DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
UNITED NATIONS

System of Environmental Economic Accounting

System of Environmental-Economic Accounting—Ecosystem Accounting

Section 13.4 on Accounting for climate change

of the draft document submitted to the Global Consultation on the complete document

October 2020

Note: This is just an extract from the complete draft of the SEEA EA that can be accessed at: https://seea.un.org/sites/seea.un.org/files/documents/EEA/Revision/1._seea_ea_complete_draft_for_global_consultation_oct_2020.pdf

Disclaimer:
This draft has been prepared under the guidance of the SEEA Experimental Ecosystem Accounting Technical Committee under the auspices of the UN Committee of Experts on Environmental Accounting (UNCEEA). It is part of the work on the Revision of the System of Environmental-Economic Accounting 2012—Experimental Ecosystem Accounting being coordinated by the United Nations Statistics Division. The views expressed in this document do not necessarily represent the views of the United Nations.

13.4 Accounting for climate change

13.4.1 Role of accounting in supporting decision making about climate change

13.37 Climate change is one of the major global challenges of our time. Ecosystem accounting provides an important tool to understand the key role ecosystems play in greenhouse gas (GHG) cycling on global, national and regional scales that underpin the carbon concentration in the atmosphere. In addition, ecosystem accounting helps to understand the impact that climate change is having on ecosystems and biodiversity. SEEA as an integrated statistical framework thus can play an important role in supporting international and national policy discussions related to climate change. Furthermore, it can provide the underlying data that link climate change to other environmental topics – e.g., biodiversity, circular economy.

13.38 The SEEA EA accounts in combination with the accounts from the SEEA Central Framework and SNA can support various aspects of climate change policy – e.g., carbon stock assessment and management, carbon markets, linking air emissions and economic activity, recording and modelling climate change outcomes on ecosystems, ecosystem services and economic activity, sector based assessments (e.g., agriculture), ecosystem focused planning (e.g., peatlands), inform on the co-benefits of carbon projects and policies, impacts of mitigation responses

13.4.2 Applying the SEEA EA to inform climate policies

13.39 Several of the accounts from SEEA EA provide useful information to support climate change policies. This section describes how the ecosystem accounts can be used to inform on climate change. Furthermore, the carbon stock account is introduced, which brings together in a comprehensive framework all relevant carbon stocks and flows, including some flows not covered in the SEEA Central Framework or SEEA EA accounts like CO_2 and CH_4 emissions from ecosystems. Finally, some of the SEEA Central Framework accounts relevant for climate change and their relation with the SEEA EA accounts are briefly described.

SEEA EA accounts

13.40 The extent account shows the managed and unmanaged conversions in ecosystem types that directly underpin changes in carbon uptake and release from ecosystems. Data from extent accounts can therefore be linked to the assessment of GHG emissions arising from land use, land use change and forestry (LULUCF).

13.41 The condition account contains ecosystem characteristics and indicators that are highly relevant for climate change. Relevant physical state characteristics that that relate to carbon stored in ecosystems include carbon in biomass, soil organic carbon, etc. Carbon stock indicators for biomass provide a direct link to the carbon stock account described below. Condition indicators are also particularly relevant to describe the impact of climate change on ecosystems, for example the effects on local temperatures, rainfall patterns and ocean acidification.

13.42 The reference list for selected ecosystem services (Table 6.2) includes several ecosystem services that are particularly relevant for climate change policies. Global climate regulation services are the ecosystem contributions to the regulation of the concentrations of gases in the atmosphere that impact on global climate, primarily through the retention of carbon in ecosystems. The physical and monetary ecosystem service flow accounts (chapters 6, 7 and 9) show what ecosystem types play an important role in carbon sequestration and retention and how these change over time. Physical data on carbon retention and sequestration by ecosystem type are embodied in the carbon stock account described below.

13.43 Furthermore, there are several regulating ecosystem services that mitigate the effects of climate change. Local climate regulation services are the ecosystem contributions to the regulation of ambient atmospheric conditions. Examples include the evaporative cooling provided by urban trees and the contribution of trees in providing shade for livestock. Rainfall pattern regulation services are the ecosystem contributions of vegetation at the sub-continental scale, in particular forests, in maintaining rainfall patterns through evapotranspiration. Flood mitigation services, including both seawater surge and river flood mitigation, are the ecosystem contributions in the protection river banks and seashores and thus mitigating the impacts of floods on local communities. Storm mitigation services are the ecosystem contributions of vegetation, especially linear elements in the landscape, in mitigating the impacts of wind, sand and other storms (other than water related events) on local communities. The accounts indicate what ecosystem types are the main contributors to mitigating the effects of climate change, but also who the main beneficiaries are of these ecosystem services.

