The Application of Emerging Principles of International Environmental Law to Human Activities in Outer Space

by

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For Sherry, the love of my life

Abstract

This thesis proposes a legal régime for the environmental protection of outer space. The proposed régime aims to avoid the shortcomings of current environmental protection practices based on human self-interest by placing emphasis on respect for all of nature. Chapter I describes the physical parameters of human space activities, with an emphasis on near-Earth space, the Moon, Mars and Venus. Chapter II proposes the biocentric (life-centred) moral perspective as a rational basis for international environmental law on Earth and in outer space. Chapter III deals with four basic principles of international environmental law, which are analysed in order to develop a biocentric approach when addressing environmental issues on Earth and in outer space. Chapter IV describes existing principles and techniques of biosphere management and proposes a strategy of biosphere risk assessment for managing ecosystems according to the biocentric perspective. Chapter V analyses current international space law to ascertain what restrictions, if any, environmental principles of that law may impose on the biocentric approach to management of the planetary environment. Chapter VI proposes a protocol to the *Outer Space Treaty* designed to protect the planetary environment from harmful human space activities. Chapter VII applies the techniques of biosphere risk assessment to the hazards posed by space debris, the first major environmental problem in outer space arising from human activities.

Resumé

Le but de cette thèse est de présenter un régime législatif pour la protection de l'environnement de l'espace extra-atmosphérique. Le régime législatif proposé, en se fondant sur le respect de la nature, tente de combler les lacunes qui existent dans les pratiques courantes de protection de cet environnement pour des fins personnelles. Le premier chapitre décrit les paramètres de l'activité humaine dans l'espace, en particulier dans l'espace près de la Terre, sur la Lune, sur Mars, et sur Vénus. Au chapitre II, l'auteur nous propose une perspective biocentrique pour rationaliser les principes de base du droit de l'environnement pour la Terre et pour l'espace extra-atmosphérique. Le chapitre III traite de quatre principes de base du droit international de l'environnement. En se basant sur ces principes, l'auteur développe une approche biocentrique pour résoudre les problèmes liés à l'environnement terrestre et à l'espace extra-atmosphérique. Le Chapitre IV décrit les principes et les techniques pour gérer la biosphère. L'auteur nous propose une stratégie pour évaluer les risques liés à la gestion biocentrique des éco-systèmes. Le chapitre V analyse le droit international de l'espace actuel afin de déterminer les restrictions, le case échéant, que ce droit imposent pour la gestion biocentrique des planètes et de leur environnement. Le chapitre VI propose un protocole d'entente pour l'application du Traité sur l'espace extra-atmosphérique conçu pour protéger de l'environnement planétaire des activités spatiales néfastes de l'homme. Au dernier chapitre, en

utilisant les diverses méthodes d'évaluation des dangers pour la biosphère, l'auteur évalue les risques que posent les débris spatiaux pour l'espace extra-atmosphérique.

Acknowledgements

This thesis is the culmination of more than 20 years academic experience in the fields of philosophy, environmental studies and law. Notwithstanding the passage of time, I still see clearly before me the visages of three individuals from the earlier years, who were not only clear thinkers, but whose conduct always conveyed the convictions of their beliefs. I take this opportunity to acknowledge the influence of Dr Harold A. ("Skip") Bassford, Professor of Philosophy, York University, who introduced me to the beauty of philosophy and the fundamental nature of ethics; John Livingston, Professor, Faculty of Environmental Studies, York University, who opened the door to the wonders of ecology and to humankind's biological heritage; and to Gerry Carruthers, the first Dean, Faculty of Environmental Studies, who was always there when you needed him.

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Preface

Candidates have the option of including, as part of the thesis, the text of one or more papers submitted or to be submitted for publication, or the clearly-duplicated text of one or more published papers. These texts must be bound as an integral part of the thesis.

If this option is chosen, **connecting texts that provide logical bridges between the different papers are mandatory**. The thesis must be written in such a way that it is more than a mere collection of manuscripts; in other words, results of a series of papers must be integrated.

The thesis must still conform to all other requirements of the "Guidelines for Thesis Preparation". **The thesis must include:** a Table of Contents, an abstract in English and French, an introduction which clearly states the rationale and objectives of the study, a review of the literature, a final conclusion and summary, and a thorough bibliography or reference list.

Additional material must be provided where appropriate (e.g., in appendices) and in sufficient detail to allow a clear and precise judgment to be made of the importance and originality of the research reported in the thesis.

In the case of manuscripts co-authored by the candidate and others, **the candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent.** Supervisors must attest to the accuracy of such statements at the doctoral and oral defence. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to make perfectly clear the responsibilities of all the authors of the co-authored papers.

This study contains material previously published by the candidate as sole author. This material is found in Chapter V, Sections A-C, and in Chapter VII, Sections B.1 and B.3. The material in Chapter V originally appeared in H.A. Baker, "Protection of the Outer Space Environment: History and Analysis of Article IX of the Outer Space Treaty" (1987) 12 Ann. Air & Sp. L. 143; the material in Chapter VII, in H.A. Baker, "Space Debris: Law and Policy in the United States" (1989) 60 U. Colo. L. Rev. 55.

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INTRODUCTION

A comprehensive legal régime does not yet exist for effective protection of the environment of outer space, including the Moon and other celestial bodies, from the anticipated increase in space activities during the coming decades. The purpose of this study is to propose such a régime which would avoid the weaknesses of current environmental law and practices, based on human self-interest, by emphasizing respect for all of nature.

In the study, Part One addresses the foundations of international environmental law, which are rooted in the environment in which human activities take place. Because the focus of the study is the entire planetary system, the physical parameters of human space activities, with an emphasis on near-Earth space, the Moon, Mars and Venus, are explored. An outline of the basic moral perspectives applicable to environmental protection provide the ground for developing the biocentric (life-centred) moral perspective as a basis for international environmental law as it applies to human activities on Earth and in outer space.

Part Two describes the emerging principles of international environmental law on which a future legal régime for the environmental protection of outer space can be based. The current status of the four basic principles of international environmental law is reviewed and their content analysed in order to develop a biocentric approach for addressing environmental issues in both the terrestrial and outer space environments. Following a brief analysis of existing principles and techniques of biosphere management, a strategy of biosphere risk assessment is proposed for managing Earth ecosystems according to the biocentric perspective.

Part Three applies the principles and techniques of biosphere management to human space activities. It begins with an analysis of the environmental principles in space law to ascertain what restrictions these principles may impose on the biocentric approach to management of the planetary environment. Next a protocol to the *Outer Space Treaty* is proposed for the protection and preservation of the planetary environment from human space activities. In addition to recommending a legislative format for the protocol, the proposal applies to space activities the basic principles of international environmental law and the legal obligations of biosphere management developed in Part Two of the study. Chapter VII applies the techniques of biosphere risk assessment to the risks posed by space debris, the first major environmental problem in outer space arising from human activities.

PART ONE: PHYSICAL AND MORAL FOUNDATIONS OF INTERNATIONAL ENVIRONMENTAL LAW

> We have developed from the geocentric cosmologies of Ptolemy and his forebears, through the heliocentric cosmology of Copernicus and Galileo, to the modern picture in which the earth is a medium-sized planet orbiting around an average star in the outer suburbs of an ordinary spiral galaxy, which is itself only one of about a million million galaxies in the observable universe. Yet the strong anthropic principle would claim that this whole vast construction exists simply for our sake. This is very hard to believe.[1]

> If we continue to the planets and the stars, our chauvinisms will be shaken further. We will gain a cosmic perspective.[2]

The foundations of international environmental law are rooted both in the surroundings ("environment") in which human beings ("humankind") conduct their activities and in the nature of humankind's attitude toward, and relationship with, its environment. The purpose of Part One is to set out the physical parameters of, and a moral perspective for, international environmental law as it applies to the conduct of human activities in outer space, on the Moon and on other celestial bodies.

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[1] S.W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes* (Toronto: Bantam Books, 1988) at 126.

[2] C. Sagan, *Cosmos* (New York: Random House, 1983) at 342.

CHAPTER I: PHYSICAL PARAMETERS[3]

So it is that our envoys are star children.[4]

A. Introduction: Space Activities in the Planetary Environment

Physical parameters are set by the environment in which activities occur. Until the middle of the twentieth century, humankind's activities were basically confined to Earth and its atmosphere. But on 4 October 1957, after some 15 years of experimentation,[5] humankind took its first tentative step in the exploration and use of outer space when the first artificial satellite, Sputnik (Traveller) 1, was launched from the rocket test range at Tyuratam in the

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[3] The material in this chapter is assembled from several primary sources. These are, in alphabetical order: J. Baugher, *On Civilized Stars: The Search for Intelligent Life in Outer Space* (Englewood Cliffs, NJ: Prentice Hall, 1985); S. Chang, "Organic Chemical Evolution" in J. Billingham, ed., *Life in the Universe* (Cambridge, Mass.: MIT Press, 1981) 21; T.D. Damon, *Introduction to Space: The Science of Spaceflight* (Malabar, Fla.: Orbit Books, 1989); Hawking, *supra*, note 1; F. Jackson and P. Moore, *Life in the Universe* (New York: W.W. Norton, 1987); Sagan, *supra*, note 2; I. S. Shklovskii and C. Sagan, *Intelligent Life in the Universe* (New York: Dell, 1966). Additional sources will be cited where used.

[4] G.S. Robinson and H.M. White, Jr., *Envoys of Mankind: A Declaration of First Principles for the Governance of Space Societies* (Washington, DC: Smithsonian Institution Press, 1986) at 3.

[5] The first rocket, the prototype for every rocket to follow, was the V-2. It was successfully launched in October 1942 by Nazi Germany under the direction of Wernher Von Braun, who would become a key player in shaping the US space program. W.A. McDougall, *...the Heaven and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985) at 43 and W.E. Burrows, *Exploring Space: Voyages in the Solar System and Beyond* (New York: Random House, 1990) at 32.

former Union of Soviet Socialist Republics ("Soviet Union").[6] An aluminum sphere with four extruding rod antennae circled the globe for three months and provided data concerning the Earth's ionosphere and the temperature regimes through which it passed.[7] On 31 January 1958, the United States joined the "space race" with the launching of Explorer 1, a 23-kg experimental satellite which discovered the Van Allen radiation belts that encircle Earth.[8]

Today most space activities are confined to three basic regions beyond Earth: low-Earth orbit ("LEO") ranging in altitude from 200 to 4000 km, middle-Earth orbit ("MEO"), from 1500 to 10,000 km,[9] and the geostationary orbit ("GEO"), at 35,800 km. Geostationary transfer orbits ("GTO") are used for moving satellites from LEO to GE0. As well, several satellites have visited the distant planets, while a small number will explore outside our solar system.

LEO hosts a wide variety of spacecraft: research, military and commercial telecommunication satellites, as well as remote sensing and other earth

[6] See McDougall, *ibid.* at 59-62.

[7] D. Hart, *The Encyclopedia of Soviet Spacecraft* (London: Bison Books, 1987) at 121.

[8] McDougall, *supra*, note 5 at 168.

[9] R. Chipman, ed., *The World in Space: A Survey of Space Activities and Issues* (Englewood Cliffs, NJ: Prentice Hall, 1982) at 341.

observation and data-gathering satellites. It is also used for storage of satellites prior to their transfer to higher orbits, and temporary residence for humans launched into orbit. As well, LEO currently hosts crewed spacecraft: the Soviet Salyut (Salute) and Mir (Peace) space stations, the latter having been in continuous orbit and operation since its launch on 19 February 1986[10]; and the US space shuttle orbiters which, by Spring 1996 had flown their 75th mission.[11] In the near future, LEO will be used for mobile telephones, data messaging, two-way videoconferencing and high quality voice, video and radio transmissions.[12] Future uses of LEO will likely include an international space station, managed by the United States, with the participation of the European Space Agency, Japan, Canada and Russia.

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[10] Hart, *supra*, note 7 at 174. The first Soviet space station, Salyut 1, was launched on 19 April 1971 and remained in orbit for about six months. *Ibid.* at 160.

[11] The United States completed its 75th shuttle mission in March 1996. "Columbia Mission Produces Microgravity Advances" *A.W.S.T.* (11 March 1996) 68.

[12] In March 1993, the World Administrative Radio Conference approved the allocation of radio spectrum for these services. "Delegates Bestow Mobile Mandate" *Space News* (9-15 March 1992) 1 and 20. The four major competitors at this time are the Inmarsat subsidiary ICO Global Communications, a 10-satellite system with launches beginning in 1998; Globalstar, which plans to launch the first of its 48 satellites in mid-1997; Iridium, a 66-satellite constellation, expected to launch its first satellite in late 1996; and Odyssey, a system of 12 satellites, with its first launch planned for 1999. "Space Phone Firms Vie for Marketing Advantage" *Space News* (6-12 November 1995) 3 and 21.

In MEO, satellites for global positioning operate. Satellites in GEO serve telecommunications and broadcasting (68 per cent); research, experimentation and meteorology (16 per cent), and national security (16 per cent).[13]

Beyond the realm of Earth orbits, humans have visited the Moon, both in person and by proxy; have successfully landed uncrewed space probes on the planets Venus and Mars; have flown satellites by all the planets and many of their moons; and in four cases, have seen their satellites leave our solar system[14]. Sometime in the future, it is likely that a crewed lunar base will be

[13] L. Perek, "The Scientific and Technical Aspects of the Geostationary Orbit" (1988) 17 Acta Astronautica 589 at 591.

GEO is a geosynchronous, nearly circular orbit around Earth, with an inclination of approximately 0 degrees. Space objects in GEO appear from Earth to be stationary. Due to perturbations characteristic of objects in GEO, satellites there require frequent "station-keeping" manoeuvres in order to maintain their relatively stable positions. See United States National Research Council, *Orbital Debris: A Technical Assessment* (Washington, DC: National Academy Press, 1995) at 199-200.

[14] All four satellites are efforts of the US solar exploration programme. They are Pioneer 10, launched 2 March 1972; Pioneer 11, launched 5 April 1973; Voyager 1, launched 5 September 1977, and Voyager 2, launched 20 August 1977. Burrows, *supra*, note 5 at 426-428. Which of Pioneer 10 and Voyager 1 is the first extra-solar satellite depends on how "solar system" is defined. If it is defined as the outer limits of the planets, then Pioneer 10 left first, on 16 March 1983. If it is defined as the limit of the Sun's influence (the solar heliopause), then Voyager 1 will leave first. *Ibid.* at 320n.

established and uncrewed missions sent to Mars.[15] Exploration of asteroids and comets also is being discussed.[16]

During less than 40 years since the advent of space exploration, humankind has not only investigated the surface of the Moon, but has also cast its net wider by means of technological extensions to broaden its spheres of activity to the surfaces of Mars and Venus and to the outskirts of the other planets. The two Voyager and two Pioneer spacecraft are true envoys of humankind as they begin their journeys into the interstellar space beyond our solar system en route to the stars.[17] If they remain intact, they will travel through the vastness of interstellar space until they settle in orbit about the centre of our galaxy, the Milky Way.[18]

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[15] The United States is planning to launch an uncrewed mission to the Moon in October 1997. This mission is the first in a series which is expected to culminate in a crewed lunar base. "Government and Private Industry Set Sights on the Moon" *Space News* (27 November - 03 December 1995) 10. The United States also is planning a series of uncrewed missions to Mars, the first launch date scheduled for November 1996. "Russian Instrument May Ride on Mars Lander" *Space News* (13-26 November 1995) 6.

[16] The first spacecraft of the New Millennium project is expected to explore a comet, asteroid or some combination of so-called small bodies. "First Contract Due for New Millennium" *Space News* (4-10 September 1995) 1.

[17] Voyagers 10 and 11 will need 40,000 years to reach the star nearest to the Sun.

[18] R. Maurer, *Junk in Space* (New York: Simon & Schuster, 1989) at 46. The power supply providing communications with Pioneer 11 was disconnected on 30 September 1995. "After 22 Years, NASA Turns Off Pioneer 11" *Space News* (2-8 October 1995) 2.

It seems appropriate, therefore, to consider briefly the geophysical parameters of this study. As a practical matter, most space activities for some time will likely be confined to our solar system, with an emphasis on our own planet, the Moon, Mars and Venus. It should be kept in mind, however, that in the long-term, the environment in which humankind will carry out its space activities will be nothing less than the universe itself. For who can tell when the next major technological breakthrough will occur, enabling humankind to travel more quickly and less expensively through the vastness of interstellar, even intergalactic, space.

It is important, therefore, to understand and appreciate this ultimate cosmic context and humankind's place in it. In so doing, the appropriate moral perspective on which to ground an effective and adequate system of international environmental law may be determined.

B. The Physical Nature of the Universe

1. Our Galaxy, the Milky Way

Our galaxy, known as the Milky Way, is comprised of some 400 billion stars and an astounding volume of interstellar space. The mass of the Milky Way is overwhelmingly in the form of stars, with the interstellar gas and dust of interstellar space accounting for approximately 1 per cent of the total mass. The Milky Way takes the form of a flattened system with a central bulge and is surrounded by a halo of stellar gas called the galactic corona. The Milky Way is about 100,000 light years in diameter; its greatest thicknesses is around 10,000 light years.[19] From "above" or "below", the Milky Way appears spiral in form.

The interstellar space separating the stars in the Milky Way is not a vacuum, but is composed largely of clouds of interstellar gas and cosmic dust in a ratio of approximately 100 to 1. The material in these clouds is distributed irregularly and unevenly throughout the Milky Way and the universe as a whole.[20]

The dimensions of cosmic dust grains are about the same size as the wavelength of visible light, in the range of one hundred-thousandth of a centimetre. These grains are built up as the result of low-energy collisions among the atoms and molecules of the interstellar medium. The evidence

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[19] The light year is used as a unit of measure for interstellar and intergalactic distances. One light year is the distance travelled by light in one year moving at a velocity of 300,000 km per second, or 9.6 trillion km.

[20] If the material in the clouds were spread uniformly throughout the universe, the concentration of matter would be approximately three hydrogen atoms per cubic cm.

suggests that cosmic dust is composed primarily of molecules of the atoms of carbon, nitrogen, oxygen and hydrogen and of ice, silicates, graphite, macromolecular organic compounds and mixtures of these ingredients.[21]

The density of the interstellar gas is extremely low, averaging approximately 1 atom per cubic cm in regions near the galactic plane. This gas is considered to be a uniform, continuous medium, with a chemical composition in which, like the stars, atoms of hydrogen and helium predominate; heavier atoms are comparatively rare. As well, the simplest molecular compounds are present in detectable amounts. It is believed that interstellar magnetic fields are associated with these gas clouds and move with them. The general direction of the lines of magnetic force associated with these fields coincides with the direction of the arms of the spiral structure of the galaxy. The interstellar magnetic fields are closely associated with the primary cosmic rays which fill interstellar space.

2. Our Solar System and its Star, the Sun

It is a basic tenet of the science of chemical evolution that all matter in our solar system had a common interstellar origin. One current model suggests

[21] Most of the organic compounds produced in the interstellar environment are found on Earth.

that our solar system began to form some 5 billion years ago due to the gravitational collapse of an interstellar cloud. This collapse resulted in an enormous disk of gas and dust, the primitive solar nebula, shaped like a flying saucer with the proto-Sun at its centre. As the inner region of the solar nebula cooled, minerals formed from the hot gas, yielding solids. Eventually, accretion of the fine-grained condensed material led to larger and larger objects and ultimately to the formation of one star (the Sun), nine bodies in elliptical orbits about the Sun (the planets) and lesser bodies, the satellites in orbit about the planets and the asteroid belt. The planetary bodies near the freshly-luminous Sun lost most of their volatile elements such as hydrogen; farther out, these substances were retained.

The Sun is about 33,000 light years from the centre of the Milky Way and lies just beyond the inner edge of one of the galactic spiral arms. It is estimated that it takes the Sun about 200 million years to make one revolution about the axis of the Milky Way, a period of time sometimes termed a cosmic year.[22] The Sun has a diameter of approximately 1.4 million km, a surface temperature of about 6000 degrees Celsius and a core temperature of some 15 million degrees Celsius. The Sun contains about 2 per cent of the heavier

[22] It is estimated that our solar system, from its birth as a cloud of gas to its present state, is some 25 cosmic years old.

elements of the universe because it is a second- or third-generation star, formed some 5 billion years ago. Notwithstanding its age, the Sun is not expected to run short of energy-producing fuel for another approximately five billion years.

The Sun is the source of virtually all energy particles and waves in our solar system.[23] The Sun's energy is produced in its core, a nuclear furnace. Heat energy is carried from the core to the photosphere, where it flows into space, mostly as infrared and ultraviolet light. Gamma rays also are produced in the core, but do not normally reach the photosphere to radiate into space. If they did, life as we know it would be impossible anywhere in our solar system.

The Sun also adds energy/matter to our solar system through the injection of streams of charged particles, known collectively as the solar wind. These charged particles are formed when the electrons are stripped from atoms, leaving only their nuclei. In this state, atoms are said to be ionized.

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[23] Non-solar energy sources include comets and extra-solar cosmic rays. As well, the planets themselves could contribute some energy. On Earth, for example, there is a small amount of energy emanating from the radioactive decay of Earth materials. R.G. Barry & R.J. Chorley, *Atmosphere, Weather and Climate*, 5th ed. (New York: Routledge, 1987) at 10.

An ionized hydrogen atom consists of a nucleus with one proton (It has no neutrons to begin with.) and is called a proton; an ionized helium atom hastwo protons and two neutrons in its nucleus and is called an alpha particle.

The solar wind blows outward from the Sun past the planets, some two or three times farther from the Sun than Pluto,[24] filling our solar system with a steady stream of charged particles, mostly electrons, protons and alpha particles. Normally, it takes three to four days for the solar wind to travel the 149 million km from the Sun to Earth. During periods of high solar activity, however, the solar wind increases in speed and density.[25]

Another type of particle found in interplanetary space is known as the cosmic ray, even though it is not a ray. The majority of cosmic rays originate outside our solar system and, possibly, outside the Milky Way. Solar cosmic rays originating on the Sun are protons which may be accelerated to speeds of up to

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[24] The point at which the pressure of the solar wind is exceeded by the pressure of the interstellar plasma is called the heliopause.

[25] At these times, while exposure to the solar wind is comparable to a human being exposed to low-level radioactive material, the dosage does not usually reach a dangerous level.

one-quarter the speed of light, during gigantic, explosive eruptions on the solar surface. These events are known as solar flares.[26]

3. Satellites of the Sun

The planets in our solar system are divided into two groups, the inner and outer. The inner group includes, from the Sun outwards, Mercury, Venus, Earth and Mars. An asteroid belt exists between Mars and Jupiter, the closest member of the outer group of planets. All members of the inner group have solid bodies and, during the early days in the formation of our solar system, it is believed that they had many of the same physical and chemical characteristics.

On the far side of the asteroid belt is the outer group: Jupiter, Saturn, Uranus, Neptune and Pluto. With the exception of Pluto, these planets have relatively small cores, surrounded by liquid layers (mainly hydrogen), which are overlaid by gaseous atmospheres, hydrogen and helium being dominant, but also

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[26] Although the most intensive solar-flare events are relatively infrequent, cosmic rays released during such an event would reach the vicinity of Earth in about 30 minutes and would be lethal to terrestrial inhabitants, unprotected mission crew members and mission crew members "protected" by the cabin walls of a US space shuttle orbiter. During this half-hour period, a mission crew member could be exposed to more radiation than is allowed a radiation worker in a year.

including methane, ammonia and water.[27] Additionally, Jupiter, Saturn and Uranus have strong radiation zones and powerful magnetic fields surrounding them. The same is probably true of Neptune. The compositional status of the outermost planet, Pluto, is currently in doubt.

All planets, except Mercury and Venus, have their own satellites. The larger satellites, with the total number for each planet in brackets, are: Earth -- the Moon; Mars -- Phobos and Deimos (2); Jupiter -- Io, Europa, Ganymede and Callisto (16); Saturn -- Titan (23); Neptune -- Triton (2); Uranus (5), and Pluto (1).

(a) Mercury

Mercury is the planet closest to the Sun, at a distance of 0.39 Astronomical Units (AU)[28]. The second-smallest planet, it has a diameter of 4880 km, a solar orbit of 88 Earth days and rotates on its axis (axial rotation) once every 58.6 Earth days. The surface temperature on Mercury ranges from 480 degrees Celsius when facing the Sun, to -170 degrees Celsius when it is not.

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[27] Evidence suggests that, of the inner planets, at least Earth should have exhibited a similar atmosphere in its earliest days.

[28] One Astronomical Unit is equivalent to 149 million km, the average distance of the Earth's orbit from the Sun.

(b) Venus

Venus is the Earth's nearest planetary companion. In size and mass, Venus is the twin of Earth. With a diameter of approximately 12,100 km, Venus has a mean distance of 0.72 AU from the Sun, an orbital period of almost 225 Earth days and an axial rotation period of 243.01 days. Of all the planets, only Venus rotates in the direction opposite to which it orbits the Sun.[29]

The surface temperature of Venus is in the range of 465 to 480 degrees Celsius, which is believed due to a "runaway" greenhouse effect. In its early history, Venus was thought to be much like Earth, with a cooler temperature, a thinner atmosphere and perhaps liquid water flowing on the surface. Over time, the Sun's heat raised the surface temperature, vaporizing the liquid water into the atmosphere. The newly formed water vapour trapped solar energy near the surface, causing the temperature to rise even further until it forced carbon dioxide out of the surface rocks. This process did not stop until all surface water was vaporized and all carbon dioxide was forced out of the rocks. Consequently, all water vapour and carbon dioxide on Venus are found in its atmosphere.

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[29] Technically, the rotation of Uranus is also "backwards" or retrograde; this, however, is a marginal case.

Three distinctive types of terrain have been identified on Venus: lowlands, comprising 27 per cent of the surface; rolling plains, 65 per cent; and the highlands (8 per cent), which may be analogous to the large continental land masses of Earth.

A dense, cloud-laden atmosphere permanently conceals the surface of Venus. This atmosphere is mainly carbon dioxide gas (96 per cent), with relatively small amounts of other gases, including argon, sulphur dioxide, nitrogen and water vapour. The atmospheric clouds contain a great deal of sulphuric acid. The top of the atmosphere appears to lie about 400 km above the surface, and the upper clouds, at 70 km. At an altitude of 50 km, there is a clear layer, while below it a layer of denser cloud and then, at 47 km, a second clear region. The clouds end at 30 km above the surface. The lowest atmospheric region consists mainly of droplets of water, rich in sulphuric acid, and has been described as a corrosive, superheated smog.

It is thought that the extreme surface temperatures eliminate the possibility of any forms of life on the surface of Venus.[30] Given that about only 1 per cent of the sunlight reaching the upper layers of the atmosphere penetrates to the

[30] Organic or any other conceivable living molecules would fall to pieces.

surface, speculation about life on Venus has shifted from the surface to the atmosphere.

(c) The Earth-Moon Environment

(i) Earth

Earth and its sole satellite, the Moon, are estimated to be some 4.6 billion years old. The distance of Earth to the Sun is 1 AU and its diameter, 12,756 km, with a solar orbit of approximately 365 days and an axial rotation of 24 hours.

The Earth's surface is undergoing a process of constant alteration, destruction and reformation,[31] with its current composition being approximately 20 per cent land and 80 per cent water. At its northern- and southern-most regions are polar caps, covering about 7 per cent of the Earth's surface. The southern cap contains about twice as much ice as the northern one.

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[31] The crust and mantle of Earth down to a depth of 100 km are divided laterally into 10 major continental plates. The plates "float" on top of a 150-km-thick layer of partially molten mantle and migrate laterally at a rate of a few centimetres per year. The result, then, is that a map of Earth would change significantly during a time period as short as 500,000 years.

Initially, Earth was very hot and had no atmosphere. It cooled over time and acquired its initial atmosphere from the emission of gases from the rocks. While the composition of the primal atmosphere is not without controversy, it is clear that nitrogen and oxygen, its current major constituents at 78 per cent and 21 per cent, respectively, were not present.[32] Other components of the atmosphere include argon (about 1 per cent), water vapour (varying from virtually 0 to 4 per cent), smaller amounts of carbon dioxide, helium, neon, methane and krypton, measured in parts-per-million ("ppm"), and trace amounts (0.5 ppm or less) of hydrogen, nitrous oxide, carbon monoxide, ammonia, nitrogen dioxide, sulphur dioxide, hydrogen sulphide and ozone.

Earth's atmosphere may be divided into vertical layers called the troposphere, stratosphere, mesosphere, thermosphere, ionosphere, exosphere and magnetosphere.[33] As a whole, the atmosphere is a mixture of gases with constant proportions up to some 80 km, with the exceptions of ozone, which is concentrated in the lower stratosphere, and water vapour, in the lower troposphere.

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[32] It is thought that nitrogen evolved from the effect of solar ultraviolet radiation on ammonia molecules and that the same radiation released oxygen from molecules of water vapour, present in much greater abundance initially than it is today.

[33] Information on the composition and structure of the atmosphere is based on Barry & Chorley, *supra*, note 23 at 51-55 and 58.

The lowest 10 km is the troposphere, where all living things reside. It contains 75 per cent of the gaseous mass and virtually all the water vapour. Next is the stratosphere. With a temperature of -50 degrees Celsius at its lowest level, it extends upwards from the troposphere to an altitude of about 50 km. The stratosphere contains the most of atmospheric ozone, with a peak density at approximately 22 km. In this region, low-level solar ultraviolet radiation breaks up oxygen into ozone. The ozone, in turn, absorbs solar ultraviolet light of longer wavelengths and prevents the shorter wavelengths (below 3000 angstroms), which are hazardous to life on Earth, from reaching the planet. This chemical reaction also heats up the stratosphere.

The layer between 50 and 80 km is the mesosphere, where the temperature begins to decline once again.[34] The thermosphere begins at approximately 80 km, where the temperature begins to rise once again, and extends through to 100 km. Next is what is often termed the ionosphere. In the ionosphere, the oxygen atoms and nitrogen molecules are stripped of their electrons by the absorption of X-rays and long wavelength ultraviolet rays emitted by the Sun. The result is a layer of electrically-charged (ionized) particles, a more localized version of plasma. The heat generated by ionization causes the temperature to

[34] There is no universal agreement on the divisions of the upper atmosphere, which begins at about 50 km.

rise yet again. The ionosphere extends upwards to somewhere between 500 and 750 km, at which point the exosphere begins. The exosphere consists mainly of atoms of oxygen, hydrogen and helium, which are able to escape into interplanetary space because it is unlikely that their escape will be slowed by collisions with other atoms.[35]

Beyond the exosphere in the magnetosphere,[36] there are mostly the charged particles of the plasma blown in by the solar wind.[37] These charged particles are concentrated in two bands at about 2000-5000 km and 13,000-19,000 km, where their radiation is particularly intense. These regions, known as the Van Allen belts, are believed to be the result of the trapping of the charged particles by the Earth's magnetic field[38]. Due to interactions with the solar wind

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[35] In order for an object to escape the gravity of any planet, it is necessary for that object to achieve a certain speed, its critical velocity. On attaining this velocity, which on Earth is about 11 km per second, the ejected object will escape the planetary atmosphere and travel indefinitely, i.e., it is moving so rapidly that the gravity of Earth cannot drag it back.

[36] In cases where magnetic effects are the subject of investigation, the term "magnetosphere" may apply from an altitude of 100 km and up. L. Perek, "The Environmental Impact of Space Activities", at 1. Preprint of a chapter prepared in 1987 to appear in B. Jasani, ed., *Outer Space: A Source of Conflict*, a study prepared by the Stockholm International Peace Research Institute and United Nations University.

[37] It appears that the flow of plasma is not all one way. Lower energy plasma is supplied to the magnetosphere from the ionosphere. Large quantities of this plasma then move into near-Earth space. See D. Dooling, "Satellite Data Alters View on Earth-Space Environment" (1987) 29 Spaceflight (Supp. 1) 21 at 21-23.

[38] The atmospheric magnetic field is believed to result from patterns of electric current in the molten core of Earth.

blowing past Earth, the magnetosphere is distorted in appearance. It has an extended tail on the side of Earth away from the Sun; on the side toward the Sun, it is compressed. The magnetosphere acts as a shield to protect life on Earth from the deadly solar wind particles.[39] At the height of some 80,000 km, the magnetosphere probably merges with the atmosphere of the Sun.

Earth hosts a diversity of life forms, in the process of evolution for some four billion years. This life, consisting of a great variety of plant and animal organisms, would not be possible without the Sun's energy in the form of heat and light. Minimal conditions for life as it has evolved on Earth include, in addition to solar energy, a moderate surface temperature to maintain the appropriate heat and light; liquid water as a nurturing medium for life forms; organic (carbon-based) molecules and inorganic nutrients necessary for the creation and maintenance of life; protection from the life-threatening charged particles carried by the solar wind, and oxygen which is probably necessary for breathing in air and for the development of higher multicellular organisms with brains and muscles.

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[39] There are two weak points in the Van Allen belts over the polar regions where the hazardous solar radiation can enter the Earth's atmosphere. The ozone layer in the stratosphere effectively mitigates the effect of this hazard on the surface of Earth. See *supra* at 21. The outer Van Allen belt has a peak radiation intensity sufficiently high to be a health hazard to humankind and should be traversed by crewed spacecraft as quickly as possible.

(ii) The Moon

The Moon is a satellite of Earth. Its orbit about Earth ranges from 356,410 to 406,697 km, with an average distance of 384,400 km. The diameter of the Moon is 2376 km. With no permanent atmosphere[40] and no magnetic field, the surface of the Moon is fully exposed to the extremes of solar radiation by day and solar wind by night. The lunar surface temperature varies from 70 degrees Celsius during the lunar day to -50 degrees Celsius at night. From Earth, approximately the same face of the Moon is always observed, due to the forces of tidal friction early in the history of our solar system.

The Moon is composed of materials similar to those found on Earth. Most abundant are the silicates of iron, aluminum, titanium and magnesium. The lunar surface exhibits several distinct features, including craters, *maria*, mountains and peaks, swellings and domes, and crack-like features known as clefts or rills. As well, a steady rain of tiny meteorites erodes the surface rock and turns over the soil. Absent from the Moon is any trace of water.

[40] The density of the Moon's atmosphere is negligible and corresponds to what is considered a laboratory high vacuum. The atmosphere that exists is a gas of hydrogen, helium, neon and argon, in which no collisions occur. Occasionally, short-lived atmospheric events (transient lunar phenomena) are observed. These phenomena are believed to be the result of short-lived emissions from below the lunar surface.

Craters are the Moon's dominant feature. Pock-marking the lunar landscape, they are walled circular structures, ranging in diameter from 300 km or more to tiny pits invisible from Earth. The *maria* are the roughly circular, darker areas of the Moon. Only one major *maria* extends to the far side of the Moon. Created by asteroid impacts early in the history of our solar system, the *maria* were later filled with lava, flowing up from the lunar mantle and solidifying.

The lunar soil consists of a loose upper layer (regolith) from 1 to 20 m deep. This layer is a breccia, complex rocks made up of shattered, crushed and melted fragments. Below the regolith is 1 km of shattered bedrock, followed by a 25-km layer of more solid rock. Beneath this solid layer is a denser rock. Then comes the hot metal-rich core, some 1000 to 1500 km in diameter.

Based on evidence recovered during the lunar landings,[41] there is no life on the Moon nor were there living organisms in the past. There is, however, an exceedingly remote possibility of some form of microbiological life deep below

[41] During a period of 3.5 years, from 16 July 1969 to 7 December 1972, the US Apollo programme successfully landed on, and returned from, the Moon six crewed lunar probes. Burrows, *supra*, note 5 at 425-427.

the surface, if water is available, or some form of other types of organized matter such as "mineral organisms" or "physical life".[42]

(iii) Cislunar Space

The region between the farthest reaches of the Earth's atmosphere and the Moon is called cislunar space. This region is what is commonly referred to as outer space, a near-vacuum, populated by molecules and charged particles carried by the solar wind and by other solar and extra-solar phenomena: electromagnetic energy in the form of waves (x-rays, ultraviolet, gamma rays, visible light, infrared, radio waves, microwaves), cosmic rays, meteoroids, and small pieces of dust and debris, which are thought to be matter left over from the formation of the solar system.

