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ANNOTATED OUTLINE – NATURAL CAPITAL

Prepared by Robert Smith, Statistics Canada

1. **Definition of natural capital**
    a. What is a natural asset
        i. Natural assets are separately identifiable elements of the natural environment that provide welfare benefits over time either in the form of a flow of valuable goods or a flow of valuable services.
        ii. To qualify as an asset, ownership rights must be exercised over the element of the environment in question. These rights can be private or collective, meaning that publicly owned elements of the environment (such as public forests) qualify as natural assets.
        iii. To qualify as an asset, the element of the environment in question must also provide a flow of benefits under current conditions of technology, price. Thus, an oil deposit that cannot be profitably extracted under current technology and price conditions does not qualify as a natural asset, even if its existence is know.
    b. The categories of natural capital
        i. Natural resources
            1. *Non-renewable* natural resources such as minerals, fossil fuels, so-called "fossil" groundwater
            2. *Conditionally renewable* natural resources such as surface and non-fossil groundwater, timber, fish and soil
        ii. Land
            1. Land is defined as natural capital because it provides the space within which extensive human activities such as

settlement, transportation, agriculture and natural resource extraction can take place.

iii. Ecosystems
    1. Ecosystems are separately identifiable natural systems of biotic and abiotic elements that provide welfare benefits through the provision of a variety of environmental goods and services.
    2. Ecosystems are the most complex of the three forms of natural capital and are closely related to the first two. For example, forest ecosystems provide the conditionally renewable natural resource of timber, among other things.

2. Natural capital within the overall capital framework

a. Like other forms of capital, natural capital is important for sustainable development because it provides flows of goods and services that enhance welfare over time. If human development is to be sustainable over time, it must not result in the continual and irreversible loss of natural capital unless such losses can be entirely compensated by increases in other forms of capital. As will be seen below, the possibilities for such substitution are limited.

b. A strength of measuring SD from a capital perspective is that the measurement challenge is reduced to measuring just those elements of the environment that qualify as natural assets. This helps eliminate the *ad hoc* character of much measurement of the environment by providing a clear focus for what should be measured and, equally, what need not necessarily be measured in the effort to evaluate sustainable development. As an example, from a natural capital perspective, measures of the overall functioning of forest ecosystems (*e.g.*, forest extent, species and age distribution, degree of forest fragmentation) are what are needed, as these determine the forest's overall capacity to provide welfare enhancing flows. These kinds of measures are quite different from what might be required, for example, by foresters responsible for determining allowable cut in a given forest area.

c. Measures of natural capital are relevant to policies aimed at ensuring sustainable development because they reveal overall trends in the state of natural assets that provide welfare enhancing flows over time. They can serve as signals alerting policy makers to possible future declines in these flows, thereby allowing them to take corrective measures.

3. Substitution between natural capital and other forms of capital

a. The question of substitutability is central to the capital framework in general and to natural capital in particular. Substitution refers to the replacement of welfare enhancing flows from one form of capital with those of equal value from another form of capital. Given indifference on the part of humans as to the source of their welfare, substation allows the

possibility of maintaining welfare in the face of declining capital of one type by increasing capital of another type.

b. It is clear both from historical experience and from common sense that some forms of natural capital are highly, even perfectly, substitutable with other forms of capital. This is especially true of sub-soil assets such as fossil fuels and minerals, which do not have an intrinsic value beyond their value in use. It seems unambiguously true that human welfare is equally well served by the combination of highly efficient central heating systems (produced capital) with a lesser amount of fuel oil (natural capital) as by a (much) greater amount of coal burned in an inefficient open hearth. The advent of modern heating systems is, then, an example of a welfare maintaining substitution of produced capital for natural capital.
c. The possibilities of welfare maintaining substitution for other forms of natural capital are not as clear cut. One could argue that we are as well off with smaller forests (and therefore less timber) and highly efficient wood processing technology as we would be with larger forests and less efficient technology. This ignores, however, the complication that forests provide welfare enhancing flows beyond timber.
d. There are some types of natural capital for which the possibility of welfare maintaining substitution is negligibly small. These are assets such as the global atmosphere or ozone layer that provide life-sustaining services that no human technology can hope to reproduce. Such forms of capital are often dubbed “critical natural capital” because their continued existence is critical to human survival. Any reduction in these forms of capital necessarily translates into a reduction in human welfare. Complicating matters further is the existence of thresholds in some natural systems. These are points at which systems can suddenly change state, moving from one regime in which certain welfare benefits are present to another regime in which a completely different set of benefits (perhaps of much lower value) are present. The existence of thresholds implies the need for sound science to be applied to the measurement of natural capital, as only science can determine the existence of thresholds and the degree to which ecosystems may be close to a state change.
e. There exists, then, a spectrum of substitution possibilities for natural capital that runs from near-perfect substitutability for simple forms of natural capital with uni-dimensional welfare benefits to zero substitutability for complex forms of natural capital with multi-dimensional and irreplaceable welfare benefits. In between these poles lie a number of other cases in which substitutability is a possibility given appropriate conditions.