13.44 Finally, flows of several ecosystem services, including provisioning and cultural services, will be impacted by climate change e.g., water supply, biomass provision, recreation services etc, although isolating the precise contribution of climate change to the flows of ecosystem services is not the ambition in the accounts.

Carbon stock (and change in stock) account

13.45 Carbon has a central place in ecosystem and other environmental processes and hence accounting for carbon stocks and transfers between them is an important aspect of environmental-economic accounting. The carbon stock account provides a comprehensive overview of all relevant carbon stocks and flows on a national or sub national level.

13.46 Carbon stock accounts are closely linked to the SEEA EA accounts. The carbon stock account provides partial indicators of ecosystem condition such as net carbon balance and primary productivity. In addition, carbon accounts can also provide information to support measures of the ecosystem services of carbon sequestration and storage of carbon. Finally, they are also closely linked to accounts of the SEEA Central Framework (e.g., physical assets of fossil fuels an minerals, carbon emissions to air, physical product flows to and from the rest of the world).

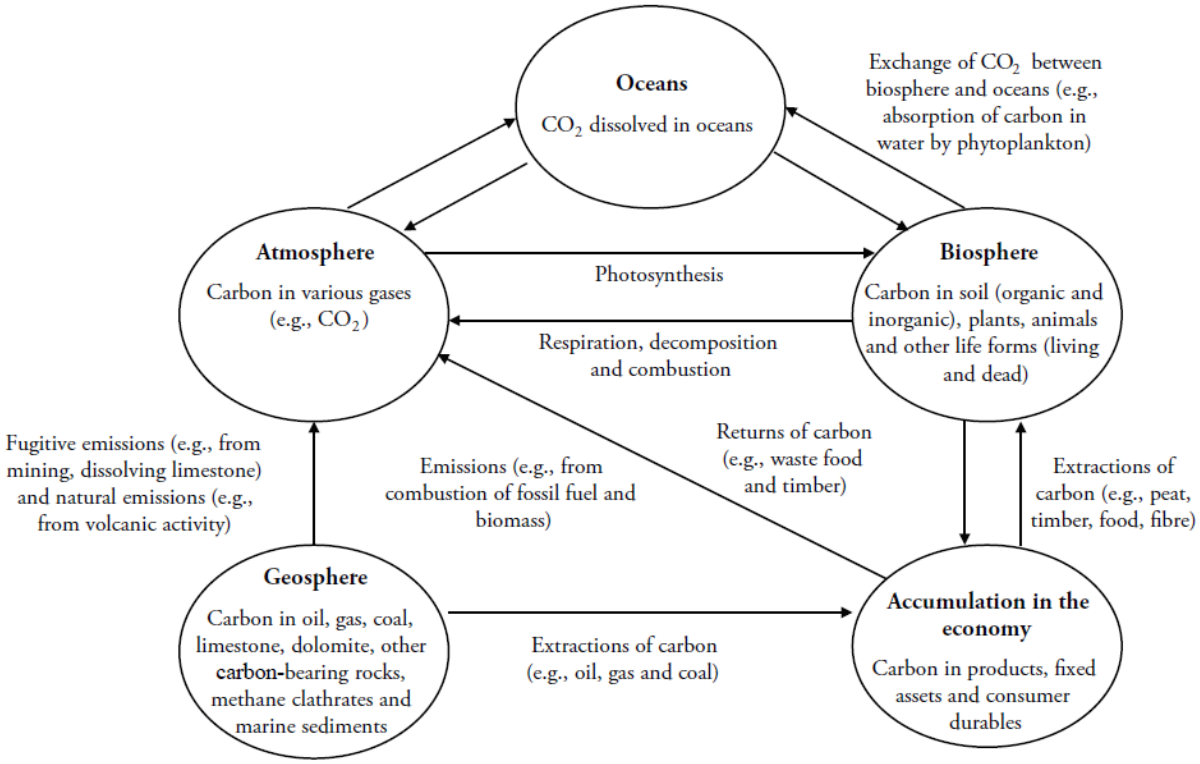
13.47 The measurement of stocks and flows of carbon can support discussion of many policy relevant issues. These issues include the analysis of greenhouse gas emissions, sources of energy, deforestation and land use change, loss of productivity and biomass, and sources and sinks of carbon emissions. For example, carbon stock accounts can complement the existing flow inventories developed under the United Nations Framework Convention on Climate Change and the Kyoto Protocol thereto. Since carbon is also a common focus of policy response, for example carbon taxes, its direct measurement is of high relevance.