[42] "Mineral organisms" would include life forms substituting silicon for carbon in the basic building-block molecules, sulphur for oxygen or liquid ammonia for water. "Physical life" refers to physical systems with life-like characteristics, such as plasma in certain zones of a star consisting of ordered patterns of magnetic forces and electrical charges. See Jackson & Moore, *supra*, note 3, c. 10. See also, A.G. Cairns-Smith, *The Life Puzzle* (Toronto: University of Toronto Press, 1971) and G. Feinberg & R. Shapiro, *Life Beyond Earth: The Intelligent Earthling's Guide to Life in the Universe* (New York: William Morrow, 1980) c. 12.

The libration or Lagrangian points are a focal feature of the cislunar environment.[43] A libration point is a location in space where an object under the gravitational influence of two larger objects remains motionless relative to those other two bodies.[44] In other words, the object will appear always to stay in the same place. Relative to Earth and the Moon, there are five such points; two of them, named L4 and L5, are stable.[45]

(d) Mars

Mars is the Earth's second-closest neighbour, with a minimum distance of about 58 million km. Mars has a mean distance of about 1.5 AU from the Sun, a diameter of 6760 km, a solar orbital period of 686.98 Earth days and an Earth-time axial rotation period of 24 hours 37 minutes and 22.6 seconds. The Martian surface reaches temperatures as high as 0 degrees Celsius during the day, dropping to -85 degrees Celsius at night. In its polar regions, Mars is never warmer than -70 degrees Celsius.

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[43] There is also a Sun-Earth libration point at a distance of 1.5 million km from Earth in the direction toward the Sun. A scientific satellite at this point observes solar activity and provides early warning of periods of high solar activity. Chipman, *supra*, note 9 at 354.

[44] "A Lagrangian Point" *Space News* (20-26 April 1992) 14.

[45] To locate the two stable libration points, draw a straight line between the centres of Earth and the Moon. With Earth as the starting point, measure 60 degrees on each side of the centre line and draw two additional lines through these angles until they intersect the orbit of the Moon. L4 and L5 are located at these intersections.

The physical characteristics of the surface of Mars bear a strong resemblance to those of Earth, with features such as rocks, soil and sand dunes. Given the fascination over the centuries with the "Red Planet", the iron-bearing rocks of Mars are of particular interest. These rocks were oxidized to a red colour and, over the eons, eroded and have been distributed across the Martian surface. The northern hemisphere of Mars shows evidence of geological activity, including extinct volcanoes, lava flows, canyons and what appear to be dry river valleys and glacial deposits. The southern hemisphere of Mars is covered with old, eroded impact craters, much like those on the Moon.

There is ample evidence that liquid water once ran through the channels etched in the Martian surface. Now, all water is found either as vapour in the atmosphere or as water ice in the subsoil and the thick layers of the white polar caps. The smaller northern cap is thought to be composed of water ice; the colder southern cap, mainly of carbon dioxide.

The interior of Mars is believed to be similar to that of Earth, containing many of the same minerals in a silicate-rich mantle and crust and a metal-rich core. The Martian atmosphere is exceedingly thin. It composed of 95 per cent carbon dioxide gas, with the remainder a combination of nitrogen and argon, supplemented with traces of oxygen, other gases and water vapour, which shows seasonal variations. As well, ultraviolet radiation reaches the Martian surface at full strength.[46]

Mars has no surface vegetation. The speculation that Mars harbours any advanced form of plant or animal life was largely laid to rest by the experiments undertaken during the two Viking landings in 1975. The bulk of evidence obtained from the Viking experiments, while inconclusive biologically, seems to suggest that there is no life on Mars.[47] However, there still remains the possibility that some hardy microscopic organisms, which evolved in some earlier time, are present in the soil.

(e) The Asteroid Belt and Meteorites

Between Mars and Jupiter lies the asteroid belt, containing countless numbers of solid bodies in orbit about the Sun, ranging in size from 350 km in diameter to pea-size and smaller. More than 5000 asteroid orbits have been identified

[46] The additional distance of Mars from the Sun would not be sufficient to protect humans from the hazardous effects of the solar wind's radiation.

[47] For a description of the two Viking missions and a non-technical discussion of the life-detection experiments, see Burrows, *supra*, note 5, c. 8. See also, B. Adelman, "The Question of Life on Mars" (1986) 39 J Brit. Interplanetary Soc. 256.

and characterized. It is estimated that the main asteroid belt contains as many as a "million chunks of rock with diameters of a kilometer or more".[48] Asteroids are believed to be the remnants of a planet that never formed. During their passage, asteroids frequently collide with one another, often breaking off small pieces which are ejected into elongated orbits. Some of these pieces intersect with the orbit of Earth about the Sun; others could possibly collide with comets[49]. Of these, a small fraction collide with Earth and then are known as meteorites.[50]

Meteorites are of two basic varieties, iron and stone. About two per cent of the stony type contain significant quantities of organic matter (carbonaceous meteorites). Of these, some 0.5 per cent by mass are composed of organic molecules, yielding proportionately a million times more organic matter than

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[48] I. Peterson, *Newton's Clock: Chaos in the Solar System* (New York: W.H. Freeman, 1993) at 181.

[49] Comets originate well outside the solar system in interstellar space and are found in extremely elongated orbits about the Sun at the distance of about one light year. The general view is that comets are composed of a primitive, icy material combined with methane, ammonia and impurities, the study of which could provide evidence as to the origins of the universe. On the matter of comets, see C. Sagan and A. Druyan, *Comet* (New York: Pocket Books, 1986).

[50] Asteroid pieces are named according to their spatial location: In outer space they are "meteoroids"; when passing through the Earth's atmosphere, they are "meteors"; if they survive atmospheric passage and collide with Earth, they are "meteorites". W. Flury, "Europe's Contribution to the Long Duration Exposure Facility (LDEF) Meteoroid and Debris Impact Analysis" (1993) 47 ESA Bull. 70 at 70.

there is on Earth. It is now clear that organic chemical evolution prior to, or on, asteroids yielded substances which on primitive Earth may have constituted the building blocks of the first living organisms.

(f) The Outer Group

Jupiter is the largest of the planets. It has a diameter of 143,100 km and is 5.2 AU from the Sun. Twice as massive as all the other planets put together, Jupiter has an axial rotation of less than 10 Earth hours. The temperature in its upper atmosphere is -160 degrees Celsius; models suggest that the surface temperature could be some 2000 degrees Celsius. Jupiter is largely liquid and gas, with the surface composed of hydrogen and helium gas. The upper layer of the mantle is made of hydrogen and helium liquid; at about 30,000 km, the hydrogen breaks up into a mixture of protons and electrons. The central core may be rich in metals and silicate compounds. Jupiter's atmosphere is thick and dense, composed of hydrogen gas (81 per cent), helium gas (19 per cent) and traces of methane, ammonia, water vapour, phosphine, germane, acetylene and ethane.

Saturn, at 10.4 AU from the Sun, is about twice as far from our solar system's heat source as is Jupiter. Smaller in size only than Jupiter, Saturn is a dense gaseous ball, composed of hydrogen and helium at the surface. The outermost layer of its mantle is made of liquid hydrogen and helium, while further inwards there is a mix of liquid-metallic hydrogen. At its centre is believed to be a dense, metal-rich core. The atmosphere of Saturn features mainly hydrogen and helium gas, with trace amounts of ammonia and methane. Saturn's ring system is a gigantic sheet of water ice particles, each of which travels around the planet in its own separate orbit.[51]

Uranus and Neptune are virtual twins, each approximately 50,000 km in diameter. Uranus is 20.8 AU from the Sun, while Neptune is 30 AU. Consequently, both planets are exceedingly cold, with upper atmospheric temperatures estimated to be less than -200 degrees Celsius. Largely liquid and gaseous in composition, their surfaces are likely a mixture of water, ammonia and methane. Their atmospheric composition is likely dominated by hydrogen and helium, with a significant amount of methane.

Pluto is the smallest and coldest of the planets, with a diameter between 3000 and 3600 km and an estimated temperature of -230 degrees Celsius on its bright side. While its distance from the Sun averages 40 AU, Pluto passes

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[51] Jupiter and Uranus also have ring systems, which, unlike Saturn's, are almost invisible from Earth.

inside the orbit of Neptune for a portion of its passage around the Sun. Pluto is believed to be composed largely of frozen compounds such as methane, ammonia or water. Its surface is probably covered with a methane frost.

CHAPTER II: MORAL PERSPECTIVES ON HUMANKIND'S RELATIONSHIP WITH NATURE

> [H]e who accepts the ambiguities of his culture without protest and without criticism is rewarded with a sense of security and moral justification. A certain kind of unanimity satisfies our emotions and easily substitutes for truth. We are content to think like the others, and in order to protect our common psychic security we readily become blind to the contradictions -- or even the lies -- that we have all decided to accept as 'plain truth'.[1]

A. Introduction

In any situation, humans rely on a set of principles as to what is right and wrong and, based on these principles, decide what actions should be taken. These moral principles provide the basis for a complex set of learned "values, beliefs, habits and norms"[2] which determines how humans will treat other humans, non-human biological entities[3] and physical entities. When considering human relationships with other biological entities and with physical entities, and in determining what conduct is appropriate when

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[1] T. Merton, "The Wild Places" in R. Disch, ed., *The Ecological Conscience: Values for Survival* (Englewood Cliffs, NJ: Prentice-Hall, 1970) 37 at 37.

[2] B. Devall & G. Sessions, *Deep Ecology* (Salt Lake City, Utah: Peregrine Smith Books, 1985) at 42.

[3] Generally, an entity is any thing that has a real existence. In this very general sense, "entity" means "thing" and includes objects, thoughts and concepts. I. Leclerc, *Whitehead's Metaphysics: An Introductory Exposition* (Bloomington, Ill: University of Indiana Press, 1958) at 21-22. In this study, "entity" is used to refer to natural entities. Natural entities are all things existing in nature, both on and off Earth. Natural entities are divided into the physical and biological. Biological entities are divided into plant and animal. Animal entities are divided into human and non-human.

interacting with these entities, two moral perspectives can be clearly identified: the anthropocentric (human-centred) and the biocentric (life-centred). While the former provides the basis for international law-making,[4] the latter has been the subject of recent international policy discussions on environmental issues. A basic thesis of this study is that the biocentric moral perspective provides a reasonable and workable basis for the making of international environmental law as it applies not only to the terrestrial biosphere[5], but also to the legal regulation of human activities in outer space or on celestial bodies, including the Moon ("outer space").

A fundamental characteristic of biological entities is that they are, in the language of environmental ethics, entitled to moral consideration. In the statement "X deserves moral consideration", the term 'moral consideration' "is construed broadly to include the most basic forms of practical respect (and so

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[4] Organization for Economic Co-operation and Development, *An Introduction to Concepts and Principles of International Environmental Law*, OECD Doc. COM/ENV/TD(93) 117 (17 November 1993) at 7.

[5] The biosphere is that portion of Earth and its atmosphere in which biological entities exist. See *infra*, text accompanying notes 49-51.

is not restricted to 'possession of rights' by X)".[6] If a natural entity[7] meets the threshold criteria for moral consideration, it "deserves moral consideration from ... all rational moral agents"; if a natural entity does not meet the threshold test, then it falls outside the scope of moral consideration and has no standing in the moral sphere.[8] The criteria for bringing natural entities within the scope of moral consideration are developed by discovering "empirically respectable"[9] common characteristics of natural entities.[10]

Where a class of natural entities with common characteristics is identified, every entity which is a member of that class has inherent worth. To say that an entity has inherent worth is to say:

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[6] K. Goodpaster, "On Being Morally Considerable" (1978) 75 J. Phil. 308 at 309. This article represents the first contemporary account of moral considerability in the context of environmental ethics.

[7] See *supra*, note 3.

[8] Goodpaster, *supra*, note 6 at 309.

[9] *Ibid.* at 323. For a discussion on what constitutes an empirically respectable common characteristic, see W.M. Hunt, "Are Mere Things Morally Considerable"? (1980) 2 Env. Ethics 59 at 63-65.

[10] See A. Brennan, "The Moral Standing of Natural Objects" (1984) 6 Env. Ethics 35 at 37.

> A state of affairs in which the [natural existence] of X is realized is better than an otherwise similar state of affairs in which [the natural existence of X] is not realized (or not realized to the same degree).[11]

If an entity has inherent worth, that worth is independent of any value which that entity may have for any biological entity.[12] Such worth is also independent from reference to the natural existence of any other natural entity.[13]

The effect of ascribing inherent worth to the natural entities in a particular class is substantial. Each member of a class of entities with inherent worth (1) is equally deserving of "respectful consideration for its existence in nature";[14] (2) is equally entitled to "making the same claim-to-fulfilment" of its natural

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[11] See P.W. Taylor, *Respect for Nature: A Theory of Environmental Ethics* (Princeton, NJ: Princeton University Press, 1986) at 75. In this precedent-setting book, Professor Taylor sets out an original, lucid and philosophically complete biocentric environmental ethic. The author acknowledges his indebtedness to the ethical system set out in this work. It furnishes the concept of "inherent worth" and the basic moral framework and management principles for the biocentric moral perspective set out in this chapter.

[12] Professor Taylor distinguishes three types of value which may be attributed to natural entities. *Ibid.* at 72-74. An event, condition or experience has intrinsic value if "that activity is carried on for its own sake or as an end in itself". *Ibid.* at 73. An experience, end or interest has instrumental value if it is carried on by a biological entity as a "means to further ends". *Ibid.* An object or a place has inherent value if humans believe that it should be preserved for its "beauty, or historical importance, or cultural significance,[independently of] its commercial value". *Ibid.*

[13] *Ibid.*

[14] *Ibid.* at 76.

existence and to "the promotion and protection" of its natural existence;[15] and (3) is equally the subject of a moral duty owed by humankind to promote and protect its natural existence[16].

Within the anthropocentric moral perspective, only humans have inherent worth. When a biocentric moral perspective is adopted, the scope of inherent worth is expanded to include all biological entities. The remainder of this chapter sets out the basic positions of each of the anthropocentric and biocentric moral perspectives. It will be argued that there are two versions of the anthropocentric moral perspective; that both versions are ineffective for dealing adequately with environmental problems; and that the biocentric moral perspective provides an effective and rational framework for addressing environmental problems that do, and will, affect both the terrestrial biosphere and outer space, the Moon and other celestial bodies.

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[15] *Ibid.* at 78.

[16] *Ibid.*

B. The Anthropocentric Moral Perspective

1. Two Versions -- Similarities and Differences

There are two versions of the anthropocentric moral perspective, the absolute and the enlightened. Both ascribe inherent worth only to humans, who see themselves as "the source of all value, the measure of all things".[17] Both view all non-human biological and physical ("non-human") entities as mere instrumentalities for human goals, as means for the betterment of humankind.

The difference between the absolute and enlightened versions of anthropocentrism lies in the attitude each expresses toward the human use of, and responsibility toward, the non-human entities constituting terrestrial ecosystems[18]. The absolutist position is that there are no limits to the human use of non-human entities, nor does humankind have any responsibility to human or non-human entities for any adverse consequences which may arise from such use. The enlightened position, currently the predominant one, places some restrictions on the human use of non-human entities and accepts limited responsibility for some adverse consequences arising from such use.

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[17] J. Seed, "Anthropocentrism" in Devall & Sessions, *supra*, note 2, 243 at 243.

[18] The components of an ecosystem are all the biological and physical entities in nature, the relationships between these entities and the surroundings in which both the entities and relationships exist.

When either version of the anthropocentric moral perspective is accepted, the only entities in nature which need to be treated with respect are humans. This respect entitles all human entities to the fulfilment, promotion and protection of their natural existence. Further, humankind owes a duty to extend these entitlements only to other members of the class of human entities.

Both absolute and enlightened anthropocentrism regard humankind's relationship with non-human nature as one in which humans dominate. As dominant, humankind sees itself as "above, superior to, or outside" non-human nature.[19] Whenever any entity in nature is perceived by humankind as

[19] See Devall & Sessions, *supra*, note 2 at 43-44. On the concept of human dominance over nature, see L. White, Jr., "The Historical Roots of Our Ecologic Crisis" in P. Shepard & D. McKinley, eds, *The Subversive Science: Essays Toward an Ecology of Man* (Boston: Houghton Mifflin, 1969) at 341 (dominance as a logical consequence of the Judeo-Christian ethic) [hereinafter *Shepard & McKinley (Science)*]; J.A. Livingston, *One Cosmic Instant: Man's Fleeting Superiority* (Boston: Houghton Mifflin, 1973) (dominance as an inheritance of Western civilization); W. Leiss, *The Domination of Nature* (Boston: Beacon Press, 1974) (investigation into the relationship between the concept of dominance and the development of science and technology in shaping attitudes toward nature); and D. Ehrenfeld, *The Arrogance of Humanism* (New York: Oxford University Press, 1985) (dominance as a consequence of humankind's faith in the power of reason and its offspring, science and technology).

having a use, that entity becomes a natural "resource"[20], to be developed according to human wishes.[21]

2. Absolute Anthropocentrism

The absolute anthropocentrist is symbolized by the "pioneer, the frontier culture hero", whose success "depends on his ability to fight the wilderness and win".[22] To achieve his or her objectives, the pioneer employs to the fullest extent possible the technological tools of the day to overcome natural obstacles and to tame the wilderness.[23] In undertaking development projects[24] for the

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[20] J.A. Livingston, *The Fallacy of Wildlife Conservation* (Toronto: McClelland & Stewart, 1981) 17-18 [hereinafter *Livingston (Fallacy)*]. Following Livingston, "resource" is placed in quotations to indicate that resources, either renewable or non-renewable, come into existence only when non-human entities become useful to man, i.e., they have some instrumental, intrinsic or inherent value. See also H. Rolston III, *Philosophy Gone Wild: Essays in Environmental Ethics* (Buffalo, NY: Prometheus Press, 1986) at 119-121. The quotations also serve to indicate that "resources" exist only as objects of discussion, divorced from their relations to personal experience, abstracted from the experience of being-in-nature. See N. Evernden, *The Natural Alien: Humankind and the Environment* (Toronto: University of Toronto Press, 1985) at 125-144.

[21] For a general statement of the fundamental propositions of anthropocentrism, see S. Paradise, "The Vandal Ideology" in P. Shepard & D. McKinley, eds, *Environ/mental: Essays on the Planet as a Home* (Boston: Houghton Mifflin, 1971) [hereinafter *Shepard & McKinley (Essays)*] 222 at 223-226.

[22] Merton, *supra*, note 1 at 37.

[23] See *ibid.* at 37-39.

[24] In this study, a development project is any human activity that interferes with natural entities or their natural surroundings. This interference may be direct (e.g., culling animal populations; clear-cutting a wooded area; removing an ore deposit from under the surface) or indirect (e.g., excavating fields to build structures; introducing industrial by-

betterment of humankind, the absolute anthropocentrist considers him- or herself to be unfettered. Natural "resource" use is unlimited; development projects are free from restrictions, controls or any other regulation.

Any adverse effects on other human and non-human entities, which may arise from development projects, are considered irrelevant. Moreover, absolute anthropocentrists neither accept that they are responsible to natural entities for injury or destruction which may arise from such projects, nor consider that any form of compensation is necessary when loss or damage occurs.

3. Enlightened Anthropocentrism

(a) Use of Natural "Resources"

The shift from absolute anthropocentrism to enlightened anthropocentrism arises when the adverse or potentially adverse effects of development projects on human and non-human entities are recognized and when action is taken to avoid these effects.[25] The enlightened project developer remains

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products of manufacturing and processing into a water system).

[25] "The danger of complete man-centredness in relation to nature is like the danger of immediate and thoughtless selfishness everywhere: the momentary gain results in ultimate loss and defeat. 'Enlightened self-interest' requires [that] some consideration ... [be given] to relations between man and the rest of nature." M. Bates, *The Forest and the Sea: A Look at the Economy of Nature and the Ecology of Man* (New York: Vintage Books, 1960) at 261.

anthropocentric because the goal of any remedial action is limited to the betterment of the human condition, to the exclusion of non-human entities.[26]

In trying to address the adverse effects created by development projects, the enlightened anthropocentrist assumes the role of steward.[27] As such, the enlightened anthropocentrist understands that if the contemporary human use of non-human entities is not controlled, the result will be a decrease in humankind's standard of living or, quite possibly, the extinction of the human species. To avoid these consequences, the steward places limits on development projects in order to ensure that natural "resources" will be maintained for human use, protected for the benefit of current and future generations of humankind.[28]

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[26] For an overview of the basic "reformist" position of enlightened anthropocentrism and its variations, see Devall & Sessions, *supra*, note 2 at 52-61.

[27] On the various stewardship positions, see *ibid.* at 120-125.

[28] The most significant policy statement in support of the enlightened anthropocentric moral perspective is found in World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987). Released in 1987, this report to the United Nations Commission on Environment and Development appears to have become the fundamental document for international policy on regulating the human use of non-human entities. It advocates a global action plan for sustainable development in order to ensure the survival of life on Earth. Sustainable development is viewed as development which meets the needs and aspirations of the present and future generations of humankind and, at the same time, protects and conserves non-human entities to ensure the maintenance of terrestrial ecosystems for the benefit of humankind. See World Commission on Environment and Development, *ibid.* at 43-46. The first co-ordinated international effort to develop law based on this policy culminated in June 1992 at the "Earth Summit" in Rio de Janeiro, Brazil. On the concept of sustainable development,

To provide for an adequate supply of those natural "resources " believed to be necessary for meeting human needs and aspirations and to ensure that adequate limits are placed on the use of these "resources" so as to maintain their sustainability, the anthropocentric steward employs scientific management plans based on the notion of "wise use".[29] In producing such a plan, the "wise use" steward determines what is the maximum sustainable yield for any "resource" which may directly or indirectly be adversely affected by a development project.

Maximum sustainable yield will vary according to the natural "resource" under consideration. If the "resource" is "renewable" (non-human biological entities such as fish and trees), the maximum sustainable yield is that quantity of the resource which may be used to allow for its "regeneration and natural growth".[30] If the "resource" is "non-renewable" (physical entities such as minerals and fossil fuels), then the maximum sustainable yield is that quantity

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see Chapter III, *infra*, Section D.

[29] For arguments made in support of "wise use" management, see Livingston (Fallacy), *supra*, note 20 at 42-46.

[30] World Commission on Environment and Development, *supra*, note 28 at 45. Query whether in practice there is such a thing as a renewable resource: "If 'resource' continues to mean something put to human use, then no resource is renewable. Our demands have quite outstripped the capacity of those resources to satisfy them, much less to satisfy them on a sustainable basis." Livingston (Fallacy), *ibid.* at 43.

of the "resource" which may be used "to ensure that the resource does not run out before acceptable substitutes are available".[31]

Once the maximum sustainable yield has been calculated, the management plan sets out the limits to be placed on the development project to ensure the sustainability of the potentially affected natural "resources". Under this plan, non-human entities become quantifiable variables in a resource management equation, with their instrumental value calculated according to the economic benefit humankind will derive from their use. The economic benefit of the natural "resource" in question provides the project developer with an objective standard for determining the financial viability of a development project and, if viable, the economic benefits and costs of the development and conservation[32] of the natural "resources" and any other non-human entities which may be affected by the development project.[33]

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[31] World Commission on Environment and Development, *ibid.* at 45-46.

[32] "Conservation" is used to refer to the management strategy employed by enlightened anthropocentrists in order to maintain natural "resources" for future human use, in contrast to "preservation", which is used to refer to the fundamental biocentric management strategy for protecting non-human biological entities and their ecosystems from present and future human use. See Livingston (Fallacy), *supra*, note 20 at 15-16 and Taylor, *supra*, note 11 at 185. On preservation, see *infra*, Section C.2(a).

[33] For an example of the approach of the "resource" economist in the context of wilderness conservation, see Devall & Sessions, *supra*, note 2 at 115-117.

(b) Limits on "Resource" Depletion and Environmental Degradation

During the lifetime of a development project, certain non-human entities will be depleted and the surroundings in which these entities exist may be degraded. To address the concerns of "resource" depletion and environmental degradation, the steward places strong reliance on the basic lessons of ecology.[34] Generally, ecology teaches that the biological and physical aspects of nature are interrelated and that, if humankind is to survive, then a scientific understanding of the requirements for a healthy and sustainable biosphere is a necessity.[35]

Within the moral perspective of the enlightened anthropocentric, ecology is a multi-purpose management and economic tool of the project developer. Ecology applied in this manner (1) furthers "the maximum utilization of the

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[34] Ecology has been defined as "the study of the structure and function of nature". E.P. Odum, *Ecology* (New York: Holt, Rinehart & Winston, 1963) at 3. A more recent definition states that ecology is "the study of the natural environments and of the relations of organisms to each other and to their natural surroundings". R.E. Ricklefs, *Ecology*, 3d ed. (New York: W.H. Freeman, 1990) at 806. While both are useful, the author prefers the second because it specifically acknowledges that ecology concerns itself not only with biological entities, but also with relationships between those entities and their natural surroundings.

[35] "[A]s we contemplate the need for global management of natural resources, we are doomed to fail if we do not understand their structure and function, an understanding that depends on the principles of ecology". Ricklefs, *ibid.* at 3-7. See also, Odum, *ibid.* at 1-2 and *infra*, text accompanying notes 49-51.

earth as raw material in the support of one species";[36] (2) ensures that such use is neither inefficient nor unnecessarily destructive;[37] and (3) assists in the calculation of the maximum sustainable yield of non-human entities in order "to preserve the biotic capital while maximizing the income"[38].

For the enlightened anthropocentric, the concept of sustainable development provides the basis for assigning responsibility for any injury or destruction to natural entities, arising from development projects. The position of the steward is that humankind is responsible for ensuring that the terrestrial biosphere can continue to support human life in the manner to which humankind has become accustomed. Humankind fulfils this responsibility by developing management plans, which attempt to limit the adverse impact of development projects and to conserve natural "resources" and other incidentally affected non-human entities, in order to provide functioning terrestrial ecosystems for sustained human use. This responsibility also includes the creation of compensation schemes to be applied in cases where the consequences of development projects have adverse effects on human interests.

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[36] Evernden, *supra*, note 20 at 22.

[37] *Ibid.*

[38] D. Worster, *Nature's Economy: The Roots of Ecology* (San Francisco: Sierra Club Books, 1977) at 315, quoted in Evernden, *ibid.* at 22.

C. The Biocentric Moral Perspective

1. Basic Premises

The biocentric (life-centred) moral perspective is in fundamental conflict on philosophical grounds with both the absolute and enlightened anthropocentric moral perspectives. To adopt the biocentric moral perspective is to reorient completely the bases of one's moral framework for action.[39] This radically different moral perspective is based on two premises: the biological nature of humankind and the equality of all members of the class of biological entities.

(a) Biological Nature of Humankind

As to the first foundation, all humans are considered not merely as human beings, but rather have common characteristics as members of the broader class of biological entities, which includes humans, all animals and plants.[40] All biological entities "face certain biological and physical requirements for [their] survival and well-being";[41] have "a good of their own to realize";[42] are

[39] If individuals were to replace an anthropocentric moral perspective with a biocentric one, "[w]e would see ourselves and our place in the natural world in a new light. Our whole ethical orientation would undergo a deep and far-reaching transformation, entailing profound revisions in our treatment of the Earth and its biotic communities. A total reordering of our moral universe would take place." Taylor, *supra*, note 11 at 134.

[40] See generally, *ibid.* at 101-116.

[41] *Ibid.* at 101.

[42] *Ibid.*

capable of "being in a position to be able to pursue [their] existence and [their] own good",[43] and have a "common origin"[44].

Consequences which flow from these commonalities include: (1) the "biological requirements of survival and physical health" become the "normative guides" for survival;[45] (2) all biological entities are, to the extent they are able, free to be absent from constraints in pursuing the fulfilment of their natural existence;[46] and (3) humankind, in its common origin with other biological entities, "fit[s] into the same structure of reality that accounts for every other form of life"[47].

During the process of coming to understand humankind's biological nature and humankind's place in the natural world, a biocentrist looks to both the knowledge acquired from the science of ecology and the experience of

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[43] *Ibid.* at 108.

[44] *Ibid.* at 111.

[45] *Ibid.* at 103.

[46] See *ibid.* at 105-111.

[47] *Ibid.* at 113. See also, *ibid.* at 111-113.

ecologists to "suggest, inspire and fortify" his or her perspective.[48] Three related ecological concepts are central to the biocentric moral perspective: "interdependence", "ecosystem" and "biosphere".

Ecology teaches that the world of living organisms, biological entities, is firmly rooted in Earth and its atmosphere, the world of physical entities.[49] In fact, the world of biological entities is totally dependent on the world of physical entities. Furthermore, the biological world is an extension of the physical world, in that biological entities are predetermined to a certain extent by the physical entities. Yet, while the physical world is necessary for the survival of the biological world, the reverse is not the case: The world of physical entities would continue its evolution without the world of biological entities.

From an ecological perspective, the evolution of life resulted from a combination of physical and biological factors. Through these combinations, the worlds of physical and biological entities became, and still are,

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[48] A. Naess, "The Shallow and the Deep, Long-Range Ecology Movement. A Summary" (1973) 16 Inquiry 95 at 98.

[49] Unless otherwise indicated, the information in this paragraph and the three subsequent paragraphs is based on material from Ricklefs, *supra*, note 34 at 31-35 and 45-47. In addition to the components of Earth and its atmosphere, such as land, water, carbon and oxygen, inorganic nutrients and salts, the physical world includes temperature and light. See *ibid.* at 48-69.

interdependent. While the land, water and atmosphere made the emergence of biological entities possible, the biological world also transformed entities in the physical world: atmospheric oxygen would not exist but for photosynthesis, the process by which plants use the light energy of the Sun to combine carbon dioxide and water into basic nutrient sugars. In some instances, this biological/physical interdependence is mutually advantageous. As soil and water are providing the essential nutrients for plant life, for example, plants are influencing the development of soil and the movement of water.

The ecosystem concept, a fundamental principle of ecology, is premised on the idea of the interdependence of biological and physical processes. In an ecosystem, the processes of energy transformations in, and of movements of material through, biological and physical systems, couple biological processes to physical processes in a single functional whole. One practical effect of this interdependence is that any change in one part of an ecosystem will "cause adjustments to be made throughout" the ecosystem.[50] The intimate interdependence of the physical and biological realms of existence is what any ecosystem depends on for its survival.

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[50] Taylor, *supra*, note 11 at 116-117.

The living portion of the terrestrial ecosystem is called the biosphere, a fragile shell interwoven with the outer edge of the planet. "The biosphere, all organisms combined, makes up only about one part in ten billion of the earth's mass [and] is sparsely distributed through a kilometre-thick layer of soil, water and air stretched over a half-billion square kilometres of surface."[51]

(b) Equality of Biological Entities

The second foundation of the biocentric moral perspective is that all members of the classes of human and non-human living entities are equal, solely by virtue of their being biological entities. As a result, all human and non-human biological entities have equivalent inherent worth. Physical entities, on the other hand, are seen as having instrumental, intrinsic or inherent value, to the extent that they are useful to the survival and well-being of biological entities.

Regarding all biological entities as having inherent worth by virtue of their very existence is considered a basic tenet of respect for nature.[52] As biologically equal, every human, non-human animal and plant is considered a unique

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[51] E.O. Wilson, *The Diversity of Life* (Cambridge, Mass: Belknap Press of Harvard University Press, 1992) at 35.

[52] See e.g., Taylor, *supra*, note 11 at 129-130; Naess, *supra*, note 48 at 95-96, and Devall & Sessions, *supra*, note 2 at 67-69.

centre of natural existence, capable of realizing its existence in its own way,[53] and exhibiting "a constant tendency to protect and maintain [its] existence"[54] during the process of realization. As a subject of inherent worth, each biological entity is entitled to respectful consideration for its existence in nature, is entitled to the fulfilment, promotion and protection of its natural existence, and is owed by humankind a duty to promote and protect its natural existence.[55]

Acceptance of the biological equality of all human and non-human living entities also entails "a total rejection of the idea that human beings are superior to other living things".[56] For a biocentrist, the needs and desires of humankind are no longer the standard of judgment for what is good, valuable or beneficial. Rather, the standard of judgment becomes the needs of biological entities.[57] Consequently, as one among many biological entities, humankind will be subject to constraints on its interactions with all non-human biological entities (by virtue of their inherent worth) and any physical

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[53] Taylor, *supra*, note 11 at 100.

[54] *Ibid.* at 122.

[55] See *supra*, text accompanying notes 14-16.

[56] Taylor, *supra*, note 11 at 129.

[57] See *ibid.* at 129-131.

entities which may have instrumental, intrinsic or inherent value for the survival or well-being of biological entities and their ecosystems.

2. Implications for Human Treatment of Non-human Biological Entities

(a) Focus on Preservation

The implications of the biocentric moral perspective for the human treatment of non-human biological entities are substantial. The focus is no longer on the maximum sustainable yield of natural "resources" for the use of present and future generations of humankind, sustained by means of conservation management plans.[58] Instead, respect for nature entails the preservation of biological entities-in-ecosystems [59] from present and future human use. In acting out of respect for nature, biocentrists strive to preserve the existence of biological entities by maintaining their natural ecosystems and by ensuring that the physical entities in those ecosystems are "beneficial to a great variety

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[58] For a summary of the arguments against maximum sustainable yield as applied to wildlife management, see T. Regan, *The Case for Animal Rights* (Berkeley: University of California Press, 1983) at 355-357.

[59] In this study, unless otherwise indicated, the term "biological entities" includes humans, non-human animals and plants, and "ecosystem" includes any other biological entities, physical entities, their surroundings and the interrelationships among them necessary for the fulfilment of the natural existence of the biological entities. The term "entities-in-ecosystems" is used instead of the more traditional "entities and their ecosystems" to emphasize that the interrelationships among the parts are necessary for fulfilment of the natural existence of both the parts and the whole.

of biotic communities".[60] Within the biocentric moral perspective, the nature of ecosystems as a web of biological entities, physical entities and the relationships between them,[61] dictates that preservation cannot be only of individual biological entities. Preservation must also include their habitats.[62] Habitat preservation ensures the survival and protection of the diversity[63] of

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[60] Taylor, *supra*, note 11 at 81.

[61] See *supra*, text accompanying notes 49-50.

[62] Wilson, *supra*, note 51 at 259. A habitat is a "[p]lace where an animal or plant normally lives, [and is] often characterized by a dominant plant form or physical characteristic (that is, the stream habitat, the forest habitat)". Ricklefs, *supra*, note 34 at 811. Habitats, therefore, may comprise a portion of, or an entire, ecosystem.

[63] One aspect of ecology is the study of communities, which may be defined as "association[s] of interacting [species] populations". Ricklefs, *ibid.* at 656-657. A species is "a population [of biological entities] whose members are able to interbreed freely under natural conditions". Wilson, *ibid.* at 38. A species population is "reproductively isolated from all other kinds" of biological entities. Ricklefs, *ibid.* at 824. Biological diversity, or biodiversity, is "a measure of the variety of species in a community that takes into account the relative abundance of each species". *Ibid.* at 806. The preservation of biodiversity is considered to be "the key to the maintenance of the world as we know it" because it gives ecosystems a "resilience" to natural adversities; without biodiversity, ecosystems would decay beyond the point of self-restoration. See Wilson, *ibid.* at 14-15.

Since at least the late 1950s, naturalists have stated that survival of the biosphere requires the preservation of biodiversity and that the preservation of biodiversity requires a change in humankind's attitude toward nature. E.g., Marston Bates published the following in 1960: "Our anxiety about the future, when we analyze it, turns largely on three related things: the likelihood of continuing warfare, the dizzy rate of human population growth, and the exhaustion of resources. ... How, in the face of our power, in the face of our danger, do we develop a guiding philosophy? ... Insofar as man's relations with the rest of nature are concerned, I think we must make every effort to maintain diversity -- that we must make this effort even though it requires constant compromise with apparent immediate needs." Bates, *supra*, note 25 at 252-253. Despite this awareness, the gradual increase in both the global human population and the nature and extent of human interactions with ecosystems has resulted in a rapid rate of extinction of species non-human biological entities and the continued (and continual) interactions both among these entities and between these entities and their ecosystems. In this way, habitats preserve the natural evolutionary process.[64]

(b) Constraints on Human Conduct

To ensure preservation of biological entities-in-ecosystems in accordance with respect for nature requires that constraints be placed on human conduct "for the purpose of avoiding doing harm to or interfering with the natural status of" non-human biological entities-in-ecosystems.[65] Any human action that is undertaken in relation to non-human biological entities should "fit in and flow with" natural processes[66] and should be taken solely "out of consideration and concern"[67] for the fulfilment of their natural existence, without any regard for human benefit[68].

