THE WORLD AS A GARDEN

A Philosophical Analysis of Natural Capital in Economics

by

Christopher Tyler DesRoches

M.A., Philosophy & Economics, Erasmus University Rotterdam, 2009
M.A., Economics, University of Victoria, 2004
B. Comm., Honours Economics, Saint Mary's University, 2002

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ABSTRACT

This dissertation undertakes a philosophical analysis of "natural capital" and argues that this concept has prompted economists to view Nature in a radically novel manner. Formerly, economists referred to Nature and natural products as a collection of inert materials to be drawn upon in isolation and then rearranged by human agents to produce commodities. More recently, nature is depicted as a collection of active, modifiable, and economically valuable processes, often construed as ecosystems that produce marketable goods and services *gratis*. Nature is depicted as consisting of various unproduced mechanisms or "natural machines" that are first discovered and then channeled so as to serve human ends. In short, nature as an ideal is a kind of garden that is characterized by natural objects purposefully arranged by intentional human agents.

This dissertation first lays out working definitions of the key terms, such as capital and Nature, and then traces the historical roots of natural capital in the writings of eminent classical political economists, such as Adam Smith, John Stuart Mill, and Karl Marx. I then examine the question of substitutes for "critical natural capital", and argue that the preservation paradox is warranted: no one can restore or preserve a part of Nature without turning it into an artifact. Following the recent work of Debra Satz and Michael Sandel, I finish my dissertation by situating the question of natural capital in the broader context of whether some goods should not be for sale, particularly those I define as Basic Ecological Goods.

PREFACE

This dissertation is the original, unpublished, independent work by the author C. Tyler DesRoches. A modified version of Chapter Four was submitted for publication as "Economics and Basic Ecological Goods." Some parts of this dissertation are published as "On Aristotle's Natural Limit" in *History of Political Economy* (DesRoches 2014).

TABLE OF CONTENTS

LIST OF FIGURES

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CHAPTER ONE

The World as a Garden

An Introduction

Adam Smith was no stranger to the spontaneous productions of the Earth. In the *Wealth of Nations* he explicitly recognizes nature as a genuine producer, one that has a special role to play in agricultural production where he claims that "nature labours along with man" ([1776] 1976, 363). Smith also recognized that nature is capable of producing certain goods that are never augmented by human industry. In Book I, Chapter 11 (Of the Rent of Land), Smith observes that:

> Kelp is a species of sea-weed, which, when burnt, yields an alkaline salt, useful for making glass, soap, and for several other purposes. It grows in several parts of Great Britain, particularly in Scotland, upon such rocks only as lie within the high water mark, which are twice every day covered

> with the sea, and of which the produce, therefore, was never augmented by human industry ([1776] 1976, 161).[1]

Smith was not alone in recognizing such "natural productions". His immediate predecessor, François Quesnay, the progenitor of Physiocracy in France, held that nature was the only *bona fide* producer. For Quesnay and the Physiocrats who wrote during the late eighteenth century, wealth was generated by agricultural production alone, a process whereby human labour merely served as the mid-wife to economic production. Unassisted human labour was deemed barren since it could merely modify or transmute the objects produced by nature.

In his authoritative *Principles of Political Economy*, John Stuart Mill ([1848] 2006) also explicitly acknowledges nature as a producer, though he also recognized its limitations as such. Towards the beginning of this work, Mill cites a variety of nature's products generated by natural causes, including the bees that produce honey and some caves that could be used by people for shelter:

> It is to be remarked, that some objects exist or grow up spontaneously, of a kind suited to the supply of human wants. There are caves and hollow trees capable of affording shelter; fruit, roots, wild honey, and other natural products, on which human life can be supported; but even here a considerable quantity of labour is generally required, not for the purpose of creating, but of finding and appropriating them. In all but these few and

[1] Even in this instance, however, it is to be remarked that the kelp is burnt *by human agents* to yield alkaline salt.

> (except in the very commencement of human society) unimportant cases, the objects supplied by nature are only instrumental to human wants ([1848] 2006, 25).

While Mill was familiar with the existence of such original or natural objects, however, he affirmed that they were, on the whole, scant and relatively unimportant to economic science. Nature's productions almost always require a significant amount of human labour to not only locate, but to prepare and process for human consumption.

Classical political economists and their immediate predecessors recognized nature's productions, particularly their use value, but they generally viewed such productions as capricious and manifestly deficient for human purposes. Nature's unassisted productions were certainly not produced *for* human beings and, therefore, it is unsurprising that they almost always fell short of the standards set by humanity's predilections. Most of the goods and services that were bought and sold in the marketplace bore the stamp of human labour, either directly or indirectly through manufactured machines. Thus, it is for good reason that, when it came to economic production, economic theorists almost always focused on the goods and services directly produced by human agency in combination with other factors of production, such as land and capital. Given the spontaneity of nature's productions, along with the underlying supposition that such productions could always be improved by labour, it is unsurprising that this category of production was eventually expelled from economic discourse altogether.

In her book *The Natural Origins of Economics*, Margaret Schabas (2005, 5) argues that, by the mid-nineteenth century, John Stuart Mill's political economy

rendered explicit the role of human agency as the framework for economic analysis. Before Mill, economic theorists regarded their target phenomena as part of the same natural world that was to be studied by natural philosophers (see Davis 1989 as well). However, as the marginal revolution took hold during the 1870s, this viewpoint among economic theorists began to wane. Thus, it comes as little surprise to hear the prominent capital theorist Luigi L. Pasinetti open his *Lectures on the Theory of Production* by stating, "one of the most outstanding characteristics of human societies is, without doubt, that *they* produce the goods and services which they need" (1977, 1; emphasis added). This univocal emphasis on human agency as the chief source of goods and services to be consumed by human agents is not Pasinetti's own quirky view, but is one that, by and large, was shared among economists throughout the twentieth century.

During this period, the majority of production functions and economic growth models, first popularized by Robert Solow (1956), posited two and only two factors of production: capital and labour.[2] This convention was to be enshrined in the Cobb-Douglas production function where the familiar formula $Y = K^{\alpha}L^{\beta}$ represents total aggregate production (Y) that depends on capital (K) and labour (L) (and $\alpha + \beta = 1$). As for the status of "Land", a mainstay of classical political economy, this factor of production was dropped from such formulations under the implicit assumption that capital could always serve as a substitute for land. As the environmental economists Klaus Hubacek and Richard van der Bergh observe, "by the second half of the 20th Century land or more generally environmental resources, completely disappeared from the production function and the shift from land to other natural inputs to capital and

[2] My claim is not that no economist has ever cited land as a factor of production in a mathematical production function.

labour alone" (2006, 15). Similarly, the economists William D. Nordhaus and James Tobin explain that:

> The prevailing standard model of growth assumes that there are no limits on the feasibility of expanding the supplies of non-human agents of production. It is basically a two-factor model in which production depends only on labor and reproducible capital. Land and resources, the third member of the classical triad, have generally been dropped … the tacit justification has been that reproducible capital is a near perfect substitute for land and other exhaustive resources (1972, 14).

Since capital is universally viewed as a factor of production that we humans produce, one that invariably depends on the *ex-ante* savings decisions of economic agents, such formulations portray the production of all economically valuable goods and services as emerging from human agency alone.[3] Even when the aggregate variable of "resources" was ultimately introduced to such formulations after the oil shock of 1973, when economists were genuinely concerned with the question of sustained economic production in the face of a declining stock of fixed resources, this variable was largely taken to represent a conglomerate of inert materials that were capable of producing only when conjoined with the other two factors of production, capital and labour (see, for example, Dasgupta and Heal 1979; Solow 1974). Recounting how economists generally treat nature and resources, Dasgupta states that "we economists see nature, when we

[3] While it is true that the increase in capital is motivated by *ex-ante* savings decisions, it is the *ex-post* realization – the interaction with other factors of production – that determines whether capital is actually accumulated over time.

see it at all, as a backdrop from which resources and services can be drawn in isolation" (2009, 2). Under this view, Nature is depicted as a repository of sorts, one that is generally taken to be located in a realm beyond human agency, where there exists a collection of items that, to be rendered useful, are transformed to serve human ends. This image, by and large, portrays Nature as merely furnishing the materials that are to be subsequently used as inputs in human-directed, technological forms of economic production. For the purpose of this dissertation, I will refer to this view as the *Warehouse Image of Nature*.

A main claim of this dissertation is that the relatively new concept of "natural capital" subverts this orthodoxy. No longer is Nature regarded as a collection of inert materials to be improved by human labor and manufactured capital, or one that is subject to human-centered technological production processes alone; rather, nature is, to an increasing extent, taken to be a blind or mindless producer of economically valuable goods and services. Instances of natural capital, often construed as ecosystems, a concept that is borrowed from the science of ecology, are claimed to be capable of independently producing a wide variety of goods and services. The environmental economists Edward B. Barbier and Geoffrey Heal state,

> A new paradigm is emerging in environmental economics. It views the natural environment as a form of capital asset, natural capital … Natural capital consists not only of specific natural resources, from energy and minerals to fish and trees, but also interacting ecosystems. Ecosystems comprise the abiotic (nonliving) environment and the biotic (living groupings of plant and animals species called communities. As with all

> forms of capital, when these two components of ecosystems interact, they provide a flow of services. Examples of such ecosystem services include the water supply and its regulation, climate maintenance, nutrient cycling, and enhancing biological productivity (2006, 1).

This relatively new view of nature is captured by the concept of natural capital, which denotes, among other things, a rich variety of active, modifiable, and economically valuable production processes and structures that are afforded to human agents by nature, *gratis*.[4] Under this view, the whole world does not merely consist of a pile of inert materials waiting to be rearranged or modified by human agents as it did under the Warehouse Image, but includes a diversity of unproduced "natural mechanisms" or "natural machines" that are generally found and then subjugated to serve human ends (Daly and Costanza 1992). While it remains true that the ecosystems denoted by the concept of natural capital can be modified and improved to better serve humanity's predilections, as will be argued in Chapter Five, these ecosystems cannot be described as producing for any particular purpose independent of those attributed to them by intentional human agents. Under this view, which I will term the *Garden Image of Nature*, the ideal state of affairs is to have every last ecosystem producing goods and services for human agents. This image foresees the whole Earth as a kind of garden, one that consists of natural objects purposefully arranged and modified by intentional human agents to serve their own objectives. In short, the world as a garden enmeshes productive processes found in nature by adapting them to human wants and

[4] Chapter Three will explain why this is a relatively new view of nature and not merely "Physiocracy restored".

needs. Figure 1 outlines some of the main differences between the *Warehouse Image of Nature* and the *Garden Image of Nature*, many of which will be drawn upon and detailed throughout the remainder of this dissertation.

WAREHOUSE Image of Nature	**GARDEN Image of Nature**
Emphasis on humans as the exploiters of natural resources.	Emphasis on humans as managers or stewards of "natural assets".
Pristine wilderness exists on Earth in the sense that there is "Nature" beyond the realm of human agency.	No pristine wilderness left on Earth in the sense that there is "nature" beyond the realm of human agency.
Emphasis on passive or inert materials.	Emphasis on active materials (ecosystems/biodiversity).
Emphasis on passive or inert materials as inputs to human-directed technological forms of production.	Emphasis on nature's unassisted and assisted productions.
Nature (or "land") is indestructible.	Natural processes are depletable or depreciable.
The ecological conditions required for human economic activity are taken as given.	The ecological conditions required for human economic activity are not taken as given.

Figure 1. The Warehouse Image and Garden Image of Nature

Recognizing that nature is "productive" in this sense has significant consequences for economic science, not least because it implies that non-human agency is a proximate cause of economic phenomena. Another noteworthy consequence of the Garden Image is that nature *qua* collection of economically valuable natural machines is to be treated like all other forms of capital: to be managed efficiently. Thus, the Garden Image not only involves treating parts of nature in ways that they were not treated before – in this case, as capital assets – but it also involves an extension of the human economic realm to a whole range of phenomena that were not so explicitly recognized by economists operating under the *Warehouse Image of Nature*.

Before outlining the remaining five chapters of this dissertation, more needs to be said about the economist's ideal of the world as a garden. In fact, the notion of nature as a garden is hardly a novel idea. The environmental historian, Carolyn Merchant (2004, 1996, [1980] 1990) for one, has convincingly argued that the whole of Western culture is, in actuality, a recovery narrative from the Fall of Man. On Merchant's account, there are three main subplots that organize her argument: the Genesis story of the fall provides the beginning; science and capitalism, the middle; recovery of the garden, the end. The ultimate objective of Western culture, according to Merchant, has been to reinvent the Earth, thereby recovering the Garden of Eden. She convincingly shows that the original "Baconian-Cartesian-Newtonian project" was based on developing the power of technology in order to subdue, dominate, and master Nature so as to hasten the return to the Garden of Eden. This recovery plot was to be a long and slow process that would necessarily involve laboring in the Earth but that would ultimately return humans to their original Edenic state. Merchant (1996) argues that mechanistic science itself was originally developed for the purpose of reinventing the Garden of Eden on Earth. Bacon's *Novum Organum* in particular was meant to be part of *Instauratio magna* or "the great restoration" – to reorganize the sciences for a very specific purpose: to restore the mastery over Nature that was lost by the fall. In this canonical work, Bacon states that, "Man by the fall, fell at the same time from his state of innocency and from his dominion over creation. Both of these losses can in this life be in some part repaired; the former by religion and faith; the latter by arts and science." Humans, he asserted, could still "recover that right over nature which belongs to it by divine bequest," and should endeavour "to establish and extend the power and dominion of the

human race itself over the [entire] universe".[5] Nature "is either free and follows her ordinary course of development as in the heavens, in the animal and vegetable creation, and in the general array of the universe; or she is driven out of her ordinary course by the perverseness, insolence, and forwardness of matter and violence of impediments … or lastly she is put in constrained, molded, and made as it were new by art and the hand of man; as in things artificial."[6]

The simple point being made here is that the image of nature as a garden is certainly not without precedent. For the purpose of this dissertation when I state that the economist's *ideal* is to view the whole world or nature as a garden, I want to be very clear about what I mean. I mean that, according to economists who deploy the concept of natural capital, including Partha Dasgupta, Charles Perrings, Herman Daly, Edward B. Barbier, and Geoffrey Heal, the Earth is, increasingly comprised of economically valuable ecosystems and that such items are to be arranged and managed, like any other kind of capital, for the benefit of human beings and their interests. Unlike Merchant's historical claim that certain prelapsarian ideals were fundamental to establishing the modern period that was characterized by the rise of modern science, I make no claim that economists seek to restore the Garden of Eden on Earth. Again, what I am claiming is simply that the ideal of nature among economists now envisions every last object in our ecosystems serve human needs. This claim, although compatible with Merchant's thesis, should not be viewed as endorsing it. Nature as a garden consists of what would

[5] Francis Bacon is quoted by Merchant (1996, 136). Donald Worster also describes Bacon as promising to remake nature and improving it for the human condition in general. He states, "Bacon promised to the world a manmade paradise, to be rendered astonishingly fertile by science and human management. In that utopia, he predicted man would recover a place of dignity and honor, as well as the authority over all the other creatures he once enjoyed in the Garden of Eden" (1977, 30).
[6] Bacon is quoted by Merchant ([1980] 1990, 170).

otherwise be natural objects that have been co-opted and purposefully arranged by intentional human agents to serve our own ends.

Perhaps the clearest vision of what I mean by the world as a garden was put forward by none other than Thomas Henry Huxley, Charles Darwin's bull-dog. In his *Evolution & Ethics* ([1893] 2009), Huxley invokes the Hobbesian distinction between the "state of Nature" and the "state of Art". We are told that the former possesses products – "works of nature" – that have been created solely by "the cosmic process" while the latter, which is separated from the state of Nature by a wall, is filled with items that have been created, sustained and, for their continued existence, remain dependent upon mankind's incessant activities. Huxley refers to this "state of Art" as a kind of garden, which is "as much a work of art, or artifice, as anything that can be mentioned" ([1893] 2009, 10).

Huxley also maintains that Nature is forever hostile to the garden and therefore, the gardener must constantly maintain his work of art. Huxley states, "the tendency of the cosmic process is to bring about the adjustment of the forms of plant life to the current conditions; the tendency of the horticultural process is the adjustment of the conditions to the needs of the forms of plant life the gardener desires to raise" ([1893] 2009, 13). Fascinatingly, Huxley did not believe that Darwin's (1859) mechanism of natural selection operated in the garden since man *qua* gardener or horticulturalist selected the traits of organisms to merely suit *his* fancy and not for any other purpose. Huxley states:

> The gardener … restricts multiplication; provides that each plant shall have sufficient space and nourishment; protects from frost and drought;

> and, in every other way, attempts to modify the conditions, in such a manner as to bring about the survival of those forms which most nearly approach the standard of the useful, or the beautiful, which he has in mind ([1893] 2009, 14).

Indeed, Huxley's hero in *Evolution & Ethics*, the horticulturalist, cannot but manage the whole garden according to his own ends and purposes, whether these devotions are grounded in aesthetic value or usefulness. Huxley goes so far as to imagine, as did his student, H.G. Wells, that the gardeners might, one day, even establish an earthly paradise – "a true garden of Eden" – in which all things serve the gardeners and their well-being.[7] Under this state of affairs, with the garden under the firm grip of the gardeners, Nature, or the cosmic process that is characterized by "the coarse struggle for existence of the state of nature", would be completely eliminated. There would be no more Nature since the state of nature would be superseded by a state of Art. This state of affairs is characterized by "every plant and every lower animal [being] adapted to human wants" ([1893], 2009, 19-20).

With the *Garden Image of Nature* made plain, the next chapter introduces criteria for distinguishing natural capital from manufactured capital, and lays out a

[7] Huxley's most enthusiastic student and author of *The Time Machine*, H.G. Wells, seems to have followed in the footsteps of his great teacher when he depicts the Earth of the distant future (the year 802, 701 AD, to be exact) as a garden. In chapter four of this novel, the main character – the Time Traveller – states, "there were no hedges, no signs of proprietary rights, no evidences of agriculture; the whole earth had become a garden." Although Huxley draws a firm distinction between agriculture – the farm – and the garden in this quotation, the distinction is not entirely obvious. It should also be remarked that the co-founder of the theory of evolution by natural selection, Alfred Russell Wallace (1864), also anticipated the day when the future of the Earth would become entirely domesticated. In *The Origin of Human Races and the Antiquity of Man Deduced From the Theory of Natural Selection*, Wallace states, "we can anticipate the time when the earth will produce only cultivated plants and domestic animals; when man's selection shall have supplanted "natural selection"' and when the ocean will be the only domain in which that power can be exerted, which for countless cycles of ages ruled supreme over all the earth" (1864, clxviii).

working definition of "Nature" for the purpose of this dissertation. It will be argued that since natural capital is conceived by contemporary economists as both a homogeneous fund of value and as a set of concrete heterogeneous particulars, it has what historians of economic thought have termed a (1) dual nature. The spatio-temporal particulars denoted by the concept of natural capital, such as ecosystems, are objects (2) capable of producing, (3) depletable, (4) beneficial, (5) original, and (6) self-generative. This chapter argues that, among these six characteristics, the first four are shared with manufactured capital, while the last two – original and self-generative – drive a wedge between natural and manufactured capital.

Chapter Three, "Natural Capital: Novel Concept or the Same Old Stew?", explores in greater depth some of the assertions and claims made at the outset of this chapter by tracing the historical roots of nature conceived as a producer in the works of the Swedish botanist Carl Linnaeus' (1749) *Oeconomia Naturae* and the Physiocrats of France during the mid-18th Century. This chapter argues that if natural capital is taken to denote nature as an unassisted producer of readily consumable goods and services, then it can hardly be considered a novel concept. There is a nascent category of the concept of natural capital to be unearthed in the writings of classical political economists, such as Adam Smith, John Stuart Mill, and Karl Marx. When such economic theorists referred to the "spontaneous productions of the Earth" and nature's "natural products", they had a distinctive class of production in mind, one that denotes nature's independently generated products.

Chapter Four, "Critical Natural Capital and Sustainable Development", tackles a version of the most vexing question concerning natural capital: to what extent can manufactured capital serve as a substitute for natural capital? Economists influenced by

the life sciences have long argued that there is a subset of natural capital, *critical* natural capital, for which there are no substitutes. This special category of natural capital is meant to denote the ecological conditions essential to the continued existence of economic agents and therefore, sustainable development. However, the problem is that no one has explained what these conditions might be and why they are essential for this purpose. To resolve this issue, this chapter introduces a new theory of "basic ecological goods" (BEGs). It is shown that BEGs are distinct from ordinary goods in consumer choice theory since the former are objective ecological conditions that must be met for the continued existence of economic agents. BEGs are required for the continued existence of a given agent because they possess objective causal properties essential for this purpose. The upshot of this theory is that the ecological conditions required for human economic activity and, therefore, sustainable development, are no longer shrouded in mystery as they were under the canopy of "critical natural capital". The theory of BEGs explains what these minimal ecological conditions are and what conditions would have to be met for any good to *potentially* serve as a substitute for such goods.

Chapter Five, "No One Can Preserve Nature", begins by recognizing a corollary of the *Garden Image of Nature*. At first glance, this ideal view of Nature would seem to entail domesticating every last economically valuable ecosystem to serve human ends. As a result, the status of "wild ecosystems", "wilderness", and "untrammeled Nature" are called into question. While this chapter does not consider the desirability or goodness of such a domesticated world, it does argue that the preservation paradox is warranted. This paradox, well-known among environmental ethicists, contains three premises: nature is that realm of phenomena that is independent of intentional human agency;

preserving and restoring Nature requires intentional human agency; therefore, no one can preserve (or restore) Nature. While some scholars have argued that the preservation paradox is misguided, this chapter argues that no one can restore or preserve nature without turning it into an artifact. To defend this claim, this chapter delineates three features that distinguish artifacts from natural objects: artifacts are designed or planned, they possess a function attributed to them by an intentional agent, and they must be modified by an intentional agent. By relying on James Woodward's (2003) analysis of absence causation, this chapter argues that even those aspects of Nature that are merely preserved, where human activity is intentionally omitted, qualify as artifacts.

Finally, Chapter Six concludes by acknowledging the limitations of this dissertation and by considering a future direction of research: delineating the moral limits to buying and selling natural capital and ecosystem goods and services. Specifically, an argument is sketched for the moral limits to buying and selling water. Following the recent work of Michael Sandel and Debra Satz on the moral limits to markets, it is argued that, in desperate circumstances, when water is radically scarce, buying and selling water in the marketplace will almost certainly violate what Robert Nozick (1974) refers to as "Locke's Proviso" – a constraint on original acquisitions that requires such activities do not worsen the situation of others.

CHAPTER TWO

On Nature and Capital

The subject of this dissertation is the concept of natural capital in economics. Both "Nature" and "capital" are notoriously capacious terms, a statement that makes "natural capital" all the more perplexing. What makes matters worse, at least for the philosopher of economics, is that when deploying the concept of natural capital, economists rarely begin by first delineating the precise meaning of the terms "nature" or "capital". Any reflection on the concept of natural capital is bound to give rise to many unanswered questions. What, if any, concept of "Nature" is presupposed by the economists who deploy the concept of natural capital? What does it mean for natural capital or Nature to "produce" anything at all, let alone welfare enhancing goods and services that are to be consumed by human agents? Why are some natural processes, and not others, denoted by the concept of natural capital? Do harmful natural processes count as instances of natural capital or is it only those processes that are judged to be beneficial to human agents in some way? What or who determines whether any natural process is beneficial or harmful? How is natural capital distinct from ordinary man-made or manufactured

capital? Is natural capital merely a species of capital or is it something else altogether? These conceptual questions have not been adequately addressed in the literature and, without answering them our understanding of natural capital remains an impoverished one. The purpose of this chapter is to help fill this void by establishing a coherent picture of natural capital as it is used by economists.

This chapter proceeds by first distinguishing natural capital from manufactured capital and then proposes a working definition of the concept "Nature". Before developing an account of natural capital, a few caveats are in order. The focus of this dissertation is the concept of natural capital in economics, but natural capital is not a concept that is only used by economists. Natural capital is an interdisciplinary concept that has been, and continues to be, employed by a wide variety of biophysical scientists, including conservation biologists, and ecologists. Indeed, many such non-economists have done much (perhaps the most) to popularize the concept of natural capital; this is particularly true for the related concept of "ecosystem services". Moreover, such biophysical scientists continue to publish original books and research articles on the topic of natural capital and ecosystem services, not only in biology and ecology journals, but in the top environmental economics journals as well, including, for example, *Ecological Economics*, *Journal of the Association of Environmental and Resource Economists*, *Environmental and Resource Economics*, and the *Journal of Environmental Economics and Management*. Indeed, many such publications are co-authored with the best environmental and resource economists, including the Nobel Prize winner, Kenneth Arrow, and the Cambridge economist, Partha Dasgupta, as well as Charles Perrings, Herman Daly, Edward B. Barbier, Bob Costanza, and Geoffrey Heal. Despite the artificial boundaries circumscribed by this project – the concept of natural

capital in economics – the reader should keep in mind that natural capital is not a concept that is hermetically sealed-off from other sciences. On the contrary, I would conjecture that, when it comes to the concept of natural capital, there is significant conceptual trade between economics and the biophysical sciences and that it is almost certainly the case that natural capital in economics has been, and will continue to be, shaped by this interaction. Therefore, the reader should recognize that, from time to time, this dissertation will invoke the research of biophysical scientists, but that the purpose for doing so is to illuminate the concept of natural capital as it is used by a growing number of economists, such as those just mentioned.

The ideal would appear to require establishing necessary and sufficient conditions for natural capital since doing so would enable one to arbitrate between the correct and incorrect uses of this concept. With such a definite concept, one could then determine, for any given thing, whether it is an instance of natural capital. Establishing such rigid boundaries around the concept of natural capital would be a misguided project, however. Although environmental economists today share a relatively stable understanding of the concept, establishing necessary and sufficient conditions for natural capital seems unnecessary and at worst, imprudent. Indeed, it would appear that no single definition is able to pin down all the necessary and sufficient conditions for the concept. Be that as it may, relinquishing the prospect of establishing necessary and sufficient conditions for natural capital still leaves a lot of room to advance a useful account of natural capital that will help to shed some light on this relatively new means of production, not only for its own sake, but to inform the problems faced in the remaining chapters of this dissertation.

To begin with, it is worth recognizing that many economists use the concept of "natural capital" as a blanket term to denote the entire resource base.[8] However, the far most interesting use of this concept is when it is used to denote specific welfare-enhancing entities and processes that are capable of producing without direct human intervention. On the whole, I submit that natural capital has (1) a dual nature, which means that it is conceived both as a homogeneous fund of value and as concrete heterogeneous particulars. These temporally and spatially located particulars are (2) capable of producing, (3) depletable, (4) beneficial, (5) original, and (6) self-generative. Each of these characteristics requires elaboration and, as we will see below, their attribution to particular instances of natural capital is also qualified in some way. By and large, I will maintain that the first four characteristics just given are shared with what economists refer to as manufactured capital, while the last two – "original" and "self-generative" – drive a wedge between these two species of capital. While it is true that instances of natural capital can be original and self-generative, probably no instance of manufactured capital possesses either of these properties.

"Capital" is a notoriously contested term. What do economists mean by capital when invoking the concept of natural capital? Invariably, when economists today treat nature or certain parts of nature as capital, they are treated as a means of production – a factor of production that is capable of producing goods and services which possess economic value. This is true in cases where natural capital is an aggregate variable in production functions and it is also true when specific processes denoted by the concept of natural capital produce economically valuable goods and services. This conception of capital as a means of production might well be considered a Schumpeterian pre-analytic

[8] For example, Dasgupta (2009) refers to natural capital as a "mesh of resources".

vision of capital that has roots in the writings of Adam Smith ([1776] 1976) and other economic theorists, such as David Ricardo (1817), Thomas Robert Malthus (1820), and Jean Baptiste Say (1821).[9] Indeed, to gain a better understanding of what contemporary economists mean today by capital when they invoke the complex concept of natural capital, it will be valuable to provide a brief historical survey of capital on its own terms.

The Physiocrats of France were the first to develop a clear outlook of capital and its role in production (Hennings [1987] 1990). These self-described "économistes", most prominent in France circa 1750-1770, rejected the reigning Mercantilist doctrine of privileging foreign trade to enlarge the Kingdom's "stock". In their circular-flow model, the Physiocrats showed that farmers, combined with the natural powers of nature, are the only productive social class (Meek 1962). The other two classes in the model, the landowners and artisans, rely on the farmers for their basic needs and subsistence. The latter are considered all but "sterile" because while manufacturers might succeed in transmuting various natural objects into useful items, such actions are mere modifications and do not represent true production. In this model, nature yields a surplus or "produit net" that circulates annually among the three main social classes. Capital was principally understood as an "advance", a pre-condition to the whole production process that derived from the wealthy landowning class (Hollander [1987] 1992). Such advances were directed to the agricultural sector (to invest in seed, buildings, drainage, hired labor, oxen, ploughs, and other improvements) where it was used to sustain the farmers during the production process. Among historians of economic thought, it is worth emphasizing that it is generally held that the Physiocrats claimed nature alone was truly productive.

[9] See Schumpeter (1954).

John Locke, in his *Second Treatise of Government* ([1689] 1980), had argued that the original source of value derived from mixing one's labour with physical goods. God gave nature in common to all of mankind and the penury condition of man required him to labour. Endowed with industriousness and rationality, mankind was obligated to subdue the earth and improve it for the benefit of life. Unassisted nature, for Locke, produced virtually no value at all. In fact, he argued that unimproved land is waste, "the benefit of it amount[s] to little more than nothing" ([1689] 1980, 26; my brackets). In stark contrast to the Physiocratic position, Locke supposed that nature provided man with inert or passive materials that were to be acted upon and improved:

> of the products of the earth useful to the life of man nine tenths are the effects of labour: nay, if we will rightly estimate things as they come to our use, and cast up the several expences about them, what in them is purely owing to nature, and what to labour, we shall find, that in most of them ninety-nine hundredths are wholly to be put on the account of *labour* ([1689] 1980, 25; italics in the original).

In *The Wealth of Nations* ([1776] 1976), Adam Smith is decidedly Lockean when he argues that the first price of anything is the toil and trouble of acquiring it. Be that as it may, there are also clear vestiges of Physiocratic thought in Smith's *magnum opus*, particularly in those passages that refer to agricultural production. The productivity of nature is displayed prominently when Smith states:

> in agriculture … nature labours along with man; and though her labour costs no expence [sic], its produce has its value, as well as that of the most expensive workmen. The most important operations of agriculture seem intended, not so much to increase, though they do that too, as to direct the fertility of nature towards the production of the plants most profitable to man ([1776] 1976, 363).

But while Smith agreed with the Physiocrats that nature had a role to play in the agricultural sector, he did not maintain that all value derives from the ground. Similar to his immediate predecessor, A.R.J. Turgot ([1770] 1898), who placed commerce and manufacturing on equal footing with agricultural production, Smith departs from the Physiocratic view of manufacturing as sterile. Rather, he insists that, in the manufacturing sector, nature does nothing and man "does all".[10]

Smith's conception of "stock" corresponds to the Physiocratic conception of "advances" in at least one fundamental way: the accumulation of capital is only made possible by the thrift or prior abstinence of its owner. But Smith goes even further, arguing that capital is a pre-condition to the division of labour, a time-intensive roundabout production process, that itself serves to create ever more capital. Otherwise, when Smith employs the term "stock" throughout *The Wealth of Nations* he means one of two things: either the capital that affords its owner revenue in production or that

[10] On the contrary, in his *Principles of Political Economy and Taxation*, David Ricardo ([1817] 1951, 76) asks, "Does nature do nothing for man in manufactures? Are the powers of wind and water, which move our machinery, and assist navigation, nothing? The pressure of the atmosphere and the elasticity of steam, which enables us to work the most stupendous engines – are they not the gifts of nature? To say nothing of the decomposition of the atmosphere in the process of dyeing and fermentation. There is not a manufacture which can be mentioned, in which nature does not give her assistance to man, and give it too, generously and gratuitously."

portion of stock that supplies its owner with the means for immediate consumption. Smith further divides the category of capital into either an agglomeration of physical things, instances of "fixed capital", such as machines or livestock, or "circulating capital", an investment fund that is more or less freely available to be directed towards alternative uses. Furthermore, Smith tells us that different kinds of occupations and production processes will require different degrees of fixed and circulating capital and that, generally, there is an inverse relationship between stocks and profits.

Classical political economy was initiated by Smith, and consolidated by David Ricardo's *On the Principles of Political Economy and Taxation* ([1817] 1951). Ricardo maintained, with Smith, both the distinction between fixed and circulating capital and the proposition that capital is a produced means of production that requires continuous maintenance. Land, which occupies a prominent role in Ricardo's "corn model", represented the "original and indestructible powers of the soil" ([1817] 1951, 67). Unlike capital, Ricardian land did not depreciate over time. It was also considered more or less permanent and fixed in supply. Land was treated as distinct from capital, not only because it did not have a period of production but also because it was the only non-reproducible (by human effort) factor of production.

When John Stuart Mill endorsed Ricardian economics in his *Principles of Political Economy* ([1848] 2006), it was effectively crystallized in the minds of political economists until the neo-classical revolution began in the 1870s. Mill defined capital as a previously accumulated stock that affords assistance to labourers in the production process. Thus, capital is a subset of wealth whose origin necessarily lies in prior human agency. In physical terms, instances of capital, such as the machines used in the manufacture of commodities, are simply modified "appropriate natural objects" that

human agents locate in their environment and transmute to their benefit. While Smith had insisted that in the manufacturing sector nature does nothing, Mill, like Ricardo before him, argued that nature's powers are used to produce all commodities. Capital goods are employed by human agents for a particular purpose or goal and, therefore, it is human agents who ultimately determine whether any object is capital.

When Mill claims that labourers engaged in a production process subsist on previously accumulated capital, he shares the opinion of a long line of classical political economists. Capital can be conceived as a "fund" – the part of one's possessions committed to carrying on a new production that is provided to labourers in advance. Without capital, we are told that current production can only be directed towards the immediate sustenance of labourers; circulating capital gives rise to the possibility of a longer production process because it provides labourers with the necessaries that are consumed during the production process. Capital affords labourers with shelter, protection, tools, and other requisite materials in a production process and therefore, it can manifest itself in a variety of forms, including buildings, machines, or inventory. It can also be more or less permanent (sunk capital).

Although capital is the product of human agency and arises due to some degree of abstinence from immediate consumption, Mill is emphatic that all capital is eventually consumed as well. Drawing an analogy to the human population, he argues that capital is sustained, not by preservation, but by perpetual reproduction. Everyone eventually dies, but if births exceed deaths every year, the population will always increase. The same can be said for the stock of capital. Although not a single person who composed the original population is alive today, and was not alive until a very recent date, the overall population today far exceeds the population of earlier times. Similarly, in the

case of capital, sustaining this means of production over time requires humans to constantly engage in its perpetual reproduction.

The marginal revolution, initiated by William Stanley Jevons ([1871] 1957), Léon Walras ([1874] 1954), and Carl Menger ([1871] 1981), involved a turn away from fundamental classical tenets, such as the labour theory of value, class conflict, the wages fund doctrine, and Malthus's doctrine of population; these rudiments were replaced by individualism, utility maximization, a subjective theory of value, and a penchant for mathematical formalism. The revolution caused something of a rupture in how economists conceived of capital as well.

Daniel Hausman (1981) explains that most early neoclassical capital theorists began to associate capital exclusively with some factor of production, usually a fund conception of capital, and to regard the rate of interest as its price. Notwithstanding some agreement among theorists, capital persisted as a vague term. Competing theories of capital led to no fewer than three so-called "capital controversies" throughout the twentieth century. The first was between John Bates Clark and Eugen von Böhm-Bawerk, mostly in response to Marx's theory of capital (Cohen 2008); the second involved the Chicago economist Frank Knight, who attacked Friedrich Hayek and the Austrian idea of a "period of production"; the third "Cambridge Capital Controversy" was initiated by Joan Robinson (1953) and involved capital theorists at the Cambridges on both sides of the Atlantic. While the technical details of these controversies do not concern us here, the competing conceptions of capital do.

