debate, however. It is beyond the scope of this paper to resolve the issue of whether or not expenditures on environmental improvement should be deducted from provincial or national income. However, the information itself is useful and, when placed in a proper context, could provide information on trends within regions over time in environmental protection, as well as aiding in the comparison of different regions. If a decision were made to factor environmental protection expenditures into a formula for macro-economic income adjustments, the information in the aggregation tables on environmental protection and improvement expenditures would be useful.

The Input-Output Table

A second aggregate table is included in the system and takes the form of a regional input-output framework. The input-output matrix is compiled using information from the user accounts, the valuation accounts and existing socio-economic data. Flows of commodities, both economic and ecological, are identified by source and by destination in a commodity-by-industry framework.

Environmental input-output analysis has been discussed by several authors, notably Cumberland (1966), Daly (1968), Isard (1972) and Victor (1972). More recently, Lonergan and Cocklin (1985) have reviewed existing literature and have commented on the continuing usefulness of input-output for quantitative analysis of economic and ecological-economic linkages.

The model proposed for use here most closely resembles that of Isard (1972), where the format follows the commodity-by-industry structure outlined in Table 3. This has numerous advantages, including allowance for multiple commodity production from single industries, or sectors as they are called in the framework table. The make matrix shows the flow of all commodities from their sectors of origin. Row totals show total sectoral production, while column totals show total commodity output. The use matrix represents the flow of all commodities by their sector of destination. Row totals show total commodity production and should ideally balance column totals in the make matrix; that is, to the economic sectors of the use matrix. Thus flows of these ecological commodities to ecological sectors need not be identified, eliminating the necessity for detailed ecological models suggested by the ecological-ecological sector of the Daly (1968) model. Second, data availability should be a function of the state of the resource records themselves; the input-output table should be among the last aspects of the framework to be implemented. Third, the spatial resolution of the accounting model may be too fine for economic input-output analysis. Thus the applicability of the input-output provision should be assessed in a case-by-case fashion. And fourth, earlier comments notwithstanding regarding the difficulties of disparate metrics, it would be possible to use information in the input-output table in raw form. Hannon (1991) has discussed the use of an ecological accounting system based on the input-output framework, advocating physical units of measure.

Conclusion

The development of resource accounting methodology is contemporary and has occurred over a short time period. Most of the concern has been directed at the supplementing existing economic accounts. Naturally, one might expect that if economic accounting is macro-level, satellite economic accounts detailing natural resource depletion should be compiled at the aggregate level. This has been the norm. However, some recent reflections on the nature of the problem suggest that more diverse resource accounting systems may be preferable. Regional accounts offer the advantage of flexibility in capturing the spatial heterogeneity of environmental systems. A regional approach is also more decentralized and politically immediate. New problems introduced by a regional approach include the modifiable areal unit problem, and pervasive differences in the spatial orientation of biophysical and socio-economic data. These difficulties demand careful consideration.
A collection of resource records, each with its own central, user and valuation accounts, together with component linkage analysis, is suggested as the core of our system, supplemented by aggregation tables and an ecological/economic commodity-by-industry input-output table. Resource records are compiled for both ecosystems and individual components. The delineation of regions for the system is to be accomplished by combining watersheds on Vancouver Island according to user specific needs and using the Ministry of Environment’s Hierarchical Watershed Coding System dictionary of streams. Overall, an attempt has been made to facilitate the inclusion of a breadth of the natural patrimony while also allowing for incremental implementation of the system and incremental derivation of useful results from it. A number of aggregate indices are included to make the model more useful from a public policy standpoint.

In actual usage, the framework will take on characteristics as a function of user need. However, one might expect that emphasis on the derivation of resource depletion and degradation indices for significant market resources on the Island (for example, timber resources and commercial fish resources) would result in the preferential compilation of central, valuation and possibly user accounts for these resources; one might also envisage the integration of these resources into the regional input-output table.

The critical weakness of the regional framework is likely also its greatest strength; that is, while the model is intended to cover a breadth of the natural patrimony, data requirements for a full implementation are onerous. There is some question as to whether such a system would ever be fully implemented given budgetary and time constraints. However, this does not diminish the utility of the framework since, as outlined, incremental implementation is possible -- even recommended. At the same time, the design reflects a desire to outline what is possible in resource accounting, as well as what is pragmatic.

References


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