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populations and, consequently, now poses a serious threat to the biodiversity, and hence the survival, of the biosphere. See Wilson, *ibid.* at 253-259 and 272. The two current critical human threats to global biodiversity are the logging of primeval forests and the acceleration of global climate change. See *ibid.* at 259-278.

[64] See Devall & Sessions, *supra*, note 2 at 126-127.

[65] Taylor, *supra*, note 11 at 81.

[66] Devall & Sessions, *supra*, note 2 at 145.

[67] Taylor, *supra*, note 11 at 84.

[68] See *ibid.* at 84-85.

(i) *Prima Facie* Moral Duties

For biocentrists, the constraints on human actions are derived from three *prima facie* moral duties. The first and most fundamental duty is "not to do harm to any [biological] entity"[69]. Such harms include killing individual biological entities or species populations, the destruction of habitats or ecosystems, or any other action that would be "seriously detrimental" to biological entities-in-ecosystems.[70] The second duty is to avoid interference with "the normal activity and healthy development" of biological entities-in-ecosystems.[71] Interference occurs when constraints are placed either on biological entities, by preventing or hindering the fulfilment of their natural existence,[72] or on their ecosystems, by preventing or hindering the attainment of their natural evolution and healthy development.[73] Where either of these duties is breached, the third basic duty is to make restitution in order to preserve or promote the natural existence of biological entities-in-ecosystems.[74]

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[69] *Ibid.* at 172.

[70] *Ibid.* See also, *ibid.* at 172-173.

[71] *Ibid.* at 173.

[72] *Ibid.* at 173-175.

[73] *Ibid.* at 175-176.

[74] See *ibid.* at 186-187. On restitution, see *infra*, Section C.2(b)(iii).

Preservation of non-human biological entities-in-ecosystems does not, however, constitute a blanket prohibition against harm to, or interference with, them.[75] Killing non-human biological entities or destroying physical entities is permissible in self-defence in cases where a non-human biological entity or a physical entity threatens the natural existence of any human entity.[76] Where the life or basic health of human entities is threatened by non-human biological entities or physical entities, humans may defend themselves by those means causing "the least possible harm" to the threatening entity, if humans, "using reasonable care, cannot avoid being exposed to [such an entity] and cannot prevent [such an entity] from doing serious damage to the environmental conditions that make it possible for [humans] to exist and function as moral agents[77]".[78]

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[75] "[A]ny realistic praxis necessitates some killing, exploitation, and suppression." Naess, *supra*, note 48 at 95. See also, Devall & Sessions, *supra*, note 2 at 67.

[76] Taylor, *supra*, note 11 at 264-265. Cases in which interference is permissible are addressed, *infra*, Section C.2(b)(ii).

[77] As moral agents, the existence and functioning of humankind are governed by the rights of subsistence and security (the right to life), liberty and autonomy. See Taylor, *supra*, note 11 at 226-241. These moral rights are not absolute, but may be waived in situations where their infringement is morally justifiable. See *ibid.* at 243-245. Such situations, which arise when humans with an attitude of respect for nature interfere with non-human biological entities-in-ecosystems, are addressed, *infra*, Section C.2(b)(ii).

[78] Taylor, *supra*, note 11 at 264-265. On the principle of self-defence, see *ibid.* at 264-269.

(ii) Biocentric Management

The three moral duties set out in the immediately preceding section form the basis of biocentric management, which provides the framework for the constraints on human activities. The goal of biocentric management is to ensure that human projects neither harm, nor interfere with, the fulfilment of the natural existence of all non-threatening non-human biological entities-in-ecosystems.[79] To meet this goal, all potential development projects are subject to review in order to ascertain (1) the nature of the project; (2) given the nature of the project, whether harm to, or interference with, non-human biological entities-in-ecosystems is justified; (3) when harm or interference is justified, what are the appropriate measures for implementing the project; and (4) when the project is implemented, what restitution is required to compensate for any harms to, or interference with, non-human biological entities-in-ecosystems.[80]

(A) Nature of the Project

[79] Where non-human biological entities pose a threat to human entities, the latter are entitled to prevent the threat by means of self-defence. See *infra*, text accompanying notes 75-78.

[80] The conceptual framework for biocentric management is based on Taylor, *supra*, note 11 at 269-310.

To determine the nature of a project, a biocentrist considers the human interests[81] which the project is intended to promote. These interests may be either basic[82] ("needs") or non-basic[83] ("desires"). Basic interests include food, water, shelter, security, love, play, creative expression, intimate relationships with nature[84] and spiritual growth.[85]

Non-basic interests may be either exploitive or non-exploitive. An exploitive non-basic interest ("exploitive interest") is one in which the interest is, in and

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[81] Interests are "objects, events or conditions [which] serve to preserve or protect to some degree" the natural existence of an entity. See *ibid.* at 270.

[82] Basic interests are those objects, events or conditions which, if absent, would totally prevent or severely impair an entity from the fulfilment of its natural existence. For a biocentrist, the fulfilment of natural existence is according to the biological entity's "species-specific nature". See Taylor, *supra*, note 11 at 271-272.

[83] Non-basic interests are those objects, events or conditions which treat entities as having instrumental, intrinsic or inherent value and, in so doing, destroy, harm or otherwise interfere with the fulfilment of the natural existence of those entities. See *ibid.* at 273-277.

[84] It has been hypothesized that there is a direct relationship between psychological, sociological and cultural well-being of humankind and the ability of humans to bond with nature, much in the way that children are able to bond with their mothers and other significant persons. See H.F. Searles, "The Role of the Non-Human Environment" in Shepard & McKinley (Essays), *supra*, note 21 at 80 and D. Cayley, *The Age of Ecology: The Environment on CBC Radio's Ideas* (Toronto: James Lorimer, 1991) at 16-18 (conversation with Paul Shepard). This thesis is fully developed in P. Shepard, *Nature and Madness* (San Francisco: Sierra Club Books, 1982).

[85] See e.g., Devall & Sessions, *supra*, note 2 at 68-69, 70-71, 74 and 129, and Livingston (Fallacy), *supra*, note 20 at 80-81.

of itself, "inherently incompatible with the attitude of respect for nature".[86] For a biocentrist, projects undertaken to satisfy exploitive interests include killing or capturing biological entities so that the entity or its parts can be used for private collections, for fashion and luxury products or for recreational enjoyment.[87] A non-exploitive non-basic interest ("non-exploitive interest") is one in which the interest is not, in and of itself, "incompatible with the attitude of respect for nature".[88] Projects undertaken to satisfy non-exploitive interests include harm to, or interference with, non-human entities in order to construct structures for housing and public utilities and for commercial, governmental and cultural activities; for developing outdoor recreational areas such as parks and wilderness areas, and for growing food.[89]

(B) Justification of the Project

To determine whether a project is justified, a biocentrist looks to the nature of the human and non-human biological interests affected by the project, with a

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[86] See Taylor, *supra*, note 11 at 274.

[87] See *ibid.* at 273-276. Generally, projects for the furtherance of exploitive interests are motivated solely by profit and other personal benefit. Exploitive projects include foraging, hunting and fishing for sport.

[88] *Ibid.* at 276.

[89] See *ibid.* at 274. Projects undertaken to satisfy non-exploitive interests generally have some element of public benefit.

view to adhering to the *prima facie* moral duties flowing from the attitude of respect for nature. Where a project gives rise to a conflict between non-human basic interests and human exploitive interests, there can for a biocentrist never be any justification for the project.[90] Should such a conflict present itself, humans with an attitude of respect for nature will neither undertake projects intended to fulfil exploitive interests nor support, condone or otherwise participate in such projects.

Where a project gives rise to a conflict between non-human basic interests and human non-exploitive interests, the project will be justified if the non-exploitive interests are determined by a human community to promote and preserve the instrumental, intrinsic or inherent values of central importance to that community.[91] Where a project merits central importance in a community, it will be undertaken only if the course of action for implementing the project is the one which results in "the lowest number of violations" of the fundamental duty not to do harm to non-human biological entities-in-

[90] *Ibid.* at 278-280.

[91] While values of central importance will vary according to their merit within a community, their basis is similar: "the goals and practices that form the core of a rational and informed conception of a community's highest values". Taylor, *supra*, note 11 at 281. On instrumental, intrinsic and inherent values, see *supra*, note 12.

ecosystems,[92] and if restitution is made for breach of this *prima facie* duty[93] ("principle of minimum wrong").[94]

Where a project gives rise to a conflict between the basic interests of non-humans and humans,[95] the project may be undertaken only if the conflict cannot be avoided. Where such a conflict can be avoided, "situations of rivalry and competition [should be transformed] into patterns of mutual accommodation and tolerance".[96] Where such a conflict is unavoidable, as in circumstances where a limited quantity of food is available to meet the basic interests of both human and non-human biological entities, the project is justified if the subject matter of the conflict is distributed in such a manner that each party to the conflict "is alloted an equal share" of the subject matter,[97] where possible; if restitution is made for breach of this *prima facie*

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[92] Taylor, *supra*, note 11 at 282-283.

[93] *Ibid.* at 286-287.

[94] See generally, *ibid.* at 280-291.

[95] The most common sources of this class of conflict occur where humans require non-human biological entities for food and shelter or physical entities for air, water and shelter, and where the survival of an individual biological entity, a species population, a habitat, a physical entity or the relevant ecosystem itself is at stake. See *ibid.* at 293-297.

[96] *Ibid.* at 296-297.

[97] *Ibid.* at 292.

duty[98] ("principle of equal distribution");[99] and if human action in undertaking such projects is "guided by the principle of minimum wrong".[100]

Complex, intractable disputes often arise which cannot be resolved solely by resorting to these principles of conflict resolution. In these cases, a biocentrist looks to the "ethical ideal" which underlies the principles of conflict resolution, i.e., the biocentric "best possible world",[101] and asks what course of action would be taken in "a world order on our planet where human civilization is brought into harmony with nature"[102]. In this ideal world, "human civilization" is "the total set of cultures on Earth at any given time", sharing and demonstrating the attitude of respect for nature;[103] and "harmony" is a state of affairs such that all human action complies with the basic biocentric duties of avoidance of harm to, and interference with, biological entities-in-ecosystems, and is guided by the principles of conflict resolution.[104]

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[98] *Ibid.*

[99] See generally, *ibid.* at 291-297.

[100] *Ibid.* at 294.

[101] *Ibid.* at 264.

[102] *Ibid.* at 308.

[103] *Ibid.* at 308-309.

[104] *Ibid.* at 309-310.

(c) Implementation of the Project

In determining the appropriate measures for the implementation of justifiable projects, a biocentrist, in light of the goal of preservation, looks for methods which will have a "minimum rather than maximum impact" on biological entities-in-ecosystems.[105] The strategies employed will vary according to whether the human interest under consideration is non-exploitive or basic.

[105] Devall & Sessions, *supra*, note 2 at 68.

-- Strategies to Eliminate Harms and Degradation

For conflicts involving non-exploitive human interests and requiring application of the principle of minimum wrong, the aim of biocentric management is to eliminate both the harms[106] done to non-human biological entities-in-ecosystems, species populations, natural habitats and ecosystems, and the degradation[107] of ecosystems. Biocentric strategies focus on the elimination of direct killing of non-human biological entities, harms to habitats and degradation of ecosystems.[108]

Direct killing of non-human biological entities is the intentional destruction of such entities; indirect killing, in contrast, may arise from harms to habitats and ecosystem degradation.[109] To eliminate direct killing, a biocentrist first re-examines the question "whether the human values are really worth the extreme cost being imposed" on non-human biological entities.[110] If the answer is

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[106] In this study, harms include destruction, injury and depletion.

[107] In this study, "degradation" means any change to the natural conditions of an ecosystem through the introduction into that ecosystem of foreign materials by humankind.

[108] See Taylor, *supra*, note 11 at 287-291.

[109] *Ibid.* at 290. An example of direct killing of animals is the death of laboratory animals for scientific, educational and research purposes. An example of direct killing of plants is the use of chemical biocides to kill road-side plant growth. *Ibid.*

[110] *Ibid.* at 290-291. Proponents of animal rights would argue that it is never appropriate to kill certain animals, particularly mammals. See P. Singer, *Animal Liberation*, 2d ed.

affirmative, alternatives are sought which will satisfy the human interest, while destroying the least number of non-human biological entities.[111]

The need to eliminate the harms to habitats is more pressing because these harms often lead to the destruction or depletion of species populations and ecosystems. A major biocentric policy in this regard is to avoid any future "massive" development project, on the grounds that what remains of the biosphere is necessary for the survival of the biosphere and all biological entities in it.[112] Contemporary alternatives to traditional practices for eliminating harm to habitats include the designing and planning of human living, working and recreational structures and spaces so that they become integrated with nature to as great an extent practicable, thereby preserving the

(New York: New York Review Books, 1990) and T. Regan, *supra*, note 58. While making valuable contributions in their own right, neither of these ground-breaking volumes is particularly supportive of the biocentric moral perspective. Singer's position is utilitarian and, therefore, sacrifices the right of the individual to the welfare of the group. Regan takes a rights-based approach supported by a concept related to inherent worth ("subject-of-a-life"), but excludes from the application of this concept all plants and most animals. See Regan, *ibid.* at 243-248 and 264.

[111] Taylor, *supra*, note 11 at 291. Some or all killing of animals for educational, scientific and research purposes could be avoided through the development of alternative methods of obtaining the same information. See Regan, *supra*, note 58 at 364-392. Killing of road-side plant growth with chemical biocides could be replaced by employing human labour to cut the plants before they pose safety hazards to road users.

[112] Devall & Sessions, *supra*, note 2 at 129.

integrity of ecosystems;[113] the development and implementation of projects within smaller, autonomous communities based, if possible, on natural land divisions, also known as bioregions;[114] the reuse of inhabited regions when they "are in a deteriorating state or have been abandoned", as an alternative to developing untouched natural landscapes;[115] controlling population growth;[116] and changing "habits of consumption"[117] and materialist expectations[118].

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[113] "I believe that ecology provides the single indispensable basis for landscape architecture and regional planning [and] ... has now, and will increasingly have, a profound relevance for city planning and architecture. ... I say that any project, save a small garden or the raddled heart of a city where nature has long gone, which is undertaken without a full comprehension and employment of natural process as form-giver is suspect at best and capriciously irrelevant at worst." I.L. McHarg, "An Ecological Method for Landscape Architecture" in Shepard & McKinley (Science), *supra*, note 19, 328 at 328 and 330. See also, Taylor, *supra*, note 11 at 299.

[114] Every natural environment has "an appropriate expression of physical process ... . One would then expect to find distinct morphologies for man-nature in each of the major physiographic regions". I. McHarg, "Values, Process, and Form" in Disch, *supra*, note 1, 21 at 34. See also, Naess, *supra*, note 48 at 98; Devall & Sessions, *supra*, note 2 at 145-146, and D. Oates, *Earth Rising: Ecological Belief in a Scientific Age* (Corvallis, Or: Oregon State University Press, 1989) at 161-162.

[115] Taylor, *supra*, note 2 at 287.

[116] "Present rates of population growth cannot continue. They already compromise many governments' abilities to provide education, health care, and food security for people, much less their abilities to raise living standards." World Commission on Environment and Development, *supra*, note 28 at 95. See also, D.H. Meadows *et al.*, *The Limits to Growth* (New York: Signet/New American Library, 1974).

[117] Taylor, *supra*, note 11 at 288.

[118] See Oates, *supra*, note 114 at 154-155.

To eliminate ecosystem degradation requires both the removal of all foreign materials introduced by humans into ecosystems, particularly pollutants[119], and a prohibition on the further introduction of such materials. While elimination is the "ultimate goal",[120] a biocentrist acknowledges that the changes in attitude and the development of appropriate operational methods and technological design take time and that "interim management measures" for the minimization of ecosystem degradation are required in the short-term.[121] Biocentric strategies for eliminating ecosystem degradation include development and implementation of degradation-free technologies;[122] development and implementation of appropriate industrial manufacturing and production technologies that are "carefully controlled, small-scale [and]

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[119] In this study, "pollutants" means those materials which, when introduced into ecosystems, cause harm to, or interfere with, the fulfilment of the natural existence of entities-in-ecosystems.

[120] Taylor, *supra*, note 11 at 289.

[121] See Devall & Sessions, *supra*, note 2 at 156-157. See also, Taylor, *supra*, note 11 at 289.

[122] Degradation-free technologies, or "clean" technologies, contribute to the restoration of the biosphere to its pristine state, to the extent possible. See S. Keller, "Ecology and Community" (1992) 19 Env. Aff. 623 at 631-632. "Soft" technologies are a class of clean technology. They contribute to biospheric restoration by reliance on energy sources derived from wind, sun and water (wave) to replace reliance on the degrading (and depleting) "hard" technologies based on the use of coal, oil, gas and uranium. See A. Lovins, *Soft Energy Paths: Towards a Durable Peace* (Harmondworth: Penguin, 1977) at 38-39, 42-45 and 148-152.

simplified";[123] removal of foreign materials from degraded ecosystems; reduction of human waste products and elimination of toxic wastes for which there are no safe methods of disposal;[124] and changing "habits of consumption"[125] and materialist expectations[126].

-- Strategies to Minimize Project Impact

Where conflicts involving the basic interests of human and non-human biological entities are unavoidable, the aim of biocentric management is to apply the principle of equal distribution in order to minimize, to as great an extent possible, the impact of human projects on entities-in-ecosystems.[127] Strategies for achieving minimum impact include wilderness preservation, restoration, rotation, common conservation and design with nature.

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[123] Taylor, *supra*, note 11 at 290. The aim of appropriate technologies is to overcome the tendency of business and industry to grow simply for the sake of growing, by asking what size of enterprise is needed in any situation and what technology is appropriate for fulfilling a particular human interest. E.F. Schumacher, *Small Is Beautiful* (London: Abacus, 1974) at 52-55. See also, Taylor, *ibid.* at 289-290; Oates, *supra*, note 114 at 166-168, and G. McRobie, *Small Is Possible* (New York: Harper and Row, 1981).

[124] See Taylor, *supra*, note 11 at 288-289. In this study, a safe method of disposal is one which will not now or in the future cause harm to, or interfere with, the fulfilment of the natural existence of entities-in-ecosystems.

[125] *Ibid.* at 288.

[126] Oates, *supra*, note 114 at 154.

[127] See Taylor, *supra*, note 11 at 296-304.

Wilderness preservation is the permanent setting aside, for the exclusive use of non-human biological entities, of specific habitats or ecosystems which have been subject to no or minimal interference by human intervention and which are large enough to ensure the healthy, uninterrupted promotion of biodiversity.[128] For a biocentrist, wilderness preservation enables non-human biological entities to receive their fair "share of the benefits of the Earth's physical environment" (i.e., physical entities-in-ecosystems) and to exist "free from human interference".[129] Wilderness preserves are not only necessary for the benefit of non-human biological entities, but are considered necessary for the fulfilment of basic human interests.[130]

Restoration is the process by which habitats or ecosystems subject to human use are relinquished and given over permanently for the exclusive use of non-human biological entities. Restoration is essentially a process of rehabilitation during which non-human biological entities are reintroduced into a region formerly used by humankind, and humankind contributes, to as great an

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[128] *Ibid.* at 297 and Devall & Sessions, *supra*, note 2 at 110.

[129] See Taylor, *ibid.* and Devall & Sessions, *supra*, note 2 at 126-129. See also, Livingston (Fallacy), *supra*, note 20 at 17-18.

[130] See Rolston III, *supra*, note 20 at 121-128 and Devall & Sessions, *ibid.* at 111-114. See also, Taylor, *ibid.* at 297, n.11.

extent possible, to the recovery of the habitat or ecosystem. Once restored, the region becomes a wilderness preserve and is treated accordingly.[131]

The rotation strategy is similar to that of restoration, except that human and non-human biological entities "tak[e] turns" in occupying and using a region.[132] With rotation, an entire habitat or ecosystem is subject to human use for a functionally suitable period of time in order to satisfy basic human interests.[133] During the period of human occupation and use, harm to, or interference with, the fulfilment of the natural existence of non-human biological entities-in-ecosystems is according to the principle of minimum wrong, where possible.[134] To ensure minimum impact, human activities are subject to "strict monitoring and control".[135] When the human occupation and use has ended, the designated area is given over to the exclusive occupation and use of non-human biological entities for their benefit, with

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[131] See e.g., Devall & Sessions, *supra*, note 2 at 152-156.

[132] Taylor, *supra*, note 11 at 301.

[133] *Ibid.*

[134] *Ibid.* at 303.

[135] *Ibid.*

humans contributing to any rehabilitation which may be necessary.[136] This process may be repeated.[137]

The common conservation of non-human biological entities and physical entities used by both human and non-human biological entities is limited to circumstances in which a threat is posed to the basic interests of members of one or both of the classes of human and non-human biological entities.[138] On this basis, the biocentrist acts contrary to the fundamental biocentric management goal of preservation and conserves these shared natural "resources", or biological and physical sources[139]. Because common

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[136] *Ibid.* at 301-302.

[137] The principle of rotation could apply to projects in which a habitat is used to mine a mineral essential to human health, an underwater habitat is used for scientific studies required to further basic human interests and a habitat is used for locating temporary housing structures. See *ibid.* at 302-303.

[138] See *ibid.* at 298-299. See also, *supra*, text accompanying notes 95-100. The need for common conservation will arise in circumstances where there are limited supplies of water, air, food or shelter.

[139] For the biocentrist, non-human biological entities and physical entities are not only natural resources, but also a "source of values". Rolston III, *supra*, note 20 at 121. For the use of "sources" as natural "sources of value" which contribute to the understanding of humankind's relationship with nature, see *ibid.* at 118-142. Physical "sources" are those physical entities which are accorded respect as elements of an ecosystem for their value in contributing to the fulfilment of the natural existence of biological entities. Biological "sources" are those non-human biological entities which, in addition to being respected as biological entities, are accorded additional respect on the basis of their value for satisfying basic human needs. This superadded respect is evidenced much in the same way that aboriginal peoples respect the biological entities they use to satisfy their basic

conservation is undertaken with an attitude of respect for nature, the humans will share and conserve these sources, where possible, for the mutual benefit of all biological entities, with as little harm, depletion or degradation as possible to the sources-in-ecosystems.[140]

The strategy of designing with nature is an attempt to harmonize human projects with their natural surroundings so that the integrity of ecosystems is preserved.[141] This strategy furthers the implementation of projects involving both human basic interests and non-exploitive human interests[142] by striving to avoid the destruction of habitats or ecosystems and by enabling certain species populations to fulfil their natural existence free from human interference.[143]

(iii) Restitution for Breach of a *Prima Facie* Moral Duty

It will be recalled that a duty exists to make restitution for breach of the *prima facie* duty to avoid harm to, or interference with, the fulfilment of the natural

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interests. See Alan Herscovici, *Second Nature: The Animal-Rights Controversy* (Montreal: CBC Enterprises, 1985) at 56-67 and Devall & Sessions, *supra*, note 2 at 96-97.

[140] See Taylor, *supra*, note 11 at 298-299.

[141] *Ibid.* at 299.

[142] See *supra*, text accompanying notes 81-89.

[143] See Taylor, *supra*, note 11 at 299-301.

existence of non-human biological entities-in-ecosystems[144] and that the duty to make restitution applies to every project that is implemented according to the principles of minimum wrong and equal distribution[145]. This duty is owed to non-human biological entities, species populations, habitats, physical entities and ecosystems.

Restitution is made by "promoting or protecting" the natural existence of non-human biological entities-in-ecosystems, according to the nature of the subject of the harm.[146] Generally, strategies for restitution include (i) rehabilitation of individual non-human biological entities to a healthy state, if the harm suffered arises from human causes;[147] (ii) wilderness preservation for the protection of species populations, habitats and ecosystems;[148] (iii) restoration, rotation or common conservation for the protection of endangered and

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[144] See *supra*, text accompanying notes 69-74.

[145] See *supra*, text accompanying notes 92-94 and 96-99.

[146] See Taylor, *supra*, note 11 at 187-188.

[147] *Ibid.* at 198.

[148] On wilderness preservation, see *supra*, text accompanying notes 128-130.

threatened species populations;[149] and (iv) restoration of ecosystems to non-degraded conditions[150].

Where an individual non-human biological entity is harmed, restitution consists of the rehabilitation of the entity to its condition prior to the harm. Where such an entity is killed or cannot be rehabilitated, restitution consists of the protection or promotion of the fulfilment of the natural existence of the remaining members of its species population and its habitat.[151]

Where a species population is destroyed or depleted beyond the point of regeneration, restitution is made by giving "permanent protection to all the remaining members" of that species or by giving limited protection until the species re-establishes itself.[152] In these cases, depending on the nature of the species, the extent of its endangerment and the nature of the human interest, resort could be had to one or more of the biocentric management strategies

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[149] On restoration, rotation and common conservation, see *supra*, text accompanying notes 131-140.

[150] On restoration, see *supra*, text accompanying note 131.

[151] See Taylor, *supra*, note 11 at 188.

[152] *Ibid.*

used to minimize the impact of human projects which give rise to conflicts between the basic interests of human and non-human biological entities.[153]

Where a habitat or ecosystem is partially destroyed, restitution is made by restoration, to the extent possible, of the habitat or ecosystem to its condition prior to the harm.[154] Where a habitat or ecosystem is totally destroyed, restitution is made by the preservation and promotion of the fulfilment of the natural existence of non-human biological entities in a habitat or ecosystem of the same type,[155] by means of one or more of the strategies used to resolve conflicts between non-human basic interests and non-exploitive human interests,[156] or by the wilderness preservation of one or more pristine natural regions which are threatened by human projects[157].

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[153] See *supra*, text accompanying notes 127-143.

[154] On restoration, see *supra*, text accompanying note 131.

[155] Taylor, *supra*, note 11 at 189-190.

[156] See *supra*, text accompanying notes 106-126.

[157] Taylor, *supra*, note 11 at 191. On wilderness preservation, see *supra*, text accompanying notes 128-130.

PART TWO:
EMERGING PRINCIPLES AND PRACTICES
OF INTERNATIONAL ENVIRONMENTAL LAW

Part One provided an overview of the physical parameters and moral perspectives applicable to international environmental law. In so doing, a foundation has been laid for the development of an international legal régime for environmental protection, applicable to humankind's activities in outer space, on the Moon and on other celestial bodies. The purpose of Part Two is to describe the emerging principles and practices of international environmental law on which such a régime can be based.

Chapter III reviews and analyses the four basic principles of international environmental law in order to develop a biocentric approach for addressing environmental issues in both the terrestrial and outer space environments. Chapter IV describes the general principles and techniques for managing ecosystems and proposes a régime for management of the biosphere in accord with the biocentric perspective.

CHAPTER III: BASIC PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW

International environmental law is a relatively new field of law, having begun in 1972 with the United Nations Conference on the Human Environment which provided a forum for consideration of global environmental problems. Since then principles and practices, binding and non-binding international instruments, as well as scholarly treatises and periodical literature have been generated at a dizzying rate. After more than two decades, it is possible to discern certain basic principles, not sufficiently settled to be regarded as general legal principles, but with enough support and substance to be treated as emerging principles of international environmental law.

In this study, four basic principles of international environmental law are identified. They are considered basic because without them it is unlikely that adequate protection would be available for the global and outer space environments. The "principle of common biospheric concern" acknowledges the global nature of environmental problems and the need for transnational solutions. The "principle of good neighbourliness" holds States internationally responsible for environmental harms to other States, the global commons and other areas of common biospheric concern. The "principle of precautionary measures" emphasizes that environmental protection requires a planned, preventive approach. The "principle of sustainable development" calls for constraints on human conduct in order to prevent environmental harms.

The purpose of this chapter is two-fold: to review the current status of these principles and to analyse each of them from the biocentric moral perspective, so that they can be applied to all biological entities-in-ecosystems.

A. The Principle of Common Concern for the Biosphere

1. Current Status

The fundamental principle underlying contemporary international environmental law is that of common concern for the biosphere. This principle is grounded in an understanding of the systemic nature[1] of biospheric functioning[2] and in a "growing awareness that ecological problems are

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[1] Professors Alexandre Kiss and Dinah Shelton, in their search for a new conceptual framework for international law "in accordance with present international realities", adopted a systems approach. A-Ch. Kiss & D. Shelton, "Systems Analysis of International Law: A Methodological Inquiry" (1986) 17 Netherlands Y.B. Int'l L. 45 at 46. The systems approach views natural entities, both physical and biological, as "sets of integrated relationships". *Ibid.* at 47-51. They base their approach on the reality of subatomic existence as dynamic, interrelated "patterns of process". *Ibid.* at 49. Professors Kiss and Shelton apply the systems approach to, *inter alia*, environmental protection. *Ibid.* at 60-67.

[2] "As our understanding of the environment has grown, we have recognized that agreements need to be directed to conserving ecological systems, not only to controlling specific pollutants or conserving particular species." E.B. Weiss, "International Environmental Law: Contemporary Issues and the Emergence of a New World Order"

problems of whole systems"[3]. Not yet fully developed, the principle of common biospheric concern represents the evolution of a multiplicity of concepts involving the relationship among humankind, its governing institutions and their effect on the biosphere. The concept can be divided for analytical purposes into two parts: the relationship between the State and environmental protection and the legal characterization of the benefits arising from the use of natural "resources".

Sovereignty is a concept of modern public international law, which accords each State virtually unlimited power to make and enforce the law within its territory.[4] Global political and economic changes, including increased

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(1993) 81 Geo. L.J. 675 at 690.

It has been suggested that all supranational law governing States is "system-oriented, in the sense that it stresses the kind of normative system law is, rather than some particular or exclusive set of power relations as fundamental to the nature of law". N. MacCormick. "Beyond the Sovereign State" (1993) 56 Mod. L. Rev. 1 at 8. See also, *ibid.* at 8-10.

[3] E.B. Weiss, "Global Environmental Change and International Law: The Introductory Framework" in E.B. Weiss, ed., *Environmental Change and International Law: New Challenges and Dimensions* (Tokyo: UN University Press, 1992) 3 at 17.

[4] See D.J. Fleming *et al.*, "State Sovereignty and the Effective Management of a Shared Universal Resource: Observations Drawn from Examining Developments in the International Regulation of Radiocommunication" (1985) 10 Ann. Air & Sp. L. 327 at 327-330.

recognition of biospheric environmental concerns,[5] may rekindle interest in the more universalist conceptions[6] as advocated by Grotius and Vattel[7]. Indeed, since the end of World War II, the world has seen in the rapid proliferation of multinational institutions, "a movement away from an international legal order based solely on absolute sovereignty" and an agreement by States to "surrender some of their control" to the international institution established to pursue the particular supranational concern.[8]

Increasingly it is being recognized that "the nature and scope of state sovereignty or autonomy is undergoing dramatic change".[9] States are now more properly seen as having sole jurisdiction to implement and enforce

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[5] Four forces "inexorably undermining sovereignty and the special status that states occupy in traditional international law" include "(1) the technological changes that are facilitating the creation of a global economy and global society; (2) the growing concern about the environment; (3) the expanding role of international organizations in the world: and (4) the changing perceptions of peace and security". C. Grossman & D.D. Bradlow, "Are We Being Propelled Towards a People-centered Transnational Legal Order?" (1993) 9 Am. U. J. Int'l L. & Pol'y 1 at 10.

[6] A return to the original "law of nations" would "more readily signal the diversity and complexity of the subject". M.W. Janis, "International Law?" (1991) 32 Harv. Int'l L.J. 363 at 372.

[7] See Janis, *ibid.* at 364-365.

[8] Grossman & Bradlow, *supra*, note 5 at 4-5.

[9] G. Handl, "Environmental Security and Global Change: The Challenge to International Law" in W. Lang, H. Neuhold & K. Zemanek, eds, *Environmental Protection and International Law* (London: Graham & Trotman, 1991) 59 at 85.

legislation dealing with matters of exclusively domestic concern, while obliged to co-operate with other States in the resolution of regional and global common issues, which were formerly considered to be within exclusive State jurisdiction.[10] With the removal of the State as sole international law-maker in a growing number of areas, supranational organizations have taken their place and, in the process, have dramatically transformed the process of international lawmaking.[11]

Post-World-War II global changes have demonstrated that traditional State sovereignty is not suited to deal with the new situation and that the scope of sovereignty requires significant modification to meet the current and future needs of humanity.[12] In the environmental forum, given the need for a global perspective to deal effectively with the preservation and well-being of the

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[10] *Ibid.* at 86.

[11] See J.I. Charney,"Universal International Law" (1993) 87 Am. J. Int'l L. 529 at 543-550. "[E]specially in the case of important normative developments ... [r]ather than *opinio juri* and state practice, multilateral forums [*sic*] often play a central role in the creation and shaping of contemporary international law." *Ibid.* at 543.

[12] See e.g., S.H. Bragdon, "National Sovereignty and Global Environmental Responsibility: Can the Tension Be Reconciled for the Conservation of Biodiversity?" (1992) 33 Harv. Int'l L.J. 381; Charney, *ibid.*; Fleming *et al.*, *supra*, note 4; Grossman & Bradlow, *supra*, note 5; Janis, *supra*, note 6; Handl, *supra*, note 9; A. Kiss, "The Implications of Global Change for the International Legal System" in Weiss, *supra*, note 3, 315 at 331-339, and MacCormick, *supra*, note 2.

biosphere and all of its inhabitants, unlimited State sovereignty is clearly an obstacle to rational law-making.

Irrevocably fused with the concept of sovereignty are the legal means by which States have extended their jurisdiction and control over natural "resources" found both within the territory of a State and beyond.[13] Traditionally, sovereign States had autonomous control over natural "resources" within their territories, with any restrictions on use and exploitation prescribed by the State or the legal person with title of ownership to the property. Outside State territory another system prevailed.

Territories beyond the jurisdiction of any State were originally characterized as either *res communis* or *res nullius*. The former were considered the property of all, such as the high seas, and could not be subjected to appropriation; the

[13] The "principle of permanent sovereignty over natural wealth and resources" means that "natural wealth and resources located within the territorial jurisdiction of a sovereign state belong to the community, i.e., the people themselves" and incorporates "the right of all peoples to freely use, exploit and dispose of their natural wealth and resources". S.R. Chowdhury, "Permanent Sovereignty Over Natural Resources" in K. Hossain & S.R. Chowdhury, eds, ***Permanent Sovereignty over Natural Resources in International Law: Principles and Practice*** (New York: St. Martin's Press, 1984) 1 at 1-2. See also, K. Hossain, "Introduction" in Hossain & Chowdhury, eds, *ibid.* ix at ix-xv.

latter were considered the property of no State and were subject to appropriation by satisfying certain criteria.[14]

Because *res communis* could not be owned, the concepts of use and *usufructus* arose to account for the exploitation of the benefits of their natural "resources". Title, of course, entitles the owner to a "fee simple", as in real property law, and to the exploitation of all natural "resources" found therein. *Usufruct* is the "right to enjoy the property of another and to take the fruits, but not to destroy it or fundamentally alter its character".[15] Once the "resource" has been severed from the real property, *usufruct* vests in the taker all property rights accruing, or which may accrue, to the "fruits", i.e., the benefits flowing from the "resource".[16] Use entitles the user to use or occupation of the property without taking any of its fruits, or benefits.[17] On this basis, then, States had a common interest in the natural "resources" of the *res communis*. This common interest not only manifested itself in the use and

[14] See C.J. Joyner, "Legal Implications of the Concept of the Common Heritage of Mankind" (1986) 35 Int'l & Comp. L.Q. 190 at 193-194 and Fleming, *supra*, note 4 at 327-328.

[15] L.F.E. Goldie, "Title and Use (and Usufruct) -- An Ancient Distinction Too Oft Forgot" (1985) 79 Am. J. Int'l L. 689 at 691-692.

[16] *Ibid.* at 692.

[17] *Ibid.*

usufructus of those "resources", but also provided for what is now called environmental protection, in the limiting condition of *usufructus*, namely no fundamental alteration or destruction.

Over time, and with the onset of international political factions vying for control, use and *usufruct* of the world's finite endowment of natural "resources", both "renewable" and "non-renewable",[18] the concept of "common heritage of mankind" has developed, the concept of "*res communis*" has broadened and the concept of "common interest" has emerged.