Irving Fisher, the foremost pre-war American economist, defined the interest rate as "the per cent of premium paid on money at one date in terms of money to be in hand one year later" (1930, 13). According to some historians of capital theory, this was

capital theory without mention of either capital or its marginal product (Cohen and Harcourt 2003). John Bates Clark claimed that capital earns interest because it is scarce and has a positive marginal product. According to Clark, there are short-lived heterogeneous concrete physical capital goods but the greatest emphasis should be placed on the conception of capital as a quantum or permanent fund of productive wealth embodied in capital goods. For Frank Knight (1936), concrete capital goods were almost completely abandoned. He preferred an abstract conception of capital similar to that defended by Clark (Mehta 2003). Knight's conception of capital was "a homogeneous mass which was created by saving decisions, which could be invested in one industry and transferred to another, which was productive in the sense that it has a non-negative marginal product if used properly" (Hennings [1987] 1990, 116). Today, this Clark-Knight conception of capital as a distinct and productive homogeneous factor of production that earns interest and possesses a positive marginal product remains largely intact among neo-classical economists.

Austrian economists such as Böhm-Bawerk criticized Marx's claim that the return to capital involved the exploitation of labour and argued that capital ultimately resolved itself into "saved up" labour and land. Böhm-Bawerk disagreed with what he considered to be Clark's mysterious permanent fund of productive wealth and states, "Clark thinks of capital as a quantum of value 'imputed' in material goods. He strips off everything which may suggest material existence and retains only a value jelly, existing eternally" (1907, 280).[11] In his *Positive Theory of Capital*, Böhm-Bawerk (1891) argued that any production process involving capital, or intermediate goods, always involved more *time* compared to the immediate or direct production of goods. For the Austrians, time is

[11] As quoted by Cohen and Harcourt (2003).

fundamental to capital because production with capital is a "roundabout" process. According to this theory, the increased productivity of capital-intensive production processes explains why there is an interest rate and thus the "average period of production" is central to the Austrian theory. For Knut Wicksell, whose account of capital and interest became the standard portrayal of the Austrian theory of capital and interest, interest is simply the difference between the marginal productivity of saved up labour and land and the marginal productivity of current labour and land (Hennings [1987]1990; Hausman 1981).[12]

Historians of economic thought have argued that the recurring controversies in capital theory are due to the "dual nature" of capital. Avi J. Cohen and Geoffrey Harcourt state: "capital theory controversy commonalities originate in the dual nature of capital. Economists conceive of capital both as a heterogeneous collection of specific capital equipment used in production, and as a homogeneous fund of financial value that flows among alternative uses to establish a uniform rate of return" (2005, xxvii). This dual nature of capital, as we have seen, traces back to at least Adam Smith and refers to two different aspects or conceptions of capital. On the one hand, there is the physical, tangible, material, heterogeneous capital-as-goods conception where specific instances of capital might be used in disparate production processes and, on the other hand, there is the abstract homogeneous fund conception of capital as value that can be readily directed to its most valued use. Controversy in capital theory erupts when one of these conceptions is emphasized to the general neglect of the other (Cohen and Harcourt 2005).

[12] Others, aside from the Austrians, drew upon Wicksell's work as well. Such economists include the Swedish school of the 1930s, Keynes and the Keynesians, and recent monetary economists such as Michael Woodford.

I argue that natural capital, much like manufactured capital, also has a dual nature. Economists conceive of natural capital both as an abstract homogeneous fund and as specific concrete heterogeneous particulars. In fact, these two conceptions can also be said to constitute a boundary between what are two relatively distinct literatures on natural capital. In the first case, natural capital is a variable embedded in aggregate models of sustainable development. When natural capital is deployed in this sense, it invariably represents the social value of all renewable and non-renewable resources in an economy. By underscoring the totality of natural capital as an abstract homogeneous fund, this conception abstracts from the particularities or specificities that might be possessed by disparate forms of natural capital. In the second case, natural capital is customarily tied to the related concept of "ecosystem services" and instances of natural capital are considered in much more precise terms. In this second sense, natural capital denotes specific causal structures or mechanisms, many of which are *found* or discovered rather than made. Such "natural machines" are claimed to produce regularities that are beneficial or welfare enhancing to human agents.

The first conception of natural capital – the fund conception – is central to what the philosopher Bryan Norton (1992) describes as the "social-scientific approach" to sustainable development. This approach, originally developed by the Robert Solow (1974) and John Hartwick (1977), involves sustaining the productive capacity of an economy over time where "productive capacity" is represented by the aggregate level of capital, including natural capital, in an economy.[13] Such models follow the "Hartwick

[13] Also, see Solow (1986; 1993a; 1993b) and Hartwick (1978a, 1978b, 1990, 1993). It is to be remarked that Solow began with highly disaggregated Leontief models and that his later one-sector model was meant to be a pedagogically tractable version of the disaggregated model. Because of this, there is reason to doubt that Solow would accept that capital really is, fundamentally, a homogeneous aggregate (see Halsmayer 2014).

Rule", which requires that, for the goal of sustainable development, total net investment in capital to remain above or equal to zero (Neumayer 2003).

Consider, for instance, the most recent instantiation of such models. Kenneth Arrow *et al.*'s (2010; 2012) criterion of sustainability requires that an economy remain capable of providing the current standard of living across generations. This means that each generation must bequeath to its successor at least as large a quantity of an economy's "productive base", which is composed of three capital assets: human, natural, and man-made capital.[14] Man-made capital includes all of the produced means of production, such as machines, factories, and tools; human capital includes knowledge, education, skills, technology, and institutions; the stock of natural capital consists of the traditional renewable and non-renewable resources, but it also denotes various non-market phenomena such as ecosystems. Under this view, the social value of an economy's productive base is considered a country's "comprehensive wealth".

According to Arrow *et al.*'s model, inter-temporal social welfare, $V(t)$, is sustainable if and only if $dV/dt \geq 0$. Because an economy's productive base is a necessary condition for sustainability and the productive base includes three distinct types of capital, it is not surprising that what Arrow *et al.* call "genuine investment" plays a critical role. This represents the sum of the values of investments or disinvestments in each of the capital assets, whereby the value of each investment is the product of the change in the quantity of the asset times the shadow value of that asset. A change in the productive base and $V(t)$ is non-decreasing at t_2 if and only if genuine investment is non-negative at t_1. Therefore, if there is a decline in any one particular

[14] An economy's productive base also includes population, public knowledge and institutions.

capital asset, sufficient investment will maintain the overall stock of capital and the productive base, along with social welfare, will be sustained.

One of the most controversial questions, with respect to this fund conception of natural capital, is the substitutability question: to what extent can man-made capital serve as a substitute for natural capital? If it is true that some particular instances of natural capital have no substitutes then, *ceteris paribus*, its depletion would be catastrophic for the future generations that endeavor to live in a world without it. On the other hand, if manufactured capital invariably serves as a substitute for natural capital, then depleting the latter stock would be much less consequential, at least for human welfare. As we will see in Chapter Four, when a definitive answer is proposed to a version of the substitutability question, some economists have argued that certain instances of natural capital are special because they are limiting factors to economic growth and human economic activity. Scholars who argue for this thesis refer to such features of the environment as *critical* natural capital, a subclass of natural capital that represents the ecological pre-conditions to this activity. Their claim is that there are certain ecological conditions that have no substitutes and, therefore, such conditions must be maintained for the goal of sustainability.

The second conception of natural capital denotes specific and frequently undesigned mechanisms of production. In such cases, natural capital refers to natural machines or heterogeneous instances of what might be cumbersomely termed "natural capital *goods*". The literature covering this conception is both interdisciplinary and enormous. Such instances of natural capital almost always denote specific causal processes — certain unproduced structures or mechanisms — that are generally found and then recast as the means to produce ecosystem goods and services. "Ecosystems" in

this context is a term borrowed from the science of ecology and is generally understood to include a set of organisms living in an area, their physical environment, and the various interactions between them (Daily 1997).[15]

The mapping and valuation of such heterogeneous production processes is a project that involves a division of labour between biophysical scientists, such as ecologists and biologists (who are responsible for the mapping of ecosystem goods and services), and the social scientists (especially economists) who ascribe economic value to such items. This literature consists of various dimensions, including biodiversity and ecosystem function (Xiao and Lee 2000; Acharya 2000; Loreau *et al.* 2001; Swift *et al.* 2004; Barkmann *et al.* 2008; Kareiva *et al.* 2011), the policy and management of ecosystem services (Kroeger and Casey 2007; Koellner *et al.* 2008; Salzman 2005), and valuation techniques (Westman 1977; de Groot 1994; 1987; 1992; Daily 1997; Hein *et al.* 2006; Ansink *et al.* 2008).

This second conception of natural capital was first popularized by Gretchen Daily's (1997) *Nature's Service* and Robert Costanza *et al.*'s (1997) paper published in *Nature*. Daily (1997) defines ecosystem services in anthropocentric terms as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life.[16] Similarly, Costanza *et al.* define ecosystem services as "the benefits human populations derive, directly or indirectly, from

[15] The economist E.F. Schumacher (1973) referred to a concept of natural capital in his book *Small is Beautiful*. He there argued that resources should be treated as depreciable capital assets instead of an income flow.

[16] Barbier (2011) offers a similar definition of "ecosystem". An ecosystem comprises its abiotic (nonliving) environment and the biotic (living) groupings of plant and animal species, or communities. The biotic and abiotic components, and the interactions between them, are termed the "ecosystem structure".

ecosystem functions" (1997, 253).[17] Today, the concepts of "natural capital" and "ecosystem services" stretch across numerous disciplines and have figured prominently in several well-known publications, including Daily's (1997) *Ecosystem Services*: *Societal Dependence on Natural Ecosystems*, the World Bank's *Where's the Wealth of Nations: Measuring Capital for the 21st Century* (2006), Pushpam Kumar's *The Economics of Ecosystems and Biodiversity* (2010), Peter Kareiva's *et al.*'s (2011) *Natural Capital: Theory and Practise of Mapping Ecosystem Services*, and Barbier's (2011) *Capitalizing on Nature: Ecosystems as Natural Assets*.

The most celebrated study on this theme is the World Resources Institute's *Millenium Ecosystem Assessment* (2005).[18] This enormous four-year project, initiated by the United Nations, involved 1,300 scientists and policy makers who considered, for the first time, the condition and trends of the whole world's ecosystems. This study defined "ecosystem services" in very broad terms as the "benefits people obtain from ecosystems", and classified such services into four types: (i) provisioning services (food, fiber, fuel, genetic resources); (ii) regulating services (climate, natural-hazard regulation, disease regulation); (iii) cultural services (places of recreation, sacred groves); and (iv) supporting services (nutrient cycling, soil production).[19]

[17] Daily (1997) and Costanza (1997) did the most to popularize the concept of "ecosystem services", but this concept originates with Westman (1977), who referred to "nature's services"; the conservation biologists Paul and Anne Ehrlich coined the term "ecosystem services" (Ehrlich and Ehrlich 1981). See Gómez-Baggethun *et al.* (2010).

[18] There is also the recently founded interdisciplinary *Natural Capital Project*, a joint venture between Stanford University's Woods Institute for the Environment, the University of Minnesota Institute of the Environment, the Nature Conservancy, and the World Wildlife Fund.

[19] For more literature on the challenge of incorporating "cultural ecosystem services" into environmental assessments, see Satz *et al.* (2013), Chan, Satterfield, and Goldstein (2012), Chan *et al.* (2012), Satterfield *et al.* (2013), Klain and Chan (2012), and Daniel *et al.* (2012).

It is worthwhile to consider a few examples of natural capital in this second sense. One such case is pollination, which involves a pollinator species, such as honey bees, causing the movement of a flower's sex cells, and is normally conceived as the successful fertilization of flowers. Alexandra-Maria Klein *et al.* (2009) submit that species richness is required for natural pollination services and that this diversity of pollinator species in turn depends on habitat features such as suitable soils, tree cavities, and abundant floral resources. The economic benefits of pollination for important crop plants, like tomatoes, celery, rapeseed, cauliflower, papaya, almond, canola, and watermelon, have long been acknowledged (Costanza *et al.* 1997) and recent estimates suggest that the value of worldwide pollination services is approximately €195 billion (Lonsdorf *et al.* 2011).

Another example, canonical in the literature, are the ecosystem services afforded to the residents of New York from the Catskills Watershed. Historically, this watershed afforded the citizens of New York City, upwards of ten million people, with high-quality drinking water. This watershed, which covers 5000-square-kilometers, not only purified the drinking water but meted water out gradually, stabilizing drinking supply and mitigating the possibility of floods (Turner and Daily 2008). Until the early 1990s, the natural water purification processes, by root systems and soil microorganisms, together with filtration and sedimentation, cleansed the water to such a degree that the Environmental Protection Agency's (EPA) standards were met (Chichilnisky and Heal 1998). However, housing development and the pollution from vehicles and agriculture threatened the water quality of the region and in 1991 the EPA ordered New York City to build a water filtration plant, unless the city could somehow maintain water quality without it (Barbier 2011).

By 1996, New York City was confronted with a choice between restoring the Catskills watershed and constructing a water-purification plant. This choice has been construed as one between investing in either natural or manufactured capital. As it turned out, restoring the ecological integrity of the Catskills or investing in the "machinery of the watershed" was less costly than constructing a "human-constructed" water filtration system (Daily and Turner 2008). While protecting and restoring the Catskills was estimated to cost 250 million dollars over ten years (mainly to purchase and set aside over 140,000 hectares in the watershed), the overall cost was expected to reach up to 1.5 billion dollars; by contrast, the total cost of pursuing the alternative path, building and operating the filtration system, was estimated to cost between 6 and 8 billion dollars (Barbier 2011). New York City opted for the former option and, since 1997, has invested nearly 2 billion dollars in "land management changes and innovative tactics such as purchasing land around reservoirs to preserve forests and wetlands that buffer against pollution, paying landowners to restore forest along streams, and offering technical aid and infrastructure to farmers and foresters" (Daily and Turner 2008, 31).

Another example is the ongoing Mangrove deforestation in Thailand (see Sathirathai and Barbier 2001; Barbier 2011, 2008, 2007, 2003). According to Barbier's analysis, there were once two mutually incompatible ecosystem services that the natural mangroves afforded to human agents: they created nursery and breeding habitat for offshore fisheries, and formed a natural storm barrier to frequent coastal storm events, such as tsunamis, storm surges, and typhoons. For decades, it was common practice to convert mangroves into shrimp farms. The assumption was that the shrimp production was profitable. However, Barbier's analysis shows that this activity came with a putative cost since it had the effect of damaging the natural storm barrier provided by the

mangroves. Moreover, after a five-year period, the mangroves that had been converted to shrimp farm ponds could no longer be used for the purpose of shrimp farming since the "soil [became] very acidic, compacted, and too poor in quality to be used for any other productive use" (Barbier 2011, 64). The question Barbier asks is whether the net economic returns to shrimp farming justifies further mangrove conversion to this economic activity or whether is it worth investing in replanting the mangroves to rehabilitate abandoned shrimp farm areas. Barbier (2011) estimates that the annual economic returns to shrimp aquaculture is 322 dollars per ha (when discounted over the five-year period at 10-15 percent yield a net present value of 1,078-1,220 dollars per ha). Restoration costs, on the other hand, were estimated to be between 8,812 and 9,318 dollars per ha in net present value terms. According to these numbers alone, restoring the environments after years of shrimp farming would appear to be economically unfeasible since the restoration costs clearly exceed the net economic returns per ha.

Barbier then estimates the economic value of three ecosystem goods and services – the net income from collected forest products, habitat-fishery linkage, and storm protection service – all of which combine to the approximate value of 10,158-12,392 dollars per ha. This relatively high value not only implies that the decision to prevent shrimp aquaculture operations from occurring in the first place may have been the preferable outcome (since the value of ecosystem services naturally generated by the mangroves when left intact exceed the net economic returns to shrimp farming) but it also makes the *post hoc* restoration activities economically feasible as well. Barbier states, "before the decision to allow shrimp farming to take place, the restoration costs should be treated as one measure of the "user cost" of converting mangroves irreversibly, and this cost should be deducted from the estimation of the net returns to

shrimp aquaculture" (2011, 66). Barbier's study of the mangrove forests in Thailand shows the importance of valuing the ecosystem services generated by natural capital and of taking this information into account when faced with land use decisions.

Another recent study of natural capital and ecosystem services was conducted by Silvio Simonit and Perrings (2013) on reforesting land near the Panama Canal. These scholars considered the effect of planned reforestation of the Panama Canal watershed on a bundle of ecosystem services and showed that reforestation would increase the water flows needed to operate the Panama Canal during the dry season, an effect expected to have far reaching economic consequences (the flow of water through the Canal is sufficiently low to restrict its operations in approximately one in fifteen years). Simonit and Perrings developed a spatially explicit model of ecosystem services and predicted how the ecosystem services would vary with reforestation activities, particularly during the dry-season when an enormous volume of water (each lockage uses approximately 211,200 cubic meters of freshwater) is required to operate the Canal's locks. They show that reforestation is expected to not only increase and regulate the water flow used to operate the Canal during the dry season, but that such activities would have the additional benefit of contributing to the production of two other ecosystem services as well: timber production and carbon sequestration. Without reforestation, and continued deforestation, their model predicts that sediment would increasingly flow into the Canal, thus clogging the channel and resulting in the need for expensive dredging and other expensive investments in manufactured capital.

Thus far, I have only claimed that, much like manufactured capital, natural capital is conceived as a means of production that has a dual nature. The family resemblance between these two categories of capital goes deeper, however. It is widely

understood that specific instances of natural capital, such as ecosystems, are both beneficial to human agents and "depletable" or "depreciable", two characteristics that are routinely ascribed to manufactured capital as well. Describing natural capital as a depreciable asset, Dasgupta states:

> Like reproducible capital assets (roads, buildings, and machinery), ecosystems depreciate if they are misused or are overused. But they differ from reproducible assets in three ways: (1) depreciation of natural capital is frequently irreversible (or at best the systems take a long time to recover), (2) except in a very limited sense, it isn't possible to replace a depleted or degraded ecosystem by a new one, and (3) ecosystems can collapse abruptly, without much prior warning (2008, 3).

This foregoing statement implies that natural capital exists contingently and that, under certain conditions, instances of natural capital and the ecosystem services they produce can become scarce. Clearly referencing Ricardo's ([1817] 1951) canonical phrase ascribing original and indestructible powers to land, Dasgupta argues that Nature *qua* natural capital is *not* a fixed and indestructible factor of production. To the contrary, Dasgupta insists that, today, we can no longer assume that nature is an "indestructible factor of production" (2010, 6).[20] While instances of natural capital can be depleted by human causes or non-human causes, economists generally concern themselves with the former causes since it is believed that such depletions are almost always caused by the

[20] More specifically, "the problem with that assumption", Dasgupta tells us, "is that it is simply wrong" (2008, 2). For more on this theme, see Dasgupta (2007).

intended or unintended consequences of human activity. This focus on the human causes of depreciating natural capital, however, should not blind us from the observation that natural capital can be depleted by natural causes, as well. No one would deny that a large meteor striking the Earth and causing a mass extinction would effectively deplete the planet's stock of natural capital. The notion that instances of natural capital depreciate serves as a valuable image for economists since it enables them to entertain the possibility that certain natural processes, ones that produce ecosystem goods and services, may require direct human intervention to ensure that the beneficial regularities produced by natural capital continue into the future. This observation brings us to another central characteristic of natural capital, one that is also shared with manufactured capital.

Invariably, natural capital denotes processes that are beneficial to economic agents. It has become commonplace for economists to depict ecosystems as instances of natural capital or natural assets that, much like manufactured capital, produce a flow of beneficial goods and services to human agents over time (Barbier 2011).[21] Economists generally recognize that natural capital affords human agents with at least two distinct benefits: direct or indirect welfare-enhancing features and a vital biological life-support function – what are sometimes referred to as the ecological pre-conditions to human economic activity. The first class of benefits derive from traditional renewable and non-renewable resources, but also extends to a host of non-market phenomena, such as the regulation of the atmosphere's chemical composition, basic climatic stability,

[21] Daily *et al.* (2000, 395) state, "the world's ecosystems are capital assets. If properly managed, they yield a flow of vital services, including the production of goods (such as seafood and timber), life support processes (such as pollination and water purification), and life-fulfilling conditions (such as beauty and serenity)." Similarly, Dasgupta (2010) submits that the concept of natural capital denotes ecosystems generally.

photosynthesis, pollination, the purification of air and water, the detoxification of wastes, nutrient cycling, erosion control, sediment retention, genetic resources, etc. (Costanza *et al.* 1997). Alternatively, the economists Fikret Berkes and Carl Folke divide natural capital into three subclasses. They state, "natural capital consists of three major components (1) non-renewable resources, such as oil and minerals, that are extracted from ecosystems; (2) renewable resources, such as fish, wood, and drinking water that are produced and maintained by the processes and functions of ecosystems; and (3) environmental services such as maintenance of the quality of the atmosphere, climate, operation of the hydrological cycle including flood controls and drinking water supply, waste assimilation, recycling of nutrients, generation of soils, pollination of crops, provision of food from the sea, and the maintenance of a vast genetic library" (1992, 2).

The second benefit of natural capital includes the so-called ecological pre-conditions to human economic activity, a class of conditions that, as mentioned above, are referred to as *critical* natural capital. Barbier, for example, implicitly refers to such conditions when he states, "humans depend on and use this natural capital for a whole range of important benefits, including life support" (2011, 6). This special subclass of natural capital denotes those vital, essential, or non-substitutable aspects of the environment that are required for sustaining human welfare and human economic activity *tout court* (Farley 2008).

The various processes denoted by the concept of natural capital necessarily yield welfare enhancing benefits or utility to human agents. This characteristic, essential to the concept, implies that unless all natural processes are beneficial to human agents, then not all natural processes are instances of natural capital. In most cases, the natural processes denoted by the concept of natural capital will not be beneficial to human

agents merely because they are deemed "natural" (because the term "services", as economists use it, can denote virtually anything that agents might prefer for any reason, there may be circumstances in which agents prefer items denoted by the concept of natural capital because they are natural). Moreover, the concept of natural capital would seem to exclude every putatively harmful natural process, such as viral infections, or the earthquakes and volcanoes that lay waste to human beings and their property. Ecosystems are almost always considered to be instances of natural capital, but if these natural processes merely produced harmful effects for human agents, then they could not be considered as such. If ecosystems are instances of natural capital, then they are made so not because they are in some sense natural but because they are, in part, beneficial to human agents. In particular, such ecosystems will produce a stream of goods and services that yield utility to human agents over time. Since it would appear that not everything that produces welfare enhancing effects for human agents count as natural capital, we must treat natural capital as a subset of the items that are welfare enhancing or beneficial for human agents.

Natural capital has a dual nature, is productive, depletable, and beneficial to human agents. Given these characteristics, one might legitimately surmise that natural capital is merely a species of capital with the added qualification that it denotes specific items, such as ecosystems, that have not generally been denoted by the term "capital" until a recent date. While this thesis might seem *prima facie* plausible, if one takes the traditional view of capital as a produced means of production that necessarily requires human effort to be brought into existence, then it remains unclear whether natural capital can be construed as such. If all manufactured capital goods, such as machines used in manufacturing and tools, are necessarily produced by human agency, and there

are instances of natural capital that are not, then natural capital cannot simply be a species of capital. Instances of natural capital are bound to have a different genesis and etiology than ordinary capital goods. Unlike manufactured capital, the processes denoted by natural capital have no intelligent designer, save for those cases when humans engage in large-scale constructions and interventions, such as ecosystem restoration. And, while economists and biophysical scientists might attribute natural capital with a final cause in the Aristotelian sense, to produce specific goods and services, it should be clear that instances of natural capital were not generated for human purposes.

Natural capital also possesses characteristics that classical political economists used to distinguish "land" from "capital". For classical political economists, particularly Ricardo ([1817] 1951), land was considered to be more or less fixed in supply. It was an original factor of production that did not have a period of production, a genuine "gift of nature" as it were, that was non-reproducible by human effort. The economist Peter Victor (1991) has argued that natural capital is similar to land because it is not reproducible. For this reason one might conjecture that, from the viewpoint of the history of economic thought, natural capital represents something of a revival of "land" since, as stated in Chapter One, this variable is no longer considered a distinct factor of production, at least among neo-classical economists (see Blaug 2000). Among classical political economists, "originality" did not mean that land was a mysterious uncaused entity, but that it owed its existence to non-human material causes. Similarly, while instances of manufactured capital are produced means of production that depends on humans with a disposition towards saving, the original accumulation of natural capital did not require abstinence from consumption in this same sense. As Barbier remarks,

natural capital, unlike manufactured capital, is original in the following sense: "unlike skills, education, machines, tools, and other types of human and human-made capital, we do not have to manufacture and accumulate our endowment of natural assets. Nature has provided ecosystems and their benefits to us for free" (Barbier 2011, 3). While capital universally depends on human agents with a disposition towards saving, the existence of natural capital does not. Indeed, much like the category of land for classical political economists, natural capital can be described as preceding human economic activity and is therefore a *bona fide* original or unproduced means of production. Indeed, since natural capital possesses some characteristics of both land and capital, it would appear to be a hybrid concept of sorts – a cross between land and capital.

As stated above, natural capital can be depleted by either human or non-human causes, or a combination of both. But it is to be remarked that natural capital, unlike manufactured capital, can also be accumulated by these causes as well. For instance, in the case of direct or indirect human causes, instances of natural capital can be intentionally restored, improved, or augmented by human agents. On the other hand, left to its own devices there are circumstances in which natural capital is capable of self-generation and thus, accumulation, quite independently of human agency (see Dasgupta 2009; 2010). By stark contrast, no instance of manufactured capital possesses this characteristic. The capacity for self-generation goes a long way to distinguish natural capital from manufactured capital since the latter invariably depends on human agency to be accumulated over time. In short, no manufactured capital exists without human agency but this is not the case for natural capital since there are cases in which natural

capital can be produced by completely natural processes (though human effort may be required to *appropriate* such items).

Nature and Natural Capital

With some understanding of the relationship between capital and natural capital now established, another question is this: what do economists mean by "natural" or "nature" when deploying the concept of natural capital? What concept of nature, if any at all, is presupposed in such cases? How can we think of the division between nature and artifact with respect to the concept of natural capital? My answer to these questions will endorse the fairly uncontroversial philosophical thesis that everything, including artifacts and intentional human agency, is natural. Following the lead of the philosopher of conservation biology, Sahotra Sarkar (2012), I further submit that it is still useful to make an operational distinction between natural objects, on the one hand, and intentionally constructed items, on the other, along with any unintended consequences that arise from such actions.

Since economists are rarely explicit about the meaning of nature in relation to the concept of natural capital, the answer to the foregoing questions will inevitably require a certain amount of interpretation and reconstruction. It should be clear to the reader that the purpose in answering this question is not to argue for a normative thesis whereby economists should use the concept of nature in any particular way when invoking the concept of natural capital. Rather, the question is intended to be consistent with the overall objective of this chapter, namely, to establish a coherent account of natural capital that economists might adopt. There is also the worry that while economists share a relatively stable understanding of natural capital, every economist may not presuppose

one specific concept of nature, let alone form a consensus as a group. This is a sensible concern to keep in mind. However, one should also acknowledge that among those economists who share the concept of natural capital, they collectively employ the adjective "natural" to distinguish natural capital from artificial capital, that is, the produce of human agency.

For Aristotle, the concept of "nature" had several meanings (see Collingwood [1945] 1976, 81-85). In one sense, it denotes specific items that exist by nature, and not by any other causes. This concept of nature emphasizes the origin or genesis of an item and requires that natural objects exist by non-human causes. In other words, this concept of nature presumes that there are things that exist by skill (the artificial) and things that exist on their own when left to themselves (natural objects). Aristotle has this sense of nature in mind when, for example, he reviles usury. As Joel Kaye explains, "Aristotle believed usury was the most despicable and unnatural, because in the usurious loan, money, which was invented solely as an instrument of exchange, is made to generate itself, to give unnatural birth to itself" (1998, 87). Money does not exist by nature, but by law or convention (*Nichomachean Ethics*, 1133a30ff).[22] The charging of interest involves money begetting money and is unnatural because this activity is not in accordance with the end for which money was originally created (to facilitate exchange).[23] Aristotle condemns usury because this activity distorts the purpose of money.

[22] All references to Aristotle in this dissertation refer to Benjamin Jowett's translation found in Jonathan Barnes's ([1984] 1995) edited volume, *The Complete Works of Aristotle*.

[23] Aristotle also recognizes that money can serve as a unit of account and a store of wealth.

In his *Physics*, he introduces a concept of nature that corresponds particularly well with how economists actually use "nature" when deploying natural capital. Aristotle affirms that nature denotes an inner principle of change that is characteristic of self-moving things.[24] Unlike artificial objects, natural ones are involved in a process of growth, change, and flux. Nature, in this sense, is deeply intertwined with how things behave when left to themselves, free from human agency. Since instances of natural capital can produce in a self-generative way whereby production processes materialize from within – without the need for external causes – this concept of nature is particularly fitting for understanding what economists mean by nature when they invoke the concept of natural capital, particularly when the concept is used to denote ecosystems.

One virtue of this Aristotelian concept of nature is that it can account for the fact that instances of natural capital can be manipulated, modified, and generally controlled by human agents without necessarily losing their essential identity as items of natural capital (becoming purely artificial). In Book 2, Chapter 1 of his *Physics*, Aristotle gives the example of a wooden bed. While the shape and structure of the bed has been fashioned by an intentional human agent, the carpenter, this formal cause is merely "human impositions on the unchanged matter that remains a natural product" (Bensaude-Vincent and Newman 2007, 5). If one were to plant the bed in the ground and that bed were to sprout anything at all, it would not generate beds, but trees. In this case, the inner principle of change or motion is independent of the form that is imposed

[24] For much more on the detail of Aristotle's distinction between "natural" and "artificial", see *Physics* 2.1, 192b12-23.

on it by the carpenter and the nature of the object is associated with the unchanged matter.

In this sense of "nature", the natural world would be one that owed its entire existence to natural causes and, therefore, would exclude all intentional human activity. This world would be one populated by objects, whether biotic or abiotic, without any forms imposed on them from without. It would be a world that was left entirely to itself, independent of human agency. Indeed, this Aristotelian concept of nature can serve us with a good thought experiment to give shape to what a *bona fide* natural world would look like independent of any form imposed on them by intentional agents. Of course, one can easily imagine a contrary world as well, one where there is no biotic or abiotic items that are left to be naturally expressed, where every last object and bit of material has been subject to the intentional activity of human agents. Indeed, the philosopher Alan Holland (2003) describes such a world as a "human-made world", since it would be one where every object owed its form to human causes.[25]

In his *A Treatise of Human Nature* David Hume ([1739-40] 2000, 304) remarks that there is no more ambiguous and equivocal word than "Nature".[26] Hume also recognized that, in ordinary parlance, the word is often invoked as a rhetorical device to oppose the rare or unusual. In *The Origin of Species*, Charles Darwin (1859) recognizes nature simply as a "web of complex relations", whereby no single organism can live independently of that web (Worster [1977] 1993, 156). In the 1872 version of the same text, Darwin states, "I mean by Nature, only the aggregate action and product of many

[25] For more of Holland's work on the concept of natural capital, see Holland (1995; 1997).

[26] See Soper (1995).

natural laws, and by laws the sequence of events as ascertained by us."[27] Another conception of nature that adds to our understanding of natural capital is the concept of nature as a collection of things – the sum total of natural objects (see Collingwood [1945] 1976, 43).

More recently, the critic Raymond Williams (1976, 184) echoes Hume by stating that nature is "perhaps the most complex word in the English language."[28] The environmental historian, William Cronon (1996) emphasizes that nature is merely a social construct, an idea that never exists independently of the interpretive meanings we attach to the term (Wapner 2010, 16). In their *The Moral Authority of Nature*, Lorraine Daston and Fernando Vidal (2004) take "nature" to task by exposing the authority of this term when it is invoked in human affairs. To suggest that specific social conventions and political arrangements are "by nature" or "natural", is often to assert that such institutional arrangements are either irrevocable or optimal. All too often, Daston and Vidal state, "Nature appears as an external authority, even if its imperatives are lodged deep in the body or psyche. Nature's authority can also be internalized, made "natural" in the sense of seeming inevitable or effortless" (2004, 9). Bernadette Bensaude-Vincent and William R. Newman (2007) concur with Daston and Vidal's analysis. In their *The Artificial and the Natural*, they state "the concept of nature functions and has always been used as a cultural value, a social norm, and a moral authority" (2007, 3). Since terms such as "nature" and "natural" do not merely possess a descriptive component, but a normative one as well, it is crucial to recognize that the concept of *natural* capital is not exempt from such influences (particularly when it is deployed by economists in

[27] See Inkpen (2014, 10).
[28] Also, see Williams (1980).

debates about sustainable development). Indeed, the concept of natural capital would appear to be one instance of what Bernard Williams (1985, 140-3) refers to as a "thick concept" – a concept that is not merely descriptive, but action-guiding as well. For the purposes of this dissertation, it will be sufficient to point out, as a cautionary note, the moral authority that pervades the concept of natural capital when this it is invoked by economists.

In one of his *Three Essays on Religion*, the essay entitled *Nature*, J.S. Mill ([1874] 2006) considers a variety of possible meanings behind "nature". Eventually, Mill boils his analysis down to two distinct concepts of nature. He states:

> It . . . appears that we must recognize at least two principle meanings in the word 'nature'. In one sense, it means all powers existing in either the outer or inner world and everything which takes place by means of those powers. In another sense, it means, not everything which happens, but only what takes place without the agency, or without the voluntary and intentional agency, of man. This distinction is far from exhausting the ambiguities of the word; but it is the key to most of those on which important consequences depend ([1874] 2006, 375).

Mill's first concept of nature denotes everything actual and everything possible, including human agents and their intentional activities. The second concept of nature, the one that Mill prefers, drives a wedge between intentional human agency and that realm of phenomena that has not yet been affected by human agency (Schabas 1995). It is worth noting that G.F. Hegel and Karl Marx recognized these two concepts of nature,

but placed them under the same general heading of "Nature". As Leo Marx (2008) explains, for these scholars, "First Nature" is the biophysical world as it existed before the evolution of *Homo sapiens*, and "Second Nature" is what most would refer to as the artificial: the material and cultural environment that our species has imposed upon "First Nature". This view of Nature sustains a division between human activity and everything else, but, ultimately, it is in agreement with Mill's first concept of nature as denoting everything actual and possible.

It would appear that Mill's second concept of nature fits natural capital particularly well since economists are wont to claim that specific instances of natural capital, unlike manufactured capital, are production processes that generate welfare-enhancing benefits to economic agents in a manner that is relatively detached from human agency. Moreover, at least some of the time, economists appear to distinguish natural capital from manufactured capital by emphasizing materials or processes that have not yet been subject to direct human agency. This is especially true when it is acknowledged that the items denoted by natural capital are generally unproduced means of production that do not have to be intentionally built or constructed by human labour.