13.48 Further, carbon stock accounts can provide consistent and comparable information for policies aimed at, for example, protecting and restoring natural ecosystems, that is, maintaining carbon stocks in the biosphere. Combined with measures of carbon carrying capacity and land-use history, biosphere carbon stock accounts can be used to:

- Investigate the depletion of carbon stocks and the resulting CO_2 emissions due to conversion of natural ecosystems to other land uses
- Prioritize use of land for restoration of biological carbon stocks through reforestation, afforestation, revegetation, restoration and improved land management, taking account of differing trade-offs in respect of food, fibre and wood production
- Identify land uses that result in carbon removal and storage

13.49 The fact that carbon plays an extensive role in the environment and the economy calls for a comprehensive approach to its measurement. Accounting for carbon must therefore consider stocks and changes in stocks of carbon of the geosphere, the biosphere, the atmosphere, oceans and the economy. Figure 13.1 presents the main components of the carbon cycle. It is these stocks and flows that provide the context for carbon accounting. The same accounting principles can also be applied to account for other GHG including NO_x.

Figure 13.1: The main components of the carbon cycle



Source: SEEA 2012 EEA, Figure 4.1 (United Nations et al., 2014b).

13.50 The structure of a carbon stock account is presented in Table 13.3. It provides a complete and ecologically grounded articulation of carbon accounting based on the carbon cycle and, in particular, the differences in the nature of particular carbon reservoirs. Opening and closing stocks of carbon are recorded, with the various changes between the beginning and end of the accounting period recorded as either additions to, or reductions in, the stock. A more detailed description of the carbon account is provided in Annex 13.1.

13.51 Carbon stocks are disaggregated into: geocarbon (carbon stored in the geosphere) and biocarbon (carbon stored in the biosphere, in living and dead biomass), carbon in the oceans (carbon stored in seawater, can in sediments is part of biocarbon or geocarbon), carbon in the atmosphere and carbon accumulated in the economy.

13.52 The row entries in the account follow the basic form of the asset account in the SEEA Central Framework: opening stock, additions, reductions and closing stock. Additions to and reductions in stock have been split between managed and unmanaged expansion and contraction. The net carbon balance equals addition to stock minus reductions in stock.

13.53 All values in the carbon stock account should be in equivalent carbon weights (e.g., ton carbon). Accordingly, methane (CH_4) and carbon dioxide (CO_2) emissions should be expressed in ton carbon, not in the actual mass of CH_4 and CO_2. Similarly, for products like recycled

plastic or paper the equivalent carbon content should be determined, using the average composition of these materials to determine the carbon content. For emissions to the atmosphere, a bridge table may be compiled both in ton carbon and in CO2 equivalents, as the latter links to the SEEA Central Framework air emission accounts.

Table 13.3: Carbon stock account structure

	Geocarbon					Biocarbon			Carbon in the economy			Carbon in the seas	Carbon in the atmosphere	Total
	Oil	Gas	Coal	Limestone and marl	Other	Terrestrial	Freshwaters and saline wetlands	Marine	Inventories	Fixed assets, cosumer durables	Waste	Total	Total	
Opening stock														
Additions to stock														
Natural expansion														
Managed expansion														
Discoveries														
Upwards reappraisals														
Reclassifications														
Imports														
Reductions in stock														
Natural contraction														
Managed contraction														
Downwards reappraisals														
Reclassifications														
Exports														
Net carbon balance														
Closing stock														

GHG emission accounts

13.54 The SEEA Central Framework air emission account records the generation of air emissions by resident economic units by type of substance. These include the greenhouse gasses CO_2, CH_4, N_2O and the F gasses. All emissions by establishments and households as a result of production, consumption and accumulation processes are included.