With the likelihood of deep seabed mineral mining and the future possibility of mining on the Moon, the less developed States, without the financial and industrial capacity to carry out such development projects, undertook a concerted effort to modify the concept of *usufruct*, giving rise to the concept of the "common heritage of mankind". This concept incorporates "the idea that the management, exploitation and distribution of the natural resources of the area in question are matters to be decided by the international community ...

[18] On the meaning of "renewable" and "non-renewable", see Chapter II, *supra* at n.30.

and are not to be left to the initiative and discretion of individual States or their nationals".[19]

What the concept of the "common heritage of mankind" essentially does is replace an individual State's right of *usufruct* with a communal right to *usufruct*, vesting in all States the right to share any and all benefits accruing from mineral exploitation of a certain area.[20] The less developed States also argued[21] that the concept of "common heritage of mankind" vested in the

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[19] B. Cheng, "The Legal Regime of Airspace and Outer Space: The Boundary Problem. Functionalism versus Spatialism: The Major Premises" (1980) 5 Ann. Air & Sp. L. 323 at 334. See also, Fleming, *supra*, note 4 at 330-331 (general overview); A.J. Dolman, *Resources, Regimes, World Order* (New York: Pergamon Press, 1981) c. 5 (origins of the concept, application to the Law of the Sea Conference, implications for global resource management); P.L. Saffo, "The Common Heritage of Mankind: Has the General Assembly Created a Law to Govern Seabed Mining?" (1979) 53 Tul. L. Rev. 493 (effect on customary law governing seabed mining), and Joyner, *supra*, note 14 (analysis of the nature of the concept and its place in international law).

[20] See A. Pardo & C.Q. Christol, "The Common Interest: Tension Between the Whole and the Parts" in R.St.J. Macdonald & D.M. Johnson, eds, *The Structure and Process of International Law: Essays in Legal Philosophy, Doctrine and Theory* (Dordrecht, The Netherlands: Martinus Nijhoff, 1986) 643 at 649-650. While this statement generalizes a complex situation, it is sufficient for the purpose of placing the concept of the "common heritage of mankind" in the context of international environmental law.

[21] For a succinct statement of the positions of the industrialized *versus* the less-developed States, see Goldie, *supra*, note 15 at 695-698 and 712-714.

international community titular rights of ownership in all the mineral resources contained in the deep seabed.[22]

In effect, the common heritage of mankind imposes a prohibition against mineral "resource" development unless the global community consents to such a project, but does not modify the condition that the "fruits" are to be neither destroyed nor fundamentally altered.

In contemporary environmental parlance, the concept of *res communis* has been replaced by "global commons". Regularly mentioned as examples of global commons are the high seas, air space beyond national jurisdiction, outer space,

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[22] Ownership does not appear necessary, however, in order for non-industrialized States to receive the benefits which the "common heritage of mankind" was intended to deliver. See Goldie, *ibid.* at 702-704. Ascribing ownership is not desirable from the biocentric perspective because it only legitimizes domination of non-human biological entities and exploitation of physical entities.

the deep seabed, the atmosphere and Antarctica.[23] More recent additions include the ozone layer and the global climate.[24]

The inclusion of Antarctica in the list is, from a historical perspective, puzzling, given that the continent was originally *res nullius*. If Antarctica were *res communis*, then the existing claims of sovereign title to most of the continent would be invalid.[25] Increasingly, however, areas once considered to be *res nullius*, and even those claimed by seven States, are treated as part of the global commons.[26] Whether this new status makes Antarctica *de facto res communis*, or something else, is not clear.[27]

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[23] See *eg* A. Kiss, "The International Protection of the Environment" in Macdonald & Johnson, *supra*, note 20, 1069 at 1084; United Nations Environment Programme [hereinafter *UNEP*], Background Paper Number One, Environment and Trade, "Concepts and Principles in International Environmental Law: An Introduction" (Draft) September 1993, at 3-4 [hereinafter *UNEP Draft Principles*]; Organization for Economic Co-operation and Development [hereinafter *OECD*], Environment Directorate & Trade Directorate, Joint Session of Trade and Environment Experts, *Environmental Principles and Concepts* (Draft) COM/ENV/TD(93)117/REV1 (25 May 1994) para. 22 [hereinafter *OECD Draft Principles*]; P.W. Birnie & A.E. Boyle, *International Law and the Environment* (Oxford: Clarendon Press, 1992) at 91, and K. Leigh, "Liability for Damage to the Global Commons" (1993) 14 Austl. Y.B. Int'l L. 129 at 130.

[24] See e.g., Kiss, *ibid.*; UNEP Draft Principles, *ibid.* at 4; OECD Draft Principles, *ibid.* and Leigh, *ibid.* Birnie & Boyle, *ibid.*, more properly leave these areas for consideration as "common concerns". See *infra*, text accompanying notes 28-34.

[25] Leigh, *ibid.* at 133.

[26] See Weiss, *supra*, note 2 at 704.

[27] Leigh, *supra*, note 23 at 133.

The changing legal status of Antarctica and treating the ozone layer and global climate as *res communis* are indicative of a recent trend relating to the jurisdictional competence of sovereign States. This trend finds its legal expression in the concept of "common concern". Areas of common concern have been identified as the ozone layer, the global climate, tropical forests and world heritage areas.[28] Areas of common concern encompass both *res communis* and all other territories within the exclusive State jurisdiction which raise environmental concerns with implications for the well-being of the biosphere and, hence, for the survival of humankind.[29] With this characterization, areas within territorial jurisdiction become the subject of international attention.[30] In a manner analogous to the common heritage of mankind in *res communis* areas, areas of common concern within exclusive State control become legitimate subjects of international management for the benefit of humankind.[31]

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[28] *Ibid.*

[29] Birnie & Boyle, *supra*, note 23 at 85.

[30] "'Common concern' is the term first used by the UN General Assembly to justify treating the global climate as a unity, regardless of national sovereignty over subjacent airspace and land territory. Its most important implication is that it places the protection of these areas or phenomena on the international agenda and makes them the legitimate object of international attention, overriding the reserved domain of domestic jurisdiction or the possible contention that they related to matters within the exclusive sovereignty of individual states." *Ibid.*

[31] OECD Draft Principles, *supra*, note 23 at 12.

The concept of "common concern", then, may be viewed as applying to all environmental concerns which require international action for efficient and effective resolution.[32] From this perspective, the heretofore distinct global commons combine to become the biosphere.[33] Correspondingly, areas of common concern include all *res communis*, because no individual State has the authority to take action, and all *res nullius* and State territory where environmental concerns of a transborder and other non-exclusive jurisdictional nature are raised. In its application to the biosphere, the concept of common concern encompasses both biological and physical "resources" and, where appropriate, entails the management of the allocation of any benefits to be derived from these "resources" according to the concept of "common heritage of mankind".[34] Such a characterization simplifies the conceptual approach to environmental concerns, eliminating debates over the geophysical location of environmental concerns. For example, the phenomenon of global warming is believed to be caused by excessive human-made gases. Because global warming affects the survival of humankind, the question whether those gases are located

[32] Kiss, *supra*, note 23 at 1084 and Leigh, *supra*, note 23 at 147.

[33] Leigh, *ibid.* at 148.

[34] "The basic principle is that such elements of the world should be conserved and in order to do so they must be correctly managed, in the interest of present and future generations." Kiss, *supra*, note 12 at 335.

within or outside the boundaries of any States is no longer in issue. Rather, the debate addresses the best way for the global community to remedy the common concern of global warming.

2. Biocentric Critique

For the purpose of addressing environmental issues,[35] the concept of common concern for the biosphere supports the biocentric moral perspective, which requires recognition of the biological nature of humanity. On a global level, this biological nature finds its expression in the ecological, systemic premise that the "intimate interdependence of the physical and biological realms of existence is what any ecosystem depends on for its survival"[36]. The concept of common biospheric concern also acknowledges the need for international action to deal with environmental problems regardless of their geographical location.

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[35] The concept of "common concern" has thus far been limited to matters of international environmental law. The common concern, or the "internationally shared interest in environmental protection", is just one of three facets of the generic concept of "common interest", which is found in public international law. See J. Brunnée "'Common Interest' -- Echoes from an Empty Shell?: Some Thoughts on Common Interest and International Environmental Law" (1989) 49 Heidelberg J. Int'l L. 791.

[36] Chapter II, *supra*, text accompanying notes 50-51.

The concept of "common biospheric concern" is inadequate, however, with regard to the second basic premise of the biocentric perspective, namely, that the equivalent inherent worth of all biological entities entitles them to equivalent respect for their existence in nature and to the fulfilment, promotion and protection of their natural existence.[37] The status of human and non-human biological entities as morally equal also means that all biological entities are owed a duty by humankind to promote and protect their natural existence according to a standard based on the needs of all biological entities, not just humankind.[38] In contrast, anthropomorphic interests are the sole objective of current international environmental law[39] and its conceptual bases, such as "common biospheric concern"[40]. The human-centred focus for remedying environmental concerns entails protection of the interests of humankind for current and future generations, with consideration given to the interests of non-human biological entities only where they are necessary for meeting the needs of humankind.

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[37] *Ibid.* at Section C.1(b).

[38] *Ibid.*, text accompanying note 55.

[39] A. Kiss & D. Shelton, *International Environmental Law* (Ardsley-on-Hudson, NY: Transnational Publishers, 1991) at 10-11.

[40] "While initially directed at climate change, [the concept of common concern] was subsequently adopted to refer to the protection of the environment generally, including living resources, as the common concern of humankind". Leigh, *supra*, note 23 at 147.

That the biocentric approach is not yet recognized as a basis for international environmental protection is demonstrated by Principle 1 of the *Declaration on Development and the Environment* [*Rio Declaration*], adopted in 1992 by 178 states at the Rio Conference.[41] Principle 1 of the *Rio Declaration*[42] states in part: "Human beings are at the centre of concerns for sustainable

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[41] See UNEP Draft Principles, *supra*, note 23 at n.2. See also, G.P. Supanich, "The Legal Basis of Intergenerational Responsibility: An Alternative View -- The Sense of Intergenerational Equity" (1992) 3 Y.B. Int'l Env. L. 94 at 103 and OECD Draft Principles, *supra*, note 23, para. 6.

The United Nations Conference on Environment and Development [hereinafter *UNCED*] took place in Rio de Janeiro, Brazil, in June 1992. Known as the Earth Summit, the Conference is a descendant of the Stockholm Conference *via* the 1986 World Commission on Environment and Development. P.H. Sand, "UNCED and the Development of International Environmental Law" (1992) 3 Y.B. Int'l Env. L. 3 at 3. The World Commission's report required that "some guidance should be given in the form of general principles to governments and to peoples, in particular concerning the institutional and legal aspects of common action". A. Kiss, "The Rio Declaration on Environment and Development" in Luigi Campiglio *et al.*, eds, *The Environment after Rio: International Law and Economics* (London: Graham & Trotman, 1994) 55 at 55. The purpose of the Earth Summit was to address "the environment and the relationship between environment and development, which involves the potential for sustained growth inflicting the least possible damage on the environment as population grows and individual consumption increases". E. Richardson, "Prospects for the 1992 Conference on the Environment and Development: A New World Order" (1991) 25 J. Mar. L. Rev. 1 at 2. With the adoption of the *Rio Declaration*, the *Biodiversity Convention*, the *Climate Change Convention* and other instruments, the Earth Summit "may be seen as another incremental step in the evolution of international environmental law". Kiss, *ibid.* at 56.

[42] *Rio Declaration on Environment and Development*, 14 June 1992, UNCED Doc. A/CONF.151/5/Rev. 1 (1992), reprinted in 31 I.L.M. 874 [hereinafter *Rio Declaration*]. The *Rio Declaration* is not legally binding. It is an instrument based on consensus between the industrialized States, favouring a more biocentric, legally-binding declaration, and China and the Group of 77 less developed States, interested in development as a priority. On the positions of the two factions, see C.K. Mensah, "The Role of the Developing Countries" in Campiglio, *ibid.*, 33. On sustainable development, see *infra*, Section D.

development." This principle "represents a victory for the delegates of a human-centered approach to the Rio Declaration".[43] While the Northern States

> sought to place the environment at the centre of developmental concerns ... [so that] human beings would be at the service of the environment and would thus be held responsible for the well-being of the environment ... [t]he South saw a right to a healthy environment as having legal implications which would allow the North to interfere with the South's development plans. A right to a healthy environment at this point would delay the development of human beings.[44]

To make the common concern for the biosphere compatible with the biocentric perspective requires a relatively simple conceptual adjustment, but a profound psychological one[45] -- simply substitute "biokind" for "humankind": Common biospheric concern would address the needs of biokind. Where appropriate, any "resource" projects would be biocentrically managed for the benefit of present and future generations of biokind.[46]

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[43] J. Kovar, "A Short Guide to the Rio Declaration" (1993) 4 Colo. J. Int'l L. & Pol'y 119 at 124.

[44] Mensah, *supra*, note 42 at 41.

[45] "[T]here does not appear to be any principled basis why the idea of an extended community should be limited to *homo sapiens* and why it should not encompass nature as a whole. For here the legal recognition of our interconnectedness with nature simply represents a sound, (eco)logical step in the progressive development of our moral and legal conventions." Supanich, *supra*, note 41 at 103.

[46] See Chapter II, *supra*, Section C.2(b)(ii).

Only one international instrument acknowledges the equivalent inherent worth of all biological entities and supports biocentric respect for nature, the largely neglected *World Charter for Nature*. Adopted by the UN General Assembly in 1982, by a vote of 111 in favour with one against (United States) and 18 abstentions, most of which were from the Amazonian States,[47] the *World Charter* provides in its Principle 1 that humankind "shall" have respect for

[47] W. E. Burhenne & W.A. Irwin, *The World Charter for Nature: A Background Paper* (Berlin: Erich Schmidt Verlag, 1983) at 16. The abstaining States were Algeria, Argentina, Bolivia, Brazil, Chile, Columbia, Dominican Republic, Ecuador, Ghana, Guyana, Lebanon, Mexico, Paraguay, Peru, Philippines, Suriname, Trinidad and Tobago, and Venezuela. *Ibid.* at 97-98.

The United States did not submit its comments on the draft *World Charter* for three years. On the day that the draft *World Charter* was debated in the General Assembly, the United States stated that unless the vote were postponed in order to "work out our differences in the interest of a consensus text", the US delegation would vote against the Resolution. The US negative vote was seen in UN circles as "a thinly-veiled pressure tactic ... that in reality was the product of the recent policy to mollify South American nations upset that the US had sided with the United Kingdom in the Falklands matter". *Ibid.* at 15-16. For the US position, see H.W. Wood, Jr., "The United Nations World Charter for Nature: The Developing Nations' Initiative to Establish Protections for the Environment" (1985) 12 Ecology L.Q. 977.

nature[48]. As a UN Resolution, the *World Charter* is not a legally binding instrument; it is, however, morally and politically persuasive.

B. The Principle of Good Neighbourliness

1. Current Status

The concept of "common concern for the biosphere" expands the scope for international participation in remedying environmental harms. Before the international community can take action against conduct resulting in harm to the environment, States, including their natural and legal persons, must be under an international legal obligation to conduct themselves according to a specific standard. If a State should breach this standard, that State will be

[48] *World Charter for Nature*, GA Res. 37/7, UN GAOR, 34th Sess., Item No. 21, UN Doc. A/37/L.4 and Add.1 (1983), reprinted in 22 I.L.M. 455 [hereinafter *World Charter*], states *inter alia* that the General Assembly,

> Convinced that:
>
> > (a) Every form of life is unique, warranting respect regardless of its worth to man, and, to accord other organisms such recognition, man must be guided by a moral code of action, ...
>
> Adopts ... the present World Charter for Nature, which proclaims the following principles of conservation by which all human conduct affecting nature is to be guided and judged.
>
> I. GENERAL PRINCIPLES
>
> 1. Nature shall be respected and its essential processes shall not be impaired.

internationally responsible for its action. The principle of good neighbourliness provides the necessary legal basis.

The principle of good neighbourliness finds its source in Roman times and addresses the issue of responsibility for one's actions. The Roman principle, *sic utere tuo ut alienum non laedas* has been translated as: "One must use his own so as not to injure another"[49] and "Use your own property so as not to injure that of another"[50]. This principle has been "frequently referred to in modern international law" and has been adopted by civil and common law systems.[51]

The principle of good neighbourliness was restated in the *Corfu Channel* case[52]. In that case, two British warships were damaged by mines in the territorial sea of Albania. Albania knew of the presence of the mines, but failed to give any general notice of their presence and failed to warn the British ships. The World Court held Albania responsible under international law for the damage

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[49] J. Brunnée, *Acid Rain and Ozone Layer Depletion: International Law and Regulation* (Dobbs Ferry, NY: Transnational Publishers, 1988) at 87.

[50] H.M. Kindred *et al.*, *International Law Chiefly as Interpreted and Applied in Canada*, 4th ed. (Toronto: Emond Montgomery, 1987) at 847.

[51] Brunnée, *supra*, note 49 at 87.

[52] *United Kingdom* v. *Albania* (Corfu Channel - Merits), [1949] I.C.J. Rep. 4.

because every State has an "obligation not to allow knowingly its territory to be used contrary to the rights of others".[53]

On its facts, the *Corfu Channel* case is limited to circumstances where the damage and the act causing the damage both occur in the territory of the State responsible for the act. The *Trail Smelter* arbitration[54] enunciated the duty of each State to prevent its territory from being used to cause injury to the territory of another State. A landmark case in the field of transboundary air pollution, the *Trail Smelter* arbitration arose when sulphur dioxide emitted from a smelter in the Province of British Columbia, Canada, damaged crops located in the State of Washington, USA. The smelter operator admitted responsibility for the damage, but was unable to resolve with the defendant the question of liability for damages. Pursuant to the terms of the "Convention of Ottawa, signed April 15, 1935, between the Government of the United States and the Government of the Dominion of Canada", an Arbitral Tribunal was "established to pass upon the claim of the United States for damages to

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[53] *Ibid.* at 22.

[54] *United States* v. *Canada* (Trail Smelter Arbitration) (1931-41), 3 R.I.A.A. 1905.

American citizens".[55] The Tribunal, in deciding in favour of the United States, stated in *obiter* that

> under the principles of international law, as well as of the law of the United States, no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.[56]

This passage is, in spite of its limitations,[57] generally considered to state a rule of customary international law. Taken together, the judgments in the *Corfu Channel* and *Trail Smelter* cases support the view that each State is internationally responsible for activities within its territory which cause harm to other States.

The *sic utere* principle, as employed in the *Corfu Channel* and *Trail Smelter* cases, lacks specificity. The cases themselves have been criticized as consisting of

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[55] A.K. Kuhn, "The Trail Smelter Arbitration -- United States and Canada" (1937) 31 Am. J. Int'l L. 785 at 785.

[56] *Trail Smelter* Arbitration, *supra*, note 54 at 1965.

[57] The limitations of this passage are related to the test for damage and the fact that Canada had accepted liability prior to arbitration. Brunnée, *supra*, note 49 at 88-89. It is not settled whether "there was sufficient state practice and *opinio juris*" to elevate the Tribunal's finding to a principle of international law. See S.A. Williams, "Public International Law Governing Transboundary Pollution", [1984] Int'l Bus. Law. 243, quoted in Kindred *et al.*, *supra*, note 50 at 840-841.

"innocuous, general language", with their "effective force ... unclear but almost certainly weak".[58]

The scope of international responsibility was expanded further in Principle 21 of the 1972 *Stockholm Declaration* on the Human Environment[59]. Principle 21 states:

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

This principle is now universally accepted as a rule of customary international law,[60] forming "the foundation of modern international environmental law".[61]

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[58] C.D. Stone, "Beyond Rio: Insuring Against Global Warming" (1992) 86 Am. J. Int'l L. 445 at 465.

[59] *Declaration of the United Nations Conference on the Human Environment*, 16 June 1972, UN Doc. A/CONF.48/144 (1972), reprinted in 11 I.L.M. 1416 [hereinafter *Stockholm Declaration*]. The purpose of the Stockholm Conference was to "create a basis for comprehensive consideration within the United Nations of the problems of human environment" and to bring these problems to international attention. L.B. Sohn, "The Stockholm Declaration" (1973) 74 Harv. Int'l L.J. 423 at 424-425. One idea for achieving this purpose was to draft a "declaration on the human environment dealing with 'rights and obligations of citizens and Governments with regard to the preservation and improvement of the human environment'". *Ibid.* at 423-424. This instrument became the *Stockholm Declaration.*

[60] Birnie & Boyle, *supra*, note 23 at 90-91. *International Responsibility of States in regard to the Environment*, GA Res. 27/2996, UN GAOR, 27th Sess., Item No. 49, UN Doc. A/8901 (1972) [hereinafter *UNGA Res. 2996*], states that Principles 21 and 22 of the

"Its main importance is that it recognizes the duty of states to take suitable preventive measures to protect the environment."[62] The "damage-causing activities of States" include not only those occurring in territory within State jurisdiction, "but also activities conducted by persons or ships under its 'control', wherever they may act".[63]

Principle 21 of the *Stockholm Declaration* "attempts to balance the right of a state to control matters within its territory with its responsibility to ensure that what is done within that territory does not cause damage outside".[64] Thus Principle 21 may be seen as "pro-environmental protection" because it limits State use of its natural "resources" to the extent that they would cause harm to global commons.[65] However, the *Rio Declaration*, adopted a generation

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Stockholm Declaration "lay down the basic rules governing the matter". See also, Kiss & Shelton, *supra*, note 39 at 40 and 130-131, and Brunnée, *supra*, note 49 at 92-93.

[61] M.P.A. Kindall, "UNCED and the Evolution of Principles of International Environmental Law" (1991) 25 J. Mar. L. Rev. 19 at 19-20.

[62] Birnie & Boyle, *supra*, note 23 at 92.

[63] Sohn, *supra*, note 59 at 493.

[64] *Ibid.* at 485-486. See also, W. Lang, "Environmental Protection: The Challenge for International Law" (1986) 20 J. World Trade L. 489 at 490. Principle 21 "embodies the tension between the right to develop and the responsibilities that attach to the exercise of that right". Kindall, *supra*, note 61 at 20.

[65] UNGA Res. 2996, *supra*, note 60, provides that "states must not produce significant harmful effects in zones situated outside their national jurisdiction". "An overbroad

after the *Stockholm Declaration*, contains language that could either redress the balance or see the pendulum swing in the opposite direction.

Principle 2 of *Rio Declaration* duplicates the language of Principle 21 of the *Stockholm Declaration*, except in one important respect. The former has amended the latter so that the sovereign right of States to exploit their natural "resources" is now according to "their own environmental and developmental policies" rather than according to "their own environmental policies". Consensus is lacking on the effect of this amendment. On the one hand, there is the view that with the addition of these two words, Principle 21 has merely "been updated to reflect developmental concerns".[66] On the other, the position has been taken that the *Rio Declaration* was expected to be a more biocentric document, blending the human-centred focus of the Stockholm Conference with the "more ecological approach of the World Charter for Nature".[67] However, the less developed countries of the South, whose views

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interpretation of this sovereign right [of a State to exploit its resources] would be inconsistent with the rest of the Declaration which emphasizes the fact that no part of the global environment can be separated from the rest and that it has to be preserved and improved for the benefit of all the people of both the present and future generations. No state can claim an absolute right to ruin its environment in order to obtain some transient benefits." Sohn, *ibid.* at 492.

[66] Kovar, *supra*, note 43 at 125.

[67] H. Mann, "The Rio Declaration" (1992) 86 Proc. Am. Soc. Int'l L. 405 at 409.

were represented by the Group of 77 ("G-77"), took the position that "the environmental ethos was a tool by which their development was to be held back".[68] The effect of this stance "was a decoupling of the rights and obligations [of Principle 21] in order to reverse the perceived priority of environment over development".[69] When read together with the language of Principles 3 and 4 of the *Rio Declaration*, the addition of the words "and developmental" in Principle 2 raises the question whether development now has priority over environmental concerns.[70]

Principle 3 of the *Rio Declaration*[71] states: "The right to development must be fulfilled so as to equitably meet developmental and environmental needs of the present and future generations." It has been suggested that Principle 3 reflects the balance "encapsulated by the concept of sustainable development".[72] If this is the case, the balance has shifted in favour of development because the interpretation of "sustainable development", if nothing else, gives priority to

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[68] *Ibid.*

[69] *Ibid.*

[70] *Ibid.* at 410.

[71] *Supra*, note 42.

[72] Kovar, *supra*, note 43 at 126.

development.[73] The language of Principle 4 of the *Rio Declaration*,[74] as well as the positions taken by the industrialized nations of the North and by the "have-not" States of the South,[75] support this view.

2. Biocentric Critique

In approaching the good neighbourliness principle from the biocentric perspective, the neighbourhood includes all human and non-human biological entities, their ecosystems and the relationships inherent in their development and well-being. A biocentric good neighbour is one who, in acting out of respect for nature and the inherent equality of all biological entities, "strive[s] to preserve the existence of biological entities by maintaining their natural ecosystems and by ensuring that the physical entities in those ecosystems are beneficial to a great variety of biotic communities".[76] Such preservation is accomplished by generally avoiding harm to, or interference with, non-human

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[73] See *infra*, text accompanying notes 171-178, 183-185 and 199.

[74] Principle 4 of the *Rio Declaration*, *supra*, note 42, states: "In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."

[75] The North proposed "to have development be an integral part of environmental protection . ... [T]he South made sure that at no time should the environment be considered in a way that it would take precedence over development." Mensah, *supra*, note 42 at 43. The language of Principle 4 reflects the South's position. *Ibid.*

[76] Chapter II, *supra*, text accompanying note 60.

biological entities-in-ecosystems.[77] At present, international responsibility in international environmental law does not meet this standard.

In the context of common concern for the biosphere, the responsibility portion of Principle 21 of the *Stockholm Declaration* reflects an enlightened anthropocentric approach. In holding States internationally responsible for damage to territories beyond their jurisdiction and control, Principle 21 implicitly acknowledges that the biosphere and its component ecosystems are necessary for the survival of humankind. The responsibility portion also dampens the effect of the absolute anthropocentricity found in the exploitation portion of Principle 21 because it limits State projects using their own natural "resources" so that they do not "cause" damage beyond their territories. In so doing, Principle 21 does reflect a fundamental requirement of the biocentric perspective, prevention of adverse effects to the biosphere, eschewing the traditional *ex post facto* model of permitting biospheric damage, followed by reparation, where possible.

Given the status of Principle 21 of the *Stockholm Declaration* as a principle of customary international law and its significance in the development of

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[77] See *ibid.* at Section C.2(b)(ii).

international environmental law, it is unclear what effect Principle 2 of the *Rio Declaration*, read together with its Principles 3 and 4, will have on the future progressive development of international environmental law. These principles clearly emphasize the priority of development over environment. If this emphasis is widely accepted, Principle 2 could constitute a regressive legal step because it (1) fails to acknowledge as valid the concept of common concern for the biosphere within State jurisdiction; (2) re-emphasizes human interests at the expense of common biospheric concerns; and (3) in conjunction with the newly emerging principle of sustainable development,[78] could lead to a practical, if not legal, severance of the connection between developmental rights and preventive responsibilities found in Principle 21 of the *Stockholm Declaration*.

From a biocentric perspective, Principle 21 of the *Stockholm Declaration*, as opposed to Principle 2 of the *Rio Declaration*, is the preferred starting point because it recognizes that limits to development are necessary for a healthy biosphere. Given the current anthropocentric nature of international environmental law, responsibility for "not caus[ing] damage to the environment" beyond State territories is for the benefit of humankind. If the

[78] See *infra*, Section D.

benefit of biokind were the goal, State responsibility would extend to avoiding biospheric harms that would adversely affect biokind. Transforming the States' sovereign "right to exploit their own resources" to a biocentric common concern is more problematic due to the long-standing predominance of the human self-interest of States in the exploitation portion of Principle 21 and, more recently, the reactionary stance in Principle 2 of the *Rio Declaration*, with its apparent pre-occupation with development projects for the well-being of humankind,[79] to the exclusion of environmental concerns, if necessary. Whatever the strength of this human-centredness, to be biocentrically acceptable, both environmental and developmental policies of States would have to demonstrate respect for nature by removing these policies from exclusive State domain and into the hands of international decision-makers who operate with a biocentric appreciation of the global nature of biospheric

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[79] The provisions of the *Rio Declaration* on the right to development reflect, to a certain extent, the need for international monetary and technological assistance for development in the South to ease the "poverty, desperation and environmental destruction" found in many less developed nations: "The North, ravaged by one of the worst recessions in decades, found itself virtually under siege by the South demanding money in return for exercising environmentally safe development." R.K.L. Panjabi, "The South and the Earth Summit: The Development/Environment Dichotomy" (1992) 11 Dick. J. Int'l L. 77 at 136. Such assistance could result in development which would be less environmentally degrading. See R.K.L. Panjabi, "From Stockholm to Rio: A Comparison of the Declaratory Principles of International Environmental Law" (1993) 21 Den. J. Int'l L. & Pol'y 215 at 235-238. If the developmental assistance issues can be satisfactorily resolved, and if their resolution results in a less harsh effect on the biosphere, it is always possible that the language of Principle 2 of the *Rio Declaration* would have little, if any, "decoupling" effect on Principle 21 of the *Stockholm Declaration*.

concerns and a corresponding understanding of actions necessary to meet the interests of biokind.

C. The Principle of Precautionary Measures

1. Current Status

If the good neighbourliness principle requires States not to cause harm to environments other than their own, then in order to abide by this duty, States should have scientific and legal methods available to determine which substances and activities cause what harm and to adduce evidence in support of causation. However, the multiplicity of interrelated elements inherent in any ecosystem have rendered the traditional methods for fact-finding inadequate when addressing problems of causation in international environmental law.

In dealing with harms to the environment, scientists traditionally have "emphasized cause-and-effect relationships that can be demonstrated between substances and the environment, and not relationships that may exist but which, despite extensive scientific testing, remain hidden".[80] Given the

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[80] R.M. M'Gonigle *et al.*, "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making" (1994) 32 Osgoode Hall L.J. 99 at 101.

functional complexity of ecosystems, it is "impossible" to make exact predictions on the effects of substances and activities on the behaviour of ecosystems.[81] This predictive inexactitude has recently been increased following the rejection by most ecologists of the concept of the "balance of nature"[82] and its replacement by a "non-equilibrium" model[83]. These factual gaps in scientific knowledge mean that the "cause" of environmental harm cannot be known with any degree of certainty. In other words, whether a particular project will have an adverse effect on the biosphere or one of its ecosystems is uncertain.[84]

In response to the need to predict the risk of environmental harms, scientists have developed mathematical and statistical tools to "quantif[y] the

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[81] J. Cameron & J. Abouchar, "The Precautionary Principle: A Fundamental Principle of Law and Policy for Protection of the Global Environment" (1991) 14 B.C. Int'l & Comp. L. Rev. 1 at 2 & n.3.

[82] D. Tarlock, "The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law" (1994) 27 Loy. L.A.L. Rev. 1121 at 1135.

[83] See *ibid.* at 1129-1130. The new model is based on findings of the "new" physics, which views all natural systems as thermodynamically open and far from equilibrium, and which relies on statistical probability for its findings of "fact". See *ibid.* at 1125-1130. See also, D. Bohm, *Quantum Theory* (Englewood Cliffs, NJ: Prentice-Hall, 1953) and I. Prigogene & I. Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Toronto: Bantam Books, 1984). The non-equilibrium model has a significant effect on the management of ecosystems. See Chapter IV, *infra*, Section B.

[84] On scientific uncertainty in environmental regulation, see M'Gonigle, *supra*, note 80 at 102-112.

probability of the kind of error that is often ignored: failing to detect a specified effect when one is present".[85] These methods estimate harm to the environment by assessing the statistical probability of a particular risk posed by a specific project to the relevant ecosystem. If the risk is statistically significant, preventive action may be taken "upon the scientifically based presumption of a causal link 'even when there is no conclusive evidence'" of such a link.[86] In these circumstances, management of ecosystems can be based on forecasting and preventing the possible adverse effects which could arise from projects, rather than controlling the adverse effects arising from projects subsequent to their implementation.[87]

Traditionally, legal standards for proof of causation are "often so restrictive that, despite strong suspicions of harm, clear environmental degradation or damage to human health must occur before legal action can be taken".[88] To be effective at international environmental law, and in order to complement the development of new scientific methods for environmental problem-solving,

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[85] *Ibid.* at 168.

[86] *Ibid.* at 156.

[87] See *ibid.* at 161-164. See also, Chapter IV, *infra.*

[88] M'Gonigle, *supra*, note 80 at 102.

basic principles of legal evidence will require modification, particularly the burden of proof and the standard of proof.[89] Because the factual basis for evidence is no longer causation of harm, but rather likelihood of causation, it would appear that at least a reduction in the standard of proof will be required.

To meet a precautionary standard of proof, a complainant should be required only to prove a risk of harm based on a balance of probability or, where the costs of the risk to the complainant outweigh the benefits to the project developer, prove a mere risk of harm.[90] The burden of proof would then shift to the developer, who should be required to demonstrate, according to the circumstances, that the project poses no risk or a minimal risk of harm, that no reasonable alternatives are available and that the public benefit to be derived from the project outweighs the cost of the risks to the complainant.[91]

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[89] *Ibid.* at 115.

[90] See *ibid.* at 139-142.

[91] In other words, the developer should be required to justify the project as promoting a non-exploitive, non-basic interest. See Chapter II, *supra*, text accompanying notes 88-89 and 91-94. On contemporary standards of defence, see M'Gonigle, *ibid.* at 143-149.

The principle of precautionary measures initially arose from an increasing awareness in the international community that a fresh basis was required for determining causation in environmental systems, in contradistinction to the traditional standard for causation established in the *Trail Smelter* arbitration[92]. The Arbitral Tribunal in that case held that a State is responsible for harm caused in the territory of another State, if the harm is "serious" and can be "established by clear and convincing evidence".[93] With no requirement under the uncertainty principle for establishing actual harm to the environment, the *Trail Smelter* test becomes moot and needs to be replaced by one based on a quantitative threshold of probability of risk of harm.

Generally, the principle of precautionary measures provides that where scientific uncertainty exists about the adverse effect of an activity or substance on an ecosystem, the activity or substance should be prevented from causing that effect.[94] The preventive nature of the precautionary principle "anticipates that damaging effects may become irreversible before there is conclusive

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[92] *Supra*, note 54.

[93] *Ibid.* at 1965.

[94] See e.g., E. Christie, "The Eternal Triangle: The Biodiversity Convention, Endangered Species Legislation and the Precautionary Principle" (1993) 10 Env. & Plan. L.J. 470 at 480; Cameron & Abouchar, *supra*, note 81 at 2; OECD Draft Principles, *supra*, note 23, para. 41, and M'Gonigle *et al.*, *supra*, note 80 at 158.

scientific proof as to their precise impact".[95] In legal terms, this preventive nature finds support in existing international law, to the extent that good neighbourliness provides a duty to avoid harm[96] and "institutionalizes caution" in the legal process[97]. The use of the principle of precautionary measures in international environmental law to date reveals a wide variation in its scope of application, the threshold for its invocation and the nature of the preventive measures required.[98]

The principle of precautionary measures is found, *inter alia*, in the *Rio Declaration*[99] and the *Climate Change Convention*[100]; is referred to in the

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[95] Christie, *ibid.* at 480. See also, M'Gonigle *et al.*, *ibid.* at 158.

[96] Birnie & Boyle, *supra*, note 23 at 95.

[97] Cameron & Abouchar, *supra*, note 81 at 3.

[98] Since its introduction in 1987 at the Second International Conference on the Protection of the North Sea, the principle of precautionary measures has appeared in domestic legislation, regional multilateral instruments and globally international instruments. For history and analysis of the principle of precautionary measures, see Cameron & Abouchar, *ibid.* at 6-18.

[99] *Supra*, note 42.

[100] *United Nations Framework Convention on Climate Change*, 9 May 1992, UN Doc. A/AC.237/18 (Part II)/Add.1 and Corr.1 (1992), reprinted in 31 I.L.M. 851 [hereinafter *Climate Change Convention*] (entered into force 21 March 1994).

preambles[101] to the *Montreal Protocol*[102] and the *Biodiversity Convention*[103]; and has been explicitly adopted by the United Nations Environment Programme ("UNEP") and "accepted implicitly or explicitly by four international declarations on the dumping of waste at sea"[104]. Despite its wide incorporation, the status of the principle of precautionary measures at international law is not yet settled. Some argue that in light of its relatively quick reception by the global environmental community, the principle is indicative of "instant" customary international law,[105] and could eventually become a general principle of international law[106]. Others believe that the widely differing standards of evidence in the many versions of the principle

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[101] The material found in the preambles to international instruments is generally historical and hortatory, with no legal effect.