But, while instances of natural capital are often considered to be "original" or "a gift of nature", in much the same way that land was described by classical political economists, not every instance of natural capital is like this. In some cases, whether through ecosystem engineering and ecosystem restoration, it is difficult to deny that such instances of natural capital are intentionally constructed or built by human agents for some intended effect (this point will be made all the more clear in Chapter Five when it is argued that no one can restore or preserve nature without turning nature into an

artifact). Moreover, there are other cases in which the productivity of natural capital is improved or enhanced by direct human intervention, as would be the case when so-called "invasive species" and other undesirables are extricated from specific ecosystems. Specific production processes denoted by natural capital can be modified or transmuted by human labour so that they persist in generating desired ecosystem goods and services. The economically valuable pollination services afforded by pollinator species and the water filtration services provided by specific watersheds are both instances of natural capital, and yet they can both be modified and improved by human intervention without losing their status as instances of natural capital. Dasgupta, Ann Kinzig and Perrings state that, "many ecosystems are deliberately 'simplified' (through the removal of pests, pathogens, predators or competitors) in order to increase their value for particular purposes. The best examples of this are to be found in agriculture, aquaculture, forestry, and urban systems. The biodiversity in such systems is managed to enhance production of particular services" (2013, 168). Thus, while it is clear that natural capital denotes specific cases of unproduced means of production, ones that are capable of producing in a manner that is relatively detached from human agency, not every instance of natural capital is separated from human agency in the sense that would be required of Mill's second concept of nature.

In fact, even if economists were committed to Mill's second concept of nature, that realm of phenomena or domain on Earth that has not yet been subject to human agency, then the extension of this concept would appear to be empty. This is because, strictly speaking, there is no longer any part of the Earth that remains completely unaffected by human technologies (Bensaude-Vincent and Newman 2007; Wapner 2010). In his *The End of Nature* Bill Mckibben states,

> An idea, a relationship, can go extinct just like an animal or a plant. The idea in this case is 'nature', the separate and wild province, the world apart from man to which he has adapted, under whose rules he was born and died. In the past we have spoiled and polluted parts of that nature, inflicted environmental 'damage' … We never thought we had wrecked nature. Deep down, we never really thought that we could: it was too big and too old. Its forces, the wind, the rain, the sun – were too strong, too elemental. But, quite by accident, it turned out that the carbon dioxide and other gases we were producing in pursuit of a better life – in pursuit of warm houses and eternal economic growth and agriculture so productive it would free most of us for other work – *could* alter the power of the sun, could increase its heat. And that increase could change the patterns of moisture and dryness, breed storms in new places, breed deserts. Those things may or may not have begun to happen, but it is too late to prevent them from happening. We have produced carbon dioxide – we have ended nature. We have not ended rainfall or sunlight … But the meaning of the the wind, the sun, the rain – of nature – has already changed (Mckibben 1990, 43-4. Quoted in O'Neill *et al.* 2008, 125-6).

Mckibben's (1990) claim that nature is dead is not meant to suggest that there is nothing left that is actual and possible – Mill's first concept of Nature – but simply that there is no longer any part of the Earth's surface that can be truly described as detached from human agency. Paul Wapner (2010) draws a similar conclusion when, in his recent

book *Living Through the End of Nature*, he remarks, "the wildness of nature has indeed largely disappeared as humans have placed their signature on all the earth's ecosystems" (2010, 19). Wapner continues:

> Empirically, a growing human population, unparalleled technological prowess, increasing economic might, and an insatiable consumptive desire are propelling us to reach further across, dig deeper into, and more intensively exploit the earth's resources, sinks, and ecosystem services … the cumulative force of our numbers, power, and technological mastery has swept humans across and deeply into all ecosystems to the point where one can no longer easily draw a clean distinction between the human and nonhuman realms. Whether one looks at urban sprawl, deforestation, loss of biological diversity, or ocean pollution, it is clear that humans have been progressively overtaking large swaths of nature and thereby imprinting themselves everywhere (Wapner 2010, 4).

Indeed, the technology of our species is now so vast that it has extended far beyond the sub-lunar region to include the Cydonia (the region of Mars) (Bensaude-Vincent and Newman 2007). While this may be news to some, even Karl Marx had remarked that, "the nature which preceded human history no longer anywhere exists" (1968, 59). Thus, it would appear that the claim that there is some realm of phenomena on Earth that remains unaffected by human agency is simply false and if there is nothing left on Earth that remains unaffected by human agency, then the very processes denoted by the

concept of natural capital, could not be considered genuinely "natural" in this Millian sense.

The alternative concept of nature proposed by Mill ([1874] 2006), however, maintains that everything possible and actual is part of nature. *Prima facie*, this concept is attractive since it is clearly compatible with naturalism, the thesis that there are no supernatural phenomena. As Daniel Dennett reminds us, "artificial environments are themselves a part of nature, after all" (1990, 192). The problem with this all-encompassing concept of nature, however, is that it also appears to be discordant with natural capital for the obvious reason that everything actual and everything possible includes manufactured capital as well. If this first Millian concept of nature requires that everything is part of nature, then it would appear to be a poor fit for shedding light on what economists mean by natural capital. What good is a concept of nature if, by deploying it, it destroys the very features or characteristics that make natural and manufactured capital distinct in the first place?

These two Millian concepts of nature appear to present us with a dilemma. Mill's second concept of nature has to recognize the empirical claim that everything on Earth is – in some sense – artificial because the whole planet has been, directly or indirectly affected by human activity. Mill's first concept of nature, on the other hand, insists that all humans and their intentional activities are part of nature, full stop. Indeed, it would appear that neither horn of this dilemma is going to be particularly useful for understanding the concept of natural capital in economics.

Fortunately, this dilemma is more apparent than real. The way out of this rabbit hole is to concede that while everything, metaphysically, is natural we can still operationalize the concept of "Nature" for our purposes by insisting that those items

which remain *relatively* detached from human agency, those items that do not possess significant features caused by intentional human agents, are natural. In taking this pragmatic approach, I am following Sahotra Sarkar when he states:

> Even if humans are conceptualized as part of nature, we can coherently distinguish between humans and the rest of nature. There is at least an operational distinction; that is, one that we can straightforwardly make in practical contexts. We can distinguish between anthropogenic features (those largely brought about by human action) and non-anthropogenic ones (2012, 19).

By making this operational distinction, Mill's two concepts of nature are treated as compatible since one does not necessarily preclude the other. Mill's first concept of nature is more fundamental since, even the most artificial of objects, such as atomic bombs and jumbo jets, are natural. On the other hand, for practical purposes, these same items are deemed artificial since they were intentionally built by human agents and they possess a variety of anthropogenic features. The same is true for items denoted by the concept of natural capital. Since everything actual and everything possible is natural, every instance of natural capital must also be natural. However, in light of the empirical claim that no phenomena denoted by the concept of natural capital is completely insulated from human agency, it is always a question about the relative detachment that such items – the ecosystems denoted by the concept of natural capital – have in relation to human agency.

Thus, the natural and artificial are located along a spectrum or continuum with the most natural objects being those that remain relatively detached from human agency and the most artificial objects are those that have been built and constructed by intentional human agents. There is no *sui generis* difference between artificial and natural objects since the difference is always a matter of degree. In other words, there is a blending of the natural and the artificial. As Bensaude-Vincent and Newman state, "artifacts are never really unnatural. As physical and chemical systems they belong to nature and generate a number of effects independent of the intentions of their designers" (2007, 2). This approach to the natural/artificial distinction has the virtue of preserving the practically significant distinction between, for example, intentionally modified environments such as city centers, from environments that have been subject to relatively little human agency, such remote uninhabited islands that were recently generated by natural causes in the Pacific.

For the purpose of this dissertation, particularly Chapter Five, it will be useful to explicate a bit further what is meant by "relatively detached" with respect to Nature as a realm of phenomena that is separated from intentional human agency. Rather than imposing a strict division between natural and artificial objects, what I propose is that the artificial/natural distinction be described as a continuum or spectrum whereby phenomena are branded as more (less) natural or more (less) artificial, depending on their degree of detachment from intentional human agency. It will be useful to distinguish objects that remain completely detached from human agency from those which have a *first* or *second* degree of detachment. These divisions are represented in Figure 2.

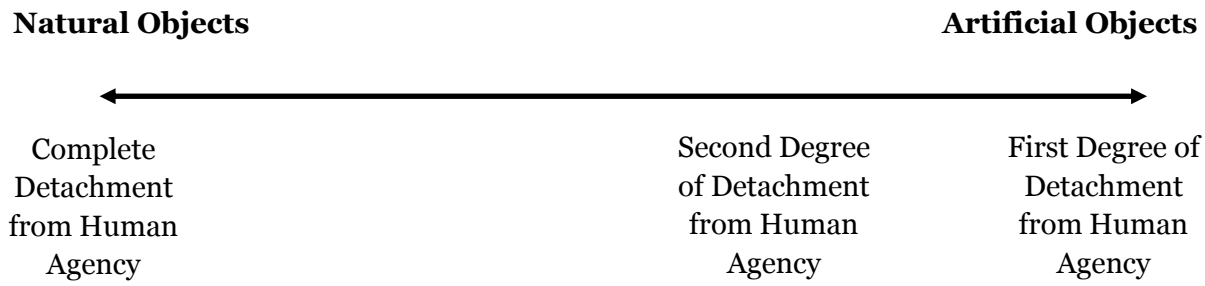

Figure 2. The Artificial/Natural Continuum

According to this Figure directly above, the natural or most natural objects in the universe are those found to the left side of the continuum. They remain completely detached from human agency in the sense that they have not causally interacted with intentional human agents: they have been neither affected directly nor indirectly by human agents. If there truly is no longer any part of the sub-lunar region that is completely detached from human agency, then it follows that describing the Earth, or parts of the Earth, as entirely natural, would be incorrect. Be that as it may, parts of the Earth might well still be described as "*relatively* natural" when compared to objects that owe their forms to human agency and have been completely instrumentalized to serve human ends. Only that part of the universe which has not yet been affected by human agents is a candidate for complete detachment from human agency.

On the opposite end of this continuum, to the right side of Figure 2, are those items that have been completely instrumentalized by intentional human agents to serve their own ends. This category includes ordinary technical artifacts, such as chairs, that use materials found and subjected to the intentional modifications of human agents. Not only are chairs intentionally planned and built by the woodworker, often in combination

with manufactured machines, but the actual construction of such artifacts will normally involve transforming or modifying materials to bring about certain desirable characteristics of the object at hand. Under this framework, all such items, including capital goods, such as manufactured machines and tools, possess what I term a *first degree* of detachment from intentional human agents.

Finally, objects that have been either directly or indirectly affected by human agency but that have not yet been completely instrumentalized by intentional human agents can be described as possessing a *second degree* of detachment. This category includes items that have not been intentionally made by human agents but that, nonetheless, have arisen at least in part as a consequence of human activity. For example, the sawdust caused by the woodworker building the chair is a consequence of intentional human agency but since it is not the goal of such activity and has not (yet) been instrumentalized for human purposes, it can be described as having a *second degree* of detachment. Therefore, unlike those items which can be described as having a first degree of detachment from human agents, establishing that some object has a second degree of detachment is much weaker since it merely requires that there be some causal connection between some intentional human agent and that object.

This chapter has established that while both natural capital and manufactured capital share many of the same characteristics, there are at least two features that make the former theoretical category distinct from the latter. As conceived by economists, natural and manufactured capital both have a dual nature since, depending on the context of analysis, they are both conceived as heterogeneous particulars and homogeneous funds of economic value. And, while the specific instances of both categories are declared to be capable of producing, depletable, and beneficial, only

instances of natural capital can be original or unproduced means of production capable of self-generation. This means that there are some instances of natural capital that, rather than being necessarily made by human agency, they are simply found and then declared to be an instance of natural capital whose attributed function is to produce ecosystem goods and services. However, since the items denoted by the concept of natural capital, such as ecosystems, can be improved, modified, and restored by human intervention, there are instances of natural capital that can be brought into existence by a combination or mixture of human and non-human agency as well. The implication of this statement is that while no instance of manufactured capital comes into existence merely by non-human material causes, the etiology of natural capital does not necessarily rely on anthropogenic causes.

As for the concept of nature, for the purpose of illuminating the concept of natural capital, this chapter effectively collapsed Mill's two concepts. Mill's first concept of nature denotes everything actual and everything possible, including human agents and their intentional activities. His second concept, by contrast, denotes that realm which has not yet been affected by human agency. With respect to this second concept, because there is virtually no part of the surface of the Earth that is completely insulated by human activity, I claimed that the question is one of relative, not absolute detachment. The problem with adopting Mill's first concept of nature, on the other hand, is that it would be of little use when enforcing the distinction between manufactured and natural capital since everything, by definition, would be natural. To evade this difficulty, I proposed to accept Mill's first concept of nature as the most fundamental, but, for operational purposes, to distinguish between humans and their activities from the rest of nature. This unassuming move enables one, for practical

purposes, to distinguish between anthropogenic features and non-anthropogenic features, a division required to make sense of the distinction between manufactured and natural capital, without being obligated to explain how it is that intentional human agency is somehow "outside of nature".

CHAPTER THREE

Natural Capital:

Novel Concept or the Same Old Stew?

The most striking feature of natural capital is the idea that Nature not only affords human agents with passive materials and raw resources to be improved by human labour, but that, in many cases, it endows us with relatively stable welfare-enhancing production processes. The concept denotes various unproduced means of production that generate goods and services ready-made for human consumption, in a manner that is relatively detached from human agency. Consider, for instance, the pollination "services" provided by pollinator species, such as honey bees. Economists have claimed that such species perform economically significant roles in the cultivation of numerous crop plants, such as tomatoes, celery, and rapeseed. As recognized in the previous chapter, recent estimates suggest the economic value of worldwide pollination services is approximately €195 billion (Lonsdorf *et al.* 2011). Another sweeping study published in the journal *Nature* suggests the Earth's entire biosphere, including a wide range of natural services, such as the purification of water, nutrient cycling, and the

detoxification of wastes, is worth between $14 and $54 trillion dollars, annually (Costanza *et al.* 1997).

In the previous chapter, it was argued that at least two features distinguish natural capital from manufactured capital: originality and self-generation. Instances of manufactured capital are never original or self-generative since they are a produced means of production that depend on the investment decisions of economic agents; moreover, manufactured capital goods are incapable of producing autonomously, completely free from human agency. Simply because natural capital is distinct from manufactured capital, however, does not entail that the two characteristics which make it so are without historical precedent. The objective of this chapter is to deepen our understanding of natural capital by situating the concept in the history of economics. While natural capital is a relatively new concept among contemporary economists, I will argue that the characteristics which make it so have roots in the writings of classical political economists.

No other school of thought in the history of economics emphasizes the inimitable role of land and Nature's capacity to generate wealth more than the French Physiocrats of the mid-eighteenth century. It would seem that if the concept of natural capital were to have a forerunner of any kind it would be found in the writings of the Physiocrats. However, I will argue this is not the case. The founder of this school, the physician François Quesnay, and his associate Anne-Robert-Jacques Turgot, claimed that land (often called "Nature") needed to be animated by human labour first.[29] As such, the independence of Nature's productions among the Physiocrats, a distinctive feature of natural capital, is called into question. Within the Physiocratic model of economic

[29] To be clear, Turgot was not a Physiocrat.

production, Nature or land is the unique and necessary but insufficient condition for the production and circulation of wealth in a given society. Thus, it is an overstatement to claim that, for the Physiocrats, Nature is the lone source of wealth.

Nonetheless, I will submit that envisioning the whole of Nature as producing for human agents, one that is presumed by economists who deploy the concept of natural capital, has roots in the writings of Carl Linnaeus who depicts the whole Earth and all of its productions as the "*oeconomy of nature*". From this viewpoint, the Earth was perceived as a world to be managed for maximum output and human beings had the obligation to make nature's productions accrue to the enrichment of the human economy (Worster [1977] 1994). While it is true that economists today have stripped Nature's productions from the explicit theological and teleological clothing in which Linnaeus originally dressed them, Nature *qua* independent producer is on full display in during the 18th Century with Linnaeus' *Oeconomia Naturae* (1749). Moreover, I will claim that there is a nascent category of natural capital to be unearthed in the writings of other eminent economic thinkers, such as Adam Smith, John Stuart Mill, and Karl Marx. When these theorists referred to the "spontaneous productions of the Earth" or Nature's "natural products" they had a distinctive class of production in mind, one that denotes Nature's independently generated products. And, while such products were, on the whole, treated as scant or relatively unimportant for the purpose of economic theorizing, such productions can be considered as a harbinger to the items denoted by the concept of natural capital today.

The distinctive feature of natural capital, the one that makes this concept so remarkable in the first place, is that it presumes *ex hypothesi* that aspects of Nature which have not been directly subject to human agency are capable of independently

producing economically significant natural products. In the very least, those who regularly deploy the concept of natural capital do not rule out such unaided productions *a priori*. Of course, neither of the foregoing statements implies that instances of natural capital cannot be augmented or improved without losing their status as natural capital (as we have seen in Chapter Two), but it does suggest that there are specific cases in which economists tacitly suppose that non-human agency alone is the proximate cause of certain economic phenomena. What I mean by non-human agency here is not anything metaphysically mysterious or fantastical. On the contrary, when economists claim that a specific instance of natural capital produces they suppose, implicitly or explicitly, that unassisted Nature is not only causally efficacious, but that there is some structure or mechanism, not originally produced by humans, that is sufficiently effectual to generate some stream of goods and services to be consumed by human agents. Thus, unlike manufactured capital, natural capital can be found, not made. Thus, while the claim that Nature has agency does *not* entail that Nature consciously or intentionally produces goods and services for human agents, or for any other purpose, it also does not rob Nature of its capacity to spontaneously generate economically valuable goods and services.

Perhaps the most interesting point of departure, when attempting to situate the concept of natural capital in the history of economic thought, is to consider the Physiocrats of France who are widely known for having claimed that Nature or land alone is truly productive. "*Physiocratie*" means "reign of nature" (Vardi 2012). On the surface at least, it would seem that if there is any theory of economic production in the history of economic thought that would qualify as being a progenitor to the concept of natural capital, the Physiocratic doctrine would be it. This is because it is generally

accepted that no other group of economic thinkers emphasized land as the origin of wealth more than the Physiocrats. In what follows, however, I will submit that unlike natural capital, which distinctively captures Nature's unassisted productions, the same cannot be said for the Physiocrats. While their creed involved the notion that land was the ultimate source of wealth, human labour was required to set it into motion. It is true that the Physiocrats claimed land was the crucial source of society's wealth; however, they also held that the natural fertility of the soil was, on its own, insufficient to automatically generate it. Wealth generation and the ensuing circulation of wealth throughout a given society could only be activated by an equally special causal factor: human agency. In particular, a specific class of individuals – the Farmers or Husbandman – was required to cultivate the land in order to take advantage of the original powers of the soil. The well-known implication of this statement is that, on the Physiocratic account, no other class of individuals was truly productive.

In his *Theories of Surplus-Value*, Karl Marx describes the Physiocrats as "the true fathers of modern political economy." Describing the Physiocratic account of the economy during a period when political economy was in its infancy Marx states, "this was an extremely brilliant conception, incontestably the most brilliant for which political economy had up to then been responsible." [30] Adam Smith also held Physiocracy in the highest esteem, particularly its founder, François Quesnay. In fact, it is well-known that, had Quesnay still been alive in 1776, the year that Smith published the *Wealth of Nations*, Smith would have dedicated his *magnum opus* to Quesnay. Smith states that the Physiocratic school, "with all its imperfections" was "the nearest

[30] *Theories of Surplus Value* in *Economic Manuscript* of 1861-63 (see Marx and Engels 1989, 239-40, as quoted by Vardi 2012, 12).

approximation to the truth that has yet been published upon the subject of political economy."[31] Of course, not every economic theorist was equally spellbound by the Physiocrats. David Hume, for one, was outright scornful towards Physiocrats, thinkers that he believed to be the most fanciful of men. When corresponding with abbé Morrelet, a Physiocratic sympathizer, Hume urged, "thunder [the Physiocrats], and crush them, and pound them, and reduce them to dust and ashes! They are, indeed, the set of men the most chimerical and arrogant that now exist."[32]

The Physiocrats, who described themselves as "les économistes", were most prominent circa 1750-1770 and are widely recognized for inventing various "tableau économique". These pictures represented the dynamics of production and distribution across the entire economy, most often on an annual basis (these dynamics are depicted in one version of The Marquis de Mirabeau's tableau économique Figure 3). The Physiocrats are also widely known for having influenced Smith's systematizing of economic phenomena in the *Wealth of Nations*, and for rejecting the reigning Mercantilist doctrine that had been led by the Director of the East India Company, Thomas Mun, who privileged foreign trade (the balance of trade doctrine) to enlarge the Kingdom's stock or treasure. Headed by François Quesnay, the personal physician to King Louis XV and Madame de Pompadour, the Physiocrats were the most influential school of economic thought during the mid-18th Century and according to at least one historian they were also the first to develop a clear view of capital's role in economic production (Hennings [1987] 1990). Although Quesnay's success is normally attributed to his theoretical accomplishments, his main goal was practical: to derive maxims of

[31] Smith ([1776] 1976, 678).

[32] This quotation is from a letter from Hume to Morrelet in 1769. Quoted by Skinner (2009, 410).

n° 211, Mirabeau, *Philosophie rurale.*

Figure 3. Tableau Économique

wise governance that would lead to the greatest possible production of commodities and the happiness of humankind (Banzhaf 2000).

Above all, the Physiocrats are renowned for having claimed that all wealth derives from the ground, a position that can be traced back to Richard Cantillon's ([1755] 1952)

Essai sur la Nature du Commerce en Général. The first sentence of Cantillon's *Essai* is telling: "la terre est la source out la matière d'ou l'on tire la richèsse; le travail de l'homme est la forme qui la produit" ([1755] 1952, 1). This means that land is the matter and labour is the form of all produce and merchandise. In this work, Cantillon had proposed a *land* theory of value, which implied that the value or what he labeled the "intrinsic value" of manufactured commodities is proportional to the quantity of land used for its production, including the upkeep of those laborers who were used to fashion such products (Brewer 1992). Land, for Cantillon, the Irishman who was famous for the large fortune he amassed from banking activities in Paris, was the unique non-reproducible and original factor that creates value. Moreover, for any given production process, labourers are required to subsist on the produce of the land. The basis of this theory can be understood in terms of what he took to be the "par" between labour and land, an idea that derives from Cantillon's main intellectual ancestor, William Petty (1623-87).

Petty, most famous for authoring *A Treatises of Taxes and Contributions* (1662) and *Political Arithmetic* (1676) had proposed a similar complex "land-and-labour" theory of value. Since land and labour could be expressed in terms of one or the other, each of these factors was placed on the same footing (see Petty 1963). As Petty states, "all things ought to be valued by two natural denominations, which is land and labour; that is, we ought to say, a ship or garment is worth such a measure of land, with such another measure of labour; for as much as both ships and garments were the creatures of lands and men's labours thereupon".[33] Cantillon also ascribed a "par" between labour

[33] Petty (1963, 44) is quoted by Alessandro Roncaglia ([1977] 1985, 80).

and land, but his version was not as symmetrical as Petty's. Because land was the ultimate or crucial scarce factor of production for Cantillon, he considered it to be even more fundamental than labour, a position that is clearly at odds with the labour theory of value (both the embodied and labour commanded theory of value) that would later become the canon of classical political economists, such as Smith, Ricardo, Mill, and Marx. At several points in his *Essai*, Cantillon reminds the reader that labour is clearly not a constraint on production since it is not truly scarce: "Men multiply like mice in a barn if they have the means of subsistence without limit".[34] Labour costs can always be reduced to the amount of land needed for the production of labourers and, therefore, although the intrinsic value of any commodity might well include the cost of maintaining the workers throughout a production process, such costs can always be expressed in terms of land alone, the one true scarce factor of production (Brewer 1988).

The link between Cantillon's *Essai* and the Physiocrats is relatively clear. The Marquis de Mirabeau, who founded the Physiocratic school of thought with Quesnay, originally planned to publish his *L'Ami des Hommes* or "Friend of Mankind" (1759) in direct response to Cantillon's *Essai* (Meek 1962). Moreover, Anthony Brewer (1992) has convincingly argued that Quesnay's economics, characterized by the sole productivity of agriculture, appears to come directly from Cantillon's *Essai*; the main difference being that for the latter, land is the only scarce resource while for Quesnay the main constraint on economic production is agriculture performing below its potential, the cause of which was almost always a lack of capital investment.

The Physiocrats developed an abstract and deductive "system" – a circular-flow model of production and consumption that consisted of three interdependent social

[34] Cantillon is quoted by Brewer (1992, 36).

classes, only one of which was claimed to be truly productive (Riskin 2003). Quesnay showed that the Farmers or Husbandmen, when combined with the natural powers of Nature, are the lone *bona fide* productive social class. The other two classes in the model, the landowners and artisans, rely on the farmers for their basic needs and subsistence. These latter two classes are considered all but sterile because while they might succeed in transmuting various natural objects into useful forms, such activities are merely modifications ("façonner") and do not represent genuine or true production ("produire"), a special activity that could only be accomplished by the Farmers.

Among the Physiocrats, capital was understood to be an "advance", a necessary pre-condition to the whole agricultural production process (Hollander [1987] 1992). Without capital that had been saved up during a previous time period, there could be no production according to the Physiocratic circular-flow model. Such advances derived exclusively from the wealthy landowning class, who themselves had originally received them in the form of rents that had been produced by the productive class during the previous period of production. Above all, policy prescriptions for the Physiocrats required that such advances be directed to the agricultural sector as investments in various tangible means of production, including seed, buildings, drainage, hired labor, oxen, ploughs, and other improvements. All such investments were required to sustain the productive class until the annual harvest. In other words, advances or capital stocks were to be invested in the only genuinely productive class of production.

The Physiocrats held that the agricultural sector alone was truly productive. Why? The chief reason for this claim was because the Physiocrats believed Nature alone was capable of yielding a surplus or "produit net" (net product), one that subsequently circulated among the three main social classes. The net product was *the* central factor –

the strategic policy variable – for the Physiocrats. Anything that increased the net product caused an expansion of economic activity while anything that reduced it, such as inadequate advances, caused a contraction (Meek 1962). As Ronald L. Meek explains,

> The Physiocrats' theoretical system was that this net product was yielded by agriculture, and by agriculture alone. Agriculture as the supreme occupation, not only because it was morally and politically superior to others, not only because its produce was primary in the wants and always in demand, but also – and mainly – because it alone yielded a disposable surplus over necessary cost (1962, 20).

Artisanal and manufacturing activities figured in the Physiocratic model, but the members of these classes were deemed sterile because, in the long run, they were unable to produce a surplus over and above the costs that were incurred in production. Therefore, the two unproductive classes of society, the landowners and artisans, were directly dependent upon the "produit net" produced in the agrarian sector. As Quesnay explains in *Extracts from 'Men'*:

> Those who make manufactured commodities do not produce wealth, because their labour increases the value of these commodities only by an amount equal to the wages which are paid to them and which are drawn from the product of landed property. The manufacturer who makes cloth, the tailor who makes clothes, and the cobbler who makes shoes, do not produce wealth any more than do the cook who makes his master's dinner,

> the worker who saws wood, or the musicians who give a concert. They are all paid out of one and the same fund (Quesnay is quoted by Meek 1962, 96).

The fund that Quesnay refers to at the end of this passage directly above is that which is generated by the land, but only after it has been properly prepared and worked by the Farmers or Husbandmen. It is crucial to recognize that, for the Physiocrats, while land is the *source* of all wealth, unassisted land or Nature is insufficient for generating it. This claim is not uncontroversial since some scholars have has argued that Nature alone is the prime mover in the Physiocratic model of economic production (Banzhaf 2000). Be that as it may, it should be clear that Quesnay and the other Physiocrats, including The Marquis de Mirabeau, maintained that, strictly speaking, human labour and capital cause the agricultural sector to prosper, stimulate industry, and increase and perpetuate wealth throughout the entire society (see, for example, Quesnay's *The 'General Maxims'*). In other words, land is a unique and necessary, but insufficient condition, for the production and circulation of wealth among the three main classes in the Physiocratic model.

Further evidence to support this claim can be found in Quesnay's *Extract from Corn* where he distinguishes between the roles played by Farmers and Artisans. He states, "one group of men causes this wealth to be generated by means of cultivation; another group prepares it for use; and those who have the enjoyment of it pay both of these groups" (Meek 1962, 73). This statement depicts an economy that produces wealth, not merely by the forces of unassisted nature or land alone, but land that is stimulated in the right kinds of ways. Moreover, without sufficient capital, or what the

Physiocrats referred to as "advances", from the landowners directed towards agricultural production, Quesnay expects pure poverty among the people. He asks, rhetorically:

> what then would be the fate of that poor man who is told to *go and plough the land*? Could he cultivate it on his own account? Would he obtain work from the farmers if they are poor? Farmers who find it impossible to meet the costs required for proper cultivation and to pay the wages of servants and workmen cannot employ the peasants. The land, lacking manure and all but uncultivated, can only leave all of them to languish in poverty" (*Extract from Corn*, quoted in Meek 1962, 82; italics in the original).

In his magisterial *Réflections sur la Formations et Distribution des Richesses* (Reflections on the Formations and Distribution of Riches), a correspondent to the Physiocrats, Anne-Robert-Jacques Turgot ([1770] 1898), was even more explicit than Quesnay when recognizing the role of human agency as the "First Cause" of wealth production. Matching Quesnay's standard Physiocratic model, Turgot, the Baron de Laune and Finance Minister to Louis XVI, also divided society into three classes: the Husbandman (productive class), the Artisans (the unproductive class), and the Proprietors (the disposable class). While scholars generally deny that Turgot was a genuine member of the Physiocrats, hardly anyone would deny that this friend and interlocutor of David Hume's accepted the inimitable role of land in the production of wealth (Vardi 2012; Riskin 2003; Meek 1962). In fact, Turgot maintained that the Husbandman or the farmer was to the realm of economic phenomena what was

Aristotle's Unmoved Mover was to the entire Universe. Just as Aristotle had concluded in Book 8 of *Physics* that, logically, there must be an initial unmoved mover to explain all of the other motion in the universe, Turgot suggests that, in the realm of economic phenomena, it is the Husbandman, and not the land or Nature that imparts the first impulse ("donne le premier movement") which generates wealth. The Husbandman's labour alone causes the land to produce, without which, "the land produces nothing" (Turgot ([1770] 1898, 16).

The portrait Turgot paints of wealth production, however edifying it may appear to be on the surface, is logically incoherent. In fact, in his *Réflections sur la Formations et Distribution des Richesses*, Turgot plainly contradicts himself when he simultaneously claims that the Husbandman is the sole source of wealth and the Earth is the sole source of wealth. The former claim is emphasized throughout most of his short book where Turgot states that it is the Husbandman who is the "sole source of all wealth", the "sole source of the riches", that, once produced, circulates throughout society, animating the other classes that constitute society. However, later on, in the very same book, when Turgot describes the first time humans cultivated the Earth when he states that:

> it is the earth which is always the first and only source of all wealth; it is that which as the result of cultivation produces all the revenue; it is that also which has provided the first fund of advances prior to all cultivation. The first Cultivator has taken the seed he has sown from plants which the earth has sown from plants which the earth had of itself produced; while waiting for the harvest he has lived by hunting and fishing, and upon wild

> fruits: his tools have been branches of trees, torn down in the forests, shaped with stones sharpened against other stones; he has himself captured in the chase animals wandering in the woods or caught them in his traps; he has brought them into subjection and trained them; he has made use of them first for food and afterwards to help him in his labour. The first fund has grown little by little; the cattle, especially, were of all moveable wealth that which was most easy to accumulate: they died, but they reproduced themselves, and the wealth which consists in them is in a way imperishable: this fund, moreover, grows by the mere process of generation, and gives an annual produce, either in milk, or in fleeces, in hides and other materials, which, with the wood obtained in the forests, have formed the first fund for the works of industry ([1770] 1898, 46).

While explicitly recognizing that Turgot may have been inconsistent when attributing different things with the status of "sole source of wealth", it is also clear that, with Quesnay, Turgot cannot be said to emphasize Nature's *unassisted* productions of wealth, or goods and services, certainly not in any way resembling what modern day economists do when deploying the concept natural capital. For both of these eighteenth century economic theorists and for the Physiocrats generally, unaided Nature was incapable of producing wealth. If it were correct that the Physiocrats emphasized Nature's unassisted productions, then their framework would have been a prime candidate for being a precursor to natural capital since both would have emphasized Nature's unaided productions.

It should be recognized that, as mentioned above, the emphasis here on Nature's unassisted productions is not meant to deny that the production processes denoted by the concept of natural capital must remain completely unaffected by human agency to qualify as instances of natural capital. On the contrary, as made clear in the previous chapter, instances of natural capital can be augmented and improved or modified by human agency. The reason to emphasize nature's unassisted productions here, and not improved instances of natural capital, is because the former is a distinguishing feature of natural capital. From this vantage point, we can see that, for the Physiocrats, Nature or land is special insofar as it is required for the inimitable role it serves in producing wealth (that subsequently animates the three main classes of society, including the farmers, landowners, and artisans). Nevertheless, unassisted Nature or land alone is an insufficient condition for generating the wealth that circulates throughout society. For the Physiocrats, labour and land are jointly necessary and sufficient for economic production, a species of activity that is only manifested by the Farmers or Husbandmen.

If unassisted Nature *qua* producer of economically valuable goods and services cannot be unequivocally aligned with the Physiocrats, then where else might one look for a nascent category of natural capital? Indeed, some of the most esteemed economic thinkers in the history of economic thought did recognize Nature's unaided productions. As we will see below, this category of production was often neglected because it was considered economically insignificant, particularly when compared to those items that had been improved by capital and human labour through the manufacturing process and other artisanal activities. Before turning to such economic theorists, however, it is worth recognizing the writings of the 18th Century Swedish botanist, Carl Linnaeus

(1707-1778) who believed that the whole Earth and its productions were to be managed for maximum output and adapted to the human economy.

Linnaeus had devised his own system of plant classifications, *Systema Naturae*, describing it as "the Creator's magnificent arrangement". Linnaeus' writings, particularly his *Oeconomia Naturae* (1749), held significant sway over not only nineteenth century naturalists, such as Charles Darwin and the geologist, Charles Lyell, but classical political economists, such as Adam Smith, as well (Koerner 1999; Pearce 2010). Robert Stauffer states, "the importance of Linnaeus in the evolution of ecology is very great, and it is striking that among the naturalists writing after Linnaeus and before Darwin, it is the geologist Charles Lyell who shows the clearest grasp of Linnaeus' ideas on the economy of nature and who makes the fullest use of them in his work" (1960, 238-9). Indeed, Darwin not only deployed the Linnaean terms of "polity of nature" and the "economy of nature" in his own works with great regularity and gleaned the notion of reciprocal dependence between organisms from Linnaeus' *Oeconomia Naturae*, but his deep admiration for Linnaeus is on full display in a famous letter written to his friend William Ogle, where Darwin refers to the Swedish botanist, along with the French naturalist and zoologist George Cuvier, as one of his "gods" (Koerner 1999, 15; Gotthelf 1999).[35]

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35 Feb. 22, 1882
My dear Dr Ogle

You must let me thank you for the pleasure which the Introduction to the Aristotle book has given me. I have rarely read anything which has interested me more; though I have not read as yet more than a quarter of the book proper. From quotations which I had seen I had a high notion of Aristotle's merits, but I had not the most remote notion what a wonderful man he was. Linnaeus and Cuvier have been my two gods, though in very different ways, but they were mere school-boys to old Aristotle. – How very curious, also, his ignorance on some points as on muscles as to means of movement. – I am glad that you have explained in so probable a manner some of the grossest mistakes attributed to him. – I never realized before reading your book to what an enormous summation of labour we owe even our common knowledge. I wish that Aristotle could have known what a great Defender of the Faith he has found in you.

In her *Natural Origins of Economics*, Margaret Schabas (2005, 30) argues that Linnaeus was one of the most important economic theorists of the Enlightenment and, furthermore, that the "oeconomy of nature" that Linnaeus depicts in *Oeconomia Naturae* is the first genuine depiction of an economy (a claim that flies in the face of the orthodoxy since it is generally presumed that the Physiocrats were the first economic theorists to depict an economy). Even among those who would dispute this claim, and question the status of Linnaeus as a *bona fide* economic theorist, there can be no question that Linnaeus held economic theorizing in the highest regard. As Lisbet Koerner recounts in her *Linnaeus: Nature and Nation*, Linnaeus' support for economic science is unquestionable when he states: "no science in the world is more elevated, more necessary and more useful than Economics, since all people's material well-being is based on it" (1999, 103).