13.55 Included in the scope the of SEEA Central Framework air emission accounts are emissions from cultivated livestock due to digestion (primarily methane), and emissions from soil as a consequence of cultivation, or other soil disturbances such as a result of construction or land clearance. Emissions from natural processes such as unintended forest and grassland fires, emissions from peatland, but also human metabolic processes are excluded. Emission from these sources, however are included in the carbon stock accounts.

13.56 In order to permit effective linking of physical flow data to monetary data, the physical flows of emissions should be classified using the same classifications used in the SNA. For household consumption, it is necessary to consider both the purpose of the consumption and the actual product being used by households. This requires consideration of data classified by COICOP (the Classification of Individual Consumption by Purpose) and using the Central Product Classification (CPC).

13.57 The GHG emissions by economic activities, as provided by SEEA, differ from the total emissions on a national territory or the emissions calculated according to the compilation guidelines of the IPCC. This is because different concepts and calculation methods underlie the different emission data. Bridge tables provide insight in the relations between the different emission concepts.

13.58 The emissions recorded for CO_2 end CH_4 in the SEEA Central Framework air emission account directly link to the uptake (managed expansion) of carbon by the atmosphere and release (managed contraction) of carbon by the economy as recorded in the carbon stock account.

Monetary accounts for climate change related transactions

13.59 The SEEA CF environmental activity accounts record transactions in monetary terms between economic units that may be considered environmental. Generally, these transactions concern activity undertaken to preserve and protect the environment. As well, there are a range of transactions, such as taxes and subsidies, that reflect efforts by governments, on behalf of society, to influence the behaviour of producers and consumers with respect to the environment.

13.60 Transactions in environmental activity accounts are classified by the classification for environmental activities (CEA). Two classes are particularly relevant for climate change: EP 1 Protection of ambient air and climate, which includes activities aimed at the control of emissions of greenhouse gases, and RM 10 Management of mineral and energy resources, which includes activities related to energy saving and renewable energy production. Selecting these classes from the accounts provides data on the mitigation costs for climate change, the economic benefits that result from the energy transition with regard to labour and the contribution to GDP.

13.4.3 Indicators derived from accounts concerning climate change

13.61 There is a wide range of indicators that may be derived from the various SEEA accounts concerning climate change. They can focus on linking levels of GHG emissions to levels of economic activity, presenting levels of GHG emissions from consumption and production perspectives and showing levels of expenditure on climate change related responses. The SEEA Applications and Extensions from provides a range of guidance in this area in particular concerning the potential to undertake relevant structural decomposition analysis and footprinting. There is also the potential for data from the accounts to support climate change modelling in terms of implications of projected climate change scenarios on economic activity.

13.62 Various indicators can be derived directly from carbon stock accounts or in combination with other information, such as land cover, land use, population, and industry value added. The suite of indicators can provide a rich information source for policy makers, researchers and the public. For example, comparing the actual carbon stock of different ecosystems with their carbon carrying capacities can inform land use decision making where there are significant competing uses of land for food and fibre.

13.63 An indicator that can be derived from the carbon stock account is the 'net carbon balance'. This indicator relates to the change in the stock of carbon in selected reservoirs over an accounting period. Commonly the focus of net carbon balance measures is on biocarbon but, depending on the analysis, the scope of the measure may also include parts of geocarbon, carbon in the economy and carbon in other reservoirs. There are also links that can be made to supporting the measurement of to SDG 13 "Take urgent action to combat climate change and its impacts".

Annex 13.1: Carbon stock account

A13.1 The rationale for carbon stock accounting in the context of ecosystem accounting was discussed in section 13.4. The present annex provides some additional details on the structure and accounting entries related to the carbon stock account as presented in Table 13.3. The carbon stock account presented in that table provides a complete and ecologically grounded articulation of carbon accounting based on the carbon cycle and, in particular, the differences in the nature of specific carbon reservoirs. Opening and closing stocks of carbon are recorded, together with the various changes occurring between the beginning and end of the accounting period recorded as either additions to or reductions in the stock.

A13.2 Carbon stocks are disaggregated into geocarbon, biocarbon, carbon accumulated in the economy, carbon in the oceans (inorganic only) and carbon in the atmosphere.