[102] *Montreal Protocol on Substances that Deplete the Ozone Layer*, 16 September 1987, reprinted in 26 I.L.M. 1550 [hereinafter *Montreal Protocol*] (entered into force 1 January 1989). The principle of precautionary measures, as set out in the *Montreal Protocol*, is not applied in practice. See Cameron & Abouchar, *supra*, note 81 at 17-18.

[103] *Convention on Biological Diversity*, 5 June 1992, UN Doc. UNEP/Bio.Div/N-7-INC.5/4 (1992), reprinted in 31 I.L.M. 818 [hereinafter "*Biodiversity Convention*"] (entered into force 29 December 1993) .

[104] Cameron & Abouchar, *supra*, note 81 at 14.

[105] See *ibid.* at 19.

[106] *Ibid.* at 25.

and the variations of its application in State practice, mitigate against its acceptance as customary international law.[107]

Whatever its precise legal status, and notwithstanding its interpretive variations, the principle of precautionary measures clearly is an emerging norm of international environmental law. The two major statements of the precautionary measures principle with application to the biosphere as a whole, as opposed to a geopolitical region or a particular ecosystem, are found in Article 7 of the *Bergen Declaration*,[108] adopted in 1990,[109] and Principle 15 of the *Rio Declaration*,[110] adopted in 1992 at the Earth Summit. Given their linguistic similarity and their related history, they could represent the future

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[107] Birnie & Boyle, *supra*, note 23 at 97-98. Interestingly, while Cameron & Abouchar. *ibid.*, argue that the principle of precautionary measures is a norm of customary international law, they also enumerate many constituencies which have adopted this principle, but do not follow it in practice. *Ibid.* at 6-12 and 17-18.

[108] *Ministerial Declaration on Sustainable Development in the ECE* [United Economic Commission for Europe] *Region*, 16 May 1990, reprinted in H. Hohmann, ed., *Basic Documents of International Environmental Law*, vol. 1 (London: Graham & Trotman, 1992) at 558 [hereinafter *Bergen Declaration*].

[109] "The Bergen Conference was organized by the Government of Norway in cooperation with the [ECE] as part of the follow-up to the report of the [Brundtland Commission], and as part of the preparations for the 1992 [Earth Summit]. Cameron & Abouchar, *supra*, note 81 at n.6. The 34 ECE signatories to the *Bergen Declaration* use the principle of precautionary measures to "guide policy", "although the principle still lacks a consistent definition". *Ibid.* at 18.

[110] *Supra*, note 42.

direction the international community may take in its application of the principle of precautionary measures. The two provisions are set out below:

Bergen Declaration, Article 7:

In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent, and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Rio Declaration, Principle 15:

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

In its reference to a "precautionary approach", Principle 15 of the *Rio Declaration* suggests that the international community does not wish to endow it with the status of a principle.[111] The scope of Principle 15 is broader than that of Article 7 of the *Bergen Declaration* because it speaks to protection of the environment and not strictly to sustainable development and its priority of developmental needs over environmental concerns. Principle 15 then retreats from this position by stating that it "shall be widely" -- not always -- applied and that, if applied, the extent of application depends on "capabilities" of

[111] "The negotiators rejected suggestions by some European countries to promote a 'Precautionary Principle'." Kovar, *supra*, note 43 at 134.

States, namely, the financial, political and social factors. In both provisions, the threshold for invoking the principle is limited to "threats of serious or irreversible damage". It is not clear whether "serious" is an alternative to "irreversible". Neither Article 7 nor Principle 15 gives any indication to what extent, if any, the burden of proof shifts. Article 7 is seen as shifting the burden to the project developer to show that an activity "will not damage the environment",[112] while the "conventional view" of Principle 15 is that the burden would shift to the developer to prove that the project is "not harmful to the environment"[113]. Finally, when the principle of precautionary measures is invoked, Principle 15 provides that the only preventive measures required are "cost-effective" ones, in keeping with the "developmental assistance" theme of the Earth Summit[114].

The principle of precautionary measures is likely to have a strong influence in the field of environmental management. New precautionary strategies for management will be required that no longer assess the effect of the harm which an ecosystem sustains from the introduction of a substance or activity, but

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[112] Cameron & Abouchar, *supra*, note 81 at 18.

[113] OECD Draft Principles, *supra*, note 23, para. 45.

[114] See *supra*, text accompanying note 79.

instead assess the risk of harm posed to an ecosystem if the substance or activity were introduced into the ecosystem.[115] Preventive management techniques include prior justification procedures,[116] "monitoring, providing early warning and prioritizing risks",[117] as well as the principles of adaptive management, which are "premised on the assumption that management strategies should change in response to new scientific information"[118]. Implementation of preventive management techniques will require the modification of environmental impact assessments so that they become environmental risk assessments.[119] Scientists, technologists and policy makers will have to develop models for determining what activities are "threats" and which of these threats are "serious" or "irreversible".[120] The global legal

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[115] See e.g., OECD Draft Principles, *supra*, note 23, para. 45 and M'Gonigle *et al.*, *supra*, note 80 at 138.

[116] M'Gonigle *et al.*, *ibid.* at 161-165. A prior justification procedure is a regulatory one, consisting of a "series of steps with which an applicant for a permit to dispose of waste at sea must comply". *Ibid.* at 162. See also, Chapter IV, *infra*, text accompanying notes 56-66.

[117] Weiss, *supra*, note 2 at 689.

[118] Tarlock, *supra*, note 82 at 1139. See also, *ibid.* at 1139-1144.

[119] Christie, *supra*, note 94 at 482-484. On environmental impact assessments, see Chapter IV, *infra*, Section C.1(a).

[120] "Because countries may vary significantly in their assessments of what constitutes serious threats or risks to shared resources and the global commons, international environmental agreements are very difficult to negotiate." OECD Draft Principles, *supra*, note 23, para. 48.

community will be charged with developing appropriate international standards of proof for evidence based, not on "harm", but on the "risk of harm", and with devising methods for the equitable allocation of the burden of proof.

2. Biocentric Critique

The principle of precautionary measures represents a significant emerging principle of international environmental law for extending respect for nature to its outermost limits, albeit within the parameters of an enlightened anthropocentric moral perspective.[121] The principle of precautionary measures, with its wholly preventive outlook, is an attempt to anticipate harm based on the probability of risk of harm, instead of the more traditional methods of regulating the introduction of substances and the implementation of projects until the harm is discovered, at which time *ex post facto* cleaning up and compensation for the harm occur.

Even with its far-reaching possibilities, the emerging trend in international environmental law appears to indicate that the principle of precautionary measures will be applied only where the probability of risk of harm is "serious

[121] See e.g., Tarlock, *supra*, note 82 at 1134-1138.

or irreversible". Yet, as humankind's understanding and appreciation of the value of non-human entities increases, it is possible that the threshold for "serious" threats of harm could be reduced.[122] As it now stands, to prove that the risk threshold has been met, the complainant is required to adduce evidence on a balance of probability. The burden of proof then shifts to demonstrate that the project should be implemented.[123] The current state of the global economy would seem to suggest that prevention of scientifically uncertain threats of harm will be required only where the preventive measures are "cost effective".

From the biocentric moral perspective, the principle of precautionary measures is a step in the right direction, with its emphasis on preventive strategies for stemming environmental harms.[124] It is, however, a small step. For a biocentrist, the principle of precautionary measures states: Where scientific uncertainty exists about whether the effects of any activity or substance arising

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[122] "We must invest some trust in the possibility that the change of consciousness we have experienced in our scientific, philosophical, and political understanding of environmental problems will extend to the interpretative consciousness of lawyers and decisionmakers [*sic*] when they approach the meaning and effect of these threshold words." Cameron & Abouchar, *supra*, note 81 at 22.

[123] See *supra*, text accompanying notes 90-91.

[124] See Chapter II, *supra*, Section C.2(a).

from a project are adverse in interest to any ecosystem, the implementation of the activity in, or introduction of the substance into, the ecosystem should be prevented unless the project developer can demonstrate, with scientific certainty, that the activity or substance fulfils the requirements for biocentric management[125].

With biocentric precaution, the scope of "ecosystem" extends to all biological entities-in-ecosystems, in accordance with biocentric respect for nature.[126] The threshold for application of the principle of precautionary measures is low, in keeping with the biocentric requirement for avoidance of interference with, and harm to, all living entities, their habitats and ecosystems.[127] For the threat to be "adverse" in interest, it need only be, "unfavourable", "contrary", "hostile" or "opposed" to the interests of an ecosystem.[128] Such a liberal interpretation of the principle of precautionary measures requires that "any

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[125] On biocentric management, see *ibid.* at Section C.2(b)(ii).

[126] See *ibid.* at Section C.1.

[127] See *ibid.* at Section C.2(a)(i).

[128] See e.g., *Dictionary of Canadian* Law (1st ed. 1991), Black's *Law Dictionary* (6th ed. 1990) and *Concise Oxford Dictionary* (8th ed. 1990).

substances, whose 'safety' has not yet been demonstrated", will be controlled[129].

To ensure to the greatest extent possible that the interests of ecosystems are not adversely affected, the biocentrist shifts the entire burden of proof to the project developer, who is required to demonstrate on the basis of objective scientific certainty that no adverse effects will ensue from the introduction of substances into, or the implementation of activities in, the ecosystem. Shifting the burden of proof requires that the project developer present evidence, based on principles of scientific uncertainty, of the non-adverse effect of the activity or substance. In cases where the project developer is disputing evidence of another party, the project developer must effectively refute any opposing claims. The standard of proof is based on the requirements of the biocentric management régime:[130] The project developer must demonstrate that the project is biocentrically acceptable,[131] that any adverse affect is justified[132] and

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[129] M'Gonigle *et al.*, *supra*, note 80 at 159.

[130] See Chapter II, *supra*, Section C.2(b)(ii).

[131] See *ibid.* at Section C.2(b)(ii)(A).

[132] See *ibid.* at Section C.2(b)(ii)(B).

has minimal impact,[133] and that appropriate restitution is made to compensate for any adverse effects the project may have[134].

D. The Principle of Sustainable Development

1. Current Status

The concept of sustainable development has emerged in a little more than a decade as the predominant international and national philosophy for environmental planning and ecological management. The kernel of sustainable development was planted in 1972 at the Stockholm Conference, where it was noted that limits to damage to the environment were necessary for "sound economic and social development".[135] The term itself was introduced in 1980[136] in the *World Conservation Strategy*[137] and was incorporated into the *World Charter*[138] as one of its four general principles.[139]

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[133] See *ibid.* at Section C.2(b)(ii)(c).

[134] See *ibid.* at Section C.2(b)(iii).

[135] Birnie & Boyle, *supra*, note 23 at 40.

[136] Supanich, *supra*, note 41 at 105.

[137] International Union for the Conservation of Nature and Natural Resources [hereinafter *IUCN*], *World Conservation Strategy* (Gland, Switzerland: IUCN, 1980).

[138] *Supra*, note 48.

[139] Principle 4 of the *World Charter*, *ibid.*, states: "Ecosystems and organisms, as well as the land, marine and atmospheric resources that are utilized by man, shall be managed to

The concept of sustainable development attained world-wide recognition through the work of the World Commission on Environment and Development ("WCED"), which was established by UNEP in 1983, in response to the awareness at the time that State activities had the potential to cause substantial harm to the biosphere and, hence, to humankind.[140] Part of the Commission's work was to propose "strategies for sustainable development".[141] The findings of the WCED, reported to UNEP in 1987,[142] are more commonly known as the Brundtland Report[143].

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achieve and maintain optimum sustainable productivity, but not in such a way as to endanger the integrity of those other ecosystems or species with which they coexist."

The *World Charter* was drafted, initially by the IUCN and then by an international committee, as a guide for regulating international environmental development. Wood, Jr., *supra*, note 47 at 977. Although non-binding, its general principles were intended to be used as "rules to guide human behavior". *Ibid.* at 980.

[140] *Report of the World Commission on Environment and Development: Our Common Future*, UN GAOR, 42d Sess., Annex, Agenda Item 83(3), para. 1, UN Doc. A/42/427 (1987) [hereinafter *WCED Report*].

[141] *Ibid.* The mandate of the WCED "was to examine critical environmental and development issues and to formulate realistic proposals for dealing with them; to propose new forms of international cooperation on these issues to influence policies and events in the direction of needed changes; and to raise the levels of understanding and commitment to action of individuals, organizations, businesses and governments". Kiss & Shelton, *supra*, note 39 at 51.

[142] WCED Report, *ibid.* at para 2.

[143] The WCED Report was subsequently published as World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987) [hereinafter *Brundtland Report*].

A major finding of the Brundtland Report concerns the application of sustainable development to the future endeavours of humankind:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:
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> - the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
> - the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.[144]

The Report defines these "needs" as the "essential human needs ... for food, clothing, shelter, [and] jobs".[145] To meet these needs "clearly requires economic growth in places where such needs are not being met".[146] Human interests beyond the essentials "[require] the promotion of values that encourage consumption standards that are within the bounds of the ecologically possible and to which all can reasonably aspire".[147] What is "ecologically possible" includes a prohibition against "endangering natural systems that support life on Earth".[148] But "every ecosystem everywhere

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[144] *Ibid.* at 43.

[145] *Ibid.*

[146] *Ibid.* at 44.

[147] *Ibid.*

[148] *Ibid.* at 45.

cannot be preserved intact": Living "resources" may be exploited so long are they are "not depleted ... within the limits of regeneration and natural growth"; use of non-living "resources" should be calculated so that the "resource does not run out before acceptable substitutes are available".[149] "Sustainable development requires that adverse impacts ... [on ecosystems] are minimized so as to sustain the ecosystem's overall integrity".[150]

Sustainable development, then, is a combination of economic, industrial and social development which avoids harm to the biosphere and its ecosystems in order to ensure that its natural "resources", renewable and non-renewable, will be available for exploitation by future generations of humankind to meet their needs.[151] The impact of this concept on environmental concerns has been all-

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[149] *Ibid.* at 45-46.

[150] *Ibid.* at 46.

[151] Articles 2 and 3 of the "Summary of Proposed Legal Principles for Environmental and Sustainable Development", Annexe 1 to the Brundtland Report, *supra*, note 143 at 348, provide, respectively, that conservation and use of the environment is "for the benefit of present and future generations" and that in using the biosphere's resources, States "shall observe the principle of optimum sustainable yield". Article 3(c) of the Proposed Legal Principles limits application of optimum sustainable yield to "living natural resources". World Commission on Environment and Development, Experts Group on Environmental Law, *Environmental Protection and Sustainable Development: Legal Principles and Recommendations* (London: Graham & Trotman, 1987) at 47-54 [hereinafter *WCED Experts Group*]. Optimum sustainable yield "means that a living natural resource or ecosystem must only be utilized in such a manner and to such an extent that benefits from those resources will be provided indefinitely". *Ibid.* at 47. It is unclear what limits are established for exploiting "non-living natural resources" other than the language of

encompassing.[152] Sustainable development is seen as a "global ethic", with moral, legal, social, cultural and economic implications.[153] It is "shaping environmental policy debates in a fundamental way".[154] Current environmental management philosophy is grounded in the theory of sustainable development, with the former's requirement that any "production system respect the obligation to preserve the ecological base for development"[155]. With the emphasis of sustainable development on "the relationship between environmental and economic factors"[156] and on the correspondingly finite limit of the Earth's natural "resources", the relationship between sustainability and population control has been highlighted.[157]

Article 9 of the Proposed Legal Principles, which calls for "equitable and reasonable" use of "transboundary natural resources". See *ibid.* at 72-75.

[152] "The phrase has found its way into practically everything written or spoken about our environmental future: it has become the environmental movement's catch phrase of the late twentieth century. ... This is a motherhood doctrine of apparently unchallengeable rectitude." M. Grant, "A European View of Sustainable Development" (1991) 9 J. Energy & Nat. Resources L. 124 at 124.

[153] Supanich, *supra*, note 41 at 107.

[154] Handl, *supra*, note 9 at 82.

[155] Brundtland Report, *supra*, note 143 at 65.

[156] Grant, *supra*, note 152 at 124.

[157] "The human population that the Earth can sustain is dependent on the global ecosystem, both as a source of natural resources and as a sink for its wastes. ... Resources like food, water and energy must be divided among an increasingly large number of people producing increasing amounts of waste. Food production levels dictate whether or not our planet can support more people." E. Rohrbough, "On Our Way to Ten Billion

Legally, the number of international instruments employing the concept of sustainable development, as well as the "legally significant expectations" it engenders,[158] "point to [its] emerging legal status ... as a principle of international law".[159] The *Rio Declaration* could possibly provide the "adequate articulation"[160] necessary to transform "sustainable development" into "a peremptory norm of international law" [161]. Another legal issue receiving significant attention arises from the support given by "sustainable development" to the idea of the "human stewardship of nature" for future generations[162]. This idea provides a basis for the international legitimization

Human Beings: A Comment on Sustainability and Population" (1994) 5 Colo. J. Int'l Env. L. & Pol'y 235 at 236. See also, A.J. Roman, "Sustainability and the New Environmental Law of the 1990s" in C.J. Holgren, ed., *Private Investments Abroad -- Problems and Solutions in International Business in 1992* (New York: Matthew Bender, 1992) 1-1 at 1-37 - 1-38.

[158] Handl, *supra*, note 9 at 80.

[159] Birnie & Boyle, *supra*, note 23 at 124.

[160] "The conclusion that international law now requires a standard of sustainable development to be met is not untenable; it simply lacks adequate articulation at present for confident generalizations to be made." *Ibid.*

[161] Handl, *supra*, note 9 at 80.

[162] "The key principle underlying sustainability is the 'human stewardship of nature.' Put simply, by former Prime Minister [Margaret] Thatcher, 'We do not hold a freehold on our world, but only a full repairing lease. We have a moral duty to look after our planet and to hand it on in good order to future generations.'" R. Mushkat, "Environmental Sustainability: A Perspective from the Asi-Pacific Region" (1993) 27 U.B.C. L. Rev. 153 at 169.

of the concept of intergenerational equity as the legal vehicle for providing the necessary stewardship.[163]

Perhaps the most lasting influence of the concept of sustainable development on the evolution of international environmental law will be felt as a consequence of the 1992 Earth Summit in Rio, which "formally anoint[ed] the concept ... for legal use".[164] "Sustainable development" was "at the origin of the Rio Conference"; "[a]ll documents adopted at Rio reflect th[e] approach that sustainable development entails the integration of environmental protection into the development process."[165] Further, the instrument with the

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[163] Handl, *supra*, note 9 at 82. On the concept of intergenerational equity, see E.B. Weiss, "The Planetary Trust: Conservation and Intergenerational Equity" (1984) 11 Ecology L.Q. 495 and, more recently, E.B. Weiss, *In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity* (New York: Transnational Publishers, 1989). The concept is not, however, problem-free. See e.g., "Agora: What Obligation Does Our Generation Owe to the Next? An Approach to Global Environmental Responsibility" (1990) 84 Am. J. Int'l L. 190; G.A. Christenson, Book Review (1990) 1 Y.B. Int'l Env. L. 382, and Supanich, *supra*, note 41 at 95-99.

[164] Sand, *supra*, note 41 at 17. Sustainable development "represented the underlying concept of the Rio Conference and dominated the *Rio Declaration* ...". UNEP Draft Principles, *supra*, note 23 at 16.

[165] A-Ch. Kiss, "Will the Necessity to Protect the Global Environment Transform the Law of International Relations?" (The Josephine Onoh Memorial Lecture, 28 January 1992) Hull, England: University of Hull Press, 1992, at 14. "Perhaps most importantly, UNCED adopted Agenda 21, a five-hundred page blueprint detailing the 'new global partnership for sustainable development' in the 21st century." OECD Draft Principles, *supra*, note 23, para. 6.

broadest reach, the *Rio Declaration,*[166] "clarifies", "further defines" and "introduces procedural requirements for implementing the concept of sustainable development".[167]

Despite its popularity, "sustainable development" is not without its problems. It is generally agreed that the meaning of its terms are vague, ambiguous and, at times, contradictory and that its practical application in both domestic and transnational law and policy is unclear and remains to be worked out.[168] Although heartily embraced in Rio, and with the process of interpretation and

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[166] *Supra*, note 42.

[167] M. Sanwal, "Sustainable Development, the Rio Declaration and Multilateral Cooperation" (1993) 4 Colo. J. Int'l Env. L. & Pol'y 45 at 48. See also, OECD Draft Principles, *supra*, note 23, para. 6.

[168] "Beyond a rather generalized impression that we should be burning fewer fossil fuels, and perhaps engaging in more recycling of materials, the actual measures that need to be taken to move towards sustainable development -- as well as the associated costs and benefits of such measures -- are not well understood. Sustainable development is open to a wide range of interpretations, not all of them compatible. Not surprisingly, the particular interpretation chosen tends to vary according to the interests of the group identifying itself with the concept." J.O. Saunders, "The Path to Sustainable Development: A Role for Law" in J.O. Saunders, ed., *The Legal Challenge of Sustainable Development: Essays from the Fourth Institute Conference on Natural Resources Law* (Calgary: Canadian Institute of Resources Law, 1990) 1 at 1. Grant, *supra*, note 152 at 125, is more openly cynical: "But the obvious risk with sustainable development is that its very acceptability reflects a lack of real substance." See also, *inter alia*, Birnie & Boyle, *supra*, note 23 at 123; Handl, *supra*, note 9 at 80-81, and OECD Draft Principles, *ibid.* at para. 6.

application only having begun in the *Rio Declaration*,[169] its practical influence on State practice remains to be seen[170].

A major criticism of "sustainable development" is the lack of clarity of distinction between "development" and "growth".[171] Conceptually, "development" is qualitative, imposing values derived from socio-political aspirations, while "growth" is quantitative, using economic indicators, such as Gross National Product or Gross World Product ("GWP"), to measure the well-being of society.[172] In practice, "development" implies a steady state, where the net level of consumption of natural "resources" by human activities

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[169] See *eg supra*, text accompanying notes 66-75.

[170] E.g., an environmental economist in The Netherlands questioned in March 1994 "whether conventional solutions currently opted for by the authorities are in accordance with the government commitment to sustainable development in the long run". "Decisions on Infrastructure Focusing on Economic, not Environmental Factors" *BNA International Environmental Daily* (3 March 1994) 1. See also, *supra*, n.168.

[171] Supanich, *supra*, note 41 at 106. The term "sustainable development" is an oxymoron because a sustainable society is a "subsistence-oriented society", in which small groups satisfy most, if not all of their own needs, while a development society is "wealth-oriented" and "embraces development and progress but faces continual crises and the need for reorganization". Grant, *supra*, note 152 at 128, commenting in reference to A. Tanner, "Northern Indigenous Cultures in the Face of Development" in Saunders, ed., *supra*, note 168, 253 at 261. See also, P.S. Elder, "Sustainability" (1991) 36 McGill L.J. 832 at 836-837.

[172] Supanich, *ibid.*

remains the same over time.[173] "Growth" implies a rising state, or an increased level of "resource" consumption, until the point beyond which ecosystems can no longer sustain the "resources" required for human survival.[174]

Arguably, "sustainable development" is not a steady-state, "no-growth" strategy[175]. "[L]argely cast in terms of economic well-being",[176] the concept of sustainable development is concerned with "sustainable growth, that is, the rate of increase".[177] The Brundtland Report makes the assumptions that the current level of GWP is low enough to sustain the increased growth it calls for and that "one can simultaneously improve the global equity among nations, ... while allowing the developed world to grow and the underdeveloped world to grow even faster".[178]

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[173] See Supanich, *ibid.* at 106-107 and Roman, *supra*, note 157 at 1-4 - 1-5.

[174] Roman, *ibid.* at 1-5.

[175] Grant, *supra*, note 152 at 125. *Cf contra*, Mushkat, *supra*, note 162 at 156.

[176] Supanich, *supra*, note 41 at 107.

[177] Roman, *supra*, note 157 at 1-5.

[178] *Ibid.* See also, P.S. Elder & W.A. Ross, "How to Ensure That Developments Are Environmentally Sustainable" in Saunders, ed., *supra*, note 168, 124 at 125-126.

Other terms in the description of sustainable development which raise interpretive questions include “compromising” and “needs”. The term “compromising” permits substitution of one “resource” for another, so that a particular “resource” may be exploited, possibly to extinction, so long as a viable option remains.[179] The term “needs” is culturally relative and “politically accountable”, providing no objective standard for what constitutes the “needs” for which development is to be sustained.[180]

The WCED Experts Group[181] and the *Rio Declaration*[182] do not appreciably contribute to the resolution of the aforementioned issues. If anything, given the generally accepted view that the *Rio Declaration* provides a pragmatic application of a concept in action,[183] and in light of the aspirations of the nations of the South at the Rio Summit,[184] “sustainable development” may be

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179 Grant, *supra*, note 152 at 125.

180 See Elder & Ross, *supra*, note 178 at 125 and Roman, *supra*, note 157 at 1-4. E.g., an urban North American would not likely agree with an African nomad or a Peruvian villager on what would be acceptable “food, clothing, shelter, jobs” under an international régime for implementing sustainable development.

181 *Supra*, note 151.

182 *Supra*, note 42.

183 See *supra*, text accompanying notes 151-157.

184 See *supra*, text accompanying notes 68-69 and 71-75, and n.79.

viewed as a growth-oriented philosophy which strives to provide as a priority an increasing level of tangible benefits to the lesser developed nations, while concurrently attempting to maintain and increase, where possible, the level of benefits accruing to the industrialized countries, without bringing renewable and non-renewable "resources" below a level of "optimum sustainable yield". Such a view is consistent with Principles 5 and 6 of the *Rio Declaration*,[185] which provide, respectively, that "eradicating poverty" is "an indispensable requirement for sustainable development" and that the "special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority". To eradicate the poverty of the least developed countries entails economic growth in order to achieve standards of living sufficient for State sustainability.

2. Biocentric Critique

The concept of "sustainable development", as the current pre-eminent *rationale* for environmental planning and ecological management, purports to dictate the nature and extent of the constraints to be placed human conduct in order to further the well-being and integrity of ecosystems for the benefit of humankind. The anthropocentric and biocentric moral perspectives both

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[185] *Supra*, note 42.

require constraints on human conduct in order to protect the biosphere and its ecosystems. The distinctions between the two perspectives largely focus on two questions: which entities comprising ecosystems are protected by these constraints, and what is the threshold of intrusion into ecosystems for applying constraints.

The concept of sustainable development is by no means an altruistic statement ascribing value to the environment independent of humankind.[186] Rather, it represents the position of an enlightened anthropocentric, expressing humankind's self-interest in survival through the use of non-human entities to meet its needs.[187] Indeed, this anthropocentricity is now entrenched in Principle 1 of the *Rio Declaration*[188]: "Human beings are at the centre of concerns for sustainable development."[189]

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[186] *Cf World Charter*, *supra*, note 48, Preamble, para. 1.

[187] See e.g., OECD Draft Principles, *supra*, note 23, para. 6; Handl, *supra*, note 9 at 80; Supanich, *supra*, note 41 at 107; Roman, *supra*, note 157 at 1-4, and Elder, *supra*, note 171 at 835.

[188] *Supra*, note 42.

[189] See also, *supra*, text accompanying notes 41-44.

From the biocentric perspective, all living things are entitled to equivalent moral consideration.[190] Accordingly, constraints are placed on human conduct to ensure preservation of all biological entities and their ecosystems and, consequently, the biosphere. A system of biosphere management is not limited to the maintenance of ecosystems to meet human needs. "The goal of biocentric management is to ensure that humankind's projects neither harm, nor interfere with, the fulfilment of the natural existence of all non-threatening, non-human biological entities-in-ecosystems."[191] To meet this goal, the conduct of humankind should be constrained to the extent necessary to provide for the maintenance of ecosystems in order that all biological entities, including humankind, can fulfil their natural existence. The threshold for imposing constraints on human conduct is minimal interference with biological entities-in-ecosystems.[192] Where harm or minimal interference is unavoidable, projects are, if justified,[193] implemented in the least intrusive

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[190] See Chapter II, *supra*, Section C.1.

[191] See *ibid.*, text accompanying note 79.

[192] See *ibid.*, text accompanying notes 69-73.

[193] See *ibid.* at Section C.2(b)(ii)(B).

manner, with equity for all biological entities, where necessary,[194] and with appropriate restitution[195].

A central concept from both moral perspectives is that of "needs". Consistent with its enlightened anthropocentric position, the Brundtland Report emphasizes the essential human needs of food, clothing, shelter and jobs. From the biocentric perspective, these needs are likewise considered basic.[196] But the biocentrist also accounts for the basic needs of non-human biological entities-in-ecosystems in relation to the basic and non-basic needs which motivate human projects.[197] The relationships between the needs of humankind and non-human biological entities-in-ecosystems play a central role in determining whether a project will be implemented.[198]

Other aspects of "sustainable development" also stand in contrast to the biocentric perspective. "Sustainable development" gives priority to

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[194] See *ibid.* at Section C.2(b)(ii)(c).

[195] See *ibid.* at Section C.2(b)(iii).

[196] See *ibid.*, text accompanying notes 84-85.

[197] See *ibid.*, text accompanying notes 81-89.

[198] See *ibid.* at Section C.2(b)(ii)(c). See also, Chapter IV, *infra*, Section C.3(a).

"development" over "environment",[199] thereby further emphasizing the anthropocentric focus. "Sustainable development" places a limit on the principle of precautionary measures,[200] which, while anthropocentric in scope and threshold, advocates prevention of harm and interference[201]. Therefore, even from the perspective of enlightened self-interest, "sustainable development" results in further restrictions on what is already a narrow interpretation of the principle of precautionary measures. Additionally, given its "express disclaimer of any intended encroachment upon state sovereignty",[202] "sustainable development" has no effect in moving environmental decision-making from the ineffective control of States into a broader, supranational forum.

[199] See Handl, *supra*, note 9 at 80 and Sanwal, *supra*, note 167 at 49.

[200] Sustainable development's "commitment to promote development" stands "in contrast to the no-growth strands that are part of the complex policy fabric of the precautionary principle". Handl, *ibid.*

[201] See *supra*, text accompanying notes 94-95.

[202] "Sustainable development is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs and does not imply in any way encroachment upon national sovereignty." United Nations Environment Programme, *Statement on Sustainable Development*, UNEP, 15th Sess., Annex II, UN Doc. UNEP/GC 15/L.37 (1989), cited in Handl, *supra*, note 9 at n.147.

CHAPTER IV: MANAGEMENT OF THE BIOSPHERE

Accompanying international acceptance of the fact that environmental concerns transcend national borders, the global community has acknowledged that remedies for these concerns likewise call for transnational measures to replace current *ad hoc*, often unco-ordinated methods. These measures take the form of a management régime, the structure and function of which will vary according to the moral perspective adopted.

The basic principles of international environmental law discussed in Chapter III are applicable to both the anthropocentric and biocentric moral perspectives. The principle of common biospheric concern reflects the transnational nature of environmental problems and the need to overcome the traditional limits of State sovereignty in order to address and resolve these problems in a rational and effective manner.[1] The principle of good neighbourliness requires that States avoid adverse effects to territories outside their jurisdiction and control and places limits on the use by States of their "resources" to avoid such adverse effects in accordance with the principle of "common biospheric concern".[2] The principle of precautionary measures

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[1] See Chapter III, *supra*, Section A.

[2] See *ibid.* at Section B.

emphasizes the need for prevention of adverse effects to ecosystems when undertaking human projects and requires that projects not be undertaken, if scientific uncertainty exists about whether the project will have an adverse effect on the environment.[3] The principle of sustainable development calls for constraints on human conduct in order to maintain the integrity and functioning of the biosphere and its ecosystems.[4]

The differences between management régimes from the anthropocentric and biocentric moral perspectives are largely ones of degree, not kind. The basic distinctions concern scope of application and threshold, with the biocentric perspective extending the scope of international environmental law to include all biological entities-in-ecosystems on an equitable basis and lowering the thresholds for placing constraints on the conduct of humankind.[5] Similarly, the basic principles and techniques for management of the biosphere, which are applicable to both the anthropocentric and biocentric perspectives, have a common conceptual basis. As with the basic principles of international environmental law, the principles and techniques of biosphere management are

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[3] See *ibid.* at Section C.

[4] See *ibid.* at Section D.

[5] See *ibid.*, text accompanying notes 190-195.

found, in one form or another, in current international environmental law. The differences between management strategies for the two perspectives are logical extensions of the variations found in the four basic principles.

The purpose of this chapter is to describe the general principles and techniques of a régime for biocentric management of the biosphere and its related ecosystems ("biosphere management") by examining the need for biosphere management, by reviewing current fundamental techniques of biosphere management and by adopting these techniques to conform with the biocentric perspective.

A. The Need for Management of the Biosphere

Improved management strategies are necessary on a supranational scale to deal effectively and efficiently with the concerns endangering the health and integrity of the biosphere and all its components,[6] particularly for those

[6] "A new approach is still more necessary for planetary environmental problems. ... Common to all these aspects of a deteriorating biosphere is the fact that individual States or even groups of States are unable to effectively respond . ... From these developments it is clear that environmental protection requires international legal rules considered in the framework of the entire international system. ... The problems ... correspond to the interest of communities beyond the boundaries of a single State." A-Ch. Kiss & D. Shelton, "Systems Analysis of International Law: A Methodological Inquiry" (1990) 17 Netherlands Y.B. Int'l L. 45 at 63 and 66. See also, *ibid.* at 60-67.

concerns affecting the biosphere as a whole[7]. Biosphere management adopts the principles of ecosystem management and applies them from a biocentric perspective. The purpose of ecosystem management is to "maintain and restore natural processes" and to "accommodate instability and change", given that "ecological systems evolve over time, often unpredictably".[8] The "core principles" of ecosystem management and, hence, biosphere management are the need for trans-jurisdictional, co-operative management structures; knowledge for an improved understanding of ecosystems;[9] "the preservation of

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[7] "Concept 3. In hierarchical organizations of ecosystems, species interactions that tend to be unstable, nonequilibrium, or even chaotic are constrained by the slower interactions that characterize large systems. ... Accordingly, large ecosystems tend to be more homeostatic that their components. This principle may be the most important of all, because it means that what is true at one level may or may not be true at another level or organization. Also, if we are serious about sustainability, we must raise our focus in management and planning to large landscapes and beyond." E.P. Odum, "Great Ideas in Ecology for the 1990s" (1992) 42 Biosci. 542 at 542.

[8] R.B. Keiter, "Beyond the Boundary Line: Constructing a Law of Ecosystem Management" (1994) 65 U. Colo. L. Rev. 283 at 295. "[E]cosystem management views the land and resource base in its entirety, as a holistic or integrated entity. Management focuses on entire ecosystems, not just individual resources ... . [E]cosystem management emphasizes the need for inter-jurisdictional coordination to ensure ecological integrity and sustainable resource systems." *Ibid.* See also, *ibid.* at 302.

[9] The requirement for knowledge is central for successful ecosystem management. It provides the feedback on the effect of prevention procedures so that "management strategies [can] change in response to new scientific information". D. Tarlock, "The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law" (1994) 27 Loy. L.A.L. Rev. 1121 at 1139.

biological diversity within regional fauna and flora"; widespread public involvement, and sustainable development.[10]

Of particular interest from the biocentric perspective is the lower threshold for applying constraints to human conduct evident within an ecosystem management framework. The standard of sustainability, which permits effects adverse to the interests of an ecosystem so long as the ecosystem is not irretrievably damaged, is replaced by a "nonimpairment standard, which would limit activities that might impair or damage the integrity of existing ecosystems".[11] Another significant feature of ecosystem management is the central role played by environmental impact assessment.[12]

The international community generally agrees on the need for some form of supranational ecosystem management and that, whatever the form of management, it includes within its framework both renewable and non-

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[10] Keiter, *supra*, note 8 at 302-303.

[11] *Ibid.* at 329. "[A] 'nonimpairment' standard provides more protection for ecosystem processes and affords clearer guidance for land managers. Although the concepts of nonimpairment and sustainability are inherently related, the two terms are not necessarily interchangeable. An unimpaired ecosystem is, by definition, a sustainable ecosystem, but a sustainable ecosystem might survive significant impairment." *Ibid.* at n.203.