For Linnaeus, "Oeconomy" is the art of household management or *oikonomikê* in the Aristotelian sense. Recall from Book 1 of his *Politics*, Aristotle grapples with the topics of wealth and household management, and investigates whether money-making and *oikonomikê* is the same thing (DesRoches 2014). He responds in the negative, arguing that "it is easy to see that the art of household management is not identical with the art of getting wealth, for the one uses the material which the other provides" (*Pol* 1256a9-11).[36] For Aristotle, natural wealth-getting involves the master of a household acquiring and administering those useful objects of wealth that constitute "true wealth"

Believe me my dear Dr. Ogle

Yours very sincerely,
Ch. Darwin

[36] It is worth noting that while Jowett's canonical work translates *oikonomikê* as an art, others have considered *oikonomikê* to be a practical science that aims at good action (See, for example, Miller 1995).

or "true riches" in order to meet the needs of all household members, including the master, his wife, children, and slaves. While Linnaeus has less to say about the relation between wealth and household management than Aristotle, Linnaeus extends Aristotle's concept of *oikonomikê* to designate the whole oeconomy of nature. As Trevor Pearce (2010, 496) explains, during the seventeenth century, the word "*oeconomia*" still had its Aristotelian meaning: the ordering of things pertaining to one's household; its usage was metaphorically extended to nature as a whole, animal bodies, and human bodies. Linnaeus simply adopted Aristotle's notion of *oikonomikê* and extended "the physiological idea of the animal economy to nature in its entirety. In [Linnaeus'] eyes, the economy of nature deserved a description as detailed and rational as that of the animal economy" (Pearce 2010, 497). In *Oeconomia Naturae*, Linnaeus states, "By oeconomy of nature we understand the all-wise disposition of the creator in relation to natural things, by which they are fitted to produce general ends, and reciprocal uses."[37] In short, Linnaeus believed that the oeconomy of nature was God's great household, a household that was to be managed for human ends.

For Aristotle, good *oikonomikê* involves becoming economically self-sufficient, mainly to avoid the constraints imposed by other people and nature. For Aristotle, the self-sufficiency of a household is sometimes understood as "autarky", "independence from others", "lacking in nothing", or "getting enough" (Meikle 1995). From the viewpoint of human lives on the whole, the self-sufficiency of households is a necessary, though intermediary, step along the road to human flourishing or *eudaimonia*. A self-sufficient *oikos* not only provides the subsistence needs of each household member, but for those individuals capable of achieving *eudaimonia*; the household's true wealth will

[37] Linnaeus (1749, 31) is quoted by Pearce (2010, 497).

also confer the basis for pursuing those non-pecuniary goods that Aristotle tells us are necessary conditions for the good life.[38] Linnaeus, too, emphasized self-sufficiency as the proper goal of *oikonomikê*. Indeed, with his strong cameralist leanings, Linnaeus had devised a grand scheme for an autarkic Sweden whereby nonindigenous species of fruits and vegetables were to be domestically grown in greenhouses (Koerner 1999; Schabas 2005).

Linnaeus' *Oeconomia Naturae* presents a static portrait of the geo-biological interactions in Nature with only one kind of change: a cyclical pattern that, inexorably, returns to the beginning (Worster [1977] 1994, 34). Linnaeus envisions all of the Earth's species of plants and animals as purposefully and perfectly arranged, living in mutually dependent relations with one another. Nature, for Linnaeus, also possessed self-regulating properties (Koerner 1999, 82). Each and every creature plays an important and specific function or "allotted place" in nature's economy (Pearce 2010). All creatures were assigned a part in the great unfolding *oeconomy of nature*; each with its own foodstuff, geological range, limits to appetites, and minimum and maximum rates of reproduction (Worster [1977] 1994). It is critical to recognize that Linnaeus' *oeconomy of nature* not only included the plants and animals, but humans, and the entire atmosphere.

Indeed, for Linnaeus, the whole world was a "terraqueous globe" that consisted of three distinct and yet mutually interdependent kingdoms: the fossil (or the crust of the

[38] For Aristotle, only the ruling free men heads of the household need complete virtue of character. Although women have the capacity for deliberation, this capacity is without authority (see Book 1, Chapter 13 of the *Politics*), which, as Roberts (2009) explains, means that women can think of their good and how they might attain it but that deliberation is not in their full control. Both women and children can achieve virtue relative to their inferior souls (*Pol*, 1260a 20-4). Slaves, on the other hand, lack practical wisdom, the capacity to deliberate, and they also have an inferior rational part of the soul (Miller 2005). For more on Aristotle's account of the nature of women, see Smith (1983).

Earth), the vegetable, which "adorns the fact of the Earth and draws the great part of its nourishment from the fossil kingdom", and the animal kingdom, which is sustained by the vegetable kingdom (Linnaeus 1749, 40). In relation to these three distinct kingdoms, we are told that "man's activities are seamlessly joined to those of plants and animals, even to the Earth's crust and atmosphere" (Schabas 2005, 30). Linnaeus describes all such interdependencies when he states,

> Everything arranged by the omnipotent Creator on our globe is performed in such a wonderful order that there is not one thing that is not dependent for its existence on the support of another … The earth becomes the food of the plant, the plant that of the worm, the worm that of the bird and the bird often that of the beast of prey … Man who turns everything to his needs, often becomes the food of the beast or bird or fish of prey or of the worm and the earth. So all things go round.[39]

For Linnaeus, the whole of nature was imbued with purpose and nature was incapable of producing waste. Just as Aristotle had famously argued that "nature does nothing in vain", Linnaeus wholeheartedly agreed with this sentiment since he believed that each and every creature was fully engaged in the *oeconomy of nature* (*De Incessu Animalium* 2, 704b12-17). Even the dead and fallen tree, for example, does not go to waste but is, without delay, efficiently eliminated by a wide variety of creatures that depend on such items for their continued existence, such as liverworts, mushrooms, beetles, caterpillars, and woodpeckers (Pearce 2010, 498). Similarly, as Donald Worster suggests, "all of

[39] Linnaeus quoted by Schabas (2005, 30).

animate nature is … bound together in common interest by the chains of sustenance that link the living to the dead, the predator to its prey, the beetle to the dung on which it feeds" (1977 [1994], 35). Linnaeus, emphasizing the obvious benefits of this state of affairs explains that:

> The whole earth would be overwhelmed with carcasses, and stinking bodies, if some animals did not delight to feed upon them. Therefore when an animal dyes (sic), bears, wolves, foxes, ravens, &c. do not lose a moment till they have taken all away. But if a horse, e.g. dyes near the public road, you will find him, after a few days, swoln, burst, and at last filled with innumerable grubs of carnivorous flies, by which he is entirely consumed, and removed out of the way, that he may not become a nuisance to passengers by his poisonous stench (1749, 121).

While it is true that, according to Linnaeus, human beings are part and parcel of the *oeconomy of nature*, these creatures still occupied a special role in this system since the whole contrivance was designed for mankind by the hand of God. This divine *oeconomy of nature* was an idea absorbed by Linnaeus who was under the influence of Robert Boyle and John Ray (Koerner 1999, 82). While Linnaeus believed that human beings were fully integrated into the *oeconomy of nature* and, like other species, are living as subordinate parts of the divine order, non-human nature remains merely an apparatus for the purposes of mankind (Worster [1977] 1994). Indeed, Linnaeus maintained that all things were made for the sake of man, an exceptional species that he describes as "the Lord of the animals"; the purpose of the whole *oeconomy of nature*

was, ultimately, to make human lives more convenient and pleasant than they would be otherwise (Koerner 1999, 85). Linnaeus states:

> we follow the series of created things, and consider how providentially one is made for the sake of another, the matter comes to this, that all things are made for the sake of man; and for this end more especially, that he by admiring the works of the Creator should extoll (sic) his glory, and at once enjoy those things, of which he stands in need, in order to pass his life conveniently and pleasantly (1749, 123-4).

Worster has argued that Linnaeus' *Oeconomia Naturae* (1749) is the first system of the *oeconomy of nature* that envisioned human beings to be at the center of his system. The role of human beings in the oeconomy of nature, it is worth recognizing, resembled that which had been encouraged by Francis Bacon in his *Novum Organum*. Bacon's dream was "to extend man's empire over nature" and "to the effecting of all things possible".[40] Linnaeus recognized humans as living amongst other creatures, all of which were a part of a divine order; however, "man must vigorously pursue his assigned work of utilizing his fellow species to his own advantage. This responsibility must extend to eliminating the undesirables and multiplying those that are useful to him, an operation "which nature, left to herself, could scarcely effect." Created to praise and emulate the Creator, men fulfill their obligations not by choosing to be "mere idle spectators" but by making nature's productions accrue to the enrichment of the human economy" (Worster [1977] 1994, 36). Indeed, as Koerner (1999) argues, there is little

[40] Bacon is quoted by Worster ([1977] 1994, 343).

doubt that Linnaeus held a sunny prelapsarian view of nature, judging the Earth to be a world that must be managed for maximum output; domesticating the wilderness to serve human purposes meant restoring it to an Edenic state. Although no one would deny that, with the concept of natural capital, contemporary economists have stripped Nature's productions from the theological and teleological clothing in which Linnaeus dressed them, it should be evident that Nature *qua* independent producer is on full display in Linnaeus' *Oeconomia Naturae* (1749).

In addition to Linnaeus, some of the most esteemed economic thinkers in the history of economic thought also recognized Nature's unaided productions. Witness John Locke's ([1689] 1980) canonical view of unassisted Nature in his *Two Treatises of Government* where he argues that the original source of value derives from mixing one's labour with Nature. In Chapter Five "Of Property" of his *Second Treatise*, Locke claimed that God gave the Earth in common to mankind and that, originally, in the "State of Nature", each person had an equal claim to make use of the Earth and its products. For Locke, much like the ancient poet Hesiod's portrayal of mankind's station in *Works and Days*, the penury condition of man required him to labour. Endowed with industriousness and rationality, Locke submits that man is to subdue the earth and improve it for the benefit of human life. From the viewpoint of Locke's prelapsarian ideal, whereby the ultimate objective was to restore or reinstate the Garden of Eden on Earth, unassisted Nature produced virtually no value at all. As a matter of fact, Locke goes even further, arguing that unimproved land is waste, "the benefit of it amount[s] to little more than nothing" ([1689] 1980, 26). Locke supposed that Nature merely provided man with inert or passive materials that were to be acted upon and improved. He states:

> of the earth useful to the life of man nine tenths are the effects of labour: nay, if we will rightly estimate things as they come to our use, and cast up the several expences [sic] about them, what in them is purely owing to nature, and what to labour, we shall find, that in most of them ninety-nine hundredths are wholly to be put on the account of *labour* ([1689] 1980, 25; italics in the original).

Locke surely recognized Nature's unassisted productions, but he also considered them to be paltry. Why? Suppose, for a moment, that unassisted Nature produced all of the economically valuable goods. In other words, suppose that Nature was sufficiently productive to independently yield *all* of the goods and services required for human consumption. If this were actually true, then the natural objects spontaneously generated by Nature would immediately possess the right kinds of characteristics and there would be no need for human toil or industry to improve them. There would be no motivation to improve any natural objects for the benefit of life, as Locke prescribes, since Nature's productions would already possess all of the characteristics desired by humankind. In this fictitious world there would also be no scarcity imposed on humanity by nature and, as a consequence, there would be no need for economic science. All of Nature's perfectly produced spontaneous productions would be available to human agents without cost.

Presumably, there are significant limitations to the usefulness of Nature's spontaneously generated products; humans are required to modify such objects because they are, on the whole, inadequate for human consumption. Indeed, the supposed

"goods" and "services" generated by Nature alone rarely possess those characteristics, qualities, and properties required to satisfy either human fancies or needs. In one of his political essays entitled, *Of Interest*, David Hume remarks that:

> every thing useful to the life of man arises from the ground; but few things arise in that condition which is requisite to render them useful. There must, therefore, beside the peasant and the proprietors of land, be another rank of men, who receiving from the former the rude materials, work them into their proper form, and retain part for their own use and subsistence ([1752] 2007, 51).

Hume surely recognizes that there are a few useful items automatically generated by Nature, but overall it is rare for the "rude materials" of the Earth to possess those specific properties desired by humankind and this is what prompts people to modify them in the first place. The transmutation of natural objects found in one's environment brings about desirable characteristics that, otherwise, would remain unavailable. Turgot propounds virtually the same position towards Nature's spontaneous productions when he states:

> the crops which the land produces to satisfy the different wants of man cannot serve that purpose, for the most part, in the state in which nature gives them; they must undergo various changes and be prepared by art. Wheat must be converted into flour and then into bread; hides must be tanned or dressed; wool and cotton must be spun; silk must be drawn from

> the cocoons; hemp and flax must be soaked, peeled, and spun; next, different textures must be made from them; and then they must be cut and sewn into garments, foot-gear, etc. ([1963] 1770, 5).

Also writing on the topic of political economy at around this time, just prior to the *Wealth of Nations* being published in 1776, was another economic theorist from the Scottish Enlightenment, James Steuart. In Steuart's *Principles of Political Economy* (1767) he also explicitly recognizes Nature's products when describing "the earth's spontaneous productions being in small quantity, and quite independent of man, appear, as it were, to be furnished by Nature".[41] For Steuart, like J.S. Mill, as we will see below, it is patently clear that there is a subclass of products – nature's products – that are merely found and not necessarily made by human agency.

Adam Smith ([1776] 1976), too, in Book I, Chapter XI of *Wealth of Nations*, also refers to Nature's unaided productions as the "spontaneous productions of the Earth" (I, XII, 112), including the kelp (as noted in Chapter One) that is not augmented by industry nor harvested directly by man. Smith is decidedly Lockean when he claims that the first price of anything is the toil and trouble of acquiring it. Moreover, there are unmistakable vestiges of Physiocratic thought in Smith's *magnum opus*, particularly in those passages that refer to agricultural production specifically. Here, Nature's (albeit assisted) productivity is displayed prominently when Smith states:

> in agriculture … nature labours along with man; and though her labour costs no expence [sic], its produce has its value, as well as that of the most

[41] As quoted by Marx ([1967] 1954, 174, fn. 1).

> expensive workmen. The most important operations of agriculture seem intended, not so much to increase, though they do that too, as to direct the fertility of nature towards the production of the plants most profitable to man ([1776] 1976, 363).

Agricultural production is a special case of production for Smith, one that is distinct from the manufacturing process; however, the distinctiveness that Smith attributes to agricultural production is not identical to that argued by the Physiocrats as was detailed above. While sustaining the view that agricultural production is unique, Smith also departs from what he perceived to be the antiquated Physiocratic view of manufacturing and artisanal activities as "sterile". This claim is evidenced by Smith's insistence that, when it comes to the manufacturing sector, Nature does nothing and man "does all" (a view that would eventually be rejected by later classical political economists, especially J.S. Mill ([1848] 2006) who, in his *Principles of Political Economy*, argues that Nature's powers are not merely to be found in agricultural production but in *all* physical objects, including the manufactured commodities that are bought and sold in the marketplace).[42]

[42] "Nature, however, does more than supply materials; she also supplies powers. The matter of the globe is not an inert recipient of forms and properties impressed by human hands; it has active energies by which it co-operates with, and may even be used as a substitute for, labour. In the early ages people converted their corn into flour by pounding it between two stones; they next hit on a contrivance which enabled them, by turning a handle, to make one of the stones revolve upon the other; and this process, a little improved, is still the common practice of the East. The muscular exertion, however, which it required, was very severe and exhausting, insomuch that it was often selected as a punishment for slaves who had offended their masters. When the time came at which the labour and sufferings of slaves were thought worth economizing, the greater part of this bodily exertion was rendered unnecessary, by contriving that the upper stone should be made to revolve upon the lower, not by human strength, but by the force of the wind or of falling water. In this case, natural agents, the wind or the gravitation of the water, are made to do a portion of the work previously done by labour" (Mill [1848] 2006, 26).

Mill's view on Nature has already been discussed at length in Chapter Two but, insofar as he was aware of Nature's unassisted productions, Mill's view more or less coincides with that of Hume and Turgot; Mill, however, is slightly more generous when recognizing the specific instances of Nature's unassisted productions. Towards the very beginning of his *Principles of Political Economy*, in the short but important chapter entitled "Of the Requisites of Production" (see page 2, Chapter 1), Mill clearly recognizes a limited number of Nature's unassisted productions, describing them as the "natural products" that "grow up spontaneously" in a manner that is quite independent of human agency. Some of these spontaneous productions that Mill lists, including caves and hollow trees, are items that, because of their favourable characteristics, are ready-made for human consumption and do not require any further transformations or transmutations brought about by direct human agency.

In *Das Kapital*, Karl Marx ([1867] 1954) appears to echo Smith when he explicitly recognizes nature labouring along with man. We are told that in the "virgin state", Nature supplies man with all of the necessaries and means of subsistence and that labour is a process in which both man and Nature participate. Nature's productions can be located in a "pure state" and can be brought "out" of this wholesome and uncontaminated realm by human agents that are involved in the labouring process. Marx clearly identifies ready-made means of subsistence such as fruits that are produced by Nature's labour but, for the most part, human industry is required to appropriate Nature's productions and to modify them so that they are made into "a form adapted to his own wants."[43] In Chapter One, section four, of *Das Kapital* entitled, "The Fetishism of Commodity and Its Secret", Marx makes the same point and thus,

[43] See Bender (1986, 360).

unequivocally agrees with the other classical political economists described above when he states, "it is as clear as noonday that man, by his industry, changes the forms of the materials furnished by nature, in such a way as to make them useful to him."[44] For Marx, laboring necessarily involves opposing oneself to Nature by using the natural forces of one's body. With this scheme, Marx draws a clear distinction between the spontaneous productions of the Earth that are produced in a manner that is relatively detached from human agency, on the one hand, from the raw materials, also produced by Nature, but that are required to undergo further manufacturing and processing to satisfy human fancies. Marx states:

> All those things which labour merely separates from immediate connexion with their environment, are subjects of labour spontaneously provided by Nature. Such are fish which we catch and take from their element, water, timber which we fell in the virgin forest, and ores which we extract from their veins. If, on the other hand, the subject of labour has, so to say, been filtered through previous labour, we call it raw material; such is ore already extracted and ready for washing. All raw material is the subject of labour.[45]

What, if anything, is remarkable about attributing productive powers to unassisted Nature? Given that most classical political economists, including Smith, Ricardo, Mill, and Marx were all wedded to some version of a labour theory of value, it is

[44] Ibid. (1986, 336).
[45] Ibid. (1986, 360-1).

hardly surprising that Nature *qua* unassisted producer of economically valuable goods and services does not *ipso facto* have a strong track-record.

The foregoing quotations would appear to be bromides, but from the purview of natural capital they are highly significant. For one, they appear to confirm the hypothesis that most classical political economists recognized a nascent category of Nature's unassisted productions and, even more significantly, this category of production was deemed to be relatively unimportant for the purpose of economic theorizing. Nature's productions suitable for immediate consumption were considered a rarity. Even in exceptional cases when nature's productions were made immediately available for human consumption, Mill reminds us that human labour is still frequently required to locate and acquire them. This observation has important consequences for the concept of natural capital. If Nature's imperfectly produced productions constituted the vast majority of Nature's productions and such products could always be improved by human labour and capital, then why bother with a trifling set of goods and services that, purely by happenstance, meet the standards set by humanity's predilections?

These quotations also reveal important limitations or constraints on how economists can possibly conceive of Nature. While it may be true that there is a subset of Nature's productions, which, by chance, possess the qualities and characteristics required for human consumption, the undesigned and mindless production processes that give rise to such items cannot produce *all* of the goods and services to be consumed by human agents. Nature might well produce goods and services but it is only because Nature is an imperfect producer at best that the science of economics gets off the ground in the first place. The science of economics must presuppose that Nature imposes some

degree of scarcity on human agents. Otherwise, there would be no economic problem to solve.

Why did classical political economists believe that Nature's unassisted productions were, on the whole, inconsequential, while economists today argue that such productions possess economic value and ought to be managed accordingly? One answer to this question is the following. Unlike contemporary economists who champion a subjective theory of value, whereby any subjectively preferred good or bundle of goods can possess a price, classical political economists were universally committed to some version of an objective labour theory of value in the tradition of John Locke. For a theorist committed to an embodied labour theory of value, the natural price or exchange value of every commodity exchanged in the marketplace is determined by the amount of labour required to produce it. For a theorist committed to a labour commanded theory of value, exchange value is determined by the labour that would be saved for the buyer of a particular commodity. Both variations of the labour theory of value, although distinct in their own right, purport to explain the value of commodities bought and sold in the marketplace by establishing a necessary connection to human labour. For such economic theorists, it would appear that nature's unassisted productions not only possess no value but, *ipso facto*, could not have possessed such value.[46] Indeed, the notion that such productions, products brought into existence

[46] With that being said, under the labor-commanded theory of value, when land commands labor in exchange for it in the marketplace, it would be considered to have value (not merely a price).

without human labour, could have exchange value is, strictly speaking, extricated from the realm of possibility.[47]

This chapter has argued that the two features which distinguish the categories of natural capital and manufactured capital, self-generation and originality, have roots in the writings of eminent economic thinkers. Since the Physiocrats emphasized the inimitable role of land in economic production, one would have expected the concept of natural capital to have a clear forerunner in this school of thought. However, it was argued that although Quesnay and other prominent Physiocrats, such as A.R.J. Turgot, claimed that land or Nature was the ultimate source of wealth, this unique wellspring from which all riches derive needed to be activated by human labour first. As such, it was claimed that the independence of Nature's productions among the Physiocrats, a distinctive feature of natural capital, is called into question. Within the Physiocratic model of economic production, it was argued that Nature or land is the unique and necessary but insufficient condition for the production and circulation of wealth in a given society.

Be that as it may, it was also shown that the ideal of envisioning the whole of Nature producing for human agents, one that is presumed by economists who deploy the concept of natural capital, has origins in the writings of Linnaeus who depicted the whole Earth and all of its productions as God's great *oeconomy of nature*. While no one denies that economists today have stripped Nature's productions from the theological and teleological clothing in which Linnaeus originally dressed them, Nature *qua* independent producer is on full display in Linnaeus' *Oeconomia Naturae* (1749).

[47] Of course, no classical political economist would have denied that land is bought and sold, and rented out for periods of time. Land, *qua* unproduced factor of production, has a price but this question is distinct from the question of whether land has value.

Additionally, I also claimed that there is a nascent concept of natural capital to be unearthed in the writings of economic thinkers, such as Smith, Mill, and Marx. When these theorists referred to the "spontaneous productions of the Earth" or Nature's "natural products" they had a distinctive class of production in mind, one that denotes Nature's independently generated products. And, while such products were, on the whole, treated as scant or relatively unimportant for the purpose of economic theorizing, such productions should be considered a harbinger to the items denoted by our current concept of natural capital.

CHAPTER FOUR

Critical Natural Capital and Sustainable Development

Introduction

Economic models of sustainable development show that, for sustainability, the aggregate level of capital in an economy must remain intact. With respect to such models, there is no greater point of disagreement than the questionable substitutability of natural capital. To what extent can manufactured capital serve as a substitute for natural capital? In response to this question, two positions are deeply ingrained in the social scientific approach to sustainable development: weak and strong sustainability.

The proponents of "weak sustainability", normally associated with the work of Robert M. Solow (1986, 1993a), claim that for the normative objective of sustainable development, the total stock of capital is to be held constant across time or between generations. Under this view, economic agents can deplete natural capital provided that it is replaced by a sufficient quantity or level of manufactured capital.

The proponents of "strong sustainability", on the other hand, are generally economists who have been influenced by the life sciences, such as ecology and conservation biology. These economists, normally associated with the work of Robert Costanza and Herman Daly (1992), argue that natural capital and manufactured capital are better viewed as complements, not substitutes. Unlike the proponents of weak sustainability who require that the total stock of capital remains intact, the proponents of strong sustainability argue that the stock of natural capital must be maintained independently.

One argument that proponents of strong sustainability have deployed against weak sustainability is the argument from *critical* natural capital. According to this argument, there exists a special subclass of natural capital, critical natural capital, for which there are no substitutes. Critical natural capital is meant to denote the ecological conditions that are essential to the continued existence of economic agents and, therefore, sustainable development. The problem with this argument, however, is that no one has explained *what* these conditions are and *why* they are essential for this purpose. Since the supporters of strong sustainability merely assert that there is a category of critical natural capital for which there are no substitutes, this argument is equivocal and, at worst, a chimera.

This chapter unmasks the concept of critical natural capital by introducing an entirely new theory of "basic ecological goods" (BEGs). It is shown that BEGs are distinct from ordinary goods in orthodox consumer choice theory since the former are objective ecological conditions that must be met for agents to exist while the latter merely yield utility to agents. The reason why BEGs are required for the continued existence of a given agent is because they possess objective

causal properties essential for this purpose. Although BEGs have no *actual* substitutes, it is argued that for any good to potentially supplant a BEG it would have to meet a two-fold requirement: it would have to play the same life-sustaining causal role and leave the agent no worse off. Thus, whereas the substitution of ordinary goods in consumer choice theory is wholly explained in terms of welfare substitution, in the special case of BEGs, a potential substitute good must, in addition to sustaining agent welfare, provide the agent with the same objective causal property required for continued existence.

The theory of BEGs upholds the claim, defended by the proponents of strong sustainability, that there are ecological conditions required for human economic activity while explaining precisely *why* such goods have no substitutes. As a consequence, the ecological conditions required for human economic activity are no longer shrouded in mystery as they were under the canopy of "critical natural capital". For this reason, the theory of BEGs helps to move the debate forward between weak and strong sustainability.

The chapter proceeds as follows. The next section introduces the debate between weak and strong sustainability, and directs the reader's attention to the argument from critical natural capital. Then, the following two sections introduce the theory of BEGs, along with necessary and sufficient conditions required for any good to potentially serve as a substitute for such goods. The chapter concludes by further probing the implications that BEGs have for the social scientific approach to sustainable development.

Sustainability Development and Critical Natural Capital

The social scientific approach to sustainable development, as described by Bryan Norton (1992), was originally motivated by The World Commission on Environment and Development's (1987) *Our Common Future*, but was pioneered by the earlier work of Robert M. Solow (1986, 1993a) and subsequently developed by David Pearce *et al.*'s (1989) *Blueprint for a Green Economy*. Invariably, this approach to sustainable development involves sustaining the productive capacity of an economy over time whereby "productive capacity" is represented by the aggregate level of capital in an economy. Models of sustainable development generally employ a Hicksian conception of capital whereby sustained income or an economy's total output depends on maintaining the level of capital intact (Hicks 1946). Sustaining the aggregate level of capital over time requires following "Hartwick's Rule" whereby total net investment in capital remains above or equal to zero (Hartwick 1977). Otherwise, if net investment were to fall below this threshold, capital would be depleted over time and since the stock of capital represents the productive capacity of an economy, production, along with the present and future human welfare that depends on it, would also decline. "Sustainability is basically seen by neoclassical economists as a problem of managing a nation's portfolio of capital to maintain it at a constant level, either *in toto* or *per capita*" (Ayres *et al.* 2001, 157).

Kenneth Arrow *et al.*'s (2004, 2010) most recent instantiation of such models show that a sustainable economy will remain capable of providing the current standard of living across generations as long as each generation bequeaths to its successor at least as large a quantity of an economy's "productive base", which is composed of three distinct kinds of capital assets: human, natural, and manufactured capital.

Manufactured capital includes all of the traditional produced means of production, such as machines, factories, and tools; human capital includes items such as knowledge, technology, and institutions; and the stock of natural capital consists the traditional renewable and non-renewable resources, but it also denotes various non-market phenomena as well, including, for example, ecosystems. Arrow *et al.* (2010) show that inter-temporal social welfare, $V(t)$, is sustainable if and only if this variable is equal to or greater than zero over time ($dV/dt \geq 0$). Because an economy's productive base is a necessary condition for sustainability and this base includes three kinds of capital, the notion of "genuine investment" plays a critical role in their model. Genuine investment represents the sum of the values of investments or disinvestments in each of the capital assets, whereby the value of each investment is the product of the change in the quantity of the asset multiplied by the shadow value of that asset. Any change in the productive base and $V(t)$ is non-decreasing at t_2 if and only if genuine investment is non-negative at t_1. In other words, a non-negative investment in capital follows Hartwick's Rule.

With respect to such models, two opposing positions have been staked out: weak and strong sustainability. The source of this division rests on the disputed substitutability of natural capital, a topic that has now filled the pages of several journals, including *Environmental Values* (Beckerman 1994, 1995; Daly 1994) and *Ecological Economics* (Daly 1997; Solow 1997; Stiglitz 1997). Most recently, in response to the role of natural capital in a model of sustainable development published in the *Journal of Economic Perspectives* (Arrow *et al.*, 2004), the substitutability of natural capital emerged as a point of disagreement in the journal *Conservation Biology* (Daly *et al.* 2007, Arrow *et al.* 2007).

What do economists mean by "substitutability"? Generally, economists distinguish between substitutions at two levels of analysis: in consumption and production (Stern 1997; Beckerman 1995). At the level of consumption, substitution is normally defined in terms of interchangeability in the agent's utility function. One good or a bundle of goods constitutes a substitute for another if it sustains the overall level of welfare or utility of a given economic agent, whereby utility derives from the satisfaction of the agent's subjective preferences. Within the context of models of sustainable development, the disputed substitutability of natural capital normally arises at the level of production. At this level, whether one factor of production can serve as a substitute for another depends on whether that factor can supplant another while sustaining the overall level of production.

Weak sustainability is traditionally associated with the work of Robert M. Solow (1986, 1993a) and it requires that the *total* stock of capital is held constant across time or between generations (Pearce and Atkinson 1993). Under this view, agents can deplete natural capital provided that it is replaced by a sufficient quantity or level of manufactured capital (Stern 1997). Hence, the presumption is that such reductions in natural capital can be offset by enlarging the stock of manufactured capital since one can serve as a substitute for the other. Economists who maintain this view frequently conceive of natural capital as an abstract homogeneous fund that can be easily directed towards alternative uses. In this sense, natural capital is not taken to serve a special role for the goal of sustainable development or the human welfare that depends on it. What matters is not that any particular stock of capital might be depleted over time but that the overall stock of capital, the productive capacity of an economy, remains intact. This is why, for example, when Dasgupta describes such models he states, "it is mostly

supposed that the growth of ideas is capable of circumventing any constraint the natural environment may impose on the ability of economies to grow indefinitely" (2001, 130). One argument deployed as a defense of weak sustainability was originally put forward by Robert Solow who claimed that "higher and rising prices of exhaustible resources lead competing producers to substitute other materials that are more plentiful and therefore cheaper" (1973, 53). As one resource is exhausted, its rising price will incentivize the production of cheaper alternatives and thus, other resources will always become available. Solow has also argued that, over time, human knowledge and technological progress increases the productivity of labour and resources by continuously reducing the amounts of resources that are required to produce a constant or increasing flow of consumer goods and services (Sagoff 1995).

Strong sustainability, on the other hand, originally derived from the work of David W. Pearce *et al.* (1989) and others, especially Robert Costanza and Herman Daly (1992). Pearce *et al.* (1989) considered four possibilities for maintaining a constant stock of natural capital: the physical quantity of the natural resource stocks should remain unchanged; the total value of the natural resource stocks should remain constant in real terms; the unit value of the services of the natural resources, as measured by the prices of natural resources, should remain constant in real terms; or, the value of the resource flows from the natural resource stock should remain constant in real terms. The proponents of strong sustainability generally argue that since natural capital and manufactured are complements rather than substitutes, sustainable development requires that *each* stock of capital should be held constant, independently. Those who argue for this view are often the biophysical scientists and ecological economists who privilege a conception of natural capital as specific and concrete heterogeneous non-

market natural processes, such as ecosystems. While the proponents of this view generally recognize exceptions to this rule – that there are instances of manufactured capital that might serve as a substitute for natural capital – the extent to which this holds true is a matter of disagreement. This is hardly surprising given that natural capital and manufactured capital are both aggregate variables that are meant to denote an enormous variety of heterogeneous items. While it is easy to conceive of *some* forms of manufactured capital that would substitute for some forms of natural capital, proponents of strong sustainability argue that it is most certainly false that all forms of manufactured capital are substitutes for all forms of natural capital or even that there is always some form of manufactured capital that can be a substitute for all forms of natural capital.

The proponents of strong sustainability have deployed several arguments to support their claim that manufactured capital and natural capital are, in general, complements rather than substitutes.[48] This chapter is only concerned with one such argument: there is a special subclass of natural capital, "*critical* natural capital", that is required for the continued existence of economic agents and therefore, sustainable development. This subclass of natural capital, first introduced by members of the London Centre for Environmental Economics, was originally meant to denote those specific instances of natural capital that were required for basic life support (Victor 1991; Stern 1997). David Pearce and Kerry Turner (1990), for instance, argued that it was possible to substitute between some instances of manufactured and natural capital

[48] For the details of these specific arguments, see Herman Daly (1994). For a critique of these same arguments, see Dale Jamieson (1998).

but they maintained that there was a minimal stock of critical natural capital for which there are no substitutes.

Since its inception, this concept has been adopted by many other scholars, including Carl Folke *et al.* (1994, 6) who state that, "there will always be a minimum or critical amount of natural capital needed to sustain any individual of the human species". Similarly, Rudolf De Groot *et al.* (2003, 189) state, "critical natural capital cannot be substituted for by human-made capital and must be individually preserved". Most recently, the authors of the highly influential *Millenium Ecosystem Assessment* (2005) declare that there are forms of natural capital that are "critical for human welfare". Joshua Farley describes critical natural capital as generating "benefits that are essential to human welfare and have few if any substitutes" (2008, 1404) and the environmental economist Barbier asserts that there are forms of natural capital that are "so essential for life" and that "humans depend on and use this natural capital for a whole range of important benefits, including life support" (2011, 6).[49]

While it may be true that there are instances of critical natural capital, the meaning of terms such as "non-substitutable", "near-impossible to substitute", and "essential" in this context remain obscure. The concept of critical natural capital requires a clearer formulation then it tends to receive. As it stands, critical natural capital merely serves as a black-box or placeholder for the ecological conditions that are required for human economic activity. The real problem is that no one has explained *what* these conditions are and *why* they are essential for this purpose. Without such an account, the argument made by proponents of strong sustainability – that there is some

[49] Similarly, Paul Ekins (2003, 278) states, "it is not possible to identify [critical natural capital] as particular elements of natural capital."

set of ecological conditions that are essential to human economic activity and therefore, these conditions ought to be sustained – is empty. A satisfactory theory of the ecological conditions essential for the continued existence of economic agents should clearly explain why the members of this subclass have no substitutes.

In response to this state of affairs, the next two sections introduce a new theory of what are termed "basic ecological goods" (BEGs) and explain what would be required for any good to potentially serve as a substitute for such distinctive goods.

A Theory of Basic Ecological Goods

Aside from anomalous goods, such as "Giffen goods" and "Veblen goods", substantive claims are rarely made about goods, aside from the fact that they contribute to the utility of agents when consumed.[50] This section introduces a novel kind of good, "basic ecological goods" (BEGs). Two features distinguish BEGs from ordinary goods. First, BEGs are ecological conditions that must be satisfied for the continued existence of a given agent. While such goods might also contribute to agent welfare, BEGs are special because they are required to be an agent with subjective preferences. In this sense, BEGs are pre-conditions to the satisfaction of subjective preferences. Second, the reason why BEGs are essential in this sense is because, for any given agent with a particular constitution, such goods possess objective characteristics or properties that afford a causal role to the agent that is not available in any other good.