4. Measurement of natural capital

a. Measurement of natural capital requires first and foremost measurement of natural capital asset stocks *in situ.* In addition to this, it requires measurement of the activities (flows) that cause changes in these stocks (additions or reductions) from one period to the next. These activities

include extraction, discovery and natural growth/loss of natural resources, changes in land use, pollution emissions and fragmentation of ecosystems.

b. A central question in the capital framework is what unit of measure to use when measuring natural capital. Broadly speaking, there are two possibilities: physical measures and monetary measures. Physical measures are applicable in all cases, whereas the applicability of monetary measures is more limited. Monetary measures are applicable only in instances where market prices are available for the asset in question or where they can be approximated using indirect methods.
c. The use of monetary measures is also limited to those forms of natural capital for which there is the possibility of substitution. The measurement of substitutable natural capital in monetary units allows the comparison of natural capital measures with those for other forms of capital. Such comparison is necessary when considering the benefits of the loss of one form of capital and its replacement with another form.
d. Critical natural capital, which cannot be substituted for by another form of capital, should not be measured in monetary terms. Physical measures of such capital will provide more accurate signals of its evolution. Moreover, monetary measures are unnecessary for critical natural capital, as there is no meaning in assessing its loss in terms of gains in another form of capital; any loss of critical natural capital represents, by definition, an irretrievable reduction in human welfare.
e. Of the three forms of natural capital, it is relatively easy to conceive of and take measurements of natural resources and land. It can be much more difficult for ecosystems. Some ecosystems (e.g., forests) are relatively easily measured, while others (e.g. river systems, the atmosphere) are much more difficult. Even conceiving of meaningful measures of the atmosphere is a challenge.
f. In cases where meaningful direct measures of ecosystems cannot be conceived or taken, it is necessary to consider what proxy measures might be used to represent the state of the ecosystem itself. One way to measure ecosystems by proxy is to ask what goods and/or services they provide and then to measure those goods/services. The presumption is that a constant or growing output of goods/services implies a constant or growing ecosystem asset. Declining output of goods/services implies the opposite.
g. Measurement of ecosystems may be easier in monetary terms than in physical terms. Estimating the value of the goods and services provided by ecosystems does not require direct measurements of the extent of the ecosystems themselves. As with proxy measurements based on the quality of ecosystem outputs, the presumption is that a stable or increasing value of the goods and services provided by ecosystems reflects a stable or increasing ecosystem and *vice versa*.
h. Although it may seem counterintuitive, the measurement of pollution emissions is a conceptual requirement in the capital framework. Pollution emissions, because of their negative impacts on ecosystem functioning, are the ecosystem analogue to extraction of natural resources. Just as

resource extraction serves to reduce resource stocks, so pollution serves to reduce the functioning (or quality) of ecosystems. Thus, the measurement of pollution emissions follows necessarily from the adoption of the capital framework.

i. Basic data on natural capital can be collected from a variety of sources. Scientific monitoring of natural capital stocks (e.g., mineral surveys, satellite information on forests and land use) is one important source. Information on the flows of natural capital (e.g., timber harvest, fish harvest) will often come from statistical surveys administered to the enterprises that are responsible for the extraction activities. Data on pollution flows can be obtained from statistical surveys of polluting units (enterprises, households and governments) and from scientific estimation.

j. The organization of basic data on natural capital into structured, coherent and comprehensive databases is best accomplished through the use of environmental extensions of the traditional national accounts. The compilation of such “environmental accounts” is already a well-established field, with many national statistical offices preparing some set of environmental accounts on an annual basis. International guidelines on their development have been prepared by the United Nations (SEEA 2003).