[12] See R.B. Keiter, "NEPA and the Emerging Concept of Ecosystem Management on the Public Lands" (1990) 25 Land & Water L. Rev. 43 at 46.

renewable "resources". The need for an international management régime has been a consistent theme in international environmental law at least as far back as the Stockholm Conference of 1972. Principle 1 of the *Stockholm Declaration*[13] provides that the "natural resources of the earth ... must be safeguarded ... through careful management or planning, as appropriate";[14] Principle 4 of the *World Charter*[15] states: "Ecosystems and organisms ... shall be managed to achieve and maintain optimum sustainable productivity, ..."[16] Although supranational ecosystem management is not specifically mentioned in the *Rio Declaration*,[17] it is logically necessary for effective transborder sustainable development and for the practical implementation of Principles 7 and 8 of the *Declaration* calling, respectively, for a "spirit of global partnership"

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[13] *Declaration of the United Nations Conference on the Human Environment*, 16 June 1972, UN Doc. A/CONF.48/144 (1972), reprinted in 11 I.L.M. 1416 [hereinafter *Stockholm Declaration*].

[14] As well, Principles 4 and 5 of the *Stockholm Declaration*, *ibid.*, provide, respectively, for maintaining, restoring and improving "vital renewable resources" and for the safeguarding and wise management of "gravely imperilled" wildlife and its habitat.

[15] *World Charter for Nature*, GA Res. 37/7, UN GAOR, 34th Sess., Item No. 21, UN Doc. A/37/L.4 and Add.1 (1982), reprinted in 22 I.L.M. 455 [hereinafter *World Charter*].

[16] As well, Principles 1, 2 and 3 of *World Charter*, *ibid.*, provide, respectively, that the "essential processes of [nature] shall not be impaired"; that the Earth's species populations shall be sustained and their habitats shall be "safeguarded", and that "[a]ll areas of the earth ... shall be subject to these principles of conservation".

[17] *Rio Declaration on Environment and Development*, 14 June 1992, UNCED Doc. A/CONF.151/5/Rev. 1 (1992), reprinted in 31 I.L.M. 874 [hereinafter *Rio Declaration*].

to carry out environmental reform and for the reduction and elimination of "unsustainable patterns of production and consumption".[18]

B. Basic Principles of Biosphere Management

Biosphere management, based on respect for nature, is first and foremost a strategy for the preservation of biological entities-in-ecosystems, i.e., individual biological entities, biological species, species populations, the biological and physical components of their habitats and ecosystems, and the interrelationships among them.[19] To ensure that the inherent worth of non-human biological entities-in-ecosystems is taken into consideration, restraints are placed on human conduct to (1) avoid harm or any action that could be seriously detrimental to biological entities-in-ecosystems and (2) avoid interference with biological entities-in-ecosystems which would prevent them from fulfilling their role in nature.[20]

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[18] Principles 20 and 22 of the *Rio Declaration*, *ibid.*, in recognizing the role of women and indigenous peoples, respectively, in achieving sustainable development, acknowledge their "vital role in environmental management and development" within State jurisdictions.

[19] See Chapter II, *supra*, text accompanying notes 59-64.

[20] See *ibid.*, text accompanying notes 65-73.

For legal implementation of biosphere management States would have three mandatory obligations: (1) respect the inherent worth of all biological entities-in-ecosystems and maintain their natural processes;[21] (2) plan and conduct all projects with the objectives of protecting and preserving both the biosphere,[22] which includes all related ecosystems, and in particular its inherent worth,[23] by avoiding any adverse effects to the biosphere;[24] and (3) in conducting projects,

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[21] "[R]espect for nature entails the preservation of biological entities-in-ecosystems from present and future use by humankind". Chapter II, *supra*, text accompanying note 59. See also, *ibid.*, text accompanying notes 60-64 and *World Charter*, *supra*, note 15, Principle 1.

[22] *United Nations Convention on the Law of the Sea*, 7 October 1982, UN Doc. A/CONF.62/122 and Corr. 1 to 11. (1982), reprinted in 21 I.L.M. 1261 [hereinafter *UNCLOS*] (entry into force 16 November 1994), art. 192, states: "States have the obligation to protect and preserve the marine environment." In the law of the sea, Article 192 expresses the "primary obligation" of States, which is "given force" in Article 194 of UNCLOS. M.L. McConnell & E. Gold, "The Modern Law of the Sea: Framework for the Protection and Preservation of the Marine Environment?" (1991) 23 Case W. Res. J. Int'l L. 83 at 88, 90. Taken together, Articles 192 and 194 indicate "a fundamental shift from power to duty as the central controlling principle of the legal regime .... Whereas previously states were to a large degree free to determine for themselves whether and to what extent to control and regulate marine pollution, they will now in most cases be bound to do so on terms laid down by the Convention." A.E. Boyle, "Marine Pollution under the Law of the Sea Convention" (1985) 79 Am. J. Int'l L. 347 at 350. On Article 194 of UNCLOS, see *infra*, note 25.

[23] On inherent worth, see Chapter II, *supra*, text accompanying notes 11-16.

[24] *Protocol on Environmental Protection of the Antarctic*, 4 October 1991, ATS Doc. XI ATSCM/2/3/2 (1991), reprinted in 30 I.L.M. 1461 [hereinafter *Madrid Protocol*] (not yet in force), art. 3, para. 1 and 2(a), state:

> 1. The protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be

take all measures necessary to prevent or, if necessary, reduce and control, in as timely a manner as possible and to as great an extent as is technologically feasible, any adverse effects to the biosphere arising from all human projects, including the introduction of any potentially harmful substance into, or the implementation of any activity in, the biosphere[25].

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fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.

2. To this end:
   (a) activities in the Antarctic Treaty area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems.

Whether the provisions of Article 3 are legally binding is not clear. See J. Angelini & A. Mansfield, "A Call for U.S. Ratification of the Protocol on Antarctic Environmental Protection" (1994) 21 Ecology L.Q. 163 at 234-236.

The restrictive nature of the provisions of the *Madrid Protocol* arises from the extreme fragility of, and the lack of scientific information about, the Antarctic ecosystems. Such a régime conforms to the highly preventive orientation of biosphere management and takes into account the fact that non-human biological entities must rely on obligations imposed by humankind on itself for the prevention of harm and interference.

[25] UNCLOS, *supra*, note 22, art. 194, para.1, states: "States shall take, individually or jointly as appropriate, all measures consistent with this convention that are necessary to prevent, reduce and control pollution of the marine environment from any source, using for this purpose the best practical means at their disposal and in accordance with their capabilities, and they shall endeavour to harmonize their policies in this connection." On the effect of this provision, see *supra*, note 22. See also, *Convention on Environmental Impact Assessment in a Transboundary Context*, 25 February 1991, ECE Doc. E.ECE.1250 (1991), reprinted in 30 I.L.M. 800 [hereinafter *Espoo Convention*] (not yet in force), art. 2, para. 1: "The Parties shall, individual or jointly, take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impact [*sic*] from proposed activities."

These legal obligations provide the basis for the attribution of legal responsibility to States.[26] If the acts of a State, including those of its natural persons and corporate nationals, should breach one of these obligations, restitution would be required.[27]

C. Techniques of Biosphere Management

The basic tool of biosphere management is biosphere risk assessment, which combines the elements of environmental impact assessment and life cycle assessment. These techniques are predictive in nature, seeking to anticipate and prevent any adverse effects on the biosphere and deriving their justification from the principle of precautionary measures. Environmental impact assessment was developed to deal with activities, while life cycle

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[26] "Thus in principle an act or omission which produces a result which is on its face a breach of a legal obligation gives rise to responsibility in international law, whether the obligation rests on treaty, custom, or some other basis." I. Brownlie, *Principles of Public International Law*, 4th ed. (Oxford: Clarendon Press, 1990) at 436. "[T]he major issue in a given situation is whether there has been a breach of duty ... ." *Ibid.* at 435.

[27] "The essential principle contained in the actual notion of an illegal act -- a principle which seems to be established by international practice and in particular by the decisions of arbitral tribunals -- is that reparation must, as far as possible, wipe out all the consequences of the illegal act and re-establish the situation which would, in all probability, have existed if that act had not been committed. Restitution in kind, or, if this is not possible, payment of a sum corresponding to the value which a restitution in kind would bear; the award, if need be, of damages for loss sustained which would not be covered by restitution in kind or payment in place of it -- such are the principles which should serve to determine the amount of compensation for an act contrary to international law." *Chorzow Factory* (Indemnity) (1928), P.C.I.J., Ser. A, no. 17, at 47.

assessment was instituted as a method to deal expressly with substances and is now applied to manufactured and processed goods as well.

1. Current Techniques

(a) Environmental Impact Assessment

The procedure known as "environmental impact assessment" has been described as "a process for examining, analysing and assessing proposed activities in order to minimise environmental degradation and maximise the potential for environmentally-sound and sustainable development".[28] It was developed in the United States and has served as a basis for similar domestic legislation in more than 75 States.[29] The need for environmental impact assessment is generally recognized as an emerging principle of customary international law.[30]

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[28] Organization for Economic Co-operation and Development [hereinafter *OECD*], Environmental Directorate and Trade Directorate, Joint Session of Trade and Environment Experts, *Environmental Principles and Concepts* (Draft), 25 May 1994, para. 63, OECD Doc. COM/ENV/TD(93)117/REV1 [hereinafter *OECD Draft Principles*].

[29] N.A. Robinson, "International Trends in Environmental Impact Assessment" (1992) 19 Env. Aff. 591 at 213 and P.H. Sand, "Lessons Learned in Global Environmental Governance" (1991) 18 Env. Aff. 213 at 256.

[30] Robinson, *ibid.* at 602 and C. Klein-Chesivoir, "Avoiding Environmental Injury: The Case for Widespread Uses of Environmental Impact Assessments in International Development Projects" (1990) 30 Va. J. Int'l L. 517 at 525.

Preventive in nature[31] and linked to the principle of precautionary measures[32], environmental impact assessment is used by States and international organizations as a "basic management tool"[33] and is "one of the few environmental management tools to consider ... [the] cumulative impacts" of "the worldwide accumulation of many discrete, isolated acts"[34]. Environmental impact assessment is considered an essential method for developing adequate ecological knowledge in order to "define impacts for purposes of risk assessments"[35] and for raising "the consciousness of economic planners to environmental concerns"[36].

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[31] Environmental impact assessment "provides a process for institutionalizing foresight". Robinson, *supra*, note 29 at 590. (emphasis in original)

[32] Without sufficient knowledge gained from environmental impact assessments about the risks associated with substances and activities, the principle of precautionary measures would be applied. See e.g., H. Thiel & E.J. Foell, "Environmental Risk Assessment for Manganese Nodule Mining and Application of the Precautionary Principle" in A. Couper & E. Gold, eds, *The Marine Environment and Sustainable Development: Law, Policy, and Science* (Honolulu: Law of the Sea Institute, 1993) 226 at 227.

[33] Robinson, *supra*, note 29 at 603.

[34] *Ibid.* at 604. Cumulative impact has been defined as "the incremental and/or synergistic impacts of several projects taken together". G. Kamaras, "Cumulative Impact Assessment: A Comparison of Federal and State Environmental Review Provisions" (1993) 57 Alb. L. Rev. 113 at 113. See also, *ibid.* at 118-119. Cumulative impact assessment "is an important tool" for preventing "the capacity of the environmental media or natural resources to absorb the impacts" "from being reached". *Ibid.* at 115.

[35] Thiel & Foell, *supra*, note 32 at 226.

[36] Klein-Chesivoir, *supra*, note 30 at 518.

Various versions of the principle of environmental impact assessment may be found in a wide range of instruments of international environmental law,[37] with several non-binding instruments dedicated to the principle itself[38]. The broadest environmental impact assessment instrument to date is Annex I to the *Madrid Protocol* to the *Antarctic Treaty*[39]. Annex I is comprehensive,

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[37] See e.g., *World Charter, supra*, note 15, Principle 11(c), applied to activities that may "disturb nature" in order to "minimize potential adverse effects"; *Rio Declaration, supra*, note 17, Principle 17, applied to activities "likely to have a significant adverse impact"; *Convention on Biological Diversity*, 5 June 1992, UN Doc. UNEP/Bio.Div/N-7-INC.5/4 (1992), reprinted in 31 I.L.M. 818 [hereinafter *Biodiversity Convention*] (entered into force 29 December 1993), art. 14, applied to projects "likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such effects"; *United Nations Framework Convention on Climate Change*, 9 May 1992, UN Doc. A/AC.237/18 (Part II)/Add.1 and Corr.1 (1992), reprinted in 31 I.L.M. 851 [hereinafter *Climate Change Convention*] (entered into force 21 March 1994), art. 4, para. 1(f), applied for "minimizing adverse effects on the economy, on public health and on the environment", and UNCLOS, *supra*, note 22, art. 206, applied where "States have reasonable grounds for believing that planned activities ... may cause substantial pollution of or significant and harmful changes to the marine environment".

[38] See *Espoo Convention*, supra, note 25; *Goals and Principles of Environmental Impact Assessment*, UNEP Dec. 14/25, UNEP Doc. GC.14/17/Annex III (1987) [hereinafter *UNEP EIA Principles*]; *Recommendation Concerning An Environmental Checklist for Development Assistance*, OECD Doc. C(89)2(Final) (1989), reprinted in 28 I.L.M. 1314, and R.J.A. Goodland, "The World Bank's Environmental Assessment Policy" (1991) 14 Hastings Int'l & Comp. L. Rev. 811.

[39] "Environmental Impact Assessment", Annex I to the *Madrid Protocol*, *supra*, note 24 [hereinafter *Annex I*].

innovative[40] and addresses some, but not all, of the shortcomings of traditional environmental impact assessment procedures[41].

The typical steps taken in an environmental impact assessment are illustrated in the procedure adopted by the World Bank. It involves "screening the proposal; preparing an initial executive project summary; preparing Terms of Reference for an environmental assessment; preparing the assessment; reviewing the assessment and incorporating its findings into the project; and conducting post-project evaluation".[42] Post-project evaluation is not as widely included, but is considered "an enormously useful and innovative step".[43]

[40] See F. Francioni, "The Madrid Protocol on the Protection of the Antarctic Environment" (1993) 28 Tex. Int'l L.J. 47 at 60-70 and K.R. Simmonds, *The Antarctic Conventions* (London: Simmonds & Hill, 1993) at 23.

[41] The environmental impact assessment process has been criticized because "the scope of the process often applies only to projects, not policies, programs, new products or new technologies; it only applies to new activities, not existing ones; its science may be poor or inadequate; there exists a lack of opportunities for public involvement; there are weak links between the E.I.A. process and the decision taken about the proposal; and there is inadequate post-project analysis". P.S. Elder, "Sustainability" (1991) 36 McGill L.J. 831 at 843. Concerns also have been raised about the classes of projects which require environmental impact assessments. See Klein-Chesivoir, *supra*, note 30 at 533.

[42] Robinson, *supra*, note 29 at 603. These steps are similar to the environmental impact assessment procedures adopted in Canada and the United States. *Ibid.*

[43] *Ibid.*

The elements of an environmental impact assessment instrument usually include the obligation to assess the environmental impact of a specified project and the degree of potential adverse effects on a specified ecosystem; notification to other States of possible adverse effects of the project within their jurisdiction and control; exchange of scientific and other information on the possible adverse effects in order to evaluate these effects; independent third-party evaluation of the possible adverse effects, if the potentially affected States cannot agree; provision of a final report to be made available to potentially affected States; dispute settlement procedures; post-project analysis, and public participation in the process.[44] Other information often found in an environmental impact assessment includes possible and prohibited alternatives to the proposed project, mitigation measures and an assessment of their effect, gaps in knowledge and uncertainties uncovered, potential effect on areas beyond State jurisdiction and control, and monitoring programmes.[45]

[44] These elements are derived from the *Espoo Convention*, *supra*, note 25. See also, Robinson, *ibid.* at 608-609.

[45] This information is based on the requirements of the *Espoo Convention*, *ibid.*, and the UNEP EIA Principles, *supra*, note 38.

<u>(b) Life Cycle Assessment</u>

If a particular substance is introduced into the biosphere, there should be no risk of probability that the substance will have an adverse effect on any ecosystem during the lifetime of the substance. Where this risk is uncertain, introduction of the substance should be prevented. Life cycle assessment is a procedure which attempts to determine the risk of a substance having an adverse effect on an ecosystem. It was developed by industry, particularly the chemicals sector, in order to account for "the environmental soundness of the whole life cycle of the production process".[46]

The goal of life cycle assessment is to eliminate to the greatest extent possible, substances with adverse effects on ecosystems.[47] Such prevention is accomplished through development of clean technologies, which are "total

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[46] E.B. Weiss, "Environmentally Sustainable Competitiveness: A Comment" (1993) 102 Yale L.J. 2123 at 2138. See also, OECD Draft Principles, *supra*, note 28, para. 61. Life cycle assessment is "an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment, to assess the impact of those energy and material uses and releases to the environment, and to evaluate and implement opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials, manufacturing, transportation, and distribution, use, reuse, maintenance, recycling and final disposal". OECD Draft Principles, *ibid.* at para. 60.

[47] OECD Draft Principles, *ibid.* at para. 53.

systems for preventing pollution throughout the life-cycle of a product"[48] and which provide a means of implementing the principle of precautionary measures[49]. Still in its formative stages,[50] life cycle assessment is applied to manufactured and processed goods as well as substances.[51] It is intended to replace traditional "end-of-the-pipe" methods of environmental management[52] with a "cradle-to-grave" approach which, with its potential for recycling and reuse, could result in "cradle-to-cradle" biosphere management.[53]

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48 *Ibid.* "Key characteristics of clean technologies include: the use of as little energy and raw material inputs as possible per unit of product output; minimal releases to air, water and soil during fabrication and use of the product; the production of goods with reduced or no harmful components; and maximisation of the durability and lifetime of products and their re-usability." *Ibid.*

49 See *ibid.* at para. 54 and R.M. M'Gonigle *et al.*, "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making" (1994) 32 Osgoode Hall L.J. 99 at 161 and 165.

50 OECD Draft Principles, *ibid.* at para. 62.

51 *Ibid.* at para. 61.

52 The "end-of-the-pipe" method of environmental management prescribes levels of substances that may be introduced into the environment, and has access to enforcement powers when prescribed levels are exceeded. See generally, M'Gonigle *et al.*, *supra*, note 49 at 129-138. Levels are typically reduced only when it is certain that damage has occurred in an ecosystem. On the technical problems of "end-of-the-pipe" solutions, see *ibid.* at 149-150.

53 See OECD Draft Principles, *supra*, note 28, para. 60.

One method of life cycle assessment being developed for international application is the "prior justification" procedure.[54] Originally designed for assessing the disposal of wastes at sea,[55] this method could be modified to make it applicable to any substance which may be introduced into any ecosystem. For any substance, the effects of which on an ecosystem are unknown, an applicant is required to obtain a permit before being allowed to introduce the substance into an ecosystem.[56]

The first stage of the application procedure eliminates hazardous substances "on the basis of sound waste management principles".[57] In the second stage, an independent third party assesses applications according to the nature of the substance, the amount of reduction and prevention at source and "the availability of technologically feasible alternatives to disposal".[58] If the introduction of a substance can be prevented at source, the applicant "must

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[54] M'Gonigle *et al.*, *supra*, note 49 at 161-162.

[55] *Ibid.* at 162.

[56] *Ibid.*

[57] *Ibid.*

[58] *Ibid.* at 164.

formulate and implement a waste prevention strategy".[59] The procedure provides priorities for substance management as follows: "(1) waste prevention; (2) on-site recycling; (3) re-use; (4) destruction of hazardous constituents; (5) treatment to reduce or remove the hazard; and (6) disposal into land, air and water."[60] If disposal is indicated, "the applicant must characterize the proposed disposal method and disposal area, and assess the risk to the environment", taking into consideration available alternatives, which also must be assessed.[61] The third stage requires that an opportunity be given to other States to "object to, or comment on, the proposed disposal operation ... [stating] "what alternatives are available or why the proposed operation is considered harmful, and ... supported by scientific argument".[62]

2. Economic Incentives

(a) The Polluter Pays Principle and Environmental Cost Internalization

Biosphere management imposes additional and often unanticipated financial costs to both the public and private sectors when methods and technologies

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[59] *Ibid.* Such a strategy includes specific reduction targets and monitoring proposals. *Ibid.*

[60] *Ibid.*

[61] *Ibid.* at 165.

[62] *Ibid.*

must be developed for the prevention, reduction and control of adverse effects to the biosphere. Traditionally, the price of goods does not include the costs to the public and private sectors for clean-up, compensation and loss of natural "resource" use, which may arise from the production of goods. These costs are externalities, i.e., costs that are "external to the resource user's decisionmaking calculus".[63] Efforts are now under way to internalize environmental externalities by requiring manufacturers and producers to absorb the costs of the adverse effects on ecosystems arising from their production and processing methods. The basic method for cost internalization is expressed in the "polluter pays principle".

According to the polluter pays principle, the party responsible for the adverse effect ("the polluter") "should bear the expense of carrying out pollution prevention measures or paying for damage caused by pollution".[64] This

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[63] R.B. Stewart, "Models for Environmental Regulation: Central Planning versus Market-based Approaches" (1992) 19 Env. Aff. 547 at 547-548.

[64] OECD Draft Principles, *supra*, note 28, para. 29. The polluter pays principle "means that the polluter should bear the expenses of carrying out the ... measures decided by public authorities to ensure that the environment is in an acceptable state. In other words, the costs of these measures should be reflected in the cost of goods and services which cause pollution in production and/or consumption. Such measures should not be accompanied by subsidies that would create significant distortions in international trade and investment." "The Polluter Pays Principle: Definition, Analysis, Implementation", OECD Doc. C(72)128 (1972), cited in OECD Draft Principles, *ibid.*

principle was developed by the OECD in the early 1970s "to encourage internalization of environmental costs in price and markets and to prevent the problem of trade distortions which might result from different pollution abatement financing models".[65] Internalization of environmental costs "implies that market prices should reflect the environmental costs of the production and use of a product in terms of natural resource utilisation, pollution, waste generation, consumption, disposal and other factors".[66] Cost internalization requires that environmental costs be quantified and cost recovery allocated either directly to the consumer and the general public or indirectly through charges to the polluters.[67]

The environmental cost internalization model is not without its problems. It suffers "not only from a lack of information about the extent and probability of possible environmental damage and the impossibility of calculating the cost

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[65] C. Stevens, "The OECD Guiding Principles Revisited" (1993) 23 Env. L. 607 at 608.

[66] OECD Draft Principles, *supra*, note 28, para. 34. "The internalisation of environmental costs is one of the main objectives of environmental policy and has been a focal point of environmental economics. It underlies the conceptual and analytical work in such areas as resource pricing, use of economic instruments in environmental policy, calculation of environmental costs and benefits, and green accounting methods." *Ibid.*

[67] *Ibid.* at para. 37.

of environmental risk, but also from a marked unwillingness on society's part to bear the economic consequences of full social cost internalization".[68]

The difficulties in implementing environmental cost internalization are particularly evident in international efforts to encourage the participation of less developed countries in reducing ozone-depleting substances, greenhouse gases and deforestation.[69] However, "where no central authority exists that can identify the pollutant or the polluter or manage enforcement", the polluter pays principle cannot be implemented effectively.[70]

The polluter pays principle first appeared in an international treaty in the preamble to the *International Convention on Oil Pollution Preparedness, Response and Cooperation*, signed in London in 1990.[71] In other global environmental

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[68] E. Rehbinder, "Environmental Regulation Through Fiscal and Economic Incentives in a Federalist System" (1993) 20 Ecology L.Q. 57 at 67.

[69] U. Kettlewell, "The Answer To Global Pollution? A Critical Examination of the Problems and Potential of the Polluter-Pays Principle" (1992) 3 Colo. J. Int'l Env. L. & Pol'y 429 at 474-477.

[70] Kettlewell, *ibid* at 477.

[71] 30 November 1990, reprinted in 30 I.L.M. 735. See H. Smets, "The Polluter Pays Principle in the Early 1990s" in Luigi Campiglio *et al.*, eds, *The Environment after Rio: International Law and Economics* (London: Graham & Trotman, 1994) 131 at 133. On the legal history and development of the polluter pays principle, see *ibid.* at 131-133 and Kettlewell, *supra*, note 69 at 431-437. On initiatives to review the principle, see Stevens, *supra*, note 65.

instruments, however, only Principle 16 of the *Rio Declaration*[72] addresses the polluter pays principle and the "broader" principle[73] of internalization of environmental costs.

A significant legal effect of the polluter pays principle is its implication that polluters are subject to strict liability for any adverse effect on ecosystems for which they are responsible. In the field of liability for "maritime environmental impairment", strict liability has been adopted and is viewed as an "effective application" of the polluter pays principle[74]. Because the polluter is responsible for the costs arising from his or her actions, strict liability is seen as a deterrent for conduct which causes or is likely to cause pollution and as

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[72] Principle 16 of the *Rio Declaration, supra*, note 17, states: "National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment." For an analysis of Principle 16, see Smets, *ibid.* at 136-141.

[73] Smets, *ibid.* at 134.

[74] P. Wetterstein, "Trends in Maritime Environmental Impairment Liability" [1994] 2 Lloyd's Mar. & Com. L.Q. 230 at 242. The liability aspects of the polluter pays principle have been raised with the International Law Commission. International Law Commission, *Ninth Report on International Liability for Injurious Consequences Arising Out of Acts Not Prohibited by International Law*, UN GAOR, 45th Session, para. 75, UN Doc. A/CN.4/450 (1993).

"the best incentive to take all necessary caution".[75] As well, fault-based liability does "not effectively deal with environmental pollution and the resulting harm".[76] Damages could include all costs,[77] including those arising from accidental adverse effects.[78] In this regard, it is interesting to note that the polluter pays principle is conspicuously absent from the more recent binding treaty instruments, such as the *Ozone Convention*,[79] the *Biodiversity Convention*[80] and the *Climate Change Convention*[81].

To assist in environmental cost internalization, incentives are offered for the development of the clean technology and processes necessary to prevent,

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[75] D. Wilkinson, "Moving the Boundaries of Compensable Environmental Damage Caused by Marine Oil Spills: The Effect of Two New International Protocols" (1993) 5 J. Env. L. 71 at 80.

[76] Kettlewell, *supra*, note 69 at 465.

[77] Smets, *supra*, note 71 at 134. As interpreted in the *Rio Declaration*, "environmental costs" include the costs arising from pollution prevention, reduction and control: damage to third parties, including victims of pollution; ecological damage, which includes "damage to the environment in general, to the ecological system, compensation to public authorities for residual damage [and] fines for excessive pollution", and environmental costs of internalization. *Ibid.*

[78] See Smets, *ibid.* at 140-141 and 143.

[79] *Vienna Convention for Protection of the Ozone Layer*, 22 March 1985, UN Doc. UNEP/IG.535 (1985), reprinted in 26 I.L.M. 1516 [hereinafter *Ozone Layer Convention*] (entered into force 22 September 1988).

[80] *Supra*, note 37.

[81] *Supra*, note 37.

reduce and control the adverse effects of activities and substances on ecosystems. These incentives include subsidies, the traditional means of support, as well as market-based and regulatory approaches.

(b) Subsidies

Although internalization of environmental costs was developed to eliminate subsidization of development activities and of the production of goods, exceptions are made to promote the prevention, reduction or control of adverse effects caused by production and development.[82] The European Community, e.g., "allows environmental subsidies to facilitate the implementation of new environmental standards if this assistance does not exceed 15 per cent of the investment and is granted only to firms in operation for two years".[83] Generally, the experience within the European Community is that intra-State

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[82] Stevens, *supra*, note 65 at 608-609. "Governmental assistance for pollution control might be given: 1) to ease transition periods when especially stringent pollution control regimes are being implemented; 2) to stimulate the development of new pollution control technologies; and 3) in the context of measures to achieve specific socio-economic objectives, such as the reduction of serious interregional imbalances. Any assistance granted under the OECD exceptions should be given for a fixed amount of time in a clearly defined program and should not create significant distortions in international trade and investment." *Ibid.* at 609. See also, Smets, *supra*, note 71 at 137-140.

[83] OECD Draft Principles, *supra*, note 28, para. 31. See also, Smets, *ibid.* at 139 and Stevens, *ibid.* at 609-610.

subsidies are rare, with individual States preferring to finance programs without the financial support of other Community members.[84]

(c) Other Incentives

Other methods for cost internalization are market-based schemes and government regulation. Market-based incentives, also known as economic instruments,[85] "impose a tax or an equivalent price incentive ... to reduce pollution" in order to meet government-set standards.[86] With public regulation, governments "instruct each resource user on exactly how to operate its activities" by means of performance standards which "require resource users to achieve a given, uniform level of environmental performance but allow them some flexibility in choosing the specific technology to achieve that performance".[87]

While each approach has its supporters, both are necessary because experience shows that environmental laws are most effective when combined with

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[84] Smets, *ibid* at 141. For examples of intra-State subsidies, see *ibid.* at 142-143.

[85] OECD Draft Principles, *supra*, note 28, para. 38.

[86] Stewart, *supra*, note 63 at 548.

[87] *Ibid.*

economic incentives.[88] Government enforcement of standards is the most important "weapon in preventing environmental degradation"[89] and may be necessary until adequate information is available on the adverse effects of substances and processes[90]. Where appropriate, the two forms of incentive can be combined for effective results.[91]

(i) Market-based Incentives

Available market-based incentives include environmental taxes, environmental user charges, deposit-refund systems, tradeable emission permits, eco-labelling and financial assistance.

The theory underlying environmental taxes and other charges is "that each emitter will reduce its emissions to the point that its costs of control become as

[88] See P. Weinberg, "Environmental Protection in the Next Decades: Moving from Clean Up to Prevention" (1994) 27 Loy. L.A.L. Rev. 1145 at 1147.

[89] *Ibid.*

[90] Stewart, *supra*, note 63 at 554-555.

[91] See e.g., *ibid.* at 555 and J.B. Nicholson, "European Economic Community -- Environmental Policy -- Economic and Fiscal Instruments -- Report of the Working Group of Experts from the Member States Proposes the Use of Economic and Fiscal Instruments to Attain Community-wide Environmental Goals" (1991) 21 Ga. J. Int'l & Comp. L. 285 at 290.

expensive as paying the tax ...".[92] Such a tax could be assessed against substances proportional to the extent that they adversely affect ecosystems.[93] Environmental tax proposals include a levy on vehicles and other machinery according to the degree of pollutant emissions[94] and a charge analogous to a value-added tax, which would internalize the cost of pollution at each stage of the manufacturing or production process[95].

A variation on the environmental tax is the "user pays principle" which provides that "the user of a public facility, or consumer of a public good, pays for the environmental good or service or the damages which may arise from that use".[96] Such fees could be charged for the use of public facilities, such as national parks and game land preserves, and to cover the costs of preserving and maintaining wilderness areas and forests where harvesting is prohibited.[97] Overlapping somewhat with environmental tax schemes, consumer "users"

[92] Stewart, *ibid.* at 552.

[93] See Sand, *supra*, note 29 at 257; Kettlewell, *supra*, note 69 at 468, and Nicholson, *supra*, note 91 at 289-290. For an overview of pollution taxes, see Sand, *ibid.* at 257-259.

[94] Nicholson, *ibid.* at 291.

[95] Kettlewell, *supra*, note 69 at 469 and Nicholson, *ibid.* at 303.

[96] OECD Draft Principles, *supra*, note 28, para. 39.

[97] *Ibid.*

could be charged for the environmental costs arising from the use of non-renewable "resources".[98] User-pay schemes have also been proposed for the disposal of wastes in public landfills.[99] Internationally, "attempts are being made to extend the user pays principle to shared resources and the global commons".[100]

A deposit-refund system combines a user fee with a subsidy. Under this scheme, polluters pay a government fee "for each unit of pollutant generated; when they properly treat and dispose of the waste, they receive a refund".[101] Deposit-refund systems could be applied to emissions from all modes of transportation. The fee would be returned to owners who employ clean technology.[102]

Another incentive for industry to develop clean technology is the tradeable allowance concept. For this scheme to work, government "imposes a limit on

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[98] See *ibid.* and Nicholson, *supra*, note 91 at 289-290.

[99] See e.g., Frank Ackerman, "Waste Management -- Taxing The Trash Away" (June 1992) Env't 2 at 2.

[100] OECD Draft Principles, *supra*, note 28, para. 40.

[101] Stewart, *supra*, note 63 at 553.

[102] Nicholson, *supra*, note 91 at 291.

the total quantity of emissions, issues allowances adding up to that total, and then allows emitters to buy and sell allowances among each other".[103] Emissions must not exceed the government limit; if they do, heavy penalties are imposed on transgressors.[104] Under tradeable allowance schemes, polluters can meet the government limits "either by reducing emissions or by buying 'emissions credits' from other polluters that have reduced emissions in excess of their obligations."[105] An innovative variation on tradeable allowances is the proposal for an environmental credit card: "Each citizen of the global community would receive a specified amount of pollution rights, which, if exceeded, would subject him to pollution liability."[106]

Eco-labelling is a co-operative program between government and industry for indicating to consumers which producers make an effort to prevent, reduce or control adverse effects on ecosystems during the production and packaging of their goods. The standards for necessary effort are set by government: labels,

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[103] Stewart, *supra*, note 63 at 553.

[104] *Ibid.*

[105] J.P. Dwyer, "The Use of Market Incentives in Controlling Air Pollution: California's Marketable Permits Program" (1993) 20 Ecology L.Q. 103 at 104. See also, C.W. Howe, "Tradable Discharge Permits: Functioning, Historical Applications, and International Potential" (1993) 4 Colo. J. Int'l Env. L. & Pol'y 370.

[106] Kettlewell, *supra*, note 69 at 470.

provided to producers who meet the government standards, are placed on consumer goods; consumers may choose to purchase these goods because of their "environmentally-friendly" quality.[107] Countries with eco-label programs include Canada, Germany and Japan; Scandinavian countries, through the Nordic Council, apply the program regionally.[108] Eco-labels have been criticized for having standards which are too subjective[109] and for imposing non-tariff barriers to trade[110].

Of the financial assistance incentives available, debt-for-nature swaps and international financing of ecologically appropriate projects illustrate efforts on a global scale to eliminate and reduce adverse effects of pollutants. Debt-for-nature swaps occur when private or government creditors "reduce the debts of developing countries in exchange for environmental conservation measures".[111]

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[107] See *ibid.* at 469 and Sand, *supra*, note 29 at 259-261.

[108] Sand, *ibid.* at 261.

[109] Kettlewell, *supra*, note 69 at 469.

[110] M. Reiterer, "The International Legal Aspects of Process and Production Methods" (1994) 17 World Comp. L. & Econ. Rev. 111 at 120-121.

[111] M.S. Sher, "Can Lawyers Save the Rain Forest? Enforcing the Second Generation of Debt-for-Nature Swaps" (1993) 17 Harv. Env. L.J. 151 at 151. In 1984, the World Wildlife Fund "proposed a scheme by which conservation organisations 'bought' a portion of a debtor's obligation, from a commercial bank on the market, at less than face value. This obligation was then converted into bonds in the currency of the debtor state. at something less than the original debt. These funds were then used by the local

The *rationale* for the swaps is that debt in less developed countries is a basic cause of ecological degradation.[112] Debt-for-nature swaps may not be the most effective means for promoting conservation; direct financing may be a more appropriate alternative. [113]

A notable example of a direct financing incentive which contributes specifically to environmental cost internalization is the Global Environment Facility, established as a three-year pilot program in 1991[114]. The Facility provides "grants or concessional loans ... to developing countries to help them implement programs that protect the global environment".[115] Assistance is available for large-scale technical and assistance projects and for smaller, "innovative" grant projects implemented by non-governmental organizations

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environmentalist groups for conservation purposes". L.C.W. Wee, "Debt-for-Nature Swaps, a Reassessment of their Significance in International Environmental Law" (1994) 6 J. Env. L. 57 at 58.

[112] Wee, *ibid.*

[113] See M.L. Minzi, "The Pied Piper of Debt-for-Nature Swaps" (1993) 17 U. Pa. J. Int'l Bus. L. 37.

[114] A. Wood, "The Global Environment Facility Pilot Phase" (1993) 5 Int'l Env. Aff. 218 at 219.