BEGs are necessary for the continued existence of a given agent. This proposition implies that agent existence is a contingent fact that depends on, among other things,

[50] Giffen goods violate the law of demand since agents consume more them when their prices rise. Veblen goods, named after the old institutional economist, Thorstein Veblen, are generally associated with conspicuous consumption.

certain ecological conditions. On the face of it, the existence of such goods will strike many as a platitude, but BEGs represent an arresting departure from consumer choice theory which takes agent existence to be a parameter, not a variable.[51] The theory of BEGs presumes that agents do not exist in a vacuum, but are embedded in an external environment that includes a totality of factors, both biotic and physical, that influence the agent's welfare and continued existence (Brandon 2012; 1990).[52] BEGs denote a distinct kind of good that populate the agent's environment; they reflect the familiar idea that life can only exist within a certain range of physical or material conditions. Although the focus here is human agents, this view corresponds particularly well with an organism's viable environment as that term is used by biophysical scientists (Beissinger and McCullough 2002). As Daniel C. Dennett explains, the continued existence of any organism requires that certain ecological conditions be satisfied:

> A tiger is viable now, in certain existing environments on our planet, but would not have been viable in most earlier days, and may become inviable in the future (as may all life on Earth, in fact). Viability is relative to the environment in which the organism must make its living. Without breathable atmosphere and edible prey – to take the most obvious conditions – the organic features that make tigers viable today would be to no avail. And since environments are to a great extent composed of, and

[51] As Mark Blaug ([1962] 1996) reminds us, ever since the marginal revolution in economics circa 1870, economists have treated population as exogenous variable.

[52] Robert Brandon's (1990) concept of external environment is different from mine since it covers those external conditions that affect the survival and reproduction of an organism.

> by, the *other* organisms extant, viability is a constantly changing property, a moving target, not a fixed condition (1996, 115).

To be a welfare enhancing agent requires that the agent is situated in some viable environment because such an environment possesses the ecological conditions required for the agent's continued existence. However, this claim is a qualified one since, as Dennett explains, any viable environment is bound to have a "moving target quality". Since environments undergo constant change and agents are themselves changing self-reproducing physical systems capable of modifying their environments, i.e., niche construction (see Lewontin 1983), even if it were discovered that a particular ecological condition qualified as a BEG for some agent at a certain time and place, that same BEG might not be classified as such in the future. To put it more precisely we can define a BEG by stating that:

> x is a BEG for agent α in environment E at time t ↔ if all variables other than x were held fixed at their values at t, and x were removed from E, then α would cease to exist (shortly after t).[53]

What would be required for some "x" to qualify as a BEG? In the short-term, say, over the lifetime of a single agent, suppose it was discovered that a particular molecule, B^2Z^6, was a BEG for that agent. This would mean that for the viability of this agent, and

[53] Throughout this chapter, the symbol "↔" should read as "if and only if". For pragmatic purposes, this definition of a BEG can be read in light of J.L. Mackie's (1980, 63) "causal field": a set of background conditions, not completely specified but taken as fixed. The causal field fixes everything but some set of variables that one is interested in.

his sustained capacity to continue being that agent, B^2Z^6 would have to be available to that agent in the right kind of way.[54] Taking an evolutionary long-term view of organisms as historical entities fashioned by the forces of natural selection (among others) in ever changing environments casts doubt on the BEG status attributed to B^2Z^6 in the short-term. From a long-term view, even though B^2Z^6 became indispensable to the continued existence of some agent along the evolutionary pathway, it is a contingent fact that such molecules became available in the first place, and that the agent's biological ancestors became dependent on it for their continued existence. Thus, although B^2Z^6 might be a BEG for some agent today, it could have been otherwise and it might fail to be the case in the future. The definition of a BEG given above accounts for such contingencies.

So far, I have only posited that, for a given agent, there are peculiar ecological conditions that are required for its continued existence. To make BEGs more palpable, more needs to be said about *why* such goods are necessary for this purpose. What makes some goods essential for the continued existence of a given agent and not others? Why, if a BEG were removed from a particular environment, would the agent cease to exist? The short answer to this question is that, unlike ordinary goods that only contribute to the utility of agents, BEGs possess certain objective properties capable of performing a causal role required for the agent's continued existence.

Two issues require elaboration: first, the idea that BEGs possess certain distinct properties and, second, that such properties perform some causal role needed for the continued existence of the agent.

[54] By "the right kind of way" I mean that such objects will have appropriate extrinsic properties in relation to the agent. It is commonly said that water is a necessary condition for life but it is obviously a sufficient condition for death as well.

Consumer choice theory normally abstracts from the properties or material attributes of goods. In the case of BEGs, however, it is useful to adopt a properties-view of goods. This outlook, while not standard to economics, is certainly not foreign to the social science. Some economists have adopted this stance towards both resources and commodities. In a seminal paper by Robert U. Ayres and Allen Kneese, they recognize that "almost all of standard economic theory is in reality concerned with services. Material objects are merely the vehicles which carry some of these services, and they are exchanged because of consumer preferences for the services associated with their use or because they can help to add value in the manufacturing process" (1969, 284). David Stern (1997, 197) also recognizes that "individual commodities and other inputs have unique physical or other properties which make them poor substitutes". Similarly, Julian Simon (1981) has forcefully argued that, in light of Malthusian worries concerning the depletion of scarce resources, what matters most is not sustaining any particular resource but the service a resource provides. Simon states,

> We are interested in the particular services that resources yield, not in the resources themselves. Examples of such services are an ability to conduct electricity, an ability to support weight, energy to fuel autos, energy to fuel electrical generators, and food calories . . . . What is relevant to us is not whether we can find any lead in existing lead mines but whether we can have the services of lead batteries at a reasonable price; it does not matter to us whether this is accomplished by recycling lead, by making batteries last forever, or by replacing lead batteries with another contraption (1981, 410-11).

Kelvin Lancaster's (1971) theory of consumer demand and Amartya Sen's (1985) capabilities-approach to human welfare both focus on the characteristics of commodities, rather than commodities themselves. For Lancaster, it is the objective characteristics of commodities and not the commodities themselves that yield utility to agents. Similarly, Sen's capabilities-approach to human welfare involves converting a commodity vector into a vector of characteristics of those same commodities. The achieved functionings (b_i) of agent *i* are defined as follows: $b_i = f_i (C(X_i))$ where f_i is a utilization function for agent *i*, $C(\cdot)$ is the function converting a commodity vector into a vector of characteristics of those commodities, and X_i is the vector of commodities possessed by the agent.

The main reason to adopt a comparable properties-view of BEGs is because *ex hypothesi* such goods have causal properties that may potentially become available in other goods. This, of course, is not to say that the causal properties of BEGs are actually available in other goods since BEGs are defined as performing an essential causal role for the continued existence of some agent. This point is crucial for understanding BEGs. BEGs are necessary because they perform a specific causal role in relation to the agent that is required for the agent's continued existence. Following the example given above, B^2Z^6 could only be properly classified as a BEG for some agent if there were no other naturally occurring molecules or synthetic molecules capable of executing a required causal role, one that is not multiply realizable under contingently existing circumstances. In this sense, BEGs are indexed to what is technologically available. It is precisely because the causal role performed by B^2Z^6 is not available in any other goods that B^2Z^6 is required for an agent with a particular constitution. Strictly speaking, what

is necessary for the continued existence of the agent in this case is not B^2Z^6 itself but the causal properties instantiated by B^2Z^6. As we will see below, this claim is central to understanding what – in principle – would be required for any good to serve as a substitute for BEGs, but for the time being more needs to be said about BEGs performing a required causal role in relation to contingently existing agents.

Many things might qualify as a BEG for a given agent and it is useful to consider a real-world example. Take, for example, oxygen molecules or dioxygen (O_2). O_2 is produced on Earth mainly by plants engaged in the process of oxygenic photosynthesis. The molecule began accumulating in the Earth's atmosphere during the Precambrian Period (4,600-561 million years ago), and our biological ancestors adapted to it, eventually becoming dependent on it for their continued existence (Williams 1992). At this particular time, there is some minimum quantity of O_2 required for the continued existence of certain agents, aerobic organisms, with a particular constitution.[55] O_2 is consumed by aerobic organisms during cellular respiration. In vertebrates, O_2 diffuses through membranes in the lungs (the capillaries are permeable to O_2) and eventually to red blood cells. More specifically, O_2 is used in the mitochondria of cells to generate adenosine triphosphate (ATP), the "molecular unit of currency" of intracellular energy transfer (Knowles 1980). Any other kind of molecule, including carbon monoxide (CO) and carbon trioxide (CO_3) cannot be used by mitochondria to generate ATP. Since O_2 is the only kind of molecule capable of executing a causal role required for the continued existence of aerobic organisms, it is a BEG for these organisms.

[55] Whether some good constitutes a BEG is not set *a priori*, but can vary according to how much an individual possesses. It is clear that since O_2 can be removed from the Earth's atmosphere without affecting the continued existence of aerobic organisms not *all* O_2 is a BEG for such organisms. One might argue that there is a possible world where no BEGs exist, but our concern is primarily with in this world, planet Earth, where there are BEGs.

The contingency of agent existence can be represented by a simple causal system whereby the dependent variable, Y (t_o), is the agent or the target system of the agent that depends on various inputs X_n (t), where $t \leq t_o$. These inputs include some set of BEGs that represent the ecological conditions necessary, not only for the present, but continued existence of the agent. Of course, X_n is likely to include a wide range of other factors and conditions, but for our purposes what matters is that it includes some set of BEGs. This means that for a given agent at t_o that does not stand in the right kind of extrinsic relation to the required set of BEGs, that agent is not embedded in a viable environment and will therefore no longer exist at time t_o or shortly thereafter.

For the sake of simplicity, from this point forward, given that the causal properties of BEGs perform a causal role in relation to a causal system – the target system of some economic agent – it is useful to adopt Robert Cummins' (1975) terminology and describe such properties as functional properties. That being said, what is meant by functional properties in this context only means that BEGs possess and execute a required causal role within a particular causal system.

The main tenets of BEGs have now been introduced. Let's take stock. BEGs are distinct from ordinary welfare enhancing goods because they possess causal properties that are essential for the continued existence of agents. While such goods might contribute to the welfare of agents, a fact determined by the agent's subjective preferences, BEGs serve another role. They are the ecological pre-conditions to the satisfaction of any agent's subjective preferences. What makes BEGs essential? For a given agent with a particular constitution, such goods alone possess the functional properties not available in any other good. It should be clear that the causal roles executed by BEGs are objective, not subjective. This means that the relations between

BEGs and the agent do not directly depend on subjective preferences but are independently determined by two factors: the kind of creature the agent is and the structure of the agent's environment.

The theory of BEGs is a descriptive theory, not a normative one. The theory posits objective ecological pre-conditions to human economic activity, but it does not follow from this statement that such goods are objectively valuable or that such goods ought to be preserved. This is not because there are no good reasons to preserve such conditions, but because normative questions such as these are treated as a separate issue from the theory presented. In Kantian terms, the theory of BEGs is located within the realm of hypothetical imperatives, not categorical ones. Under the working assumption of a subjective theory of value (more specifically, the subjective preference-satisfaction approach to agent welfare of consumer choice theory), agents might well prefer a world with BEGs to one without BEGs but there is no requirement for agents to have such a preference. Thus, strictly speaking, basic ecological *goods* only qualify as goods when the agent prefers BEGs to no BEGs. Otherwise, BEGs might well be labeled basic ecological *conditions* or something like this. Basic ecological *conditions* only become basic ecological goods when they provide utility to agents and they only provide utility when the agent subjectively prefers them over some other state of affairs. This implies, as absurd as it might sound, that undermining the ecological conditions necessary for continued existence might coincide with utility maximization. Agents might prefer death to life and the theory of BEGs is in full agreement with this prospect.

That being said, if the theory of BEGs is true and the agent prefers a bundle of goods that contains BEGs (prefers continued existence to non-existence), then this agent will require a viable environment partly constituted by such goods. In other

words, for human economic activity to take place the world might be many different ways but it cannot be any possible way.

The Substitutability of Basic Ecological Goods

Because BEGs are defined as essential for the continued existence of a given agent they can be described as having potential substitutes, but no actual substitutes. Nevertheless, one can still ask: what *would* constitute a substitute for a BEG? If a particular good were to serve as a substitute for a BEG, what condition or set of conditions would it have to meet? This section defends the claim that for any good to serve as an overall substitute for a BEG it would have to meet a double requirement: it would have to leave the agent no worse off, in the same sense required of any substitute good in orthodox consumer choice theory, but it would also have to meet an additional proviso: it would have to provide the agent with the same objective functional property as well. Therefore, unlike the substitutability of ordinary consumer goods, a full account of BEGs and their potential substitutes cannot be limited to examining the agent's subjective state alone.

First of all, what is a substitute good according to consumer choice theory? As mentioned above, substitution is normally defined in terms of interchangeability in the agent's utility function and is cashed-out behaviourally in terms of the agent's willingness to trade one good for another. Mas-Colell *et al.* (1995) define two goods, A and B, as substitutes at the price p and utility level u if $\mathrm{dh}_A(p, u)/\mathrm{dp}_B$ is greater than or equal to zero.[56] Goods A and B are substitutes when the price of good A declines (a higher demand for good A) and there is a leftward shift in the demand function for good

[56] Note that $\mathrm{dh}_A(p, u)$ is a Hicksian demand function.

B. Substitute goods have a positive cross-elasticity of demand. Conversely, goods A and B are complements when the price of good A declines (a downward movement along the demand curve for good A) and there is a rightward shift in the demand function for good B. Complementary goods have a negative cross-elasticity of demand.

The received view on substitutability, as Mas-Colell *et al*. characterizes it, can be broadly termed as welfare substitutability. Welfare substitutes maintain an agent's overall level of welfare and are wholly explicable in terms of the non-negative welfare consequences they have for the agent. In other words, a particular good is a welfare substitute because of its utility-making role in relation to the agent and not by virtue of any other factor.

Given the nature of BEGs outlined in the previous section, answering the substitutability question is going to require recognizing the objective functional properties possessed by such goods. Therefore, it is useful to draw a distinction between welfare and functional substitutes that will enable us to see how the view defended in this chapter differs from the received view. Each of the following *sui generis* substitutes is agent relative and specific to a particular time and place:

> **Welfare substitute**: Good A is a welfare substitute for Good B ↔ Good A is interchangeable for Good B in such a way that it leaves agent α equally or better well-off.

Functional substitute: Good Y is a functional substitute for Good Z ↔ Good Y provides the same functional property as Good Z for agent α.[57]

Under the assumption that agents prefer continued existence to non-existence, for any good to serve as a substitute for a BEG it must be a welfare and functional substitute. We can describe such a good as an *overall substitute* because it comprises two kinds of substitutes, welfare substitutes and functional substitutes. The central implication of this thesis is that if some Good X does not possess the same functional properties, leaves the agent worse off, or both, then it will not be an overall substitute for a BEG. These possibilities are depicted in Figure 4 where the following question is asked: would Good X serve as an overall substitute for a BEG? As shown in this Figure, only the north-west quadrant answers this question affirmatively, where Good X has both the same functional property as the BEG it supplants and leaves the agent no worse off. The other three quadrants identify instances that fail to satisfy this dual requirement. In all of these cases, Good X either leaves the agent worse off, does not possess the same functional property as the BEG it supplants, or both.

[57] John O'Neill *et al.* (2008) make a similar distinction between technical substitutes and economic substitutes. It is to be remarked that functional substitutes are defined independent of price. No matter the price of BEGs, they are required for the continued existence of a given agent. Similarly, one can determine whether any good is a potential substitute for a BEG by examining its functional properties alone (independent of price).

		Agent Welfare	
		Equally well-off or better-off	Worse-off
Functional Property	Same	YES	NO
	Different	NO	NO

Figure 4. Would Good X Serve as an Overall Substitute for a BEG?

This account of substitution for any BEG diverges from the treatment of substitution found in orthodox consumer choice theory and it also differs from, for example, Lancaster's (1971) account of substitution in his characteristics analysis of consumer demand. For Lancaster, substitution between two goods depends on their objective characteristics whereby the closeness of substitution can be predicted from technical data concerning the characteristics that each good possesses. In other words, Lancaster's framework presumes that welfare and functional substitutes coincide: if Goods X and Y share the same characteristics, including what I have termed functional properties, then they are (predicted to be) substitutes. It is by granting that the characteristics of goods yield utility to agents, and not the consumption of goods themselves, that Lancaster is able to collapse the divide between functional and welfare substitutes.

But surely a good might have the same or similar characteristics as another good without being a welfare substitute. A motorcycle might be capable of providing the same transportation function as an automobile to the agent, but the agent might well prefer to

consume no goods capable of transportation. The agent's subjective preferences might be such that neither motorcycles nor automobiles sustain his welfare. And, obviously, a good can be a welfare substitute without possessing any of the same characteristics or properties as the good it supplants. A four-bedroom house on the hillside might be a welfare substitute for a first edition copy of Adam Smith's *Wealth of Nations* when the agent freely trades one for the other, but the agent cannot take shelter in his rare book. Similarly, many loaves of bread might be a welfare substitute for a desktop computer, but the latter cannot nourish the agent; nor does the bread compute for the agent.

This is also true for welfare and functional substitutes. A good can be a welfare substitute and not a functional substitute and a good can be a functional substitute and not a welfare substitute. Welfare substitutes and functional substitutes are logically independent: they can coincide, but they need not.

To see why this is true consider John O'Neill's (2013) argument concerning the valuation of natural capital. O'Neill objects to the contention that a particular instance of natural capital is only valued by agents for the ecosystem services it provides. He distinguishes between *de dicto* and *de re* valuation and argues that for natural capital, such an approach arbitrarily privileges *de dicto* valuation over *de re* valuation and this is problematic because agents might well value certain articles of natural capital *de re*. Valuing a specific form of natural capital only for the services it provides – an instance of *de dicto* valuation – can be expressed by employing the existential quantifier:

Agent α values $\exists_x$ (X is an article of natural capital that produces service Y).

In this case, the agent values a particular article of natural capital X merely for its service or output, Y. *De re* valuation, on the other hand, involves valuing a specific form of natural capital for its individuality or distinctiveness and not only because of the service it provides. O'Neill argues that agents will sometimes value natural capital *de re*, whereby:

$\exists_x$ (X is an article of natural capital and Agent α values X).

If the agent values a particular form of natural capital in this way – *de re* – then even though two articles of natural capital might share many or all of the same characteristics, the agent will be made worse off if the instance of natural capital he values *de re* is destroyed or depleted, etc. Take, for example, a specific watershed that happens to purify water for some agent or group of agents. One agent might value this watershed only because it serves as an instrument to purify some quantity of water and for no other reason. In this case, the agent can be described as valuing the watershed *de dicto* since he attaches no value to the uniqueness of the watershed, but only to the services that it happens to afford him. In other words, the watershed is merely a vehicle that, by happenstance, produces some object of value. For this agent it would make no difference if the water purification process was executed by some other process since the watershed itself is not the object of value. If, on the other hand, the agent values the watershed not merely because it produces potable water but because of its uniqueness or distinctiveness then the agent can be described as valuing the watershed *de re*.

This distinction between *de dicto* and *de re* valuation is applicable for the case of BEGs. If the agent values a particular BEG *de re*, then even if the potential substitute

good possesses the same functional property – and thus qualifies as a functional substitute *simpliciter* – it will not serve as an overall substitute for that BEG. The reason is because even though two goods might possess identical functional properties, if the agent values BEGs *de re*, then that agent will be made worse off without consuming the specific BEG or bundle of BEGs that she values in this way.

Take the example of O_2. Earlier, it was claimed rather uncontroversially that O_2 is a BEG for certain creatures – aerobic organisms – on Earth. One batch of O_2 molecules is a functional substitute *simpliciter* for another batch of the same molecules, but no other kind of molecule is available to perform the specific causal role required for the continued existence of aerobic organisms. While O_2 has no actual functional substitutes in this world, one might easily imagine that in some possible world there is a class of molecules, call them "functional oxygen" or "FOX-O_2", whose members do possess the same functional property as O_2. If the agent values some batch of O_2 *de re* in this world, then although FOX-O_2 is a functional substitute *simpliciter* for O_2, it will not serve as an overall substitute for O_2 since agent welfare will not be sustained with FOX- O_2. On the other hand, if the agent's subjective preferences are structured in such a way that she values BEGs *de dicto* so that only the objective functional properties of such goods matter for the agent (and not the particular goods that happen to possess them), then two goods with the same functional properties will not only be functional substitutes, but overall substitutes as well. This is only a special case, however. The mere fact that two goods share the same functional properties and therefore qualify as functional substitutes *simpliciter* does not necessarily entail that the agent will be equally well-off by consuming one or the other. Although two goods might qualify as functional substitutes and these goods might also be welfare substitutes, this need not be the case.

One might object to this claim by arguing that agents do not value O_2 *de re* but only *de dicto* and therefore, my attempt to propose otherwise fails. Consider, for example, the wisdom imparted to us by the Stoic philosopher Epictetus in his *The Enchiridion*:

> With regard to whatever objects give you delight, are useful, or are deeply loved, remember to tell yourself of what general nature they are, beginning from the most insignificant things. If, for example, you are fond of a specific ceramic cup, remind yourself that it is only ceramic cups in general of which you are fond. Then, if it breaks, you will not be disturbed. If you kiss your child, or your wife, say that you only kiss things which are human, and thus you will not be disturbed if either of them dies.

In the foregoing quotation, Epictetus can be interpreted as claiming that we do (or ought) not value specific items such as ceramic cups, children, and wives *de re*. Since he does not even believe that we value (or ought) to value our significant others *de re* then surely Epictetus would find my claim – that an agent might value O_2 *de re* – to be dubious. However, my claim is not an empirical one. Rather, it follows from the subjective theory of value whereby agents can prefer any goods to any others for any reason. What I am claiming is not that it is empirically true that agents value O_2 *de re*, but that agents valuing O_2 *de re* is not ruled out *a priori* by the subjective theory of value.

We have now seen why two goods that possess the same functional properties are not, necessarily, *overall* substitutes. For example, under the working assumption of the subjective theory of value, agents might prefer any goods over others for any reason, including the characteristics of goods other than their functional properties. That being said, in the case just considered – where the agent strictly values goods *de dicto* for their functional properties and two goods possess functionally identical properties – then such goods will qualify as overall substitutes. In this case, the functional equivalence between two goods implies that the agent is made no worse off. Even in this case, however, it is crucial to recognize that the double requirement imposed on any potential substitute of a BEG is not violated because for any good to serve as an overall substitute for the given BEG it will leave the agent no worse off while simultaneously providing the agent with the same functional property as well.

Now, the task at hand is to show that a good capable of serving as a welfare substitute *simpliciter* would be insufficient to serve as a substitute for a BEG. If it were the case that welfare substitution was sufficient to account for the overall substitution of BEGs, then BEGs would be wholly analyzable in terms of subjective utility and there would be no need to account for the objective functional properties of BEGs. The claim here, however, is that under the assumption that agents prefer continued existence to non-existence, agent welfare could only be sustained by a good that possessed the same functional property as the BEG it supplants. Ergo, the dual requirement: any good that is a welfare substitute for a particular BEG will also have to possess the same functional property as the BEG it supplants. The implication is that explaining the *overall* substitutability of BEGs requires accounting for the functional properties possessed by such goods.

BEGs and Lexicographic Preferences

This chapter has argued that accounting for the substitutability of BEGs cannot be reduced to a story about subjective utility alone since any good that potentially serves as a substitute for BEGs will also have to possess the same objective functional property as well. Nevertheless, it is still worth considering the specific case of lexicographic preferences. The claim being made here is not that it is impossible to model BEGs with lexicographic preferences, a question that is beyond the scope of this chapter, but that since the standard account of lexicographic preferences presumes *ex hypothesi* that certain goods or a certain quantity of goods have no substitutes, this presumption is at odds with the objective to establish necessary and sufficient conditions for any good to potentially supplant a BEG.

A lexicographic preference that is held for one good or a specific quantity of that good implies that it has the highest priority over other goods in the same way that a dictionary is organized, by the first letter of words. Such preferences give absolute priority to the consumption of one good or specific quantity of a good over all the others and therefore, imply a strict ordering. Unlike standard preference relations which allow for one bundle of goods to be traded-off against another while keeping the agent's level of utility constant, lexicographic preferences do not permit such simple trade-offs.[58] These preferences have attracted the attention of environmental economists in particular because it has been claimed that people hold such preferences for non-marketed environmental goods, such as wildlife, wetlands, plants and ecosystems, and

[58] Lexicographic orderings are hardly unique to consumer choice theory, but can be found in a wide variety of familiar theoretical contexts. John Rawls (1971), for example, proposes a lexicographical ordering to the principle of equal liberty prior to the principle of regulating economic and social inequalities.

endangered species (Spash and Hanley 1995; Spash 2000; Lockwood 1996; Ayres *et al.* 2001).[59]

Other economic theorists have employed lexicographic preferences as a technique to account for "basic goods" or "needs" that must be met prior to choices being made over other goods (Georgescu-Roegen 1954). In such cases, lexicographic preferences are applied to part of a consumption set whereby a minimum quantity of a good represents the subsistence level of consumption required for agent survival (Spash and Hanley 1995). Under these circumstances, when a certain quantity of basic goods is not consumed, then the lexicographic ordering indicates that the agent will suffer a large and instantaneous loss in subjective utility, a loss that cannot be compensated by consuming bundles of goods that exclude this subsistence level of consumption.

Lexicographic preferences appear to provide a promising way for consumer choice theory to handle BEGs, especially since they have been used to account for the subsistence level of consumption required for agent survival and BEGs are themselves defined as goods required for continued existence. Consider an example.[60] Tom and Jerry have the following set of alternatives:

$$\boldsymbol{X} = \mathbb{R} \text{ X } \{0, 1, 2\}$$

[59] Thomas H. Stevens *et al.* (1991) found that 25% of respondents in their study revealed lexicographic preferences for wildlife preservation in the United States.

[60] A referee brought a similar example of kidneys to my attention.

where $\mathbb{R}$ is the real number line that denotes amounts of money,[61] $k = 0$ means "not being alive", $k = 1$ means "having one kidney and being alive", and $k = 2$ means "having two kidneys and being alive". Tom and Jerry each have a complete and transitive preference relation defined over the set of alternatives, $\boldsymbol{X}$.[62] Let each preference relation be denoted by '$\succcurlyeq_i$' (with $i = t, j$) (to be read 'at least as good as'). The symbol '$\succ_i$' is to be read 'preferred to'. Suppose that Tom has the following preferences over money (x) and kidneys (k):

For each $x, x' \in \mathbb{R}$ and each $k \in \{0, 1, 2\}$, $(x, k) \succcurlyeq_t (x', k) \leftrightarrow x \geq x'$,

For each $x \in \mathbb{R}$ and each $k, k' \in \{0, 1, 2\}$, $(x, k) \succcurlyeq_t (x, k') \leftrightarrow k \geq k'$

$\forall\, x, x' \in \mathbb{R}$ and $\forall\, k, k'\{0, 1, 2\}$ it is true that $k > k' \Rightarrow (x, k) \succ_t (x', k')$

Tom's preferences suggest that he values both life and money. In fact, he would never part with a single kidney, no matter how much money he was offered in exchange for it. Jerry, on the other hand, has the following preferences:

For all $x, x' \in \mathbb{R}$ and each $k \in \{0, 1, 2\}$, $(x, k) \succcurlyeq_j (x', k) \leftrightarrow x \geq x'$,

$(x + x', 1) \succcurlyeq_j (x, 2) \leftrightarrow (x + x') \geq 10^7$,

For each $x \in \mathbb{R}$, $k \in \{0, 1, 2\}$, $(x, k) \succ_j 0$

[61] The negative values represent money forgone and positive values represent money received.

[62] A standard preference relation ($\succcurlyeq$) over two bundles of goods x and y (x, y ∈ X) is rational if it is complete (for all x, y ∈ X, we have that x $\succcurlyeq$ y or y $\succcurlyeq$ x) and transitive (for all x, y, z ∈ X, if x $\succcurlyeq$ y and y $\succcurlyeq$ z, then x $\succcurlyeq$ z) (Mas-Colell *et al.* (1995, 6)).

Unlike Tom, Jerry has lexicographic preferences over a part of his consumption set since he is willing to part with an infinite amount of money to keep his kidney, when he has *one*. However, Jerry's preferences also indicate that he is willing to give up on one of his kidneys, provided he is compensated with at least $10,000,000.

This example gives us an account of kidneys, but is it the account we want? As depicted above, lexicographic preferences model substitution in terms of welfare alone. For Tom, neither of his kidneys have a substitute; for Jerry, when the price is right, one of his kidneys has a substitute (though no amount of money will serve as a substitute when he has only one kidney). In both of these cases, whether a kidney is substitutable depends entirely on the subjective preferences of Tom and Jerry and not on any other factor, such as the objective functional properties of kidneys. If the purpose is *not* to establish necessary and sufficient conditions for a good to serve as an overall substitute of a kidney then one could safely ignore the objective functional properties possessed by these organs. For such purposes, welfare substitution as it is depicted by the standard lexicographic preferences above would be entirely adequate.

However, since our objective is to establish necessary and sufficient conditions for any good to serve as an overall substitute for a kidney, modeling substitution in terms of welfare alone is restrictive. Consider, for example, the agent who prefers continued existence to death and who also happens to possess a single kidney. Suppose further that one wants to obtain the conditions that must be satisfied for any good to supplant this agent's last kidney. Answering this query cannot simply rely on a story about the structure of the agent's subjective preferences. It will also require an account of the causal role executed by a functional substitute, such as a properly functioning hemodialysis machine. But the standard account of kidneys and lexicographic

preferences, such as the one given above, does not establish the necessary and sufficient conditions for any good to serve as an overall substitute for a kidney because it normally abstracts from the causal properties of kidneys and their potential functional substitutes. On this account, if a kidney has no substitute, it is simply because it is subjectively preferred in a distinctive kind of way. The problem with this approach is that it presumes *ex hypothesi* that kidneys or, a certain quantity of them, have no substitutes when our objective is to establish necessary and sufficient conditions for any good to serve as an overall substitute for this agent's last kidney.

One might argue that establishing necessary and sufficient conditions for any good to serve as an overall substitute for a BEG is misguided since functional substitution does not concern economics, but some other science, such as ecology. This objection fails for a few different reasons. First, although the substitutability of goods in terms of their characteristics, including their functional properties, may not be pervasive in economics, Lancaster (1971) and Sen (1985) both endorse such an approach and, if Jacob Viner's famous retort that "economics is what economists do" is correct, then the substitutability of goods in terms of their characteristics or properties is part and parcel of economic science. Second, one needs to understand that the objective of establishing necessary and sufficient conditions for any good to serve as an overall substitute for a BEG is driven by what BEGs are and how they are distinctive from ordinary goods in consumer choice theory. While ordinary goods merely yield utility to economic agents, BEGs possess objective properties that afford agents with a causal role required for continued existence. Under the assumption that agents prefer continued existence to non-existence, agent welfare can *only* be sustained by a good that possesses the same functional property as the BEG it supplants. This statement not only reinforces

the claim that for any good to serve as a substitute for a BEG it must meet the dual requirement, but it also goes a long way to justify the objective of establishing necessary and sufficient conditions for any good to supplant a BEG. It is by virtue of what BEGs are and the objective properties they possess which make them distinct from ordinary goods that the question of *overall* substitutability is appropriate for these goods in particular. To demand that one must abstract from the functional properties of BEGs would be to ignore the very feature that makes these goods distinctive in the first place.

Conclusion

The largest part of this chapter was devoted to introducing a theory of BEGs and proposing necessary and sufficient conditions for any good to serve as a substitute for such goods. This theory entails that there are objective ecological conditions that must be met to *be* an agent with subjective preferences. The reason why BEGs, and not ordinary consumer goods, are required for the continued existence of a given agent is because such goods possess causal properties that are essential to the agent. Given that BEGs possess such properties, it would be a kind of category mistake to suggest they are members of a class of things that *only* yield utility to agents. BEGs are never goods that merely yield utility to agents since they also afford agents with functional properties necessary for continued existence.

The motivation to develop this theory in the first place was to unmask critical natural capital, a concept that is central to the debate between weak and strong sustainability. Among the proponents of strong sustainability, critical natural capital is meant to denote specific ecological conditions that must be met for agent existence and therefore, sustained economic production. However, the problem, until now, was that

no one had explained what, precisely, these conditions might be and why they are essential for this purpose. Without such an account, there was no way to judge whether the argument from critical natural capital was sound. The theory of BEGs, on the other hand, answers these questions and thus, helps to move the debate forward between weak and strong sustainability. Since this theory entails that economic agents require a viable environment constituted by BEGs, we can conclude that human economic activity depends on sustaining specific goods *in kind*, a proposition that is incompatible with the following:

> Resources are … fungible in a certain sense. They can take the place of each other. That is extremely important because it suggests that we do not owe the future any particular thing. There is no specific object that the goal of sustainability, the obligation of sustainability, requires us to leave untouched (Solow 1993b, 181).

While Solow argues that sustainability does not require that any particular kind of resource be retained, the theory of BEGs is a challenge to his view since it implies that there are some kinds of basic resources or ecological conditions that must be met for the objective of sustainable development. Of course, it would be misleading to claim that, on the basis of the foregoing quotation, Solow denies human economic activity depends on any ecological conditions whatsoever since he is mainly concerned with traditional resources as inputs into the production process, not BEGs. Be that as it may, his statement that "we do not owe the future any particular thing" contrasts sharply with

the proposition that there are specific ecological conditions that must be met for sustainable development.

One might resist the claim that BEGs have any implications whatsoever for sustainable development since this theory is at the level of consumption, where the relation of interest is between economic agents and goods, and sustainable development is at the level of production, where the relation of interest is between sustained output and the means of production. However, while it is true that economists normally distinguish between substitution at these two levels of analysis, limited substitution possibilities in consumption, such as those imposed by BEGs, will almost certainly have consequences for sustained productive capacity as well. As David Stern states, "limited substitution possibilities in consumption may also make it impossible to derive meaningful capital aggregates that are monotonically related to welfare" (1997, 155).

It is worth noting that the theory of BEGs implies that the consequences for economic agents extend beyond mere gains and losses in subjective utility. Without a viable environment partly constituted by BEGs at time t_1, the agent will lose her existence or agenthood and, therefore, the *possibility* of gaining or losing utility at some future time t_2. If the agent prefers continued existence to non-existence, then such a loss will be different in kind from mere gains or losses in subjective utility since it will include the agent's ability to gain or lose subjective utility.

It was argued that unlike substitutes for ordinary goods that sustain agent welfare, any overall substitute of a BEG must also be a functional substitute. Substitute goods must possess the objective causal properties required for the agent's continued existence. This implies that neither welfare substitutes nor functional substitutes are, on their own, sufficient to account for the substitutability of BEGs. One might object to this

double requirement by insisting that it should be held to account by Occam's razor: functional substitution can and should be reduced to welfare substitution. But while it is true that the functional properties of BEGs only command attention because of their connection to agent welfare, this chapter has argued that in cases where agents prefer continued existence to non-existence, agent welfare will necessarily depend on the causal properties possessed by BEGs. For any good to potentially serve as a substitute for a BEG, it will have to possess the same functional property as the BEG it supplants and this fact cannot be reduced to welfare substitution alone.

Finally, although agents depend on BEGs for continued existence, the question of whether such goods are scarce should not be neglected. To claim that some set of goods is required for the continued existence of an agent because such goods possess certain causal properties is not to claim that they are scarce or expensive. They might be ubiquitous and cheap. In the prototypical case of O_2, for example, the quantity of such molecules available to certain agents might well be abundant. Indeed, this will often – though not always – be the case for BEGs. But while the scarcity of BEGs would be crucial to any comprehensive analysis of such goods, the focus of this chapter was to make the items denoted by the concept of critical natural capital more explicit by introducing a theory of BEGs.