A13.3 Geocarbon includes all carbon stored in the lithosphere, excluding all organic carbon stored in dead biomass.[1] Basically, carbon that is part of the Earth's lithosphere is considered as geocarbon (or geological carbon: carbon present in the Earth's bedrock and sediments, primarily from marine sediment deposits), as well as carbon formed originally in the Earth's biosphere millions of years ago, that, after geological metamorphosis due to high pressure and temperatures in the Earth's crust, was transformed into e.g., oil and gas (organic geocarbon). Organic carbon in soils and in peat deposits is included in biocarbon.[2] Where the information generated from the accounts is policy-focused, the priority should be given to reporting those stocks that are being impacted by human activity (e.g., fossil fuels).

A13.4 Biocarbon includes all organic carbon in the biosphere, i.e., carbon in living biomass (plants and animals) and dead biomass (soil organic matter and sedimentary organic matter)[3] Biocarbon includes biomass in crops, grass in meadows, which is thus not considered as carbon accumulated in the economy. Carbon stored in livestock, however, is considered as part of 'carbon in the economy'.

A13.5 Biocarbon is classified by type of ecosystem, at the highest level according to the three main realms of the Global Ecosystem Typology (marine, freshwaters and saline wetlands, terrestrial). This high-level classification can be further broken-down using level 3 of the IUCN GET. Furthermore, it is recommended to separately record on at the highest-level carbon in agricultural systems, to allow the distinction between carbon uptake and release between natural and semi natural ecosystems and agricultural; ecosystems.

A13.6 The stability of the carbon stocks in the biosphere depends significantly on ecosystem characteristics. In natural ecosystems, biodiversity underpins the stability of carbon stocks by bestowing resilience and the capacity to adapt and self-regenerate (Secretariat of the Convention on Biological Diversity, 2009). Stability confers longevity and hence the capacity for natural ecosystems to accumulate large amounts of carbon over centuries to millenniums, for example, in the woody stems of old trees and in soil. Semi-modified and highly modified ecosystems are generally less resilient and less stable (Thompson et al., 2009). These ecosystems therefore accumulate smaller carbon stocks, particularly if the land is used for agriculture where the plants are harvested or grazed regularly.

A13.7 The atmosphere contains carbon mainly in the form of CO2 and methane. The atmosphere is a receiving environment with regard to carbon from the primary reservoirs geocarbon and

[1] Geocarbon is further disaggregated into oil, gas, coal resources, rocks (primarily limestone and marls), and minerals, e.g., carbonate rocks used in cement production, methane clathrates and inorganic carbon in marine sediments

[2] Soil is the layer of fine material covering the Earth's land surface influenced by and influencing plants and soil organisms.

[3] For biocarbon in soils, for practical reasons only the top 30 cm were included in this study. In particular for peat and peaty soils, this results in a strong underestimation of the total stock of biocarbon in soils. This shortcoming in the current models also potentially influences C flows in the case of water table changes exceeding this depth.

biocarbon but also from emissions from carbon used in the economy. On the other hand, carbon uptake from the atmosphere may take place by carbon sequestration in biocarbon. As CO2 and methane act as greenhouse gasses in the atmosphere, accounting for these flows is highly policy relevant.

A13.8 The oceans are the receiving environments for carbon released from primary reservoirs and for from its accumulations in the economy. Carbon in oceans includes only inorganic carbon: carbonates dissolved in seawater. Living and non-living organic carbon in oceans are part of biocarbon. Carbonate particulates (e.g., shells) in sediments are part of geocarbon.

A13.9 Accumulations in the economy, which are the stocks of carbon in anthropogenic products, are further disaggregated into the following SNA components: fixed assets (e.g., concrete in buildings, bitumen in roads, livestock); inventories (e.g., petroleum products in storage, excluding those included in agricultural ecosystems); consumer durables (e.g., wood and plastic products); and waste. In turn, these main asset categories can be further disaggregated into biobased (i.e., derived from plants or animals) and non-biobased (i.e., fossil fuels, mineral (inorganic) products and synthetic materials (plastics)). Accounting for waste follows the conventions of the SEEA Central Framework, where waste products (e.g., disposed plastic and wood and paper products) stored in controlled landfill sites are treated as part of the economy.