[115] "World Bank: Documents Concerning the Establishment of the Global Environment Facility" (1991) 30 I.L.M. 1735 at 1739 [hereinafter *World Bank Documents*].

and community groups.[116] Financing is available for projects related to protection of the ozone layer, limiting emissions of greenhouse gases, protection of biodiversity and protection of international waters.[117] The program was renewed in 1994.[118]

(ii) Government Regulation

The three most common forms of government regulation particularly applicable in international environmental law are standard setting, licence or permit programs, and lists.[119]

While market-based approaches provide important incentives, a need still exists for international standard setting: (1) "[T]here may be certain minimum levels of environmental protection and natural resource conservation which should shape the development process";[120] (2) minimum standards "help to

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[116] Wood, *supra*, note 114 at 219-225.

[117] World Bank Documents, *supra*, note 115 at 1739-1740.

[118] M.G. Schnerre, "The Restructured World Bank Facility" (June-August 1994) ASIL Newsletter 14 at 15.

[119] A. Kiss & D. Shelton, *International Environmental Law* (Ardsley-on-Hudson, NY: Transnational Publishers, 1991) at 155.

[120] Weiss, *supra*, note 46 at 2134.

resolve the potential tension" between present and future generations;[121] (3) "experts clearly believe that effective action ... can only be achieved through [transnational] action;[122] and (4) without standards, polluters in States with higher standards incur greater production costs and suffer a corresponding loss of competitiveness[123].

Four classes of standards can be distinguished: quality standards, which "fix the maximum levels of pollution"; emission standards, which "specify the quantity of pollutants, or their concentration in discharges, which can be emitted by a given source"; process standards, which "establish certain specifications applicable to fixed installations", and product standards, which "fix the physical or chemical composition of items".[124] Of these, international standards for processes and products may have a legal effect in international environmental law.[125]

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[121] *Ibid.*

[122] Nicholson, *supra*, note 91 at 300. See also, *ibid.* at 300-301.

[123] See Kettlewell, *supra*, note 69 at 447 and Reiterer, *supra*, note 110 at 124.

[124] See Kiss & Shelton, *supra*, note 119 at 158-159.

[125] "Principle 11 [of the *Rio Declaration*, *supra*, note 17] calls upon States to enact effective environmental legislation which is to be understood in the light of Principle 15, where the precautionary approach for the protection of the environment is advocated. ... Principle 16, calling for the internalization of environmental costs and the use of economic instruments, introduces indirectly the polluter-pays principle. ... [P]ollution can

International standards can be flexible to a certain extent in order to reflect "the fact that expected benefits and costs of any regime will vary from state to state".[126] Such asymmetrical standards are used "to induce broad state acceptance of a regulatory regime".[127] In matters of international environmental law, the techniques of asymmetrical standard-setting include selective incentives, such as access to funding, resources, markets and technology; differential treaty obligations according to each party's circumstances; regional solidarity, where regional groups can more easily achieve a common standard and more easily off-set asymmetries, and promotion of over-achievement by setting national standards above the minimum international level.[128]

Public regulation by licensing prohibits activities unless a government permit has been issued. For international environmental law, permits can be general

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often arise at the production level. Thus Principles 11, 15 and 16 of the *Rio Declaration*, when read together, could be interpreted as a strong indication that not only product but also process and production standards are legally relevant." Reiterer, *supra*, note 110 at 118-119.

[126] G. Handl, "Environmental Security and Global Change: The Challenge to International Law" in W. Lang, H. Neuhold & K. Zemanek, eds, *Environmental Protection and International Law* (London: Graham & Trotman, 1991) 59 at 64.

[127] *Ibid.*

[128] See Sand, *supra*, note 29 at 220-236.

and applied to an entire class of activities, such as waste disposal, or specific and applied on a case-by-case basis, e.g., for a specific substance or project.[129] Licences, when issued by international organizations, "provide for the reciprocal recognition ... by competent national authorities".[130] Alternatively, reciprocal licensing could take place on a regional or bilateral level.

Lists are characteristic of international environmental law, permitting substances to be classified according to their individual characteristics and giving the regulations some flexibility.[131] The use of lists is quite common in the law of the sea regarding the introduction of substances into bodies of water.[132]

3. Biosphere Risk Assessment

Biosphere risk assessment is a predictive technique combining elements of environmental impact assessments and life cycle assessments. It is premised

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[129] See Kiss & Shelton, *supra*, note 119 at 155-156 and M'Gonigle *et al.*, *supra*, note 49 at 151.

[130] Sand, *supra*, note 29 at 250.

[131] Kiss & Shelton, *supra*, note 119 at 156.

[132] *Ibid.* at 157-158. Lists are also widely used in international instruments for the protection of wildlife. *Ibid.*

upon the biocentric moral perspective set out in Chapter II and incorporates the four basic principles of international environmental law set out in Chapter III and the three legal obligations for biosphere management set out in Section B above. Biosphere risk assessment represents a global approach to managing the adverse effects of humankind's projects on all biological entities-in-ecosystems. It is intended to apply to all projects in all ecosystems, with modifications, where necessary, according to the nature of the activity, the ecosystem and the adverse effects. The basic elements of the procedure for biosphere risk assessment are set out below and are worded as if the process were operational.

(a) Scope and Administration

Any proposed project, and any change to an existing or proposed project, is subject to a biosphere risk assessment.[133] To ensure preservation and protection of the ecosystem project site and any related ecosystems, permission to undertake a project will not be granted unless the assessment process has been completed and approved.[134]

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[133] See *Madrid Protocol*, *supra*, note 24, art. 8, para. 1, 2 and 3, and *World Charter*, *supra*, note 15, Principle 1.

[134] See *Madrid Protocol*, *ibid.* at art. 3, para. 2(c).

The procedures required for biosphere risk assessment are set by an independent international decision maker ("the administrator") according to scientifically-based standards. The administrator is responsible for evaluating project proposals to determine whether a proposed project should proceed, be deferred or be rejected. Such an administrator is necessary in order to ensure

> greater impartiality and objectivity; greater capability for an assessment of the overall environmental risk, taking into account the possible synergic effects of the various [projects]; and the possibility of an external control and supervisory system able to authorize emergency measures and precautionary suspension of activities.[135]

Without an independent administrator it is possible that the assessment process will be viewed as "cosmetic" legitimization for projects with adverse effects[136] and that the decisions taken will not be enforced[137]. International standards, set by independent experts drawn from the relevant fields, provide (i) the basis for determining whether the potential adverse effects of proposed projects are uncertain; (ii) in cases where projects are permitted, what levels of protection are required to avoid adverse effects; and (iii) what additional measures are necessary to prevent anti-competitive conduct and trade

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[135] Francioni, *supra*, note 40 at 65.

[136] *Ibid.* at 65-66.

[137] E.F. Foreman, "Protecting the Antarctic Environment: Will a Protocol Be Enough?" (1992) 7 Am. U. J. Int'l L. & Pol'y 843 at 879.

distortions, both of which could arise from the use of State-imposed standards.[138]

(b) The Assessment Process

The assessment process has two stages, a screening stage followed by a comprehensive review. In cases where the adverse effects of any proposed project on an ecosystem are uncertain, the administrator's determinations at each stage are guided by the principle of precautionary measures. The effect of a determination is either to defer the project until its uncertainties are overcome or to terminate it.

(i) Screening Stage

At the screening stage, the appropriateness of the project is evaluated according to the biocentric *prima facie* moral duties.[139] The purpose of this evaluation is to ascertain the nature of the human interests which the proposed project promotes and whether the interests promoted conflict with the basic interests of non-human biological entities-in-ecosystems.[140]

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[138] See *supra*, text accompanying notes 120-123, and n.82.

[139] See Chapter II, *supra*, text accompanying notes 60-78.

[140] Basic interests include, as appropriate to the biological entity, food, water, shelter, security, love, play, creative expression, intimate relationships with nature and spiritual

If the proposed project promotes an exploitive non-basic interest[141] and conflicts with the basic interests of non-biological entities-in-ecosystems, the proposed project is rejected.[142]

If the proposed project promotes a non-exploitive non-basic interest[143] and conflicts with the basic interests of non-biological entities-in-ecosystems, the project is permitted if the project developer demonstrates that the project will "promote and preserve the instrumental, intrinsic or inherent values of central importance to the community"[144], and agrees to take all necessary steps to ensure that the project will result in the least intrusive adverse effects ("minimum impairment") and to make full restitution for any impairment incurred.[145]

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growth. See *ibid.*, text accompanying notes 81-85.

[141] Exploitive non-basic interests generally involve killing and destruction of biological entities-in-ecosystems solely for private gain. See *ibid.*, text accompanying notes 86-87.

[142] See *ibid.*, text accompanying note 90.

[143] Non-exploitive non-basic interests generally demonstrate a purpose in the public interest. See *ibid.*, text accompanying notes 88-89.

[144] See *ibid.*, text accompanying note 91.

[145] See *ibid.*, text accompanying notes 92-93.

If the proposed project promotes a basic human interest and conflicts with the basic interests of non-human biological entities-in-ecosystems, the project will be permitted if the project developer provides information to demonstrate that the conflict is unavoidable[146], and agrees to take all necessary steps to ensure that the subject matter of the conflict will, where possible, be shared equitably; that the project will result in minimum impairment; and that full and appropriate restitution will be made[147].

(ii) Comprehensive Review Stage

The comprehensive review stage determines whether the proposed project has addressed the issues of minimum impairment and appropriate restitution. Whether a project minimally impairs an ecosystem, including any biological entities in it, is determined by reviewing the proposed project, the nature of the proposed ecosystem project site, the possible adverse effects of the project and the measures taken to eliminate or mitigate, to as great an extent as possible, those effects. Restitution is determined according to the nature of the adverse effect.

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[146] See *ibid.*, text accompanying notes 95-96.

[147] See *ibid.*, text accompanying notes 97-98.

Information submitted on the question of minimum impairment will include all methods and data on which conclusions are based;[148] will identify "gaps in knowledge and uncertainties encountered in compiling the information",[149] and will provide a "non-technical summary" for public comment[150]. The information required for the comprehensive review is as follows:

<u>The Project</u>

(a) a comprehensive description of the proposed project, "including its purpose, location, duration and intensity";[151]

(b) a comprehensive description of all reasonable alternatives to the proposed project, including the alternative of "not proceeding";[152] and

(c) where a proposed project includes the introduction into an ecosystem of any substances, the adverse effects of which are unknown, a life cycle assessment for those substances.[153]

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[148] See Annex I to the *Madrid Protocol*, *supra*, note 39, art. 3, para. 2(c).

[149] See *ibid.* at art. 3, para. (2)(j).

[150] See *ibid.* at art. 3, para. (2)(k) .

[151] See *Madrid Protocol*, *supra*, note 24, art. 3, para. 2(c)(i) and Annex I, *ibid.* at art. 3, para. 2(a).

[152] See *ibid.*

[153] See *supra*, text accompanying notes 56-62.

The Ecosystem

(a) a comprehensive description of the proposed ecosystem project site;[154] and

(b) a comprehensively documented prediction of the future state of the ecosystem in the absence of the proposed project.[155]

Adverse Effects

(a) a comprehensive description of any potential adverse effects of the proposed project and of its alternatives on the proposed ecosystem project site and on any other ecosystem, along with the predicted consequences;[156]

(b) a comprehensive description of any potential cumulative adverse effects arising both from the various aspects of the project itself and in combination with other "existing and known planned" projects;[157] and

(c) a comprehensive description of any unavoidable adverse effects of the proposed project.[158]

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[154] See Annex I, *supra*, note 39, art. 3, para. 2(b).

[155] See *ibid.*

[156] See *ibid.* at art. 3, para. 2(a).

[157] See *Madrid Protocol*, *supra*, note 24, art. 3, para. 2(c)(ii) and Annex I, *ibid.* at art. 3, para. (2)(f). See also, *supra*, n.34.

[158] See Annex I, *ibid.* at art. 3, para. 2(h).

Mitigation

(a) where the potential adverse effects of the project include the death or destruction of any biological entities, a comprehensive description of the alternatives to killing which would promote the human interests in undertaking the project and would, at the same time, result in minimal killing or destruction;[159]

(b) where the potential adverse effects include harm to habitats, a statement explaining why less intrusive, more naturally integrative alternatives are not feasible;[160]

(c) where substances are to be introduced into ecosystems, a comprehensive description of the technical design and operational processes being developed to minimize the adverse effects of the substance in the short-term and to eliminate the substances, to as great an extent as possible, in the long-term;[161] and

(d) where the potential adverse effects give rise to an unavoidable conflict between the basic interests of human and non-human biological entities, a

[159] See Chapter II, *supra*, text accompanying notes 109-111.

[160] See *ibid.*, text accompanying notes 112-118.

[161] See *ibid.*, text accompanying notes 119-126.

comprehensive description of the plan for achieving equitable sharing and minimal impact.[162]

Waste Management

(a) a comprehensive description of the elements of the waste management plan, including waste reduction, storage, removal, recycling, re-use and final disposal;[163]

(b) a comprehensive description of programs "for cleaning up existing waste disposal sites and abandoned work sites", and for analysing and minimizing the adverse effects of waste;[164] and

(c) a comprehensive description showing how the waste management plan reduces the disposal of wastes "as far as practicable so as to minimize" any adverse effects on the ecosystem and to "minimize interference with" the inherent worth of the ecosystem.[165]

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[162] See *ibid.*, text accompanying note 127. These strategies include wilderness preservation, restoration, rotation, common conservation and design with nature. *Ibid.*, text accompanying notes 128-143.

[163] See *Waste Disposal and Waste Management*, Annex III to the *Madrid Protocol*, *supra*, note 24, art. 1, para. 3 and art. 8, para. 1 and 2(b) [hereinafter *Annex III*].

[164] See *ibid.* at art. 8, para. 2(a), 2(c) and 2(d).

[165] See *ibid.* at art. 1, para. 2.

Clean Technology and Environmental Cost Internalization

(a) a comprehensive description of the research and development being undertaken, or proposed to be undertaken, in conjunction with the proposed project for development and implementation of clean technologies and processes, which are intended to prevent, reduce and control the potential adverse effects of the proposed project on the proposed ecosystem project site; and

(b) a comprehensive description of the cost incentives available from the sponsoring State or other sources for the internalization of environmental costs arising from the research, development and implementation of these clean technologies and processes.[166]

Monitoring

(a) a comprehensive description of the "regular and effective" monitoring procedures to be implemented in order to "assess the impacts of ongoing activities, including the verification of predicted impacts", and to provide for the "early detection of the possible unforeseen effects of activities";[167] and

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[166] See *supra*, Section C.2(c).

[167] See *Madrid Protocol*, *supra*, note 24, art. 3, para. 2(d) and 2(e).

(b) a comprehensive description of the monitoring procedures to "identify and provide early warning of any adverse effects",[168] and to "assess and verify" any adverse effects.[169]

Post-Project Analysis

(a) a comprehensive description of procedures for detecting and minimizing or mitigating any unforeseen adverse effects, for monitoring compliance with the conditions for project approval, for monitoring the effectiveness of mitigation measures in the approved plan, for verifying "past predictions" for future use, and for providing early warning of, and effective response to, accidents.[170]

Restitution

(a) where potential adverse effects are expected to result in harm to individual non-human biological entities, a comprehensive description of the rehabilitation plan or, in case of the death or destruction of individual non-human biological entities, a comprehensive description of the plan for preserving the remaining species population and its habitat;[171]

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[168] See *ibid.* at art. 3, para. (2)(c)(v).

[169] See Annex I, *supra*, note 39, art. 5.

[170] See *Madrid Protocol*, *supra*, note 24, art. 3, para. 2(c)(v) and Annex I, *ibid.* at art. 3, para. 2(g). See also, *Espoo Convention*, *supra*, note 25, art. 7 and Appendix V.

[171] See Chapter II, *supra*, text accompanying note 151.

(b) where potentially adverse effects are expected to result in the destruction or the impossibility of regeneration of a species population, a comprehensive description of the plan for permanent protection of all remaining members of the species or for limited protection until the species re-establishes itself;[172] and

(c) where potentially adverse effects are expected to partially destroy or otherwise interfere with a habitat or ecosystem, a comprehensive description of the plan to restore the habitat or ecosystem to its original state, or if totally destroyed, the plan to preserve the natural existence of non-human biological entities in a habitat or ecosystem of the same or similar type.[173]

Liability

Where a proposed project results in adverse effects unforeseen at the time of the biosphere risk assessment,

(a) a comprehensive description of the steps to be taken by the sponsoring State for the "regular and verifiable" collection of information which could be used for the timely modification, suspension or cancellation of the project, in

[172] See *ibid.*, text accompanying notes 152-153.

[173] See *ibid.*, text accompanying notes 154-157.

order to eliminate, to as great an extent as possible, the unforeseen adverse effects;[174] and

(b) a comprehensive description of the means by which the sponsoring State will pay all costs arising from the unforeseen adverse effects.[175]

Third Parties

(a) a draft, including a non-technical summary, of the comprehensive review for public comment;[176] and

(b) a comprehensive description of any potential adverse effects of the proposed project which may occur outside the area within the jurisdiction and control of the State sponsoring the project.[177]

(c) Settlement of Disputes

During the course of a biosphere risk assessment, disputes will likely arise between the project developer and the general public or other private interests

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174 See Annex I, *supra*, note 39, art. 5, para. 2(a).

175 See *supra*, text accompanying notes 74-78.

176 See Annex I, *supra*, note 39, art. 3. The public comments are taken into account by the administrator in the decision-making process.

177 Where adverse effects may occur outside the jurisdiction of the sponsoring State, other States are given the opportunity to comment on and object to the proposed project by indicating, based on scientific reasoning, other potential adverse effects and other available alternatives and mitigation measures. See *supra*, text accompanying note 62. On third-party notification procedures, see *Espoo Convention*, *supra*, note 25, art. 3.

within the State, or between the sponsoring State and other States and international organizations with common biospheric concerns. Those opposing a proposed project will allege that the ecosystems for which they are responsible may be adversely affected by the project. The most common disputes will likely address disagreements over screening stage decisions, the availability and appropriateness of alternatives to the proposed project, potential adverse effects and the choice and effectiveness of mitigation or restitution measures.

In light of this eventuality, a procedure for the settlement of disputes will be made available.[178] The disputes will be adjudicated by a panel of experts, not connected to the biosphere risk assessment in issue. The members of a panel will be drawn from a roster of experts, consisting of one national from each State, experienced in biosphere risk assessment.[179] A panel will consist of three members, with the parties to the dispute each appointing one member and the two designated members agreeing on the third member, who will chair the

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[178] See e.g., *Madrid Protocol*, *supra*, note 24, Schedule on Arbitration [hereinafter *Arbitration Schedule*]. See also, *Espoo Convention*, *ibid.* at Appendix IV: Inquiry Procedure [hereinafter *Inquiry Procedure*].

[179] See e.g., Arbitration Schedule, *ibid.* at art. 2, para. 1.

panel.[180] A panel will be empowered to decide what course of action best reflects a respect for nature, the fundamental biocentric moral imperative, and the principles for resolving conflicts between human interests and the basic interests of non-human biological entities.[181] To avoid undue delays, the decision of a panel will be final and binding.[182]

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[180] See e.g., *ibid.* at art. 3, para. 1 and Inquiry Procedure, *supra*, note 178, para. 2.

[181] See Chapter II, *supra*, text accompanying notes 101-104.

[182] See Arbitration Schedule, *supra*, note 178, art. 11, para. 3.

PART THREE: APPLICATION OF THE PRINCIPLES AND PRACTICE OF INTERNATIONAL ENVIRONMENTAL LAW TO SPACE ACTIVITIES

Part I set out the physical parameters of humankind's activities in outer space and described the moral perspectives applicable to international environmental law. Part II analysed the basic principles of international environmental law in order to develop a biocentric approach to addressing environmental issues and described the general principles and techniques of a proposed régime for biosphere management. The purpose of Part III is to apply the régime for biosphere management to humankind's space activities.

Chapter V analyses the current provisions for environmental protection in the international law of outer space in order to determine the principles of environmental space law and to ascertain what restrictions, if any, these principles impose on a biocentric approach to protection of the planetary environment and biosphere management. Chapter VI describes a proposed protocol to the *Outer Space Treaty* on the protection and preservation of the planetary environment from humankind's space projects. Chapter VII applies a biosphere risk assessment to humankind's space projects in order to provide a remedy for space debris, the first major adverse effect on the global and outer space environments arising from space activities.

CHAPTER V: ENVIRONMENTAL PROTECTION IN INTERNATIONAL SPACE LAW

International space law originated in the early 1960s with debate in the United Nations regarding the development of general principles to govern humankind's activities in outer space and on the Moon and other celestial bodies ("outer space"). This process culminated with the adoption of the *Outer Space Treaty*, which will celebrate the 30th anniversary of its entry into force on 10 October 1997.

The purpose of this chapter is to determine to what extent international space law provides for the environmental protection of outer space, the Moon and other celestial bodies. The thesis of this chapter is two-fold: (1) the moral perspective of enlightened anthropocentrism coloured the development of the principles of environmental law for application to humankind's activities in outer space; and (2) the adoption of this human-centred moral perspective resulted in principles of space law for environmental protection which are overwhelmingly geared toward a utilitarian view of outer space as a natural "resource", to be developed and sustained for the ultimate benefit of humankind.

The evolution of Article IX of the *Outer Space Treaty*[1] will be examined in some detail because it is the basic provision in international space law for environmental protection. Applicable provisions in the *Moon Agreement*[2] and other legal instruments relating to space law will also be considered.

A. Environmental Protection in Outer Space, on the Moon and on Other Celestial Bodies

1. Enlightened Anthropocentrism in the Space Science Community

The attitude of the scientific community toward outer space during the early years of space exploration and use is of seminal importance. How scientists valued outer space had a significant influence on the drafters of outer space law in general and Article IX of the *Outer Space Treaty* in particular.

[1] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 27 January 1967, Can. T.S. 1967 No. 19, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 [hereinafter *Outer Space Treaty*] (entered into force 10 October 1967).

The first version of the material in Sections A-C of this chapter originally appeared in H.A. Baker, "Protection of the Outer Space Environment: History and Analysis of Article IX of the Outer Space Treaty" (1987) 12 Ann. Air & Sp. L. 143.

[2] *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, 18 December 1979, 1363 U.N.T.S. 3 [hereinafter *Moon Agreement*] (entered into force 11 July 1984).

Shortly after the 4 October 1957 launching of Sputnik I, the question of environmental harms caused by outer space activity was raised.[3] However, the major scientific bodies involved in space activities were concerned with protecting the outer space environment only insofar as it affected the interests of their professional endeavours.

The scientific community in the late 1950s regarded outer space "essentially as a pure scientific laboratory",[4] although it also recognized the possibility that harmful effects could result from experiments in outer space[5]. Consequently, to protect the unique research opportunities ushered in by the space age, the International Council of Scientific Unions ("ICSU"), a non-governmental organization composed of representatives of international scientific unions and national scientific organizations, established the Committee on Contamination by Extraterrestrial Exploration ("CETEX").[6] That committee drew attention to the fact that "early exploration attempts or ill-considered experiments ... might

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[3] I. Szilagyi, "Protection of the Outer Space Environment: Questions of Liability" (1982) 25 Colloq. L. Outer Sp. 53 at 53.

[4] C.Q. Christol, *The Modern International Law of Outer Space* (New York: Pergamon Press, 1982) at 131.

[5] I.A. Vlasic, "The Growth of Space Law 1957-65: Achievements and Issues" [1965] Air & Sp. L. 365 at 391-392.

[6] Christol, *supra*, note 4 at 132.

result in biological, chemical or radiological contamination of the lunar or planetary surfaces such as to complicate or render impossible further studies of scientific importance".[7] CETEX sought to discourage space activities which could not create or convey meaningful data, while condoning the risks involved in space exploration as long as they could be justified by the scientific value of the experiment.[8] Contamination was to be avoided, in order to maintain the purity of the "newly accessible laboratory".[9]

When CETEX was disbanded in 1959, ICSU assigned its work to the Committee on Space Research ("COSPAR"), a special entity created by ICSU.[10] Interest and concern about the possible effects of space experiments on "the composition and structure of the Earth's atmosphere" led COSPAR to establish a Consultative Group on the Potentially Harmful Effects of Space Experiments ("COSPAR-CG") in May 1962.[11] The mandate of the COSPAR-

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[7] UN GAOR C.1, 18th Sess., 1345th Mtg, para. 2, UN Doc. A/C.1/SR.1345 (1963).

[8] Christol, *supra*, note 4 at 132.

[9] *Ibid.*

[10] UN GAOR C.1, 18th Sess., 1345th Mtg, para. 2, UN Doc. A/C.1/SR.1345 (1963).

[11] *Report to the Executive Council of the Committee on Space Research [hereinafter COSPAR] of the COSPAR Consultative Group on the Potentially Harmful Effects of Space Experiments*, UN GAOR, 19th Sess., Annex III, at 5, UN Doc. A/5785 (1964) [hereinafter *COSPAR-CG Report*].

CG included examining the possible effects of back contamination[12] and "any proposed experiment or other space activities that might have potentially undesirable effects on other scientific activities and observations",[13] determining whether these experiments did have potentially harmful effects[14] and submitting appropriate recommendations to the Executive Council of COSPAR[15].

In its 1964 Report to the Executive Council,[16] the COSPAR-CG concluded that some possible pollution-related alterations "could cause interference in future experiments or can be considered harmful in other ways" and that further studies were necessary;[17] that no interference resulted from the "Project

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[12] See UN COPUOS C.1, 1st Sess., 4th Mtg, at 7, UN Doc. A/AC.105/C.1/SR.4 (1962). Forward contamination takes place through the introduction of undesirable elements into outer space by some form of human intervention, while back contamination arises as a result of the introduction of undesirable extraterrestrial matter into the environment of Earth or undesirable use of such matter by similar human intervention. S. Gorove, "Pollution and Outer Space: A Legal Analysis and Appraisal" (1972) N.Y.U. J. Int'l L. & Pol. 53 at 55-56.

[13] UN GAOR C.1, 18 Sess., 1345th Mtg, para. 2, UN Doc. A/C.1/SR.1345 (1963).

[14] J.A. Johnson, "Pollution and Contamination in Outer Space" in M. Cohen, ed., *Law and Politics in Space* (Montreal: McGill University Press, 1964) 37 at 42.

[15] UN COPUOS C.1, 1st Sess., 4th Mtg, at 7, UN Doc. A/AC.105/C.1/SR.4 (1962).

[16] COSPAR-CG Report, *supra*, note 11.

[17] *Ibid.*, Appendix I at 6 and 8.

West Ford" orbiting dipoles,[18] and that, because contamination of the Moon and planets raised the question of whether terrestrial organisms would interfere with any ecological system, especially that of Mars, it was important not to jeopardize "the value of information" that could be gained from studies of Mars[19].

COSPAR adopted a resolution on the basis of this report, which stated that "harmful contamination" of the upper atmosphere was unlikely, based on present and expected rates of experimental rocket launches; that any future experiments similar to "West Ford" were to be evaluated by the scientific community prior to their initiation to ensure they did not interfere with other scientific research; that "all practical steps should be taken" to avoid contamination of Mars until adequate standards of sterilization were developed and to set temporary sterilization levels for space vehicles engaged in planetary landing, atmosphere penetration and deep lunar drilling, and that

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[18] *Ibid.*, Appendix II. Project West Ford was a communications experiment designed to release 350 million copper filaments in outer space. See *infra*, text accompanying notes 26-28.

[19] *Ibid.*, Appendix III at 10-11.

States should postpone the launching of planetary entry and landing vehicles until there was a final determination of acceptable sterility levels.[20]

The Scientific and Technical Sub-Committee of COPUOS at its Third Session in 1964 supported the COSPAR resolution.[21] However, the language of the Sub-Committee statement considerably weakened the effect of the COSPAR resolution.[22] COPUOS adopted the recommendation of its Sub-Committee[23] and, in so doing, felt that the issue of possible interference with space activities had been settled in a manner satisfactory to all concerned.[24] Some States, notably India and the Soviet Union, expressed reservations.[25]

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[20] *Resolution Adopted by the Executive Council of the Committee on Space Research on 20 May 1964*, UN GAOR, 19th Sess., Annex II, at 1-2, UN Doc. A/5785 (1964) [hereinafter *COSPAR Resolution*].

[21] *Report of the Scientific and Technical Sub-Committee on the Work of Its Third Session*, UN COPUOS, 1964, at 16, UN Doc. A/AC.105/20 (1964).

[22] The Sub-Committee watered down the resolution by (i) substituting "full consideration" of the problem of possible interference for "taking all practical steps" to avoid such interference, given that the former does not necessitate taking any steps; (ii) enabling Member States proposing the space experiments to decide whether consultation was appropriate, and (iii) requiring a standard only of "due consideration" in evaluating whether to abide by any scientific analysis.

[23] UN GAOR, 19th Sess., 5785th Mtg, para. 33, UN Doc. A/5785 (1964).

[24] UN COPUOS, 3d Sess., 29th Mtg, at 28, UN Doc. A/AC.105/PV.29 (1964) [provisional].

[25] UN COPUOS C.2, 3d Sess., 29th-37th Mtg, at 80, UN Doc. A/AC.105/C.2/SR.29-37 (1964) and UN COPUOS, 3d Sess., 30th Mtg, at 10, UN Doc. A/AC.105/PV.30 (1964) [provisional]; UN COPUOS, 3d Sess., 26th Mtg, at 14, UN Doc. A/AC.105/PV.26 (1964)

Both COSPAR and CETEX, then, were concerned with the effects of contamination and interference only in so far as these harms would be detrimental to other scientific activities in outer space. The 1964 report of the COSPAR-CG, the corresponding resolution of COSPAR and the ultimate adoption by COPUOS of the Scientific and Technical Sub-Committee statement supported the thrust of this concern.

The response of the COSPAR-CG to "Project West Ford" further reinforces the view of the scientific community as expressed by COSPAR and CETEX. "Project West Ford" was a communications experiment designed to release from a satellite 350 million long, hair-like copper filaments (dipoles) which were expected to form a narrow belt in space around Earth.[26] The scientific community, fearing that "Project West Ford" could possibly have a detrimental effect on "other scientific activities",[27] called for a halt to the

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[provisional], and UN COPUOS, 3d Sess., 32d Mtg. at 9, UN Doc. A/AC.105/PV.32 (1964) [provisional].

[26] Johnson, *supra*, note 14 at 46. One purpose of the experiment was to assess the potential harms of the dipole belt "on space activities and other branches of science". See *United States Space Communication Experiment (Project West Ford)*, UN COPUOS, 2d Sess., Annex, at 4, UN Doc. A/AC.105/15 (1963) [hereinafter *Project West Ford*].

[27] Project West Ford, *ibid.* at 6.

experiment until it could be "established beyond doubt that no damage [would] be done to astronomical research".[28]

The question of possible interference by "Project West Ford" with other scientific activities was raised at the first meeting of the COSPAR-CG in March 1963, two months prior to the successful placement of the dipole payload in orbit.[29] Objections to the project turned on the perceived threat to the safety of future scientific space research and experimentation, with no consideration given to the risk of harm to the outer space environment *per se*.

This attitude reflects the moral perspective of enlightened anthropocentrism, according to which humankind develops its natural "resources" for purely human interests and modifies any such development only to the extent that human interests are adversely or likely to be adversely affected. In the context of space activities, the views expressed by the space science community reflect this principle of human self-interest: The value of outer space, including the Moon and other celestial bodies, is limited to its use as a laboratory for the

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[28] C.W. Jenks, *Space Law* (London: Stevens & Sons, 1965) at 35-36. See also, Project West Ford, *ibid.*

[29] Project West Ford, *ibid.* at 7. However, the launch took place *before* the COSPAR-CG announced in 1964 that the experiment would not have "significantly harmful results". See Jenks, *ibid.*

scientific activities of humankind. Any proposed space activity will be assessed as potentially harmful to the outer space environment if, and only if, it threatens the future use of outer space for scientific purposes in the interests of humankind.

From the moral perspective of enlightened anthropocentrism, outer space is "there" to be used as humankind sees fit and apparently has no value in itself. Any measures for regulating activities in outer space should ensure that space research will "yield the fruits we are entitled to expect from it".[30] The "temptation of ... limitless experimentation" is to be avoided to prevent jeopardizing the "health and life on our planet".[31] While these objectives are worthy ones, the idea that protection of the outer space environment is an end in itself is missing.

The moral perspective of enlightened anthropocentrism (hereafter in this chapter "the human-centred perspective") permeated all United Nations outer space law negotiations relating to environmental protection, beginning with the 1958 General Assembly ("UNGA") debates on whether to establish a

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[30] Jenks, *ibid* at 40.

[31] M. Lachs, *The Law of Outer Space: An Experience in Contemporary Law Making* (The Netherlands: Sijthoff, 1972) at 124.

committee on the peaceful uses of outer space and concluding with Article IX of the *Outer Space Treaty*, the basic provision of international law for protection of the outer space environment. As a result, this human-centred perspective substantially coloured the approach, content and effect of the final products of all these negotiations.

2. The *Ad Hoc* COPUOS

The human-centred perspective was evident during the 1958 UNGA debates which led to the formation of the *Ad Hoc* Committee on the Peaceful Uses of Outer Space ("*Ad Hoc* COPUOS")[32], and also influenced the decisions of that committee concerning the content, extent and *rationale* of future scientific research in outer space. No doubt existed that the "ever more frequent excursions into outer space which man would make would be first and foremost for scientific purposes"[33] and that all States had the right to carry out these scientific activities[34]. States conducting or intending to conduct experiments in outer space were to prevent harmful contamination in order to "safeguard celestial bodies for the sake of science".[35]

[32] UN GAOR C.1, 18th Sess., 982d-995th Mtg, UN Doc. A/C.1/SR.982-995 (1958).

[33] UN GAOR C.1, 18th Sess., 982d Mtg, para. 27-28, UN Doc. A/C.1/SR.982 (1958).

[34] UN GAOR C.1, 18th Sess., 987th Mtg, para. 12, UN Doc. A/C.1/SR.987 (1958).

[35] UN GAOR C.1, 18th Sess., 985th Mtg, para. 12, UN Doc. A/C.1/SR.985 (1958).

The *Ad Hoc* COPUOS was requested to report to the UNGA, *inter alia*, on recommendations for programmes for the peaceful uses of outer space.[36] In its 1959 Report, the *Ad Hoc* COPUOS cited contamination as an area for which international co-operation was necessary in order to ensure that various phases of space activities could be carried out.[37] Because certain space experiments could lead to biological, chemical or radiological contamination which might jeopardize further research and endanger possible extraterrestrial organisms, and because space vehicles on returning to Earth could contaminate the planet with extraterrestrial organisms, the Committee stated it was "desirable" to continue any research in progress "with a view to arriving at appropriate agreements to minimize the adverse effects of possible contamination".[38] Contamination of outer space was to be avoided primarily to prevent terrestrial material from "interfering with orderly scientific research". Although further studies were to be encouraged to prevent this interference and "other hazards to health and safety" which might be created by space exploration, these

[36] *Question on the Peaceful Uses of Outer Space*, GA Res. 13/1348, UN GAOR, 13th Sess., para. 1(b), (1958).

[37] *Report of the Ad Hoc Committee on the Peaceful Uses of Outer Space*, UN GAOR, 1959, at 44-47, UN Doc. A/4141 (1959) [hereinafter *1959 Report*].

[38] *Ibid.* at 47.

studies were considered non-priority items, i.e., those items which did "not yet appear ripe for solution".[39]

However, the 1959 Report did not mention any other safety and health hazards which space activities might create, the dangers that contamination posed to the outer space environment *per se* or the need for research to assess the impact of contamination on the integrity of the Earth/space ecosystem and its sub-systems. The programme for prevention of contamination presented in the 1959 Report reflected the human-centred perspective by seeking "to protect space against the emergence of conditions that could impede scientific and technological investigations".[40]

3. The 1963 General Debates

The 1963 debates in COPUOS and its two sub-committees continue to illustrate the influence that the human-centred perspective had on drafters of outer space law. The representative of one State believed that the Legal Sub-Committee should work

> to prevent the use of outer space for experiments which endangered human life or which changed the space environment in such a way that the possibility of obtaining more important

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[39] *Ibid.* at 69 and 61.

[40] Christol, *supra*, note 4 at 132.