CHAPTER FIVE

No One Can Preserve Nature

> What many conservation interests want to preserve is a nature that is not controlled, shaped, or willed by us, a nature which, as against culture, can be thought of as just there. But a nature which is preserved by us is no longer a nature that is simply not controlled. A natural park is not nature, but a park; a wilderness that is preserved is a definite, delimited, wilderness. The paradox is that we have to use our power to preserve a sense of what is not in our power. Anything we leave untouched we have already touched.
>
> - Bernard Williams (1995)

Chapter One claimed that economists have moved away from the image of *Nature as a Storehouse* to the image of *Nature as a Garden*. Whereas Nature as a storehouse generally envisions the whole of nature as a collection of inert materials to be used as inputs in human-directed production processes, Nature as a garden consists, in part, of what might be termed "ecosystem artifacts" – ecosystems that have been instrumentalized for human purposes. Since the ideal view of nature as a garden would seem to involve domesticating every last economically valuable ecosystem, the status of "wild ecosystems", "wilderness", or "untrammelled Nature", is put into question.

Certainly, John Stuart Mill would have questioned the desirability of the whole world being domesticated to serve human purposes. In his *Principles of Political Economy* (Book VI, Chapter VI) Mill states:

> It is not good for man to be kept perforce at all times in the presence of his species. A world from which solitude is extirpated is a very poor ideal. Solitude, in the sense of being often alone, is essential to any depth of meditation or of character; and solitude in the presence of natural beauty and grandeur, is the cradle of thoughts and aspirations which are not only good for the individual, but which society could ill do without. Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture ploughed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture ([1848] 2006, 756).

For Mill, a state of affairs without any spontaneous productions of the Earth, whereby all of nature is brought into cultivation, is undesirable, mainly because it would preclude humans from developing their depth of character. While this chapter will not directly consider the *desirability* of the world as a garden, it does consider a connected question

embodied by the "preservation paradox".[63] John O'Neill *et al.* (2008, 139) describe this paradox as follows: "Nature … is what exists outside of any intentional human intervention. Protection or restoration, on the other hand, requires intentional human intervention in order to put it into effect. So, how can it be possible to protect or restore, by intentional human agency, something that is supposed to be independent of intentional human agency?" As a preliminary formulation, the paradox can be summarized as follows:

1. Nature is that realm of phenomena that is independent of intentional human agency.
2. "Preserving" and "restoring" Nature requires intentional human agency.
3. Therefore, no one can preserve (or restore) Nature.

Some scholars, namely, John O'Neill *et al.* (2008) and Richard Sylvan (1998) have argued that the paradox is false. As we will see below, O'Neill *et al.* have argued that there is at least one way to restore nature without turning it into an artifact. Sylvan (1998), on the other hand, simply dismisses the possibility that preserving nature makes it more artificial. This chapter argues for the contrary thesis: no one can preserve or restore nature. In other words, I will argue that the preservation paradox is warranted. Robert Elliott (1982) and Eric Katz (1992, 2012) have made similar claims by arguing that restored nature is artificial and that, because of this, it has less value than its wild nature counterpart. While this chapter argues that the paradox is sound, it makes *no*

[63] In her *Rambunctious Garden: Saving Nature in a Post-Wild World*, Emma Marris (2011) argues that we should create the "rambunctious garden", which she takes to be a hybrid between wild nature, on the one hand, and human management on the other.

claim about the degraded *value* of restored nature. Moreover, as we will see below, the thesis of this chapter also differs from Elliott's (1982) insofar as he maintains that *preserving* nature is possible. To the contrary, I will argue that when nature is merely preserved it is *ipso facto* made into an artifact. If I am right, then the artifactual can be made, not only by intentional human activity directed at restoring ecosystems, but by intentionally *omitting* human activity from preserved "wild" ecosystems as well. This new argument will depend, in part, on James Woodward's (2003) account of absence causation.

The next section begins by reformulating the preservation paradox in order to guard it from a few criticisms. Then, to determine whether the preservation paradox holds, I will show why it is that restored and preserved nature becomes more artificial than it would be otherwise. To do this, I will outline three features that distinguish artifacts from natural objects. Unlike natural objects, artifacts are designed or lanned; they possess a function attributed to them by an intentional agent or group of agents; and, they have been modified by an intentional agent. I will then argue that since restored and preserved ecosystems share all of these features, we can conclude that restoring and preserving nature turns nature into an artifact.

Perhaps the first thing to recognize about the preservation paradox as expressed above is that it privileges a particular concept of Nature. The presumption being made here is that Nature is a realm of phenomena that is independent of intentional human agency. Under this account, intentional human agency is the unique cause that somehow makes "Nature" or "wilderness" or "wild ecosystems" become artificial. Without this particular concept of nature there would be no paradox at all. Indeed, if one were to effectively show that Nature is not some realm of phenomena that is

detached from intentional human agency, then it would become much less clear whether there is any paradox at all. For example, if Nature were taken to be everything actual and everything possible (Mill's first concept of nature) then there would be no paradox since Nature could never be destroyed. So, it is crucial to realize that the paradox depends on a particular concept of nature and that this concept might contend with others.

Nature as a realm of phenomena that is independent of intentional human agency is also problematic because, as suggested in Chapter Two, there is no longer any part of the Earth that has not been affected by human agency. If pristine and untrammelled Nature or "wilderness" or "wild ecosystem" means some bit of nature that is hermetically sealed-off from human activity, then there is no Nature left on or near the surface of the Earth.[64] Mark Woods refers to this as the "no-wilderness argument" and states, "wilderness preservation efforts seem doomed because they ignore the historical fact that we today preserve as wilderness has been impacted by people in the past. There is no such thing as de facto wilderness in North America, and all of our current wilderness areas as untrammeled wilderness are fake" (2000, 355). Following this line of thought, it would seem that there is no Nature left to be preserved, and therefore, we have another reason for thinking there is no preservation paradox.

One might suggest weakening the requirement that Nature is completely independent of intentional human agency by acknowledging that while it is true there is no longer any part of the Earth that remains completely unaffected by human agency and human technologies, there are still places and objects that remain relatively

[64] Marris (2011, 2) states, "Nature is almost everywhere. But wherever it is, there is one thing that nature is not: pristine. In 2011 there is no pristine wilderness on planet Earth."

detached from human agency. Moreover, as David Wiggins (2000, 10) has claimed, while it may be true that no pure Nature left that is completely independent of human agency, the implication is not that all of nature has yet been instrumentalized to serve human purposes.

The preservation paradox can be reformulated to reflect these two challenges. Consider the slightly modified, new preservation paradox as follows:

1. Nature is that realm of phenomena that is *relatively detached* from intentional human agency.
2. "Preserving" and "restoring" Nature requires intentional human agency.
3. Therefore, no one can preserve (or restore) Nature.

The only difference between the original preservation paradox and the new one directly above is that the former states that nature is that realm of phenomena that is "independent" of intentional human agency while the latter states that Nature is a realm of phenomena that is "relatively detached" from intentional human agency. Recall from Chapter Two that, rather than imposing a strict division between natural and artificial objects, it was proposed that the artificial/natural distinction be described as a continuum whereby phenomena are branded as more (less) natural or more (less) artificial, depending on their degree of detachment from intentional human agency. I then distinguished between those objects or items that are completely detached from human agency from those which have a *first* or *second* degree of detachment. For the remainder of this chapter, when I refer to the preservation paradox, I do not take Nature to be pristine or untrammelled, a view that Michael P. Nelson and J. Baird Callicott label

"naïve wilderness realism" (2008, 12). Rather, from now on, when I state "preservation paradox", I am referring to the new, reformulated, paradox which takes nature to be a realm of phenomena that is only relatively detached from human agency (see Figure 2, page 55).

To be clear, from this point forward, rather than using a multitude of related concepts, such as "nature" or "wilderness", I will only use the terms "ecosystems" and "wild ecosystems", since these items are often denoted by economists who deploy the concept of natural capital. The adjective "wild" in this context simply designates ecosystems that remain relatively detached from intentional human activity whereas "ecosystems" simpliciter designate ecosystems that may have been actively and intentionally constructed, restored, or managed by human agents. These latter ecosystems may have been transformed and completely instrumentalized to serve human ends.

For the purpose of this chapter we also require working definitions of "restoring ecosystems" and "preserving ecosystems". As for the activity of restoring ecosystems, this chapter simply follows the Society of Ecological Restoration's 2002 definition: "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (see Sarkar 2012, 132). Similarly, José M. Rey Benayas *et al.* (2009, 1121) describe ecological restoration as involving "the recovery of an ecosystem that has been degraded damaged, or destroyed, typically as a result of human activities." Invariably, restored ecosystems are ones that have been intentionally returned to some previous state or a "reference state" that is valued or desired by some human agent or agents (in this chapter I will not speak to the difficulties of choosing and justifying a particular reference state). Preserving ecosystems, on the other hand, generally involves no such

active human interventions but, on the contrary, are taken to be areas or reserves that are merely protected from certain activities that are prohibited or discouraged.[65]

It should be clear that by arguing that the preservation paradox is true – that no one can preserve or restore nature – I am not claiming nature or wilderness ought not to be preserved or restored in any sense. My argument is that nature cannot be preserved or restored in the specific sense that is contained by the concept "Nature" as given by the paradox. Thus, the argument of this chapter is not for or against the action of preserving wilderness spaces or ecological reserves. Rather, the main claim defended in this chapter is against the possibility of preserving nature in the specific sense that nature is presupposed by the preservation paradox. My claim here is that it is conceptually incoherent to preserve or restore Nature when it is conceived as a realm or domain of phenomena that is relatively detached from intentional human agency.

If the preservation paradox is true, then, by restoring or preserving nature one turns nature into an artifact, or – in the very least – these activities make nature more artificial than it would be otherwise. In order to argue for the truth of this paradox, I first need to give an account that explains how natural objects can be turned into artifacts. Once established, this account can serve as the basis for evaluating the further claim that restoring or preserving nature *ipso facto* turns nature into an artifact.

What makes some objects natural and others artificial? Unsurprisingly, there is no easy answer to this question. Recall from Chapter Two, that, for Aristotle, (*Physics* Book II, 9-10), artifacts are taken to be different in kind from natural objects. He states, "Of things that exist, some exist by nature, some from other causes. 'By nature' the

[65] For more on preserving nature in general, see Sagoff (1974).

animals and their parts exist, and the plants and the simple bodies (earth, fire, air, water) – for we say that these and the like exist 'by nature'." Artifacts, on the other hand, have their forms imposed on them by external causes and do not possess their own inner source of reproduction, as was established with Aristotle's wooden bed example described in Chapter Two.

In his *The Sciences of the Artificial*, Herbert A. Simon (1996, 5) identifies the following four indicia that distinguish the artificial from the natural:

1. Artificial things are synthesized (though not always or usually with full forethought) by human beings.
2. Artificial things may imitate appearances in natural things while lacking, in one or many respects, the reality of the latter.
3. Artificial things can be characterized in terms of functions, goals, adaptation.
4. Artificial things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptive.

These four criteria, however illuminating, fail to explicitly recognize the linkage between artificial things and intentional human activity. In the specific context of debating the preservation paradox, John O'Neill *et al.* (2008, 128-9) have proposed that "something is artificial only if it is the result of a deliberate intentional act" and, similarly, "something is artificial if and only if it is what it is at least partly as the result of a deliberate or intentional act, usually involving the application of some art or skill." If one accepts the putative claim that human agents are the only ones capable of such deliberate intentional acts, then, on this account, only such agents are capable of turning

natural objects into artifacts. Moreover, for any natural object to become an artifact requires that that object stand in the right kind of *causal relation* to some intentional agent whereby the artifact is the intended product or consequence of some act. This is a good initial attempt to distinguish artifacts from natural objects, not only because it recognizes artifacts as intention dependent objects, but also because it dovetails nicely with the specific concept of nature – a realm of phenomena that remains relatively detached from intentional human agency – presupposed by the preservation paradox.

Beyond O'Neill *et al.*'s account, which emphasizes artifacts as intention dependent objects, we can add three more features or characteristics of artifacts that distinguish them from natural objects. Artifacts (1) are designed or planned; (2) possess a function attributed to them by an intentional agent or group of agents (this feature matches Simon's third criterion above); and (3) have been, in some way, modified by an intentional agent. None of these features should astonish or bewilder the artifact theorist or philosopher of artifacts. In fact, all three of them are widely accepted as necessary conditions for any object to qualify as an artifact. The reason why I refrain from making the stronger claim that these three features together are necessary and sufficient conditions that any object must meet to be considered an artifact is because my purpose here is not to defend a novel or grand theory of artifacts but to simply distinguish artifacts from natural objects by employing the theoretical resources that are already available to me. Another qualification is this. For the purpose of this chapter, I am only concerned with a subclass of artifacts, *technical* artifacts, which include an enormous variety of everyday physical objects such as tables, chairs, bookshelves, roller-coasters, and houses, all of which have a practical use for intentional agents. Thus, while there are certainly exceptions to the rule, the category of technical artifacts is generally

taken to exclude intentionally made objects such as works of art, such as paintings and sculptures, for example.

First, in his *Artifacts, Art Works, and Agency*, Randall Dipert (1993) suggests that, unlike natural objects, artifacts are necessarily objects that are designed and made by an intentional agent.[66] Planning or designing artifacts normally precedes the construction of the artifact itself. Pieter E. Vermaas and Wybo Houkes (2003) concur with Dipert on this feature, suggesting that design is "a planned activity to contribute to a user plan for achieving certain goals" (2003, 288).[67] According to Vermaas and Houkes, any satisfactory theory of artifacts will need to focus on the design of the object at hand.

Second, it is widely accepted that all technical artifacts possess a function or purpose that has been attributed to them by an intentional agent or group of agents. Lynn Rudder Baker (2008, 2-3), for example, states that unlike natural objects which come into existence without human intervention, artifacts are intention dependent phenomena that are "made for a given purpose." The Finnish philosopher Risto Hilpinen (2011) also defines artifacts as essentially "objects that are intentionally made or produced for a certain purpose." Dipert (1993), too, agrees that artifacts are made for a certain purpose while making the further claim that an artifact's function is to be

[66] Dipert's (1993) *Artifacts, Art Works, and Agency* is among the first analytic explorations into artifacts (see Perlman 2004). In addition to being an object that is designed and made for a certain purpose, Dipert also adds that artifacts are made to "communicate their function". Hilpinen (2011), for one, has questioned the notion that every artifact must have been made to communicate their function. He states, "This is a plausible condition, since an F-object can presumably be a good F-object only if its potential users recognize it as such. However, this recognisability should not be taken to mean general recognisability: a mechanical shark used in making an adventure film is an artifact, but its authors do not wish the audience to recognize it as such, on the contrary. The condition of recognisability applies only to the persons who are using it in the making of the film."

[67] Vermaas and Houkes (2003) also require that any satisfactory theory of artifacts will require a structural component as well.

grounded on the use and design of artifacts (Perlman 2004). In the case of ordinary technical artifacts such as tables or chairs, all such items possess specific functions that have been attributed to them, not by Nature, but by an intentional human agent or a group of such agents. It is by virtue of being intention dependent objects that tables are for eating meals, chairs are for sitting, etc.

How, more specifically, might an object come to acquire a function attributed to it by an intentional agent? One way to understand how this process works is to consider John Searle's (1995, 2010) theory of institutional facts. His theory can be summarized by the following formula "X counts as Y in C", whereby X refers to the object being given an institutional status, Y refers to the status itself, and C refers to the conditions under which the status applies. Thus, for example, a small, malleable, and thin piece of plastic with certain origins (the Royal Canadian Mint) and that possesses certain physical features or properties (X) counts as a Canadian $10 dollar bill (Y) among Canadian citizens in the year 2014. As Searle explains, "humans have the capacity to impose functions on objects and people where the objects and the people cannot perform the functions solely in virtue of their physical structure" (Searle 2010, 7). J.P. Smit *et al.* (2011) provide another example, of a traffic light, as it would be explained by Searle's theory. They state, "The X-term would refer to the physical object, namely, the actual physical traffic light. But the traffic light does not fulfill its function due to the purely physical facts associated with it. Rather this object *counts as* a traffic light only because we collectively regard it as having a certain status. What makes it a 'traffic light', as opposed to so many lights on a pole, is that the green counts as a signal that we should go, the red counts as a signal that we should stop, etc. This status of the lights obviously does not follow from their physical constitution, but from being objects of collective

intentionality, which confers this status" (2011, 5-6). This formula, which is an essential feature to explaining all institutional facts, seems to work particularly well for technical artifacts since it helps to explain how a mere physical object can be assigned a function and have it recognized as such by intentional human agents.

The third and final feature that distinguishes natural objects from artifacts is that the object at hand must have been modified – in some way, shape, or form – by an intentional agent. Hilpinen has argued that artifacts necessarily have a maker or author, and he outlines the following *Dependence Condition* that must be met for any object to be considered an artifact:

> The existence and some of the properties of an artifact depend on an author's intention to make an object of a certain kind (Hilpinen 1992, 65).[68]

This widely accepted condition is normally interpreted as requiring that the author of an artifact must, in some minimal sense, actively modify, transform, or improve some object before it is considered to be a *bona fide* artifact.[69] This condition also helps to explain why not everything that merely happens to be produced by human agents is an artifact. The agent who intends to build a hammer with a wooden handle and a steel head, a technical artifact that is first designed and then made for striking

[68] Randall Dipert has argued that artifacts are intentionally modified tools that should also be intended by its author *to be recognized* as having been intentionally modified for a certain purpose (Dipert 1993, 29–31).

[69] Sipii (2003, 417) implicitly accepts Hilpinen's dependency condition when she states "an entity *x* is an artifact if and only if *x* has been intentionally brought into existence by causing the artifact *x* to have certain properties."

hard surfaces, does not also intend to cast a shadow against the wall of the building where he works, nor does the agent intend to produce a plume of sawdust when cutting the wood to fashion the handle. The latter two events are not the result of intentional actions, but mere happenings. In other words, there is a conceptual distinction to be made between objects that are made by intentional human agents and those things that are merely caused by human activity. Hilpinen's dependence condition helps to explain why the hammer is a technical artifact while the shadow and the sawdust are not.

It should be recognized that intentional agency may not be limited to human beings and so Hilpinen's dependence condition does not necessarily exclude all of the animal artifacts made by non-human creatures (Hilpinen 2011). On his account of animal artifacts, James L. Gould (2007) supplants intentionality as a necessary condition for making artifacts with its mere "usefulness" for a particular creature. Specifically, Gould defines an artifact as "any creation on the part of an animal, using and/or modifying available materials, which is useful to it or its offspring" (2007, 249). Animal artifacts include a wide range of objects that have been modified for their usefulness, including the silk spun by insects to make cocoons and the modified twigs used by chimpanzees to extract termites from their mounds. But while Gould extends artifacts from the human realm to the entire animal kingdom, he also maintains that there is a difference between human and animal artifacts. He states that, "in animals the vast majority of these artifacts are built according to innate specifications using a set of inborn instructions" while other animals (including *Homo sapiens*) "we see a more flexible, goal-oriented system, in which urges rather than detailed instruction seem to motivate the creation of the tools, homes, and decorative devices – sometimes with apparently traditional group specific designs" (2007, 266). In any case, while technical

artifacts are normally considered to be objects that are intentionally designed and made by human agents for specific purposes, and such artifacts are the ones emphasized in this chapter, Gould's account of animal artifacts suggests that intentional agency may not limited to human agents alone.

If restoring and preserving ecosystems involves designing and planning them, attributing them with a function, and intentionally modifying them in some way, then we can conclude that such objects are artificial and that the preservation paradox is true. How *do* restored and preserved ecosystems measure up to these three features of artifacts that I have delineated above? Are restored ecosystems designed or planned? Do they possess a function that has been attributed to them by intentional human agents? Are restored and preserved ecosystems modified by an intentional agent? Even if the answer to all of these questions happens to be positive, what about the tricky case of merely preserving *wild* ecosystems? Since these ecosystems are, by definition, relatively detached from human activity, it is puzzling to envisage how these items could be modified by intentional human agents (and therefore, satisfy Hilpinen's dependence condition as described above).

First of all, it should be evident that the activity of restoring ecosystems, the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed in order to bring about some desired effect, requires making a plan or design. In his *Nature by Design: People, Natural Process and Ecological Restoration*, Eric Higgs (2003) argues that "restoration is fundamentally about design". Planning a restored ecosystem not only requires determining the targeted historical reference state that happens to be preferred or desired by human agents, but it also requires establishing the most effective means for attaining the final product: a restored

ecosystem. Without a plan or design, even if it is imperfect or incomplete, that precedes the actual restored ecosystem it is difficult to see how any ecosystem could, in fact, be restored. Planning in this sense, even if the plan ultimately fails, is not merely required for restored ecosystems but for preserving ecosystems as well. While it is true that preserving wild ecosystems does not involve active human intervention, it does involve minimal planning insofar as the ecosystem that remains relatively detached from human agency – where specific intentional activities are prohibited or discouraged – must be cordoned off from other the other adjacent areas that are not being preserved by human agents.

Certainly, ecosystems that have been denoted by the concept of natural capital possess a function attributed to them by human agents: to produce economically valuable goods and services to human agents. This point was established in Chapter Two. It is worth emphasizing, however, that restored and preserved ecosystems are sufficiently different from ordinary technical artifacts to be considered a special class of technical artifacts. Unlike ordinary artifacts, such as tables and chairs, that do not possess a function independent of those attributed to them by intentional agents, ecosystems may possess functions independent of those attributed to them by intentional human agents.

Restored and preserved ecosystems may possess functions independent of human agents while technical artifacts are not normally considered to possess any function independent of those attributed to them by human agents. In other words, the functions of technical artifacts, such as shoes and hammers, are never considered to be a natural property possessed by such objects but is only ever attributed to them by some intentional agent.

Jay Odenbaugh (unpublished manuscript) has argued that one can make sense of an ecosystem's non-intentional natural function by grounding them in terms of Robert Cummins' (1975) theory of function.[70] Cummins' causal-role functional analysis entails that the function of an item is determined by the causal role it plays in relation to a larger system: some item possesses a function if and only if it plays a causal role in relation to some larger system under consideration (Perlman 2004). More specifically, Odenbaugh explains Cummins' account of function as follows: "suppose that *x* is some part of a system *S*, has a disposition *F*, and *S* itself has some disposition *C*. Roughly then, the systemic capacity function of *x* in a system *S* is *F* if, and only if, *x* is capable of *F*-ing and *x*'s capacity to *F* in part accounts for *S*'s capacity to *C*" (unpublished manuscript, 18). Odenbaugh gives the example of fungi. Fungi (*x*) have the function of decomposing woody products (*F*) in an ecosystem (*S*) if, and only if, fungi are capable of decomposing woody products (*F*-ing) and fungi's capacity to decompose woody products in part accounts for an ecosystem's capacity to contribute to the carbon cycle (*C*). If it is true that, as Odenbaugh argues, ecosystems possess such Cummins-style functions then it would seem that unlike ordinary technical artifacts, ecosystem artifacts can be described as possessing two distinct functions that have two distinct origins: one that is bestowed by nature, the natural function of ecosystem artifacts, and the second being put there by intentional human agents, the artifactual function of ecosystem artifacts.

The notion that there is a subclass of technical artifacts that possess two functions, one natural and the other artifactual, is not entirely novel. Dan Sperber

[70] Among ecologists, "ecosystem function" has multiple meanings. For a list of such meanings, see Jax (2010).

(2007) recently gave a similar account for what he terms biological artifacts. According to Sperber, biological artifacts perform their intended artifactual function for human agents by performing a natural or biological function. Unlike the natural function of ecosystems, however, which Odenbaugh construes in terms of Cummins-style causal role functions, Sperber adopts Ruth Milliken's (1984) etiological theory of function to explain the natural function of biological artifacts. This particular non-intentional theory of function bases the function of a trait, not on the present-day causal role it performs in relation to a larger system, as is the case for Cummins' theory of function, but on its evolutionary history. Under Milliken's (1984) account, the biological function of some trait is to be determined by how it has evolved over time under evolutionary pressures, namely, natural selection. For example, the heart can be described as having a biological function not only because it plays a causal role in relation to the organism of which it is a part, as would be the case under Cummins' (1975) account, but also because this organ contributed to the successful reproduction and continued existence of some biological species over time.

Take the case of leeches, a prime example of a biological artifact according to Sperber. Properties of these organisms have been controlled, used, and generally exploited by human agents for bloodletting for millennia. Sperber explains that, "leeches … have the artifactual function of letting blood. This is the intended effect for which they are used. This is also the effect the use of leeches has produced in the past and which causes people to go on using them expecting the same effect" (Sperber 2007, 130). The biological function of this trait, on the other hand, is to draw blood from a host, a trait that was selected for by natural selection. Somewhere along the evolutionary pathway, this particular trait was selected for because it was adaptive, or fitness enhancing, for

the organisms who possessed it. This biological function, unlike its artifactual function, came about independently of human agency.

If Odenbaugh and Sperber are correct in their respective accounts of ecosystem function and biological function, then, in addition to their artifactual functions, ecosystem artifacts and biological artifacts can be described as possessing non-intentional functions as well. In other words, ecosystem artifacts can be described as possessing multiple functions. This feature would appear to challenge orthodox theories of technical artifacts, such as Dipert's (1993), since such theories suggest that technical artifacts only possess the intentional functions attributed to them by intentional agents. Vermaas and Houkes (2003), for instance, argue that a theory of artifact function should focus on the design of an object and claim that their function is merely based on the intentions of designers, which precede the artifact. While this claim appears to cover many instances of technical artifacts, it appears to be at odds with ecosystem artifacts and biological artifacts since these entities possess functions that are independent of any function attributed to it by an intentional agent.

Some scholars deny that nature is capable of attributing functions to any phenomena, including ecological or biological phenomena. John Searle (2004), for instance, is a non-reductive naturalist who takes a conventionalist position on all functional claims. For Searle, the only source of functions, an essentially value-laden term, is the intentional activity of creatures like us who attribute functions to specific objects, including the specific traits of organisms, such as hearts, and technical artifacts, such as tables. Under his view, all functional claims are ontologically dependent on human intentionality (see Perlman 2004, 11). To claim that the function of the heart is to circulate blood in an organism is to also suppose that the heart malfunctions when it

fails to perform this task. To make such functional claims involves making inescapable value judgments and since naturalism excludes such judgments from the natural world, it must exclude functional claims as well. Thus, for Searle, to suppose that the function of the heart is to circulate blood involves an implicit commitment to a norm that values the continued existence of organisms. If human agents supposed that life and the continued existence organisms was a bad thing, we would not attribute the heart with the function of circulating blood nor would we claim that the heart malfunctions if it failed to circulate blood. Under Searle's conventionalist account, one can equally conceive of an intentional agent or group of agents who attribute hearts with the function of merely making thumping sounds rather than circulating blood. For Searle, there are no functions without intentional agency.

Peter Godfrey-Smith (2014), on the other hand, takes issue with the claim that all talk of function must be normative or teleological. He defends the use of "function" purely on methodological grounds, for the purpose of explaining biological phenomena, without any necessary implication for "goodness" or "propriety". He states:

> Within a minimal concept of function as causal role, or contribution to the activities of a system, this evaluative way of thinking about functions is clearly out of place, except as a kind of pretence. If something does not play its usual role in explaining activities of a more complex system, that need not be a bad or improper thing; it might be a step in the right direction for all concerned. In the case of the etiological concept of function, something's function is the effect it has that explains why it is there. This, again, brings with it no implication of goodness or propriety.

> The function has a role in the explanations of a certain kind, and that is all. Descriptions using the word "function" can sometimes seem richer, stronger; there can seem to be a warm glow of purpose about a thing when it fulfills its function. But this is a leftover from earlier views. It does not correspond to anything in our present understanding of living systems (2014, 64-5).

But while Searle and Godfrey-Smith differ on the question of whether the use of function *must* have some association with "goodness", neither scholar is likely to deny that the term "function" is essential to some biological explanations. The point being made here is that the function of ecosystems (denoted by the concept of natural capital), whether restored or preserved, is to produce economically valuable goods and services and that this function has been attributed to such ecosystems by intentional human agents. However, while this function is imposed on ecosystems by human agents, we have also seen that it is conceivable that ecosystems have Cummins-style functions independent of human agency. This would seem to be a difference between ecosystem artifacts and ordinary technical artifacts since it is generally supposed that the latter artifacts only ever possess a function that has been attributed to it by an intentional agent.

Finally, restored and preserved ecosystems have been modified by an intentional agent. Recall that Hilpinen's dependence condition requires that the existence and selected properties of an artifact depend on an author's intention to make an object of a certain kind. The first thing to recognize is that this condition is *causal* and that it is normally interpreted as requiring that the author of an artifact *actively* modifies some

natural object in order to turn it into an artifact. Interpreted in this way, the author of an artifact must modify some object *vis-à-vis* intentional activity for that object to be considered an artifact. If this were the only way to interpret Hilpinen's dependence condition, then my claim that preserving wild ecosystems turns them into artifacts would be problematic since wild ecosystems are, by definition, relatively detached from intentional human activity. In fact, under the standard interpretation of the dependence condition, wild ecosystems are not artifacts at all, but merely "instruments" or what some scholars have referred to as "naturefacts".

Dipert (1993), for one, would disagree with my claim that preserved wild ecosystems are artifacts. He would argue that if such an ecosystem were simply discovered and intentionally used for some purpose, it would not be an artifact but an "instrument". For Dipert (1993, 23-7), instruments are simply items that have been intentionally used but that do not possess sufficient characteristics or qualities to render them genuine artifacts. Dipert explains that,

> for an object to be intentionally used by an agent, the agent has to have conceived of one or more of these properties, deliberated about whether this or another object could better fulfill the purpose because of these properties, and concluded that the object will make a net positive contribution to the agent's purpose and that it will do better than, or as well as, other objects that are considered and equally available (1993, 25).

According to Dipert's view, instruments are generally middle-sized and moveable objects that, unlike artifacts, are not modified but are merely found or discovered and

used “as is” – natural objects that are used for some goal or purpose. For example, a fallen log that is found and then intentionally used by some human agent to serve as a seat or a foot stool qualifies as an instrument, not a genuine artifact, on Dipert’s account. The same is true of a stone that is found and then intentionally used by some agent to strike one’s foe. Dipert gives the example of the stone that David used to slew Goliath. He states, “we might guess that an object’s merely being deliberately used in intentional activity, such as the handy stone with which David slew Goliath, is not sufficient to make it an artifact. What, after all, did David *do* to the stone to make it an artifact? How does it differ from a stone that was not used intentionally?” (1993, 21; emphasis added). According to Dipert, David must *do* something to the stone in some way before it can be considered a genuine artifact. Namely, he must actively and intentionally modify it. Thus, under Dipert’s account, instruments are like artifacts in the sense that they are used by intentional agents but they are different in the sense that instruments are merely found and used, whereas artifacts are always modified or improved by intentional activity. In other words, Hilpinen’s dependence condition, or something like it, is required for any object to qualify as an artifact.

Hilpinen (2011) also recognizes a similar category of items that are “between” natural objects on the one hand and artifacts on the other. Following anthropologists and others, he refers to such items as “naturefacts”. Like Dipert’s instruments, naturefacts are items that are found and then used by creatures to serve some purpose. Hilpinen (2011) describes naturefacts as “objects taken from their natural environment and used as tools or for some other purpose form a bridge between natural objects and artifacts.” There are numerous examples of naturefacts in the animal kingdom. Wendell H. Oswalt (1973, 14-6) introduces a few, including the pebbles used by species of wasps

(*Ammophila urnaria* and *A. Yarowi*) to pound dirt into nests, and the stones used by Egyptian vultures (*Neophron percnopterus*) to break open the shells of ostrich eggs. Once again, the distinguishing feature between naturefacts and artifacts, like the distinguishing feature between Dipert's instruments and artifacts, is that the items that populate the former category do not possess properties that have been put there by the active modification, transformation, or improvements by some intentional agent. On this account, naturefacts, like instruments, are not taken to be genuine artifacts since artifacts require that modifications and improvements are caused by intentional human action.

Since restoring ecosystems requires active and intentional human intervention to bring about some desired state of affairs or intended effect (a restored ecosystem), I will take it as a matter of course that such ecosystems are objects that satisfy Hilpinen's dependence condition. The more challenging case is to sustain the claim that merely preserving nature or wild ecosystems that remains relatively detached from human activity turns nature into an artifact or an ecosystem artifact because preserving wild ecosystems does not require intervening directly in the ecosystem in the way that restoring ecosystems do. In fact, wild ecosystems are, by definition, ecosystems that remain relatively detached from human agency. So, if Hilpinen's dependence condition is interpreted as requiring that the author of artifacts to intentionally and actively modify properties of the object at hand, then it would follow that preserved wild ecosystems are *not* artifacts. If there were no other ways to interpret the dependence condition, then wild ecosystems that have been merely discovered and attributed an artifactual function would not qualify as artifacts because they have not been

intentionally modified by the activity of an intentional agent or author. They would appear to be naturefacts or instruments.

To claim that for any object to be an artifact it must be modified is to require that the artifact stand in a causal relation with its maker or author. If I am to sustain the claim that preserved wild ecosystems are artifacts while remaining true to the other two features of artifacts delineated above, then I will need to show that the dependence condition can be interpreted differently than is normally the case. I will argue that the dependence condition can be interpreted as the properties of an artifact that are dependent upon an author's intention to make an object of a certain kind by intentionally *omitting* their activity and that this omission counts as genuine causation. When Hilpinen's condition is interpreted in this way, by omission rather than action, we can see that there are circumstances in which merely preserving wild ecosystems turn such ecosystems into artifacts. If I am right, then unlike the existence of ordinary technical artifacts, such as tables and chairs, which, under most accounts, require that such object have been actively modified or improved for some function or purpose, the existence of ecosystem artifacts can depend on intentionally omitting human activity as well.

The central claim being made here is that there are cases when a wild ecosystem's continued natural expression (the intended effect) is counterfactually dependent on some agent or group of agent's intentionally omitting their actions (the cause). In other words, there are cases when intentionally omitting human activity from a wild ecosystem causes that ecosystem to express itself naturally. To understand how causation by omission is plausible I will draw upon James Woodward's (2003) manipulability theory of causation. Woodward states that "X is a … cause of Y if and

only if there is a possible intervention on X that will change Y or the probability distribution of Y" (2003, 51). He defines an intervention variable *I* and putative cause and effect *X* and *Y* only if *I* meets the following four conditions (2003, 98):

1. *I* acts as a switch for all the other variables that cause *X*. That is, certain values of *I* are such that when *I* attains those values, *X* ceases to depend on the values of other variables that cause *X* and instead depends only on the value taken by *I*.
2. Any directed path from *I* to *Y* goes through *X*. That is, *I* does not directly cause *Y* and is not a cause of any of *Y* that are distinct from *X* except, of course, for those causes of *Y*, if any, that are built into the *I-X-Y* connection itself; that is, except for (a) any causes of *Y* that are effects of *X* (i.e., variables that are causally between *X* and *Y*) and (b) by any causes of *Y* that re between *I* and *X* and have no effect on *Y* independently of *X*.
3. *I* is statistically independent of any variable *Z* that causes *Y* and that is on a directed path that does not go through *X*.
4. *I* is statistically independent of any variable *Z* that causes *Y* and that is on a directed path that does not go through *X*.

Although Woodward's theory of causation highlights a manipulability account, it is critical to bear in mind that it does not depend on what human beings can *actually* manipulate or do. This means that interventions, for Woodward, can involve non-human causes as well. Thus, for example, the gravitational pull that the Earth exerts on the moon is a genuine cause under Woodward's' theory, even though humans cannot (currently) exert the same force on this celestial body. Describing Woodward's account, Julian Reiss (unpublished manuscript) explains that, "causality does not only obtain whenever a factor *is* manipulated and a certain result ensues but also whenever *were* the

factor *to be* manipulated, the desired result would ensue" (58; italics in the original). In this sense, Woodward's theory of causation shares many features with counterfactual theories of causation, such as that defended by David Lewis (1973).