A13.10 The flows of carbon that occur within the economy are very significant and essential for understanding the interaction between economy and environment. The level at which geocarbon and biocarbon stock changes can be linked to the economy will determine the policy usefulness of the carbon stock account. This is particularly relevant in cases where raw materials can be extracted from more than one ecosystem type (e.g., biomass fuel from natural ecosystems or agricultural ecosystems; meat from agricultural ecosystems or semi-natural ecosystems) or from geocarbon reservoirs with different carbon contents and emissions profiles.

A13.11 Carbon stored through geo-sequestration (i.e., the managed injecting of gaseous CO2 into the surface of the Earth) is treated similarly, as a flow within the economy (resulting in an increase in accumulations). Any subsequent release of carbon to the environment is treated as a residual flow with a reduction in accumulations in the economy matched by a corresponding increase in carbon in the atmosphere.

A13.12 The presentation of the row entries in the account follows the basic form of the asset account in the SEEA Central Framework; the entries being opening stock, additions, reductions and closing stock. Additions to and reductions in stock have been split between managed and natural expansion and contraction. Additional rows for imports and exports have been included, thus making the table a stock account, as distinct from an asset account.

A13.13 There are five types of additions in the carbon stock account:

- Unmanaged expansion, which reflects increases in the stock of carbon over an accounting period due to natural growth or the indirect effects of human activities. Effectively, this will be recorded only for biocarbon and may arise from climatic variation, ecological factors such as reduction in grazing pressure, and indirect human impacts such as the CO2 fertilization effect (where higher atmospheric CO_2 concentrations cause faster plant growth).
- Managed expansion, which reflects increases in the stock of carbon over an accounting period due to direct human activities. This will be recorded for biocarbon in ecosystems and accumulations in the economy, in inventories, consumer durables, fixed assets and waste stored in controlled landfill sites, and also includes greenhouse gases injected

into the earth. Basically, these reflect all increases in carbon stock due to carbon input flows from other reservoirs which are directly related to human activities.

- Discoveries of new stock, encompassing the emergence of new resources added to a stock, which commonly arise through exploration and evaluation. This applies exclusively to geocarbon.
- Reclassifications of carbon stocks, which will generally occur in situations where an ecosystem asset is used for a different purpose. For example, increases in carbon in semi-natural ecosystems following the establishment of a national park on an area previously used for agriculture would be offset by an equivalent decrease in agricultural ecosystems. In this case, it is only the particular land use that has changed, that is, reclassifications may have no impact on the total physical quantity of carbon during the period in which they occur.
- Imports are recorded to enable accounting for imports of produced goods (e.g., petroleum products) that contain carbon.

A13.14 There are five types of reductions recorded in the carbon stock account:

- Unmanaged contractions, which reflect natural losses of stock during the course of an accounting period. They may be due to changing distribution of ecosystems (e.g., a contraction of natural ecosystems) or biocarbon losses that might reasonably be expected to occur based on past experience. Unmanaged contraction includes losses from episodic events including drought, some fires and floods, and pest and disease attacks, and also includes losses due to volcanic eruptions, tidal waves and hurricanes.
- Managed contractions, which are reductions in stock due to direct human activities and include the removal or harvest of carbon through a process of production. This includes mining of fossil fuels and felling of timber. Extraction from ecosystems includes both those quantities that continue to flow through the economy as products (including waste products) and is recorded net of those quantities of stock that are immediately returned to the environment after extraction because they are unwanted—for example, felling residues. Managed contraction also includes losses as a result of a war, riots and other political events; and technological accidents such as major toxic releases.
- Reclassifications of carbon stocks, which generally occur in situations where another environmental asset is used for a different purpose. For example, decreases in carbon in agricultural ecosystems following the establishment of a national park on an area used for agriculture would be offset by an equivalent increase in semi-natural ecosystems. In this case, it is only the particular land use that has changed; that is, reclassifications have no impact on the total physical quantity of carbon during the period in which they occur.
- Exports are recorded to enable accounting for exports of produced goods (e.g., petroleum products) that contain carbon.
- Catastrophic losses, which are not shown as a single entry but are allocated between managed contraction and unmanaged contraction. Catastrophic losses in managed contraction would include fires deliberately lit to reduce the risk of uncontrolled fires. For the purposes of accounting, reductions due to human accidents, such as rupture of oil wells, would also be included under managed contraction. Catastrophic losses could, however, be separately identified.