Because, for Woodward, a sufficient condition for some X to cause or have a causal effect on Y is that some change in the value of X produced by an intervention is associated with a change in the value of Y, Woodward argues that omissions or absences can be causes as well (Woodward 2009). Unlike process theories of causation that do not generally view causation by omission as being genuinely causal, Woodward's theory can account for intuitively plausible causal claims such as "I killed the plant by not watering it" (Beebee 2004).[71] Why does this qualify as a genuine causal relation under Woodward's account? Quite simply, since a change under an intervention in whether the person in charge of watering the plant is associated with a change in the value of the variables measuring whether the plant dies, the statement "I killed the plant by not watering it" is a genuine causal claim.[72] In this case, causation by omission is no different in kind from the claim that "I killed the plant by uprooting it and tossing it into the dustbin".

Perhaps the central challenge for theories of causation that imply causation by omission can be genuinely causal is to restrict the number of genuine causal claims so that they do not diverge too far from our intuitions about causation. For example, it would be absurd to claim that my *not* being blown-up by a stick of dynamite two minutes ago is the cause of me now writing my dissertation. Certainly, it is physically possible that I could have been blown-up by a stick of dynamite two minutes ago but

[71] Process theorists, such as Salmon (1984) and Dowe (2000), for example do not consider causation by omission to be genuinely causal.

[72] For more on causation by omission or absence causation, see Hall (2000) and Schaffer (2000).

then again the question is not about physical possibility. The question concerns whether an event that did not transpire, namely, my being blown-up by a dynamite stick, causes my writing this dissertation at this very moment. Do we want to judge that this non-event is the cause of me now writing this dissertation? Woodward would respond with an emphatic "no" and I agree. For every putative case of causation by omission, it would seem that some are correctly judged to be causal, as is the case with Beebee's (2004) "I killed the plant by not watering it" example, and others that might be incorrectly judged as causal, as is the case for "my not being blown-up by a stick of dynamite two minutes ago is the cause of me now writing my dissertation."

To save his theory from making causal claims that ought not to be made, particularly when it comes to causation by omission, Woodward proposes that we need to recognize "serious possibilities": possibilities that we are willing to take seriously, thereby excluding non-serious possibilities (Woodward 2003). Woodward gives the example of a Doctor *D*. Suppose it was standard practice for doctors to administer antibiotics when they notice patients displaying symptoms of fever. Suppose further that *D* noticed that his patient *P* had a fever and he administers *no* antibiotic. Woodward's (2003) manipulability theory of causation supports the judgement that the failure of *D* to administer the antibiotic to *P* causes *P* to die. Why? Since manipulating the values of the variable *A* (which reflects whether or not the antibiotic is administered) will change the value of the variable *S* (which reflects whether or not the patient dies), *D* causes *P* to die. Thus, much like the case whereby a person is judged to have killed the plant by failing to watering it, *D* causes *P* to die.

Now, Woodward asks us to consider a slightly modified case whereby some random person *X* could have administered the antibiotic but does not and it seems

correct to claim that *X* did not cause *P* to die. *X* is not a doctor, and he lives in a far off land without any responsibility for the care of the patient who is displaying signs of fever. Suppose further that *X* goes into the exact hospital where the *P* is located and he can actually see that *P* is developing a fever. Not only does *X* witness *P* in such a grim state but, as it turns out, *X* has also recently learned that administering antibiotic to patients who were in such a circumstance is the correct response required to keep *P* alive. In this case, we can say that *P*'s survival is counterfactually dependent on whether *X* administers the drug to the patient. However, relative to the first case, it is not so clear that *P* actually causes *X* to die. In fact, Woodward argues that we are not normally inclined to claim that *X* causes the patient's death. He states, "there seems no reason at all to take the possibility seriously that *X*'s failure to do these things causes the patient's death" (2003, 88).

What is the difference between these two cases? Why are we more likely to accept the first as an instance of causation by omission but not the second one? In both cases, the patient dying is counterfactually dependent on someone – *D* or *X* – failing to administer the antibiotic. In the first case, when *D* fails to administer the antibiotic, we more readily accept the causal claim that *D* killed *P*. In the second case, we are more likely to reject the claim that *X* killed *P*. To explain this difference, Woodward appeals to the notion of serious possibility. When it comes to causal judgments, particularly when there is a putative case of causation by omission, Woodward argues that there is no escaping the fact that our judgements will be influenced by what we think are true and that concern serious possibility (and this is not problematic). Thus, while Woodward's theory of causation judges that causation by omission can be genuinely causal, such relations depend on a notion of serious possibility, without which his manipulability

theory would lead to judgements that are at odds with the causal claims we normally accept as true.

Now that we have shown that, under Woodward's theory of causation, there are circumstances in which omissions or absences can count as being genuinely causal, we can return to asking whether Hilpinen's dependence condition is met when Nature (or parts of Nature) is preserved. Remember, this condition is normally interpreted as requiring that at least some of the properties of an object are dependent upon the intentional activities of some maker. By contrast, I am suggesting that the condition can be interpreted as requiring that at least some properties of an object are dependent upon an author's intention to make an object of a certain kind by intentionally omitting their activity from the object. In our case, the object at hand is a wild ecosystem that is being preserved by some intentional agent or group of intentional agents. If Hilpinen's dependence condition has been met in this way then preserving wild ecosystems turns them into artifacts (on the presumption that such wild ecosystems also meet the other two features every artifact must meet, as delineated above).[73]

My claim here is that, for those cases of preservation where the natural expressions of wild ecosystems are counterfactually dependent on omitting human activity, we can correctly claim that such an omission causes the continued natural expression of a wild ecosystem. In cases where the intentional omission of human activity did not occur, and the continued natural expression of the ecosystem would not have obtained, then we can correctly claim that the intentional omission of human activity is the cause (or a causal factor) of the natural expression of the wild ecosystem.

[73] Similarly, in his essay entitled "The Incarceration of Wildness: Wilderness Areas as Prisons", Thomas Birch (1990) argues that wilderness areas are artificial since they are products of human power (see Katz 2012).

In short, the natural expression of a preserved wild ecosystem depends on the author's (group's) intention to make an object of a certain kind by intentionally omitting their activity from that wild ecosystem.

Consider a simplified example, one that, I submit, qualifies as a serious possibility. Suppose there are only two possible outcomes for some wild ecosystem that remains relatively detached from human agency. This ecosystem will either continue to naturally express itself or not. The wilderness area will either be preserved or converted into a parking lot. If human activity is omitted from the ecosystem, it will continue to express itself. If human activity is not omitted from the ecosystem, then the ecosystem will not continue to express itself. In this case, where there are only two possible outcomes, omitting human activity can be said to cause the natural expression of the wild ecosystem. The wild ecosystem's natural expression is counterfactually dependent on whether some agent or group of agents omit their activity from an ecosystem in order to produce some intended effect: the wild ecosystem's continued natural expression. The continued natural expression of the wild ecosystem depends on some agent or group of agent's intentionally omitting their activities from the wild ecosystem because if the agent did not intentionally omit his or her action, then the wilderness area would be converted into a parking lot.

Of course, I do not deny that there are circumstances when the continued natural expression of a wild ecosystem is not counterfactually dependent on the activity that was intentionally omitted by human agents. Consider this case. Whether or not some intentional agent or group of agents omitted their activity from some wild ecosystem, the ecosystem would have continued to naturally express itself, uninhibited by human intervention. In such a case, the agent merely intends to omit his activity from some

wild ecosystem but, even if he had not done this, the wild ecosystem would have continued to express itself in any case. Under this scenario, the outcome would have been equivalent to what unimpeded nature produced had the agent not intentionally omitted his activity from the wild ecosystem. In this case, on Woodward's account of causation, it would be incorrect to judge that the agent's intentionally omitted activity caused wild ecosystem's continued natural expression because whether or not such activity was intentionally omitted, the ecosystem would have naturally expressed itself.

Consider another example. Suppose there is a planet, Vulcan, and that it was discovered in another solar system in the Milky Way.[74] It is a jungle planet that has never been touched by any intentional creatures, including human beings. For years it was analyzed passively and remotely. After it was discovered, the United Federation of Planets forbids anyone from landing on Vulcan or interfering with it in any way; it enforces its edict strictly and successfully. Has Vulcan become more artificial than it would be otherwise? If the natural processes on Vulcan would have continued *no matter what* happened, then Vulcan would not be rendered more artificial. However, if human agents had previously planned that Vulcan was to continue to exist as one big giant nature preserve, the function of which was to produce some desired (aesthetic) effect, and, most importantly, if Vulcan had not been turned into a nature preserve it would have been transformed into a parking lot for space crafts owned by members of the United Federation of Planets, then we can claim that Vulcan (even though it has not been directly affected by human activity) is more artificial than it would have been otherwise.

[74] A similar example was brought to my attention by an examiner of this dissertation.

Richard Sylvan (1998) and Robert Elliott (1982) are both critical of the claim that intentionally omitting human activity can be causal in the specific sense that I have described above. In his essay entitled "Mucking with Nature", Sylvan dismisses the whole preservation paradox as the "bottom of a barrel of rotten arguments". He is critical of the claim that "doing nothing counts as doing something, inaction as action, so non-interference itself amounts to interference" (1998, 57). While Elliott concedes that *restored* ecosystems are artificial, he maintains that merely *preserving* nature does not make nature artificial. He states:

> The idea is that by placing boundaries around natural parks, by actively discouraging grazing, trail-biking and the like, by prohibiting sand-mining, we are turning the wilderness into an artefact, that in some negative or indirect way we are creating an environment … But … what is significant about wilderness is its causal continuity with the past. This is something that is not destroyed by demarcating an area and declaring it a national park. There is a distinction between the 'naturalness' of the wilderness and the means used to maintain and protect it. What remains within the park boundaries is, as it were, the real thing (Elliott 1995, 87 in O'Neill *et al.* (2008, 139-40).

Elliott suggests that preserving wilderness is preserving the "real thing" since there is causal continuity with the past. Once certain boundaries are established, the place is not made into an artifact but remains part of nature. One problem with this line of reasoning, however, is that anything that happens to a wilderness area or wild

ecosystem would qualify as having causal continuity with the past. Another problem is that, as argued above, there are cases of mere preservation when the natural expression of nature or wild ecosystems is counterfactually dependent on omitting human activity. In such cases, the omission causes the continued natural expression of a wild ecosystem in a manner that both Sylvan and Elliott deny. It should also be clear that, contra Elliott's (1995) worry, I am not suggesting that the mere imposition of a boundary around some wild ecosystem turns that ecosystem into an artifact. Instead, my claim is that Hilpinen's dependence condition is met when preserving a wild ecosystem involves the intentional omission of human activity.

John O'Neill *et al.* (2008) have also argued that the preservation paradox is false since there is "one distinctive sense in which restoration is possible". To make their case, these authors draw an analogy between biological regeneration on the one hand and the restoration of nature on the other. They begin by observing that certain species can naturally regenerate parts of their bodies, quite independent of human agency. For example, these authors tell us that many lizards have the capacity to re-grow their tails. Similarly, they argue, nature can be restored *when non-human agency alone does the restoration*. Specifically, they claim that "a system that has regenerated entirely 'naturally', that is, without intentional or even unintentional assistance of human beings, might be said to have originated naturally, even though it no longer has the particular historical origin it once had. It has restored itself rather than being restored" (2008, 143). Thus, according to these authors, nature's unassisted agency can restore nature and, therefore, the preservation paradox is false since there is at least one instance whereby nature can be restored without the active intervention of intentional human agents.

But, while I agree that there is a distinction to be drawn between items or objects that grow up spontaneously, independent of human agents, and those which require the active intervention of intentional human agency, it remains unclear what consequence this distinction has for the preservation paradox. Restoration is essentially an intentional activity performed by an intentional agent who has the aim or goal of returning some object to a previous condition or reference state. To claim that restoration is possible when it is consummated by natural or non-human causes alone is to either speak metaphorically or to attribute intentionality to nature. However, it would appear that these authors endorse neither of these options. Of course, I am in full agreement with O'Neill *et al.* (2008) when they claim "Nature's agency" is causally efficacious in the sense that there are non-human causes or variables that operate independent of human intervention (i.e., lizards that are capable of regenerating their tails), but the point being made here is that, unless nature, or some bit of nature, is itself an intentional agent, it cannot be straightforwardly described as *restoring* itself. If nature was an intentional agent, then it would be conceivable that nature could restore itself independent of intentional human agency. Since the preservation paradox hinges on the concept of nature as that realm of phenomena that is relatively detached from human agency, any actual restoration of nature by non-human causes would render the paradox false.[75] As it stands, however, there do not appear to be any such examples. To my knowledge, no one has persuasively argued that nature is an intentional agent capable of restoring itself. Therefore, since the only intentional agents capable of restoring nature appear to be human agents and these agents and their activities are

[75] Hence, O'Neill *et al.*'s (2008, 139) claim that the paradox is "more apparent than real".

barred from Nature *ex hypothesi*, there is further reason to maintain that the paradox is true.

This chapter argued that the preservation paradox holds up under scrutiny. Since nature is taken to be what exists outside of any intentional human intervention and the preservation or restoration of nature requires intentional human intervention in order to put it into effect, these intentional activities turn nature into an artifact or, in the very least, they make nature more artificial then it would be otherwise. To be clear, my claim is not that nature ought not to be preserved or restored but that it is conceptually incoherent to preserve or restore nature when it is conceived as a realm or domain of phenomena that is relatively detached from intentional human agency. In this specific sense, I have argued that no one can preserve nature.

To make my case, I presented three features that distinguish artifacts from natural objects and then argued that restored and preserved ecosystems, including wild ecosystems (that remain relatively detached from human agency), share all of these features, thus making them artifacts as well. Unlike natural objects, artifacts are (1) designed or planned; (2) they possess a function attributed to them by an intentional agent or group of agents; and, (3) they have been modified by an intentional agent (Hilpinen's dependence condition).

The biggest challenge of this chapter was to show that at least some of the properties possessed by preserved wild ecosystems depend on intentional agency. The reason why this was a challenge is because wild ecosystems are, by definition, ecosystems that remain relatively detached from human agency, and yet Hilpinen's dependence condition, a causal condition that every artifact must meet, requires that

the existence and some of the properties of an artifact depend on an author's intention to make an object of a certain kind.

Hilpinen's dependence condition is normally interpreted as requiring that the existence and some of the properties of an artifact depend on an author's intentional *activity* to make an object of a certain kind. If there was no other way to interpret this causal condition, then preserved wild ecosystems could never be artifacts since the intentional activities of agents are excluded from these ecosystems by definition. However, following Woodward's manipulability theory of causation, I argued that it is plausible to claim that some causes by omission can count as genuine causes and that Hilpinen's dependence condition can be interpreted as requiring that the existence and some of the properties of an artifact is dependent on some author intentionally *omitting* their activity from preserved ecosystems to produce some intended effect: the continued natural expression of the ecosystem. I then argued that when a wild ecosystem's continued natural expression is counterfactually dependent on some agent or group of agent's intentionally omitting their actions then we can claim that the agent's intentional omission counts as causing the wild ecosystem's continued natural expression. This means that simply preserving wild ecosystems can also satisfy Hilpinen's dependence condition.

CHAPTER SIX

Some Water Should Not be for Sale

Conclusion

One research question on the topic of natural capital and ecosystem services to be considered at a future date is whether there are moral limits to buying and selling such items. In this chapter, before concluding this dissertation, I will first sketch an argument for why some water, a basic ecological good, should not be for sale.

The question of whether natural capital and ecosystem services *should* be for sale presupposes that the items denoted by such concepts *could* be for sale. Without the possibility that such items could be for sale there is no reason to worry about such items being bought and sold. Anything that is for sale must, in some sense, possess economic value or a price.[76] Mark Sagoff (2004; 2008) has consistently argued against the proposition that natural capital and ecosystem services have economic value. Following Locke's canonical labour theory of value and the further Lockean claim that unimproved land is waste, Sagoff does not deny the platitudinous claim that people "benefit" from the various goods and services produced by natural capital, a claim that is ubiquitous

[76] Since economists use the concepts of natural capital and ecosystem goods and services to denote various phenomena, including traditional resources, such as oil and gas, in some cases the question of whether natural capital has economic value will be a simple empirical question. In cases where instances of natural capital are non-market phenomena, however, it is much less clear whether such items actually possess economic value. This chapter is only concerned with the latter cases.

throughout the literature on natural capital and ecosystem services.[77] Instead, he objects to the proposition that such items have economic value, period. Sagoff insists that the economic value of any item is not determined by its benefit alone. His objection springs from the canonical distinction between "use value", on the one hand, and "exchange value" on the other, a distinction that can be traced all the way back to Aristotle's *Nichomachean Ethics*, and that was explicitly recognized by the most important classical political economists, including Adam Smith, David Ricardo, John Stuart Mill, and Karl Marx. Smith provides a fine description of the distinction in Book I (Chapter Four) of the *Wealth of Nations* when he states:

> The word VALUE, it is to be observed, has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods which the possession of that object conveys. The one may be called 'value in use'; the other, 'value in exchange'. The things which have the greatest value in use have frequently little or no value in exchange; and on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water: but it will purchase scarce any thing; scarce any thing can be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it ([1776] 1976, 44-5).

[77] "Nature and the earth furnished only the almost worthless materials as in themselves" (Sagoff 2008a, 94).

This quotation shows that Smith recognizes water has tremendous value *in use* but no exchange value; diamonds, on the other hand, have exchange value – a price – but almost no use value. While neo-classical revolutionaries, eventually resolved the so-called "water-diamond paradox" circa 1870, what matters for our purpose is the observation that the utility or benefit of any object does not, by itself, determine the price that is paid for it.[78] This is true no matter how useful an item might be. Thus, when Sagoff objects to the claim that every instance of natural capital has no economic value, he follows the same line of reasoning expounded by the leading classical political economists. The price of the air we breathe, Sagoff claims, is correctly priced at zero because it is abundant and free. In other words, one might surmise that the current supply of air far exceeds the demand for it. In such a case, Sagoff points out that the market mechanism has not failed to assign a price to air because it ignores its usefulness in keeping human beings alive. No matter how useful air is to the life of human beings, this property alone does not imply that air will have a price. For why would anyone pay for air if it could be obtained *gratis*?[79] In this sense, Sagoff's claim that natural capital and ecosystem services afford tangible benefits to human beings, but do not possess economic value, hinges on the further claim that such items are, in some sense, plentiful.

[78] While Smith notes that diamonds have little use value and a high exchange value, and water has significant use value and low exchange value, he did not treat this fact as a paradox. Smith uses this example to show that there is no need for exchange value and use value to move in parallel.

[79] Similarly, in his *Principles of Political Economy*, Ricardo recognized that the price of land – rent – would only be paid when land became scarce (after the first settling of a country in which land is abundant and fertile). Ricardo states, "For the reason stated why nothing is given for the use of air and water, or for any other of the gifts of nature which exist in boundless quantity … no charge is made for the use of these natural aids in production, because they are inexhaustible, and at every man's disposal" ([1817] 1951, 69).

Before confronting the issue of whether natural capital and ecosystems services are plentiful or scarce, it is worth recognizing that it remains unclear why Sagoff invokes Locke's labour theory of value to support his claim that Nature's productions have no economic value.[80] Most economists today, certainly those who self-identify as neo-classical economists, subscribe to a subjective theory of value (something that Sagoff himself concedes). Strictly speaking, if the labour theory of value were true, then it would rule out the possibility that *any* unassisted or spontaneous productions of the Earth, ones that did not require human labour to be brought into existence, possess economic value. This is because any commodity that possesses economic value would have to require a certain amount of toil and trouble – a real price – to acquire. On this account, commodities that simply appeared as manna from heaven would have no exchange value. If the labour theory of value were true, then Nature's independently produced productions could not have economic value. Be that as it may, all else being equal, the truth of this consequent depends on the truth of the antecedent, but Sagoff has not shown this to be the case.

Sagoff's objection to the claim that natural capital and ecosystem services have economic value also appears to rest on a conceptual misunderstanding. This is because his argument supposes that the concept of natural capital merely denotes Nature's *unassisted* or independent productions. Consequently, when he objects to the claim that ecosystem goods and services have economic value he is only denying that *unimproved* aspects of Nature have economic value. But if my analysis in Chapter Two is correct, then the concepts natural capital and ecosystem services do not merely denote Nature's

[80] Sagoff makes the strong and puzzling claim that *nothing* has economic value. He states: "the phrase 'economic value' has no coherent reference" (2008b, 242). But surely items with economic value are exchange value (and items with exchange value can be exchanged for other commodities in the marketplace.

unassisted productions or unimproved aspects. Instead, economists regularly count beneficial ecosystems that have been actively modified, restored, or managed by human agents as instances of natural capital as well.

The Catskills Watershed of New York, an example mentioned in Chapter Two, is such an instance of natural capital *par excellence*. In this case, the Catskills is being intentionally managed for certain desired effects, in particular, water filtration, for the citizens of New York City. This particular instance of natural capital is claimed to be productive of ecosystem goods and services, even though it has been obviously modified and improved for certain ends or purposes and not others. On the economist's account, the Catskills Watershed still counts as an instance of natural capital. Therefore, even if Sagoff's objection was compelling, it would only apply to a subset of phenomena denoted by natural capital and ecosystem services: Nature's unassisted productions, and not those which have been modified by human agents.

If it were true that, as Sagoff claims, natural capital and ecosystem service were always and everywhere plentiful or abundant, then such items would not possess economic value. While I agree with Sagoff that not every useful item produced by non-human causes has economic value, there are cases when natural capital and ecosystem services can and do have a price.

To my knowledge, no environmental economist has ever claimed that the force of gravity has economic value. This is for good reason. Gravity would appear to be beneficial for just about every human activity on Earth, including economic activity, but this does not automatically imply that gravity has economic value (even if we were to disagree on which theory of economic value is true). If gravity were to ever possess

economic value then, in the very least, it would have to be the kind of thing that is scarce or could become scarce in some sense.

With that being said, the scarcity of any item is a necessary but insufficient condition for that item to possess economic value. The unique grain of sand that I take pains to locate and acquire on Wreck Beach in Vancouver is scarce in the sense that no other object possesses all of the same properties possessed by my particular grain of sand, but the thing is not likely to have any economic value because there is no other person in the marketplace willing to exchange any other economically valuable items, including money, for it. If I have understood Sagoff's objection correctly, then his claim that no ecosystem services have economic value is very much like the claim that gravity has no economic value. The gravity on Earth is certainly useful and ubiquitous, and there appears to be no possibility on the horizon that this force of Nature will become depleted or destroyed. For these reasons, and others, (including the difficulty of appropriating it), gravity has no economic value.

Is the case of natural capital and ecosystem services the same or analogous to the case of gravity? Is it true that, like gravity, every ecosystem good and service and every instance of natural capital is so abundant and plentiful that they do not possess any economic value?

Even if one were to answer the forgoing questions affirmatively, it would seem that one would still have to concede that items which are abundant and free at one place and time can be limited and expensive at another. J.S. Mill ([1848] 2006) recognized as much when, in his *Principles of Political Economy*, he repudiated the claim that air and water are forms of wealth. Wealth, for Mill, consisted of useful material objects that possessed exchange value. Although he recognized the usefulness of air and maintained

that we were much richer with it than without it, he also recognized that in ordinary circumstances no one in the marketplace would be willing to exchange commodities or anything else for it. Mill also recognized, however, that air *can* become limited and acquire an exchange value. He gives the example of providing air to diving bells and further predicts that if "any revolution in nature the atmosphere became too scanty for the consumption, or could be monopolized, air might acquire a very high marketable value" ([1848] 2006, 8).[81] This Millian line of thinking establishes that, even if specific forms of natural capital and ecosystem services are shown to possess no economic value at one place and time, a reduction in the quantity of such items might well cause those same items to possess a positive price at another place and time.[82]

It should also be evident that, from my grain of sand example above, the scarcity of any good is not merely determined by the quantity of that good alone. If natural capital and ecosystem goods and services possess exchange value, then, at least from the vantage point of orthodox consumer choice theory, this value will be conjointly determined by the utility functions of economic agents. As Dan Hausman explains:

> If two people have almost no water and no expectations of having more soon, the first will have to offer a high price to induce the second to part with any water. Knowing only the utility functions or only the amount of water available, one could not explain why water could be exchanged for so

[81] For Mill, if nature supplies a commodity in such abundance that any demand for it can be satisfied without incurring any costs of production, then its exchange value will be zero.

[82] I would surmise that, while Sagoff insists ecosystem services have no economic value because they are abundant, he would still agree with Mill's assertion that this state of affairs is a contingent one.

> large a bundle of commodities. One needs both bits of information. The scarcity of water is derived from these two pieces of information: it is not an independent fact (1981, 25).

The agent's utility function, derivable from the agent's subjective preferences alone, like the quantities of ecosystem goods and services alone, do not imply that ecosystem goods and services are scarce and that agents will have to pay for them. As Hausman affirms, whether any good or service possess economic value depends on the utility functions of agents *and* the relative quantities of such goods and services. That being said, in the passage by Hausman just quoted the first person who is willing to pay for water may not *necessarily* have to offer a high price to induce the second person to part with her water. This proposition is true even if, as Hausman describes, the two people at hand have almost no water and no expectation for acquiring any more in the near future. Why? In the standard case of consumer choice there is a utility-maximizing economic agent who possesses subjective preferences that, when satisfied, yields marginal utility to that agent. Given the choice between two different bundles of goods and services, the agent will prefer to consume one over the other; since this theory does not privilege the consumption of any particular kind of good over any other and subjective preferences are taken as given, agents can prefer to consume any bundle of goods over any other for any reason. Even if one has empirical evidence to expect that people are willing to pay a high price for water when they have none – a hypothesis that would seem to be confirmed by the empirical evidence – the subjective theory of value is consistent with the possibility that economic agents give their water away *gratis*, no matter what the circumstance.

Now that I have established the possibility that natural capital and ecosystem services can possess economic value, my objective is to show that some do. Two conditions must be met for this to be true: first, natural capital and ecosystem services must, in some sense, be limited in quantity. This is because, if every instance of natural capital and ecosystem services were everywhere super-abundant or plentiful, then, as Sagoff argues, they would also be free. No rational economic agent will pay for ecosystem goods and services if they could simply acquire such items *gratis*. Second, such items must also contribute or be expected to contribute to human welfare, and, in this case, the currency of human welfare is reducible to the satisfaction of an agent's subjective preferences.[83]

For Sagoff, it appears that the market price of natural capital and ecosystem goods and services – zero – is identical to the economic value of these items. However, environmental and resource economists, including Dasgupta (2009), Heal (2000b), and Barbier (2000) disagree. Each scholar independently argues that the economic value of certain goods and services, "non-marketed goods and services", is not the same as their market price. Non-marketed goods and services include ecosystem goods and services, and these items have a positive economic value. Ecosystem goods and services have no market price because while these items are economically significant, there is no market for them. As Heal states, "natural ecosystems usually provide services for which there are no markets and so no market prices …" (2000a, 117). How can one determine the economic value of goods and services that have no market price? Economists have devised a variety of indirect methods to serve this purpose, including willingness-to-pay

[83] Rather than questioning this theory of human welfare, I will take it as given for the purpose of this analysis.

surveys, the travel-cost method, replacement cost, and hedonic indices. All such techniques can be used to show that, although ecosystem goods and services have no market price, they do possess economic value.[84]

One reason why natural capital and ecosystem services are becoming more economically valuable is because, as some economists have argued, these items are becoming increasingly scarce and that, in many cases, the cause of this scarcity is human economic activity. Citing recent findings of the Millenium Ecosystem Assessment (2005), Barbier (2011) declares that we are now living in the "Age of Ecological Scarcity" whereby natural systems and landscapes are being exploited by human economic activity and that this results in a loss of ecosystem goods and services that otherwise contribute to human well-being. As ecosystem goods and services become increasingly scarce, such items become objects for economic study. In other words, as natural capital and ecosystem services become increasingly scarce, they become economic phenomena.

Barbier (2011) claims that there is a fundamental trade-off between increased human economic activity, on the one hand, and the number of ecosystem goods and services available, on the other. This trade-off, however, appears to be far too crude. While it may be true that human economic activity reduces the production of ecosystem goods and services at a particular time and place, this need not be the case. Human economic activity is not merely destructive since it can also be directed towards enhancing and improving existing ecosystems so that they serve human ends by producing economically valuable ecosystem goods and services. There is also a worry, as

[84] Each of these techniques has important shortcomings. For details, see Heal (2000a; 2000b) and Barbier (2011).

stated in Chapter Two, of over-emphasizing human causes that contribute to ecological scarcity in the sense that Barbier (2011) uses this term. Increased ecological scarcity that is characterized by a reduction in the quantity or quality of the goods and services afforded by ecosystems can have non-human causes as well. Thus, while the empirical evidence would appear to support the claim that we are increasingly living in an "Age of Ecological Scarcity", where the number and quality of ecosystem goods and services are on the wane, it is not so clear that the trade-off between landscape-converting human economic activities and less ecosystem goods and services is as simple as it has been characterized by Barbier (2011).

Now that I have established that natural capital and ecosystem services can have economic value, it is important to recognize why economists and other scholars are motivated to attribute such items with economic value. Given that natural capital and ecosystem services are non-marketed goods, why bother wrestling with indirect methods to attach a price to natural capital and ecosystem services? One clear motivation is to avoid market failure. Economists, including Dasgupta, worry that if the economic value of natural capital and ecosystem services is not explicitly recognized, then these natural assets will be mismanaged. If the foregoing indirect methods are not employed, then the economic value of natural capital and ecosystem services will be underestimated or, at worst, ignored altogether. For example, if the economic value of the pollination services afforded by pollinator species remains unaccounted for, then this natural asset could be not only depleted but depleted *inefficiently*. Without attaching economic value to pollination services, economically valuable ecosystems could be over-used, depleted or exploited in a manner that does not accurately represent their economic value. Once the economic value of pollination services afforded by

pollinator species is properly estimated, then this information can be used to manage it like any other capital asset: to optimize its flow services (rate of return) to some agent or group of agents over time.

Another related motivation stems from the putative connection between attributing economic value to natural capital and ecosystem services, on the one hand, and conserving those same items, on the other. Daily has claimed that there are two main routes for conserving natural capital and ecosystem services: either by (A) moral suasion, a traditional strategy among conservationists that involves persuading others of the intrinsic and aesthetic values of those items denoted by the concept of natural capital, or by (B) attributing economic value to natural capital and ecosystem services so that these items can be managed efficiently with the market mechanism. Daily argues that (A) failed in the past and therefore, efforts should be aimed at conserving natural capital should proceed on an economic basis. Mark Sagoff's (2004) argument has the same logical structure as Daily's – a disjunctive syllogism – but he reaches quite a different conclusion. He agrees with Daily on the two routes to conserving natural capital and ecosystem services, (A) and (B), but, as we have seen above, since Sagoff denies that such items possess economic value he concludes that conservation efforts should spring from moral duty alone. For Sagoff, it is morally right for us to ascribe *intrinsic* value to various aspects of nature.

Both of the foregoing arguments are problematic. Sagoff claims that natural capital and ecosystem services do not have economic value but, following Dasgupta and Heal, I have already argued that the contrary claim is true. Attributing economic value to natural capital and ecosystem services *might* prove to be a viable strategy for conserving those items but there is no necessary connection between attaching a price to

some item, including natural capital and ecosystem services, and that item's conservation. As Heal remarks, "valuation is neither necessary nor sufficient for conservation. We conserve much of which we do not place economic value, and we do not conserve much that we value economically" (2000a, 125). Indeed, many items that once bore a price in the marketplace no longer exist. If the quantity and quality of natural capital and ecosystem services were merely governed by their economic value, then they could share this same fate. This observation raises deep worries for wedded to Daily's argument. The economic value of any class of goods and services (ecosystem goods and services) or their means of production (natural capital) does do not necessarily privilege the maintenance or conservation of those items. In fact, from an economic point of view, if it were cheaper (and technologically possible) to deplete or destroy all of the natural capital and ecosystem services on Earth, then, this action ought to be taken. For obvious reasons, this observation should concern both economists and conservation biologists who attach prices to those items denoted by the concept of natural capital with the hope of conserving them. (Of course, by the same token, economic arguments for the maintenance of natural capital do not necessarily preclude the possibility that natural capital and ecosystem goods and services should be conserved; the point being made here is that attaching economic value to natural capital is not an impervious strategy for conserving them).

Now that I have established the possibility that natural capital and ecosystem services could be for sale, the question that I want to consider next is whether such items should be for sale. Are there moral limits to buying and selling natural capital? Why not buy and sell everything? What, if any, are the limits to the kinds of things that should be for sale in the marketplace? Are there any such limits? Might there be

compelling moral reasons why some things should not be bought and sold? Most people, for example, would find it morally objectionable to buy and sell human babies, treating them as if they were ordinary commodities, like chocolate bars and paper clips. The question is, *why*? What about other goods, such as the right to vote in a democracy, kidneys, and toxic waste? Should these items be for sale alongside toilet paper and chicken nuggets?

Before proceeding any further a distinction needs to be drawn between estimating the economic value or "monetizing" natural capital and ecosystem services and putting these items up for sale. Obviously, the first does not imply the second. To see why, consider an analogy: estimating the economic value of statistical human lives (see Grüne-Yanoff 2009). The decision to either maintain an old highway or construct a new one will often involve calculating the fatality risks associated with each potential action. Economists estimate such values so that pertinent information can be used in the decision-making process, not so that people can be subsequently bought and sold in the marketplace. The same reasoning applies to natural capital and ecosystem goods and services. While the indirect methods mentioned above can be used by economists to estimate the economic value of natural capital and ecosystem services, there is no necessary connection between this activity and putting such items up for sale in the marketplace. Thus, it is important to keep in mind that if there are objections to *merely* monetizing natural capital and ecosystem services, they will likely be different from the objections to buying and selling such items.

Among the scholars who argue that there are moral limits to the market, they often disagree about when such limits apply and why there should be any limits in the first place. One might divide these scholars into two camps. The first gives explicit focus

to the harmful consequences caused by certain market transactions. For example, Debra Satz (2010) argues that the limits to free markets should be determined by the harmful consequences that are caused by buying and selling items when agents have either weak agency or vulnerability. The second camp consists of several scholars, including Elizabeth Anderson (1990), Margaret Radin (1996), Michael Sandel (2012), and Michael Walzer (1983). These scholars argue that there are moral limits to markets, not because specific market participants possess a ruinous property but because the distribution of goods should be consistent with their social meaning. These scholars, particularly Anderson (1990) emphasize that the market is not a neutral mechanism for distributing goods and services but, invariably, involves treating goods in a specific way: as commodities. Since not all goods in human life should be treated as commodities, these scholars argue that there is a class of goods that should not be for sale.

From this point forward, I will describe Satz's (2010) view as a *consequentialist view* and group Anderson (1993), Radin (1996), Sandel (2012), and Walzer (1983) together, portraying their view as a *conventionalist view*.

Debra Satz (2010) argues that when buying and selling goods in the marketplace cause extremely harmful consequences, then such transactions should be blocked. She describes such markets as "noxious" since they are characterized by participants who, as mentioned already, have either weak agency or vulnerability. Both of these undesirable properties can be the source of extreme harms to individuals and society. Weak agency is problematic for individuals who do not possess sufficient information about the nature or consequences of a particular market and, as a result, these individuals end up engaging in actions that are harmful towards their own welfare. Vulnerability, on the other hand, refers to the status of participants in a market who have very unequal needs

for the goods that are being exchanged. Consider, for example, the poor and destitute man who has no other choice but to sell his kidney to a rich foreigner in order to support his family. This kind of transaction is not voluntary and mutually beneficial exchange between two market participants. Rather, Satz argues that such a transaction is characterized by vulnerable agents who act out of desperation which can cause extreme harms for society. What kind of harms? Satz argues that such transactions promote servility and dependence while undermining democratic governance and other regarding motivations (Satz 2010, 98-9). It is critical to recognize that, for Satz, the mere existence of noxious markets does not imply that there is an objective list of items that should never be for sale, however. On the contrary, her framework, which consists of both the sources (weak agency and vulnerability) and consequences (extreme harms for both individuals and society) of noxious markets, is meant to serve as a guide for evaluating the acceptability of specific markets on a case-by-case basis.

The second camp is occupied by Anderson (1990), Radin (1996), Sandel (2012) and Walzer (1983) and underscores the social meaning of goods as the basis for limiting the reach of markets. This conventionalist view gives a reason why, for example, human babies should not be for sale. Quite simply, babies are not the kind of good that should be for sale since treating them like commodities is corruptive. Sandel explains that, "to corrupt a good or a social practice is to degrade it, to treat it according to a lower mode of valuation than is appropriate to it" (2012, 34). Under this account, slapping a price tag on a baby and selling it in the marketplace would involve valuing the baby in the wrong kind of way.

Take the example of friendship. Sandel (2012) argues that friendship is not the kind of human good that that can be put up for sale without degrading or corrupting it.

Recall that, for Aristotle, friendships are characterized by mutual liking. In other words, a friend is someone who likes and is liked by another person.[85] Character friendships in particular are essential to human flourishing and Aristotle affirms that they seem to be the greatest of external goods.[86] The primary purpose of such friendships is to develop the moral goodness of each person involved in the relationship (Cooper 1980). These relations involve well-wishing that is fully reciprocated between the parties involved and are grounded in knowledge of and love of one another's good qualities of character. Sandel argues that friendships are the kind of good that cannot be bought and sold since, as he puts it, "the money that buys the friendship dissolves it, or turns it into something else" (2012, 94). While it is true that one might be able to pay others for the services that would be expected from a friend, the friendship itself, if it is a *bona fide* relation between individuals, is not the kind of thing that can be bought and sold in the marketplace without degrading or corrupting it.

Satz agrees with the conventionalists that some goods, including friends and honorific goods (such as the Nobel Prize), should not or cannot be for sale because doing so corrupts them, but she insists that the problem is not sufficiently widespread to cause real concern. In fact, she depicts the conventionalist view as standing in opposition to her own consequentialist view and claims that the former should be jettisoned altogether. She states, "I think we should reject the main contemporary alternative arguments for limiting markets based on the social meaning of goods. As I see it, a

[85] See the *Rhetoric* (1380b36-1381a2) in Barnes ([1984] 1995).

[86] Aristotle distinguishes between three types of friendship: for virtue (*kat' aretên*) or character, for utility (*kata to chrêsimon*), and for pleasure (*kata to hêdu*). The last two are less enduring than the first. They include, for example, business relations, which cease to exist when the advantages of the relationship end; pleasure friendships merely involve loving another person for their incidental features, not for their character or virtue. It is also worth noting that, for Aristotle, friendships are "very necessary for living" and that "no one would choose to live without friends" (*NE* 1169b10).

major problem with noxious markets is not that they represent inferior ways of valuing goods (as those who link the limits of markets to social meanings claim) but that they undermine the conditions that people need if they are to relate as equals" (Satz 2010, 94).

Against Satz, I will argue that the conventionalist view is not in opposition to her consequentialist view but that the former can be subsumed by the latter. Satz provides two arguments against the conventionalist view. First, she points out that the social meanings of goods are frequently *contested*. Different individuals and different moral communities are bound to attribute a wide variety of social meanings and values to specific goods. For some individuals and moral communities, the Bible, Talmud, and Koran are all sacred texts, but for others these same texts possess no such meaning. Without a widespread consensus on the social meaning of goods, Satz argues that meaning alone should not be expected to serve as a benchmark for deciding when some item should not be for sale.

Satz's second argument against the conventionalist view is that there is only a tenuous connection between the social meaning agents attribute to a good and its distribution by the market. Conventionalists often worry that buying and selling certain socially significant goods can crowd-out or uproot other important ways of valuing such items. Satz argues, on the contrary, that "the market price is rarely the direct expression of our evaluative attitudes towards goods" (2010, 82). Once again, take the example of buying and selling sacred texts. Does the bookstore owner who sells religious texts undermine the social meaning and value of the Bible for Christians? When sacred texts are treated as mere commodities, for their instrumental value alone, are they being treated in the wrong kind of way? Does this treatment undermine other important ways

of valuing such items? Satz convincingly argues that buying and selling sacred texts in the marketplace does not seem to displace their social meaning or importance among those for whom it matters. Instead, the same item can be treated quite differently by the market participants who are involved in the same market transaction. The atheist bookstore owner can treat religious texts as mere commodities, recognizing that such items have no other value apart their contribution to his profit margin, without affecting their sacredness for the religious buyer. Satz's main point is that, in this case, the intrinsic value of sacred texts can be preserved through ordinary market transactions. The social meaning of precious goods need not be undermined when they are treated as commodities.

Satz's two arguments against the conventionalist view certainly warrant a response, but her arguments are not sufficient for rejecting the view wholesale. Why? First of all, by arguing that we should reject the conventionalist view, Satz supposes that her theory of noxious markets is more detached from this view than it actually is. We have seen that Satz argues for restricting the market in cases where buying and selling goods and services results in extremely harmful consequences for both individuals and society. But if her view is genuinely consequentialist then it should also account for the harmful consequences that arise from destroying the social meaning of certain goods for a particular individual or moral community, even if such pernicious consequences turn out to be anomalous or infrequent. Rather than viewing the conventionalist view as opposed to Satz's consequentialist view, what I propose is that it would be better to recognize the former as being subsumed by the latter. The main upshot for doing so is that we would possess a more general consequentialist theory that can account for the important social meaning of goods while explaining why some things should not be for

sale. This more general consequentialist theory would extend beyond Satz's emphasis on weak agency and vulnerability to include all sources of significant harms that arise from market transactions, including those that might arise from corrupting goods that possess social meaning for a particular moral community. If I am right, then the two camps – the consequentialist view and the conventionalist view – are not really opposed to one another but can both be captured under the canopy of Satz's consequentialist view.

But what about Satz's two arguments against the conventionalist view? She maintains that because the social meaning of goods is often contested this meaning is not an adequate standard for establishing the moral limits to markets. While Satz is right to highlight that the social meaning of goods can be contested in the manner she describes and that this disagreement can be a barrier to establishing the moral limits to markets, it should also be clear that not all socially meaning goods are equally contested. For some moral communities, there will be sufficient consensus on the meaning of a good so that members of the community can decide on the further question of whether it should or should not be treated as a commodity. What I am claiming here is not that, for example, almost no one disagrees with the claim that human babies should not be for sale. Rather, some moral communities will have achieved a relatively stable consensus on the value and social meaning of human babies and because of this, babies will not be treated as a commodity to be bought and sold in the marketplace. This indicates that, among some goods, their social meaning can reach a wide consensus and that such meaning can still be grounds to block specific market transactions.

Satz's second objection to the conventionalist view is that there is only a tenuous connection between the social meaning that agents attribute to a good and its

distribution by the market. This proposition seems to contradict the conventionalist view since these theorists are wont to emphasize the crowding-out effect of treating goods as commodities. What could be more meaningful than a sacred text that is used by members of a moral community to organize their entire lives? Yet, as Satz points out, even when these items are treated as mere commodities by some participants in the marketplace, they do not lose their sacredness for those who deeply care about such items. Her main claim is that there is no necessary connection between preserving the social meaning of a particular good and the good being treated as a commodity. I agree. However, what I disagree with is the implication of this statement. Satz argues that by showing that there is no necessary connection between the social meaning of goods and their distribution by the market, this is enough to conclude that the conventionalist view should be jettisoned. However, in order to address the conventionalist's worry in its entirety Satz is required to show that all socially meaningful goods retain their meaning when they are bought and sold in the marketplace. Given the analysis so far it remains an open question whether this is the case. The question before us now is whether all socially meaningful goods are like the Bible and other sacred texts insofar as they maintain their meaningfulness when they are treated as commodities in the marketplace. If it turns out that there are such goods and when they are treated as commodities they lose their social significance (thereby negatively affecting human welfare) then a consequentialist view should recognize such harms and grant them equal consideration.

To summarize, Satz is right to emphasize the extremely harmful consequences that can arise from specific market transactions where market participants have weak agency or are vulnerable. She is also right to point out that the social meanings of some

goods are contested and that merely treating a good as a commodity need not crowd-out other important values or social meanings that moral communities might attribute to such goods. However, Satz's objections to the conventionalist view are not enough to warrant the claim that we should reject it if doing so amounts to overlooking the harms that might arise from crowding-out the social meaning of goods. I have also argued against the claim that the conventionalist and consequentialist views are strictly detached. Where they exist, the potential harms caused by treating "socially meaningful goods" as commodities can be and should be captured by a wider version of the consequentialist view. Satz's critique of conventionalists is illuminating because we learn that the social meaning of goods will not serve as a benchmark for establishing the moral limits to markets. Be that as it may, Satz's proposal that we reject the conventionalist view goes too far because there may be cases when the moral limits to markets should be established on the basis of social meaning.

Now, with a generalized consequentialist position on the moral limits to markets in order, recall the theory of basic ecological goods (BEGs) introduced in Chapter Four. BEGs represent the objective ecological conditions that must be met for some agent to have existence and, therefore, subjective preferences that could be satisfied. To be an agent with subjective preferences requires being an agent that is situated in the right kind of relation to one's environment, an environment that is partly constituted by BEGs. These characteristics, remember, make BEGs distinct from ordinary consumer goods since the latter only ever yield subjective utility to agents while BEGs afford the agent with causal properties required for survival, a role that is not multiply realizable in any other kind of good. In this section, my main claim is that in desperate circumstances – when BEGs are radically scarce – buying and selling them in the marketplace will

almost certainly violate what Robert Nozick (1974) has referred to as "Locke's proviso". If I am correct, then, we can conclude that there are moral limits to buying and selling water. To make my case I will use the example of water, but the conclusion I reach applies to all BEGs.

In Chapter Five "Of Property" of *Two Treatises of Government*, John Locke ([1689] 1980) claims that God gave the Earth in common to mankind and that, originally, in the State of Nature, each person had an equal claim to make use of the Earth and its products.[87] Locke then grapples with the topics of original acquisition and private property. How can one person come to own previously unowned objects when such objects are entrusted to no one in particular but to all of mankind in common? Locke's answer does not rely on the social utility of private property but, instead, he argues that since each person has ownership in themselves and their ability to labour – self-ownership – people can come to own previously unowned goods by mixing their labour with them and improving such objects for the benefit of life.

Since everyone in the State of Nature initially had equal claim to the Earth, however, Locke must somehow ensure that these claims are not breached by any such individual appropriations of private property. To resolve this issue he argues that appropriations are sanctioned only insofar "enough and as good left for others". Otherwise, Locke states, "for he that leaves as much as another can make use of, does as good as take nothing at all. Nobody could think himself injured by the drinking of another man, though he took a good draught, who had a whole river of the same water left him to quench his thirst: and the case of land and water, where there is enough of

[87] For a modern day secular argument supporting the claim that the earth originally belongs to humankind collectively, see Risse (2014).

both, is perfectly the same" ([1689] 1980, 21). It is mainly from these passages that Robert Nozick (1974) famously attributes Locke with a specific proviso. Nozick explains that, "a process normally giving rise to a permanent bequeathable property right in a previously unowned thing *will not do so if the position of others no longer at liberty to use the thing is thereby worsened*" (1974, 178; emphasis added). Locke's proviso requires that all acquisitions must not worsen or harm the situation of others and, therefore, the proviso represents a *bona fide* constraint on property rights. To determine if the proviso has been violated one must show that other agents are below their baseline or starting position because of the appropriation. Thus, when contemplating whether Locke's proviso has been violated, the crucial question to ask is whether the appropriation of an unowned object has worsened the situation of others.

Presumably, I do not need to say much to motivate the claim that, for any given human agent, water is a BEG. Of course, this does not imply that *all* water is a BEG for an agent. At a specific time and place, some water with a certain degree of purity is required for that agent's continued existence. Therefore, to be more precise, a subset of water qualifies as a BEG for a given agent or group of agents.[88] For the purpose of my argument, I am only concerned with that amount and quality of water that qualifies as a BEG for some agent or group of agents. Referring to water as a BEG suggests that some water for some agent is meeting a need without which that agent would not survive. Now, the claim defended in this section – that buying and selling some water should be blocked – is restricted to cases where people urgently need it for their continued existence. I will argue that when there are no alternative sources of water available and

[88] Recall that this specific quantity and quality of water that is required for the continued existence of agents but it says very little about the quantity and quality of water required for living a *good* life. Aside from the observation that water is a necessary condition for living any life at all, good or bad, the concept of BEG remains silent.

an owner of water prevents desperate people from acquiring it, because of a prohibitively high price, or otherwise, then this transaction violates Locke's proviso and thus, should not be permitted. This argument hinges on the assumption that agents prefer continued existence over non-continued existence (if agents did not have this preference, but, instead, preferred to die of dehydration, then it is less clear whether such an agent would be harmed when prevented from acquiring the quantity and quality of water that could save her life).

Nozick (1974) maintains that, in most circumstances, appropriating unowned objects will *not* violate Locke's proviso. Presumably, there are many appropriations that would not worsen the situation of others. It seems clear enough that the proviso would not be violated if an agent were to appropriate all of the discarded toenail clippings in the world. With that being said, Nozick thus affirms that the proviso is particularly well-suited to cases where agents appropriate the necessary conditions of life. Nozick gives the example of one person coming to own all of the drinkable water in the world and argues that if such an appropriation were to take place, then it would violate the Lockean proviso (Nozick is skeptical that such an appropriation could actually happen since water eventually become prohibitively expensive to the agent attempting to appropriate it all).[89] Why? Such an appropriation would almost certainly worsen the situation of others because, unlike discarded toenail clippings, every agent requires some quantity and quality of water to live any life at all. It is important to recognize that

[89] If Locke's proviso would be violated by appropriating all of the water in the world then it would also violate the proviso if one were to purchase all of the water in the world, knowingly or not. Nozick states, "if my appropriating all of a certain substance violates the Lockean proviso, then so does my appropriating some and purchasing all the rest from others who obtained it without otherwise violating the Lockean Proviso. If the proviso excludes someone's appropriating all the drinkable water in the world, it also excludes his purchasing it all" (1974, 179).

in a case such as this, the proviso is not violated merely because some water is appropriated (recall Locke's example above when one agent drinks from a river without worsening the situation of the next agent who endeavours to drink from the same river) but because *all* of the water is appropriated and this substance has a special relation to agents, one that cannot be easily substituted for another and, therefore, is bound to worsen the situation of others.

It is crucial to recognize that the proviso can also be violated if an original acquisition combines with spontaneous natural events that, jointly, worsen the situation of others. To adapt one of Nozick's (1974) examples, suppose I were to appropriate one of ten thousand watering holes in a desert and that, in the beginning, this appropriation does not worsen the situation of others one iota. While everyone is certainly affected by my appropriation, since they can no longer appropriate my specific watering hole, no one's situation is immediately worsened by my owning the watering hole and therefore, the condition underlying Locke's proviso is met. But suppose further that quite independent of my own activities, a natural disaster strikes *post facto* – well after I had appropriated my watering hole – and, mysteriously, all of the other watering holes in the desert except for mine dry up. In this case, my appropriation of the watering hole and the natural events combined to make water radically scarce and thus violate Locke's proviso. As Nozick avows, the original process that would have normally given rise to a permanent bequeathable property right in a previously unowned thing – my watering hole in the desert – no longer applies since the situation of others has been worsened.

Of course, not every event that worsens the situation of agents violates the proviso. The proviso is only violated when agents are harmed by *specific* causes. These causes are either the acquisition of unowned things or, as demonstrated in the foregoing

case, the acquisition of unowned things *plus* certain other natural events that combine to worsen the situation of others. This means that, for example, unassisted Nature cannot violate the Lockean Proviso. An agent's situation will surely be worsened if he chooses to live as a hermit in the Negev desert and a natural disaster causes all of his water supply to evaporate. However, in this case, the condition underlying Locke's proviso would still be met because no other agent's appropriation caused the scarcity of water. No other agent's appropriation caused the desert hermit's situation to be worsened. For Locke's proviso to be violated, the hermit's situation must have been worsened by the activities of another, even if those activities are combined with natural events.

Now that we have a better idea of what Locke's proviso is and how it can be violated, what if any limits does it impose on buying and selling water? To my knowledge, free market environmental economists do not generally recognize any such limits. Some have argued that as water becomes increasingly scarce it should be privatized and subsequently bought and sold in the marketplace. For example, Anderson and Snyder (1997, 11) state, "private rights must be established to enable individuals acting in a market to determine water allocation." Without explicitly recognizing limitations to buying and selling water, Anderson and Leal (2001, 105) argue that, "because [water] is a necessity of life … it must be entrusted to the discipline of markets that encourage conservation and innovation". These authors maintain that the free market will distribute water like any other commodity: according to its most valued use. The market does this by efficiently allocating water to those who are willing and able to pay the most for it. Even in the aftermath of a terrible natural disaster, such as Hurricane Katrina, for example, some economists have defended the practise of price

gouging because charging a relatively high price for water in such urgent circumstances represents its scarcity and, moreover, such prices have beneficial consequences (Culpepper and Block 2008). As standard economic theory predicts, high prices will incentivize the owners of water to transport their water to the disaster zone and sell it, rather than choosing to sell it in a jurisdiction where the price is relatively low. This free market approach to distributing water treats water as an ordinary commodity and does not explicitly recognize any limits to buying and selling it.

The problem with this line of reasoning is that water, or, at the very least, a specific quantity and quality of water, is not merely an ordinary commodity and there are moral limits to buying and selling it. Some instances of buying and selling water – for example, during a natural catastrophe – will violate the Lockean proviso in the same way that the proviso was violated in the example above, when I came to be the sole owner of the last watering hole in the desert through a combination of my original appropriation of water and the subsequent natural events that, together, caused water to become perilously scarce. In both of these cases, as the owner of water, if I were to prevent others from obtaining it by charging a high price or otherwise, then their situation would be worsened, not merely by the natural events that took place following my original appropriation, but by my appropriation plus the natural events that were beyond my control.

While my claim is that *some* buying and selling water should not be permitted, it should also be recognized that the price of water on its own need not prevent others from acquiring it and, as a consequence, my claim that some water should not be bought and sold, even when water is extremely limited, is a qualified one. Suppose, for example, that in the case of a natural disaster the only water available is owned by a person who,

no matter what the circumstance, endeavours to sell it for a very low price – almost *gratis*. Suppose further that the price was so low that it prevented no one from actually using or obtaining it. In this case it would be difficult to sustain the claim that the situation of others was worsened by this benevolent owner's appropriation of water combined with the subsequent natural events that caused the disaster and eventual scarcity of water. In other words, it would be difficult to sustain the claim that Locke's proviso has been violated. In this special case, the grounds we had for blocking the sale of water – when its high price excludes other agents from accessing it – have been removed.[90] But, of course, this is a fictional case. No theory predicts that owners will benevolently sell their water at a relatively low price when water is scarce and others need it for survival. On the contrary, economic theory predicts that, *ceteris paribus*, the opposite to be true: owners of water will sell their water at a relatively high price when it becomes increasingly scarce, even when others need it for their continued existence. This theoretical prediction alone is sufficient reason to underscore the moral limits of buying and selling water in those cases when others urgently need it.

The proviso requires that buying and selling water in the marketplace is limited in some minimal sense.[91] If water is radically scarce and such transactions exclude agents from obtaining it, they should be blocked. We have seen that the proviso can be violated when others are harmed by the original appropriation or by the appropriation combined with certain natural events. However, Nozick explains that there is an

[90] By the term "sale" I mean the transfer of the possession of ownership or title of a good or property in exchange for money or some other commodity.
[91] There may be independent reasons against privatizing (and subsequently buying and selling) water *tout court* but my ambition here is more modest. The proviso does not require that no water is bought and sold. Since I am only concerned with the limits to buying and selling water required by the proviso I will suspend judgement on other possible limits that might be imposed on such transactions.

exceptional class of cases when the situation of others is worsened and the proviso is still not violated: when the agent who appropriates some object also compensates those who were harmed so that their situation is no longer worsened. To continue along with our example, in the case of water, any such compensation will have to be *in-kind* and involve a specific distribution: according to those whose situation has been worsened.[92]

Is the free market expected to distribute water in this manner? If the market did distribute water to those whose situation has been worsened by the appropriations of others, then, for all intents and purposes, such a distribution would qualify as compensation and it would appear that Locke's proviso would also remain intact. But the problem here is an obvious one. The market does not automatically distribute water to those whose situations have been worsened in order to safeguard Locke's proviso. Rather, the market, as just mentioned, allocates scarce resources according to their most valued use, distributing them to those who are willing and able to pay for it. Therefore, the free market outcome is not likely to coincide with the outcome required to keep Locke's proviso intact because it is unlikely that the specific agents who are willing and able to pay the most for water are not going to be the same agents who have been harmed and who need water to survive.[93]

But what is one to make of the free market environmental economist's argument that price gouging in a disaster zone signals and incentivizes the owners of water to

[92] Why *in-kind*? I cannot be compensated *post facto* for a loss in some condition required for survival. It is worth noting that the owner of water might also have to be compensated in some sense. Consider the watering hole example above. Suppose it was only through great cost and effort that I maintained my watering hole while others did not and this was, in part, the reason why my watering hole was the last one that remained after the natural disaster. The process that originally gave me property rights in my watering hole might no longer obtain since it violates the proviso but given that I have incurred great cost to maintain my watering hole I would have claim to some reasonable compensation.

[93] Even if the free market were to distribute water according to its most valued use, such a distribution would not override those who have a claim not to be harmed by the appropriations of others.

transport and sell it to those in the disaster zone? Surely, this is a beneficial consequence of the free market, one that, given the dire circumstances, should be enthusiastically embraced. After all, who would object to transporting water to a disaster zone where there are agents in desperate need of it? While I do not deny that, on the whole, such activities would seem to have positive consequences, the point that I am making is that such consequences are not likely to prove sufficient for keeping the proviso intact and it is keeping the proviso intact that is our sole concern here. Why will the proviso be violated in this case? Water might be transported into a disaster zone because it bears a relatively high price, but once again, it is not likely to distribute water in the specific way that required *by the proviso*. What matters when it comes to Locke's proviso is not merely the promise of transporting a large quantity of water to a disaster zone for the purpose of selling it, but ensuring that those agents who have had their situation worsened by the appropriation and subsequent natural events are compensated to such an extent that they are not worse-off from their baseline case. In short, the problem with the free market environmental economist's line of reasoning when applied to water is that price gouging in a disaster zone, for example, does not, on its own, ensure the conditions underlying the proviso will be met. In other words, economically efficient outcomes do not require a specific distribution but when it comes to compensating individual agents who have been harmed by the original appropriations of others (in combination with certain natural events) Locke's proviso does require a specific distribution.

An alternative policy might be used to preserve the efficiency of the price system and incentivize the supply of water where it is needed the most: to make monetary transfers to "needy" individuals (those individuals whose situations have been

worsened). Under this arrangement, the monetary transfers could be used by such individuals for any purpose, including purchasing water in the marketplace. However, whether such a policy would help to leave the proviso intact remains an open question since monetary transfers to individuals in need of water are not identical to transfers of water *in kind*. If it were guaranteed that the individuals who received monetary transfers could thereby attain sufficient water so that the proviso is left intact, then our worry about violating the proviso would be alleviated.

To summarize, this chapter began by arguing against Sagoff's claim that natural capital and ecosystem services have no economic value. While Sagoff is right to argue that the price of any item does not merely depend upon its benefits to human agents, his argument also hinges on what I argued to be the contestable claim that all such items are, in some sense, plentiful. Moreover, Sagoff's argument merely focuses on unimproved aspects of Nature, but the concept of natural capital denotes parts of nature that have been modified, restored, or managed by human agents as well. Therefore, even if Sagoff's argument was sound, it would only show that some and not all of the items denoted by natural capital possess economic value. With the possibility that natural capital and ecosystem services could be for sale, this chapter then went on to consider the question of whether such items should be for sale. A generalized consequentialist position on the moral limits to markets was developed and, by using the example of some minimum quantity and quality of water, it was argued that, in desperate circumstances, when basic ecological goods are radically scarce, buying and selling them in the marketplace will almost certainly worsen the situation of others when compared to their baseline case and, therefore, such activities should be blocked.

Conclusion

This dissertation began with the claim that, rather than depicting Nature as a collection of inert materials to be drawn upon by human agents and then subsequently used in technological forms of production, environmental economists have begun to depict the world as comprised of various unproduced means of production, such as ecosystems, that are generally found, rather than made, and then, in some cases, improved upon to serve human ends. In Chapter One, it was claimed that the clearest vision of this *Garden Image of Nature* was put forward by the evolutionary theorist Thomas Henry Huxley who, in his *Evolution and Ethics*, insisted that the world is divided by a wall. On one side this wall was the "State of Nature", which contains all of those great works of Nature produced by non-human causes or what Huxley referred to as "the cosmic process"; on the other side of this wall was the "State of Art", which contains all of those items that have been created and can only be sustained by mankind's perpetual activities. This portrayal of the world as one that is divided into two separate realms is, today, difficult to sustain. The ideal state of affairs among a growing number of economists is to have every last ecosystem on Earth adapted to human wants and needs. Since this ideal entails that the whole world is to be managed for human ends, there is no longer any firm division between Huxley's "State of Nature" and the "State of Art". In other words, there is no wall in the Anthropocene.[94] Just as Huxley's

[94] The term "Anthropocene" was first coined by the Nobel laureate Paul Crutzen in year 2000 to describe the current geological epoch that is characterized by the enormous role that human activity has for geological and ecological phenomena (Jones 2011).

student, H.G. Wells, had predicted in *The Time Machine*, the Earth has become, or is fast becoming, a kind of garden that consists of natural objects purposefully arranged and modified by intentional human agents in order to serve their own objectives.

Chapter Two established criteria to distinguish natural capital from manufactured capital. It was claimed that natural capital has a dual nature and that the spatio-temporal particulars denoted by the concept of natural capital include objects that are capable of producing goods and services. Such objects are depletable, beneficial, original, and self-generative. Among these characteristics, the last two, original and self-generative, drive a wedge between natural and manufactured capital. Since manufactured capital is always a produced means of production that depends on the savings decisions of economic agents, the members of this class are never original or wholly self-generative. In the latter half of this chapter it was claimed that, for the purposes of this dissertation, the "natural" and "artificial" are to be located along a spectrum or continuum, with the most natural objects being those that remain relatively detached from intentional human agency and the most artificial objects being those that have been built or constructed by intentional human agents.

Chapter Three began by tracing the historical roots of the idea that Nature is a producer to the Swedish botanist Carl Linnaeus' *Oeconomia Naturae* and the Physiocrats of France during the mid-eighteenth century. While this chapter probed the extent to which the Physiocrats, such as Quesnay, actually considered nature to be an independent producer, it was argued that the concept of natural capital is not entirely novel since there is a nascent category of the concept to be unearthed in the writings of classical political economists, such as Adam Smith, John Stuart Mill, and Karl Marx. When such economic theorists referred to the spontaneous productions of the Earth and

Nature's natural products, they had a distinctive category of production in mind, one that denotes Nature's independently generated products. Although this category was, on the whole, considered to be rather unimportant for economic science, it was acknowledged nonetheless and, therefore, can be recognized as a harbinger to the concept of natural capital.

As detailed in Figure 1 (p. 8), one central difference between the *Warehouse Image of Nature* and the *Garden Image of Nature* is that the former takes the ecological conditions required for human economic activity as given while the latter does not. Chapter Four considered this difference when it answered what is perhaps the most vexing question concerning natural capital with respect to the social scientific approach to sustainable development: to what extent can manufactured capital serve as a substitute for natural capital? Can the entire stock of natural capital be depleted while meeting the goal of sustainable development, provided that it is supplanted with manufactured capital? It was shown that economists influenced by the life sciences, often referred to as ecological economists, have long argued that there is a subset of natural capital, *critical* natural capital, for which there are no substitutes. These economists argue that critical natural capital must be maintained for the goal of sustainability. The problem with this argument, however, is that, until now, no one had systematically explained what these special ecological conditions might be and why they, and not others, are essential for this purpose. To resolve this issue, this chapter introduced a new theory of what were termed "basic ecological goods" (BEGs). BEGs are distinct from ordinary goods in orthodox consumer choice theory because the former are objective ecological conditions that must be met for the continued existence of economic agents while the latter only ever yield subjective utility to economic agents.

This theory gave an account of the minimal ecological conditions required for the continued existence of economic agents and, therefore, sustainable development. The real upshot to this theory is that the conditions required for human economic activity are no longer shrouded in mystery as they were under the canopy of "critical natural capital".

Finally, Chapter Five, entitled, "No One Can Preserve Nature", began by recognizing that the *Garden Image of Nature* would seem to involve domesticating every last ecosystem on Earth.[95] In response to this state of affairs, this chapter considered the preservation paradox, a paradox that is more familiar to environmental ethicists than to philosophers of economics. This paradox states that preserving or restoring Nature, when Nature is understood as that realm of phenomena beyond intentional human agency, is impossible since these activities necessarily involve human agency. Following established theories of artifacts, this chapter introduced criteria for turning natural objects into artifacts, and then argued that no one can preserve or restore nature or a part of nature without turning it into an artifact or, in the very least, making it more artificial than it would be otherwise. In other words, it was argued that the preservation paradox is warranted.

What, if any, implications do the arguments of this dissertation have for the social science of economics? For one, with the concept of natural capital, the whole of

[95] This image is very much in agreement with that held by the current Chief Scientist of the Nature Conservancy, Peter Kareiva. He states: "ours is a world of nature domesticated, albeit to varying degrees, from national parks to high-rise megalopolises. Facing this reality should change the scientific focus of environmental science. Instead of recounting doom-and-gloom statistics, it would be more fruitful to consider the domestication of nature as the selection of certain desirable ecosystem attributes, such as increased food production, with consequent alteration to other ecosystem attributes that may not be desirable. Under this paradigm, our challenge is to understand and thoughtfully manage the trade-offs among ecosystem services that result from the inescapable domestication of nature" (Kareiva *et al.* 2007, 1).

nature is construed as a producer, or, more precisely, a collection of producers, that supply valuable goods and services to economic agents. In many cases, unlike instances of manufactured capital, instances of natural capital are available to human agents without cost. While some such productions are produced in a manner that is relatively detached from human agency, in many other cases, such production processes are improved with direct or indirect human intervention so as to ensure the continued production of goods and services. With the items denoted by the concept of natural capital, it should be apparent that there are substantial non-human causes operating as a source of economic phenomena and this observation is significant for economics from a historical point of view.

As noted in Chapter One, Schabas (2005) has argued that the ascription of non-human agency in economics has been on the wane since Mill. While Mill explicitly recognizes "nature's agency" towards the very beginning of his monumental *Principles of Political Economy* ([1848] 2006), he repositions the core of phenomena studied by economists such that human agency is the proximate cause. Then, with the advent of neoclassical economics circa 1870, particularly the revolutionary works of William Stanley Jevons, Carl Menger, and Léon Walras, virtually all economic phenomena are shown to derive from human deliberation alone. If Schabas is correct, then, for neoclassical economists, human agency has become the proximate cause of economic phenomena and, by this process, economic science has become increasingly "denaturalized" (a process that, Schabas claims, has never been completed). With natural capital denoting specific ecosystems that possess economic value, however, the science of economics might well be described as fast becoming "re-naturalized" in the specific sense that non-human agency is the proximate cause of an entire class of

economic phenomena, namely, ecosystem goods and services, that are to be studied and analyzed by economists. In other words, there is a class of readily consumable goods and services produced, not directly nor indirectly, by the hands of human beings, but by nature itself. With nature being ascribed the status of an economic producer, we might well side with Adam Smith in the *Wealth of Nations* when he described the special case of agricultural production, affirming that "nature labours along with man." Indeed, with the growing emphasis on the concept of natural capital among environmental economics, it would seem that *both* humans and nature produce goods and services.

In some cases, nature endows human agents with production processes capable of producing goods and services autonomously, quite independent of human agency. In these cases, nature's "natural machines" need no improvement or active modification since they satisfy humanity's needs just as they are, without the need for direct human intervention. Because nature is not a perfect producer, however, not every instance of natural capital will be capable of producing autonomously in this way. In many other cases, instances of natural capital will require transmutation and improvement by human agents, with the expectation being that these improved production processes, which include items such as restored ecosystems, will continue to produce certain desired goods and services in the future.

If unassisted nature were a faultless producer, then we would all be living in the Garden of Eden and there would be no need to toil about in the first place. This state of affairs would eliminate the need for human economic activity altogether and, therefore, economic science *in toto*. Indeed, it should be apparent that there are significant limitations to how economic theorists can possibly conceive of nature for the purpose of economic analysis. If nature is to be construed as a collection of processes that produce

goods and services for human agents, then it must also be construed as a collection of imperfect processes of production.

Under the *Garden Image of Nature*, since every ecosystem with economic value is to be managed to serve human ends, one might well claim that, for the same reason that there is no (capital-N) Nature left on Earth, there is no natural capital either. Indeed, this statement appears to be bolstered by the conclusion reached in Chapter Five: even in the case of merely preserving parts of nature, they are made into artifacts or certainly more artificial than they would be otherwise. Such reasoning makes it appear that even if there are instances of natural capital that remain today there will be no such instances of natural capital in the near future since every item denoted by this concept will, ultimately, be arranged by either intentional human activity or the intentional omission of such activity. This conclusion, however, would be mistaken. Why? To reiterate, the concept of natural capital does not merely denote nature's unassisted productions, but includes nature's *assisted* productions as well. For instance, it includes all of those ecosystems that have been intentionally modified and improved by human agents as well. For this reason, one might maintain that while there may be no Nature left on Earth, in the sense that there is virtually no part of the surface of the Earth that remains completely unaffected by human agency, the number of items denoted by the concept of natural capital can still be expected to proliferate, not shrink. This is because the items denoted by the concept of natural capital do not have to be part of *Nature*.

This dissertation has covered a lot of ground, but it has also left many unanswered questions on the topic of natural capital. One enormous topic, briefly alluded to in the present chapter is the question of how nature is and ought to be valued.

With the encroaching *Garden Image of Nature*, the ideal state of affairs not only involves systematically managing all of the Earth's ecosystems, but it would also seem to involve managing them in a particular way: to maximize utility.

There are two distinct issues here, neither of which has been analyzed in this dissertation. The first is the questionable activity itself of governing or dominating all of the Earth's economically valuable ecosystems, including those processes that came into existence in a manner that is relatively detached from human agency. One might certainly question whether this reputed ideal, captured by the *Garden Image of Nature*, is actually an ideal, or, whether it is even desirable. Chapter Five made clear that J.S. Mill would certainly have questioned the desirability of this state of affairs. Once again, Mill states:

> Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture ploughed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture ([1848] 2006, 756).

In addition to Mill's worry about eliminating all of the spontaneous productions of the Earth, one might also ask whether it is right for one species – *Homo sapiens* – to dominate all of the others in this way. The second issue here is the putative moral

principle used to guide such activities. It is one thing to decide on whether to manage the Earth's ecosystems for the benefit of human agents and their interests, but it is quite another to decide on the principle to direct such activities. On the whole, neoclassical environmental economists take it for granted that the best state of affairs is to maximize utility. The problem here is that, when it comes to managing nature or parts of nature, and not merely (traditional) economic phenomena, this principle may turn out to be inappropriate or unsuitable. Because both of these issues, the questionable activity of managing the items denoted by the concept of natural capital and the principle used to guide such activities, are not merely the subject matter of environmental economics but environmental ethics and environmental philosophy as well, I suspect that any satisfactory resolution to them will require contributions from all three of these disciplines.

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