> scientific information was jeopardized. On rare occasions, a major experiment of such a type might be so important as to be desirable in the interests of science, but it should first be discussed and cleared.[41]

One State representative in the Scientific and Technical Sub-Committee claimed that any harm to future space experiments resulting from high altitude nuclear explosions "would be very insignificant in comparison with the value of the information gained" and that most experiments which had resulted in contamination of the upper atmosphere "had been of sufficient scientific interest to be justified".[42]

More significantly, a recommendation of the Scientific and Technical Sub-Committee during its Second Session,[43] which was subsequently approved by COPUOS, recognized the importance of the problem of preventing harmful interference, but limited the scope of this prevention to experiments which "may affect present or future scientific activities". Only in these circumstances were assurances sought that the experiments "would not adversely change the

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[41] UN COPUOS C.2, 2d Sess., 22d Mtg, at 7, UN Doc. A/AC.105/C.2/SR.22 (1963).

[42] UN COPUOS C.1, 2d Sess., 12th-20th Mtg, at 91-92, UN Doc. A/AC.105/C.1/SR.12-20 (1963).

[43] *Report of the Scientific and Technical Sub-Committee on the Work of Its Second Session*, UN COPUOS, 1963, at 9, UN Doc. A/AC.105/14 (1963).

space environment or adversely affect experiments in space".[44] Therefore, the human-centred perspective governed in COPUOS when deciding the criteria for avoiding potentially harmful interference. States supporting the Sub-Committee recommendation, "based on a genuine fear as to the safety of outer space",[45] would be forced to accept this limitation. As a result, a pivotal recommendation which could have had an influential effect on the prevention of potentially harmful interference was substantially deflated.[46]

[44] *Report of Committee on the Peaceful Uses of Outer Space*, UN GAOR, 1963, at 8, UN Doc. A/5549 (1963).

[45] UN COPUOS, 2d Sess., 21st Mtg, at 3, UN Doc. A/AC.105/PV.21 (1963) [provisional].

[46] UN COPUOS, 2d Sess., 22d Mtg, at 3 and 10, UN Doc. A/AC.105/PV.22 (1963) [provisional].

4. Paragraph 6 of the 1963 UN Declaration on Outer Space

The *1963 UN Declaration*[47] on outer space is a precursor of the 1967 *Outer Space Treaty*. Paragraph 6 of the *1963 UN Declaration* states:

> In the exploration and use of outer space, States shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space with due regard for the corresponding interests of other States. If a State has reason to believe that an outer space activity or experiment planned by it or its nationals would cause potentially harmful interference with activities of other States in the peaceful exploration and use of outer space, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State which has reason to believe that an outer space activity or experiment planned by another State would cause potentially harmful interference with activities in the peaceful exploration and use of outer space may request consultation concerning the activity or experiment.

Paragraph 6 was the first attempt to enunciate a principle calling for "international consultations in the case of dangerous activities"[48] and took into account the recommendations of the 1962 Report of the Scientific and Technical Sub-Committee, which invited the attention of COPUOS to the

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[47] *Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space*, GA Res. 18/1962, UN GAOR, 18th Sess., Item No. 28, UN Doc. A/5656 (1963) [hereinafter *1963 UN Declaration*]. The *1963 UN Declaration* has been accepted by the vast majority of States as evidence of customary international law. See UN COPUOS C.2, 5th Sess., 57th Mtg, esp. at 5 and 10, UN Doc. A/AC.105/C.2/SR.57 (1966). As such, the principles it espouses, regardless of their generality, are binding on all States not parties to the *Outer Space Treaty*.

[48] UN GAOR C.1, 18th Sess., 1342 Mtg, para. 14, UN Doc. A/C.1/SR.1342 (1963).

"urgency and importance" of preventing potentially harmful interference with the peaceful uses of outer space[49]. According to this principle, freedom of space experimentation would be limited only to the extent that a member State would fail to respect the interests of others.[50]

Paragraph 6 was viewed as a statement of principle which would guard against any outer space activities that could cause potentially harmful interference with space activities of other States.[51] Although Paragraph 6 did not include a procedure for consultation, COPUOS could use this provision as "a starting point for working out the necessary preventative and precautionary measures and for finding means for their effective international application".[52]

Objections to Paragraph 6 of the UN Declaration were raised on two grounds: the lack of a specific obligation to consult if proposed experiments could modify the natural environment of Earth in a manner which would threaten

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[49] *Additional Report of the Committee on the Peaceful Uses of Outer Space*, UN GAOR, 18th Sess., Annex, at 3, UN Doc. A/5549/Add.1 (1963) [hereinafter *COPUOS Additional Report*]. See also, UN GAOR C.1, 18th Sess., 1345th Mtg, para. 9, UN Doc. A/C.1/SR.1345 (1963).

[50] UN GAOR C.1, 18th Sess., 1343d Mtg, para. 14, UN Doc. A/C.1/SR.1343 (1963).

[51] COPUOS Additional Report, *supra*, note 49 at 7.

[52] UN GAOR C.1, 18th Sess., 1343d Mtg, para. 17, UN Doc. A/C.1/SR.1343 (1963).

the human race or the interests of other States,[53] and the failure to provide for an international authority with power to act if consultations failed[54]. However, a more important objection was not recorded: Whether to undertake international consultation was a subjective decision based on the reasonable belief of the State proposing the activity, thereby leaving it to that State to determine whether its activity would cause harmful interference.

The principle of co-operation was upheld by all during negotiations for the 1963 UN Declaration.[55] The importance of a co-operative effort for preventing space activities which might impede or make difficult the space activities of other States was stressed strongly by the Soviet Union.[56] The "due regard" principle limits the absolute freedom of use and exploration of outer space because due regard for the interests of other States requires States

[53] COPUOS Additional Report, *supra*, note 49 at 10.

[54] UN GAOR C.1, 18th Sess., 1344th Mtg, para. 24, UN Doc. A/C.1/ SR 1344 (1963).

[55] UN COPUOS C.2, 2d Sess., 22d Mtg, at 4, UN Doc. A/AC.105/C.2/SR.22 (1963).

[56] UN GAOR C.1, 16th Sess., 1210th Mtg, para. 25, UN Doc. A/C.1/SR.1210 (1961); UN COPUOS, 1st Sess., 5th Mtg, at 11 and 26, UN Doc. A/AC.105/PV.5 (1962) [provisional], and UN COPUOS, 1st Sess., 10th Mtg, at 38, UN Doc. A/AC.105/PV.10 (1962) [provisional].

to consider the effects of their space activities on the world community of States.[57]

Paragraph 6 establishes a link between the general principles of co-operation and due regard in sentence 1 and the two more specific provisions concerning potentially harmful activities in sentences 2 and 3.[58] This connection limits both the need for co-operation and mutual assistance and the interests for which States should have due regard, to those situations in which consultation is necessary, i.e., in cases where States have a reasonable belief that space activities or experiments could harmfully interfere with other space activities.[59] In sentence 2, a State carrying out a space activity has an obligation to consult prior to undertaking that activity if that State has a "reason to believe" that the proposed activity could cause potentially harmful interference with other space activities. In sentence 3, States other than the State carrying out the activity have a right to request consultation if they have "reason to believe"

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[57] Several States accepted the due regard principle on this basis. See UN COPUOS C.2, 2d Sess., 21st Mtg, at 6, UN Doc. A/AC.105/C.2/SR.21 (1963) and UN COPUOS C.2, 2d Sess., 22 Mtg, at 7 and 12, UN Doc. A/AC.105/C.2/SR.22 (1963).

[58] Jenks, *supra*, note 28 at 40.

[59] Regarding the narrow definition of corresponding interests, see *infra*, text accompanying notes 71-74.

that the space activity under consideration could cause harmful interference with other space activities.

Given that sentences 2 and 3 refer to "space activities" as well as "experiments", commercial and government activities, as well as scientific ones, are subject to consultation. Therefore, States may avoid consultation under the "reasonable belief" rule for a greater number of activities. In practical terms, the ability to control or prevent possible harmful interference has been diminished.

More significantly, the scope of application of the human-centred perspective is likewise expanded: Any proposed space activity will be assessed as potentially harmful to the outer space environment if, and only if, it threatens the future use of that environment for scientific, commercial or government activities. It may seem at first glance that increasing the scope of activities in Paragraph 6 would reduce the risk of environmental harm. However, the fact that the majority of activities capable of causing environmental harm are unlikely to threaten the future use of outer space for scientific, commercial or government activities, makes the possibility of such a reduction remote.

5. Article 10 of the US Draft Treaty and Article VIII of the USSR Draft Treaty

When US President Lyndon B. Johnson stated on 7 May 1966 that a treaty on general principles of space law was necessary, one principle which he proposed be included was: "Studies should be made to avoid harmful contamination".[60] Several months following this statement, the United States and the Soviet Union submitted to COPUOS draft proposals for general principles to govern space law.

Article 10 of the US Draft Treaty provided:

> States shall pursue studies of and, as appropriate, take steps to avoid harmful contamination of celestial bodies and adverse changes in the environment of the Earth resulting from the return of extraterrestrial matter.[61]

The first legislative provision submitted to COPUOS for avoidance of contamination, Article 10 followed the suggestion of President Johnson, which likely resulted from the acceptance of the COSPAR resolution by COPUOS in

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[60] P.G. Dembling, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and Other Celestial Bodies" in N. Jasentulyana & R.S.K. Lee, eds, *Manual on Space Law*, vol. 1 (Dobbs Ferry, NY: Oceana Publications, 1979) 1 at 6.

[61] *Draft Treaty Concerning the Exploration of the Moon and Other Celestial Bodies*, UN COPUOS C.2, UN Doc. A/AC.105/C.2/L.12 (1966) [hereinafter *US Draft Treaty*].

1964.[62] The US Draft Treaty contained no specific reference to Paragraph 6 of the 1963 UN Declaration.

Article VIII of the USSR Draft Treaty stated:

> In the exploration and use of outer space, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including activities on celestial bodies, with due regard for the corresponding interests of other States. States Parties to the Treaty shall conduct research on celestial bodies in such a manner as to avoid harmful contamination. If a State Party to the Treaty has reason to believe that an outer space activity or experiment planned by it or its nationals would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including activities on celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an outer space activity or experiment planned by another State Party would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including activities on celestial bodies, may request consultation concerning the activity or experiment.[63]

This provision broadened the scope of Paragraph 6 of the 1963 UN Declaration by including a specific reference to activities on celestial bodies,

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[62] See *supra*, text accompanying notes 20-25.

[63] *Draft Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, the Moon and Other Celestial Bodies*, UN COPUOS C.2, UN Doc. A/AC.105/C.2/L.13 (1966) [hereinafter *USSR Draft Treaty*].

thereby ensuring that activities in outer space included activities on celestial bodies. The introduction of the principle of avoidance of contamination in sentence 2 parallelled that of Article 10 in the US Draft Treaty and can also be attributed to the acceptance by COPUOS of the COSPAR resolution.

A comparison of sentence 2 of USSR Article VIII with US Article 10 is revealing. The scope of activities is broader in Article 10. "Studies" in US Article 10 includes "research" in sentence 2 of USSR Article VIII as well as commercial and government activities. The use of "studies" is significant because scientific, commercial and government activities are all bound by the contamination avoidance rule. Furthermore, a parallel is achieved with the "space activity" and "experiment" categories for which consultation is deemed necessary.

The type and scope of contamination to be avoided differs. Sentence 2 of USSR Article VIII is ambiguous in the type of contamination it prohibits. Inclusion of forward contamination is almost certain, while back contamination may be inferred because "to avoid harmful contamination" has no indirect object. While US Article 10 is more specific, providing for both forward and back contamination, the duty there is less strict. Only "steps to avoid" contamination need be taken, whereas it is mandatory that contamination be avoided in sentence 2 of USSR Article VIII. "Steps to avoid" could mean that contamination resulting from an activity would be permissible, notwithstanding the steps taken to avoid the contamination, thereby nullifying any recommended contamination procedure. However, regardless of whether a strict or narrow interpretation is applied, it is the human-centred perspective which will ultimately determine what types of contamination will be avoided -- those which could harm space activities.

Sentence 2 of USSR Article VIII did not contain specific references to either the Moon or outer space. Therefore, this provision may be interpreted to mean that harmful contamination is to be avoided only on celestial bodies other than the Moon. Further, sentence 2 could mean that when carrying out research on the Moon and in outer space, States need not avoid harmful contamination as long as the co-operation and due regard requirements of sentence 1 are met.

In Article 10 of the US draft, the contamination to be avoided varies with the location: "Harmful contamination" is to be avoided on celestial bodies, while "adverse changes" are to be avoided on Earth. The use of a different expression for each location raises serious concerns. Because adverse changes, such as, e.g., transformation of the geography of a celestial body by an accidental explosion, may not necessarily constitute harmful contamination, such changes could be permitted on celestial bodies. Similarly, importation to Earth of an extraterrestrial organism, which results in "minor" harmful contamination (e.g., the extinction of a bird species), would be permissible as long as major adverse changes do not occur. In addition, as with sentence 2 of USSR Article VIII, the lack of specific reference to the Moon and outer space implies that harmful interference need not be avoided there.

Both proposals are enlightening for what they do not say. Neither considers a standard for permissible interference, mentions the avoidance of specific activities, nor makes it mandatory to avoid activities which could harmfully contaminate the outer space environment *per se*. Furthermore, no prohibitions are invoked.[64]

These omissions illustrate the application of the human-centred perspective to treaty drafting. Because COPUOS had approved the COSPAR resolution, the US and USSR drafters were faced with the political necessity of incorporating

[64] Y.M. Kolossov, "Legal Aspects of Outer Space Environmental Protection" (1980) 23 Colloq. L. Outer Sp. 103 at 105.

into their respective texts a rule for avoiding harmful contamination. The results of their efforts ensure that any sector of the outer space environment will be preserved for future commercial, government or scientific activity. For example, consider the situation where contamination from a commercial activity irreversibly transforms the ecological balance of a celestial body. If that celestial body were unfit for future commercial, government or scientific activity, the rule would be breached. In no other case would a legal sanction apply. This change would not be considered "harmful contamination" if the three uses mentioned above were still possible; and even if the contamination were considered harmful, it could be argued that all *bona fide* efforts taken to avoid contamination failed. Any attempt to protect the environment of that celestial body would be either incidental or temporary, based on the need for future use.

6. Article IX of the *Outer Space Treaty*

The key Article IX of the *Outer Space Treaty* provides:

> In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination

> and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful use and exploration of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment.[65]

The human-centred perspective goes to the root of Article IX -- harmful activities, i.e., those space activities which contaminate and those which interfere with other space activities. Several commentators, who have pointed out the difficulties of defining "harmful", "contamination" and "interference",[66] have assumed that scientists will ultimately be the ones to

[65] *Outer Space Treaty*, *supra*, note 1.

[66] See e.g., Gorove, *supra*, note 12 at 62-63; G.C.M. Reijnen, "Some Aspects of Environmental Problems in Space Law" (1977) 26 Zeitschrift Luft Weltraumrecht 23 at 23; Kolossov, *supra*, note 64 at 105, and P.G. Dembling and S.S. Kalsi, "Pollution of Man's Last Frontier: Adequacy of Present Space Environmental Law in Preserving the Resource of Outer Space" (1973) 20 Netherlands Int'l L.J. 125 at 140-41.

define these terms.[67] However, the human-centred perspective provides the test for "harm", a test which has nothing whatsoever to do with science. An activity will be harmful only if it interferes with the future use of outer space, the Moon and other celestial bodes for space activities. This test is based on the short-term goals of humankind, not the laws of nature as interpreted by the scientist. Therefore, harmful interference and harmful contamination have no direct connection with environmental concerns. While Article IX is an attempt to regulate the unfettered freedom to use and explore outer space,[68] any material environmental protection found in Article IX is only a fortuitous by-product.

(a) Sentence 1 of Article IX

Sentence 1 of Article IX serves as an example of the practical application of the principle of international co-operation and mutual assistance, which was considered to be the keystone of the *Outer Space Treaty*.[69] From this basic

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[67] See e.g., M. Miklody, "Some Remarks on the Status of Celestial Bodies and Protection of the Environment" (1982) 25 Colloq. L. Outer Sp. 13 at 13 and Dembling and Kalsi, *ibid.* at 140.

[68] Gorove, *supra*, note 12 at 60.

[69] UN GAOR C.1, 21st Sess., 1493d Mtg, para. 49, UN Doc. A/C.1/SR.1493 (1966).

principle could be derived the duty of States to prevent contamination and to co-operate in scientific research.[70]

The principle that due regard should be given to the corresponding interests of States was considered to be "one of the most important points" in space law.[71] However, these corresponding interests are severely limited in Article IX: First, unlike Paragraph 6 of the *1963 UN Declaration*, which applies to all States, Article IX of the *Outer Space Treaty* applies only to States parties to that treaty.[72] Second, "corresponding interests" could be construed as being restricted to potentially harmful interference with space activities, harmful contamination to celestial bodies and adverse changes to the environment of Earth from back contamination caused by extraterrestrial organisms.[73] The representative of France argued that concern for corresponding interests should also account for certain effects on the territories of States in the broadest sense, including territorial waters, airspace and land-based installations, and

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[70] UN COPUOS C.2, 5th Sess., 60th Mtg, at 2-3, UN Doc. A/AC.105/C.2/SR.60 (1966).

[71] UN COPUOS C.2, 5th Sess., 68th Mtg, at 10, UN Doc. A/AC.105/C.2/SR.68 (1966) [hereinafter *Article IX Debate*].

[72] The issue of the rights and obligations of non-party States under the *Outer Space Treaty* is unresolved. See UN COPUOS C.2, 5th Sess., 71st Mtg, at 18-19, UN Doc. A/AC.105/C.2/SR.71 and Add.1 (1966).

[73] UN COPUOS, 6th Sess., 47th Mtg, at 27, UN Doc. A/AC.105/PV.47 (1967) [provisional].

should specifically include possible harmful effects resulting from direct broadcast satellites, weather modification, "certain uses of high altitude photography" and congestion in outer space resulting from overcrowding of satellites, radio frequencies and spent satellites.[74] Third, the test for "harmful", as interpreted from the human-centred perspective, further delimits the "corresponding interests" by not regulating those activities which, while not posing a risk to future space activities, may harm the outer space environment.

(b) Sentence 2 of Article IX

The contamination provision in sentence 2 of Article IX refers to forward and back contamination,[75] thereby combining US Article 10 with sentence 2 of USSR Article VIII. Forward contamination is to be avoided in outer space and on the Moon as well as celestial bodies.[76] The provision in US Article 10 for "taking steps to avoid harmful contamination", where appropriate, was modified and incorporated into sentence 2 of Article IX to allow for the

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[74] See also, Christol, *supra*, note 4 at 139, citing J. Sztucki, "International Consultation and Space Treaties" (1975) 17 Colloq. L. Outer Sp. 159.

[75] Article IX Debate, *supra*, note 71 at 3 and UN COPUOS C.2, 5th Sess., 63d Mtg, at 2-3, UN Doc. A/AC.105/C.2/SR.63 (1966).

[76] Article IX Debate, *ibid.*

adoption of appropriate measures, "where necessary", to avoid both harmful contamination in the entire outer space environment and adverse changes to the environment of Earth caused by back contamination.[77]

A bid in the Legal Sub-Committee of COPUOS by the Japanese delegation to have sentence 2 of Article IX amended to include more detailed regulation of contamination[78] was rejected. It was the Legal Sub-Committee's position that because the issue of forward and back contamination was at an early stage of development, and given that the COSPAR-CG was consulting on the matter, care had to be taken not to establish "too rigid procedures" which might hinder future research.[79] The Japanese delegation, however, was not convinced that its proposal was covered by reading the due regard principle together with the proposed contamination provision, as "some delegations" had suggested.[80] Rather, the Japanese delegation "suspected that the space powers had not

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77 For a plea to expand the scope for avoidance of contamination, see the statements of the representative of India in UN COPUOS C.2, 5th Sess., 71st Mtg, at 9, UN Doc. A/AC.105/C.2/SR.71 and Add.1 (1966) and UN COPUOS C.2, 5th Sess., 71st Mtg, at 23-26, UN Doc. A/AC.105/C.2/PR.71 (1966) [provisional].

78 Article IX Debate, *supra*, note 71 at 6 and UN COPUOS C.2, 5th Sess., 58th Mtg, at 7, UN Doc. A/AC.105/C.2/SR.58 (1966).

79 Article IX Debate, *ibid.* at 7.

80 UN COPUOS C.2, 5th. Sess., 71st Mtg, at 38-40, UN Doc. A/AC.105/C.2/PR.71 (1966) [provisional].

accepted its amendment mainly because they feared that it might tie their hands in future activities on celestial bodies".[81]

The category of activities for which harmful contamination was to be avoided was broadened to include exploration as well as research, combining "pursue studies" from US Article 10 and "conduct research" from USSR Article VIII. As indicated above,[82] "studies" could include commercial, government and scientific activities. Indeed, Article IX of the *Outer Space Treaty* refers to "pursuing studies" and "conducting exploration", totally eliminating the more restrictive concept of "research" and, in so doing, extends the avoidance of harmful contamination to commercial and government activities in addition to scientific activities.

Sentence 2 offers no direct protection for the outer space environment *per se*. States undertaking scientific, commercial or government space activities are obliged to avoid harmful forward and back contamination and to adopt measures, where appropriate, for avoiding such contamination. However, the test for "harmful" is based on the human-centred perspective and its utilitarian

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[81] UN COPUOS C.2, 5th Sess., 71st Mtg, at 13, UN Doc. A/AC.105/C.2/SR.71 and Add.1 (1966).

[82] See *supra* at 214.

interest in outer space, even though the safeguards contained in the principle of avoidance of harmful contamination were considered to include maintenance of a contamination-free outer space environment as a legitimate interest[83]. In addition, it was never intended that the protection offered by sentence 2 would apply to the environments of outer space, the Moon and other celestial bodies *per se*. Although it was suggested that possible environmental harms should be given a priority ranking, this listing was only to avoid interference of one activity with another;[84] although the freedom of States to use and explore outer space was limited to non-threatening activities, threatening activities included only those which impinge on State sovereignty;[85] and although it was argued that State parties should exercise "maximum care"[86] to preserve the resources and milieu of celestial bodies,[87] this was solely to further scientific uses[88]. Moreover, activities are not prohibited, but only to be avoided, thereby allowing for harmful

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[83] UN GAOR C.1, 21st Sess., 1493d Mtg, at 26, UN Doc. A/C.1/SR.1493 (1966).

[84] UN COPUOS C.2, 5th Sess., 7th Mtg, at 26, UN Doc. A/AC.105/C.2/PR.7 (1966) [provisional].

[85] *Ibid.* at 27.

[86] UN COPUOS C.2, 5th Sess., 71st Mtg, at 13, UN Doc. A/AC.105/C.2/SR.71 and Add.1 (1966).

[87] UN COPUOS C.2, 5th Sess., 58th Mtg, at 7, UN Doc. A/AC.105/C.2/SR.58 (1966) and Article IX Debate, *supra*, note 71 at 6.

[88] Article IX Debate, *ibid.*

contamination by default. Avoidance may be the intent; it need not be the result. Therefore, widening the scope of activities subject to the avoidance of harmful contamination only served to legitimize contaminating activities.

The duty of States to impose limits on space activities which may cause harmful contamination is minimal and ambiguous. Regulations must be appropriate -- "where necessary". Although the test for necessity is not explicitly subjective, the negotiating history of Article IX and its results belie an objective test, especially when the "reasonable belief" test for consultation is taken into account. In any case, the human-centred perspective will govern what measures are appropriate: whether the test is subjective or objective becomes a matter of the quantity of contamination, not the quality of the environment.

<u>(c) Sentences 3 and 4 of Article IX</u>

Sentences 3 and 4 apply to scientific, commercial or government space activities which may cause potentially harmful interference with space activities of other States. As a consequence of the human-centred perspective, harmful interference arises only where the future use of outer space, the Moon and other celestial bodies for space activities will be affected. Once again, environmental protection is incidental.

The consultation principle incorporated into sentences 3 and 4 of Article IX provides a forum for the scientific analysis of activities which could cause potentially harmful interference. This provision differs from USSR Article VIII only to the extent that the scope of exploration and use is widened to include the Moon as well as outer space and other celestial bodies.

The consultation provision in both sentences was intended to serve a double function. Not only would appropriate consultations be required if activities or experiments of one State might interfere with activities of other States, but every State party undertaking such an activity "would be obliged to transmit to other parties information on these activities".[89]

For a sentence 3 consultation to arise, the State undertaking the consultation must have a reasonable belief that its space activity would prevent the future use of outer space for commercial, government or scientific activities. If such a consultation situation arose, a State undertaking consultation would be

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[89] UN COPUOS C.2, 5th Sess., 68th Mtg, at 7, UN Doc. A/AC.105/C.2/SR.68 (1966).

obliged to provide information as to the nature of the activity or experiment for which consultation was sought. However, there is no requirement that the information be either complete or delivered in time for sufficient study prior to consultation.

In addition, no procedures for consultation or settlement of disputes arising therefrom are enumerated in sentence 3. Because Article III of the *Outer Space Treaty* provides that space activities are to be carried out in accordance with international law,[90] States could apply the standard dispute resolution procedures of international law as provided for in Chapter VI of the *UN Charter*[91]. However, to invoke established Earth-bound procedures for resolution of outer space disputes could distort the issue to fit the procedure. Different characteristics of outer space and terrestrial environments demand different approaches.[92]

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[90] *Outer Space Treaty*, *supra*, note 1, art. 3, states in part: "States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations ..." .

[91] *United Nations Charter*, 26 June 1945, 16 U.S.T. 1134 (entered into force 24 October 1945). Chapter VI is titled, "Pacific Settlement of Disputes".

[92] H. DeSaussure, "Maritime and Space Law: Comparison and Contrasts (An Oceanic View of Space Transport)" (1981) 9 J. Sp. L. 93 at 103.

In sentence 4, for a State to accede to a request for consultation, the requesting State must have a reasonable belief and must demonstrate that the space activity of the undertaking State could cause potentially harmful interference with the space activities of other States; i.e., the activity would jeopardize the future use of outer space for commercial, government or scientific activities. Where a State acceded to such a request, the requesting State would have a right to receive from the acceding State any additional information as to the nature of the activity for which consultation was sought. As with a sentence 3 consultation, this information need be neither complete nor timely. Also, the applicable consultation procedures are not indicated.

Sentence 4 suffers from an additional weakness in that it provides no obligation for the State undertaking the activity to accede to the request for consultation.[93] However, it has been argued that because the *Outer Space Treaty* contains obligations, "it would therefore be compulsory to comply with requests for which it provided".[94] On this basis, accession to a request for consultation would be compulsory if the requesting State could demonstrate that potentially harmful interference would result from the proposed activity.

[93] Article IX Debate, *supra*, note 71 at 9.

[94] *Ibid.* at 9.

As with the information provision, the lack of a time requirement for initiating consultations following such a request effectively negates its compulsory force.

States wishing to protect the outer space environment *per se* will rely on the sentence 4 provision, but only if they are parties to the *Outer Space Treaty*. Non-party States have no standing under the *Outer Space Treaty*, although they may be able to invoke Paragraph 6 of the *1963 UN Declaration*, given that its principles have been accepted by almost all States as indicative of international customary law.[95] Although the reasonable belief test seems to be to the advantage of a requesting State in an environmental protection context, the human-centred perspective mitigates against the success of a request to consult: The requesting State must convince the undertaking State on the basis of the human-centred test for "harm" that its space activity could cause potentially harmful interference. Because environmental protection stands outside the utilitarian nature of the human-centred perspective, success in preventing such an activity on purely ecological grounds is out of the question. Finally, States carrying out space activities which result in harmful contamination will only be under a duty to consult if those activities also cause

[95] It is reasonable to assume, however, that any State in a position to undertake space activities will become a party to the *Outer Space Treaty* prior to the time when its space activities are operational.

harmful interference with other space activities. As with other instances of potentially harmful interference, the human-centred perspective narrows the application of this duty to consult to those instances in which future space activities would be prevented.

7. Article IV, para. 4 of the *Outer Space Treaty*

Article IV, para. 1 of the *Outer Space Treaty*[96] provides:

> States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or other weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any manner.

Article IV, para. 1 contributes to protection of the outer space environment by means of an undertaking among States Parties that they will not to place nuclear weapons or other weapons of mass destruction in orbit around Earth or on celestial bodies.[97]

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[96] *Supra*, note 1.

[97] See also, *infra*, Section B.3 and Section C.1.

B. Environmental Protection of the Moon and Other Celestial Bodies

1. Article 7 of the *Moon Agreement*

Article 7 of the *Moon Agreement*[98] enhances the environmental obligations found in the *Outer Space Treaty* by enunciating specific standards of conduct to be followed on the Moon and other celestial bodies.[99] Article 7, para. 1 states:

> In exploring and using the moon, States Parties shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise. States Parties shall also take measures to avoid harmfully affecting the environment of Earth through the introduction of extraterrestrial matter or otherwise.

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[98] *Supra*, note 2.

[99] P.M. Sterns and L.I. Tennen, "Principles of Environmental Protection in the *Corpus Juris Spatialis*", at 13-14. Paper prepared for presentation at 30th Congress, International Institute of Space Law, Brighton, October 1987.

The progressive development in the *Moon Agreement* of specific provisions for environmental protection, based on the foundation established by the more general principles of the *Outer Space Treaty*, is consistent with the approach adopted by the United Nations for the orderly development of space law. According to this procedure, the broad guidelines of the *Outer Space Treaty* evolve when necessary in order to account for scientific and technological change or to resolve specific problems. See E. Galloway, "Agreement Governing Activities of States on the Moon and Other Celestial Bodies" (1980) 5 Ann. Air & Sp. L. 481 at 481-83. The *Moon Agreement* applies this procedure, with the enumeration of principles for environmental protection on the Moon and other celestial bodies being only one of several legal issues it addresses. See N.M. Matte, "Legal Principles Relating to the Moon" in Jasentulyana & Lee, *supra*, note 60, 253 at 253-55.

This paragraph overcomes many of the deficiencies found in sentence 2 of Article IX of the Outer Space Treaty[100] by supplementing "practically all lacuna's [*sic*] and controversies" found therein[101].

The requirement to "prevent disruption" is more comprehensive[102] than the duty in sentence 2 of Article IX to avoid harmful contamination in outer space, on the Moon and on other celestial bodies, and adverse changes to Earth, because both "harmful contamination" and "adverse changes" must be avoided on the Moon. Further, the exact nature of the disruption assumes less importance[103] because "or otherwise" is intended to cover all conduct which could disrupt the existing balance[104].

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[100] N. Jasentulyana, "Environmental Impact of Space Activities: An International Law Perspective" (1984) 27 Colloq. L. Outer Sp. 390 at 394 and H. Qizhi, "Towards International Control of Environmental Hazards of Space Activities", at 1-2. Paper prepared for presentation at 30th Congress, International Institute of Space Law, Brighton, October 1987.

[101] H.L. van Traa-Engelman, "Environmental Hazards from Space Activities: Status and Prospects of Environmental Control" (1982) 25 Colloq. L. Outer Sp. 55 at 59.

[102] Sterns and Tennen, *supra*, note 99 at 13.

[103] See van Traa-Engelman, *supra*, note 101 at 59.

[104] See Qizhi, *supra*, note 100 at 2.

By stating that the "existing balance" of the Moon's environment is not to be disrupted, Article 7 moves away from the utilitarian demands of the test for "harmful", as interpreted from the human-centred perspective, and invites a scientific definition of "disruption", based on the general principles of ecology. Although no specific standards are enumerated for determining when an activity contravenes the general obligation to prevent disruption of this existing balance,[105] the objective nature of scientific definition will increase the likelihood of agreement on this determination.

Article 7, para. 2 of the *Moon Agreement* states:

> States Parties shall inform the Secretary-General of the United Nations of the measures being adopted by them in accordance with paragraph 1 of this article and shall also, to the maximum extent feasible, notify him in advance of all placements by them of radioactive materials on the moon and the purposes of such placements.

Unlike sentence 2 of Article IX of the *Outer Space Treaty*, which calls for adequate regulatory measures, where necessary, the *Moon Agreement* obliges its States Parties to give notice of all preventive measures taken, thereby increasing the effectiveness of the duty to prevent disruption[106]. Also, this paragraph implies that States must "take precautions for all missions" in order

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[105] Jasentulyana, *supra*, note 100 at 394.

[106] van Traa-Engelman, *supra*, note 101 at 59.

to prevent disruption.[107] While notice of preventive measures may be *ex post facto*, advance notice is necessary for placement of radioactive materials. However, the effect of this advance notice is weakened because it need only be given "to the maximum extent feasible". Given that any State will likely be aware of any placement of radioactive materials well in advance of such an undertaking, there should in principle be no need to delay notice.

The scope of the *Moon Agreement* encompasses the Moon, "orbits around or other trajectories to or around [the Moon]" and other celestial bodies in our solar system without their own specific legal régime.[108] Therefore, protection of the outer space environment *per se* and celestial bodies outside our solar system is excluded. Also, there is no guarantee that celestial bodies in our solar system, which may have separate legal régimes in the future, will be given protection similar to that of Article 7 of the *Moon Agreement*.

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[107] Sterns and Tennen, *supra*, note 99 at 13.

[108] *Moon Agreement*, *supra*, note 2, art. 1, states in part:

> 1. The provisions of this Agreement relating to the moon shall also apply to other celestial bodies within the solar system, other than the earth, except in so far as specific legal norms enter into force with respect to any of these celestial bodies.
>
> 2. For the purposes of this Agreement reference to the moon shall include orbits around or other trajectories to or around it.

The inclusion of orbits and trajectories of the Moon within the scope of the *Moon Agreement* could offer extensive protection for near-Earth space, depending on how Article 1, para. 2[109] is interpreted. If orbits and trajectories are construed as areas of space rather than isolated locations in time, the scope of the Agreement could take in "all space in the plane of the Moon's orbit around Earth and enclosed in that orbit, since a trajectory to the Moon may be plotted anywhere in that plane".[110]

2. Article 15, para. 2 of the *Moon Agreement*

Article 15, para. 2 of the *Moon Agreement*[111] provides that a State party may request consultation if it reasonably believes that another State party has breached its duties under the *Moon Agreement* or is interfering with the rights of

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[109] See *ibid.*

[110] R.T. Swenson, "Pollution of the Extraterrestrial Environment" (1985) 25 A.F. L. Rev. 70 at 81-82.

[111] *Moon Agreement*, *supra*, note 2, art. 15, para. 2, states: "A State Party which has reason to believe that another State Party is not fulfilling its obligations incumbent upon it pursuant to this agreement or that another State Party is interfering with the rights which the former State has under this agreement may request consultations with that State Party. A State Party receiving such a request shall enter into such consultations without delay. Any other State which requests to do so shall be entitled to take part in the consultations. Each State Party participating in such consultations shall seek a mutually acceptable resolution of any controversy and shall bear in mind the rights and interests of States Parties. The Secretary-General of the United Nations shall be informed of the results of the consultations and shall transmit the information received to all States Parties concerned."

the requesting State under the Agreement. The State receiving this request must enter into consultation without delay and attempt to seek a mutually acceptable settlement. If such a settlement is not reached, the States involved must use appropriate peaceful means to settle the dispute.[112]

This provision eliminates several ambiguities found in sentences 2 and 4 of Article IX of the *Outer Space Treaty*[113]. On the Moon, consultation may be requested for all instances of contamination, not just those which are both "harmful" and could cause "potentially harmful interference". Article 15, para. 2 also extends the consultation procedure to any activity causing potentially harmful interference, if that activity would also disrupt the existing balance of the Moon's environment. Consequently, activities which would have been permitted under Article IX of the *Outer Space Treaty* due to the test for

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[112] *Moon Agreement*, *ibid.*, art. 15, para. 3, states: "If the consultations do not lead to a mutually acceptable settlement which has due regard for the rights and interests of all States Parties, the parties concerned shall take all measures to settle the dispute by other peaceful means of their choice appropriate to the circumstances and the nature of the dispute. If difficulties arise in connection with the opening of consultations or if consultations do not lead to a mutually acceptable settlement, any State Party may seek assistance of the Secretary-General, without seeking the consent of any other State Party concerned, in order to resolve the controversy. A State Party which does not maintain diplomatic relations with another State Party concerned shall participate in such consultations, at its choice, either itself or through another State Party or the Secretary-General as an intermediary."

[113] On sentence 2 of Article IX of the *Outer Space Treaty*, see *supra*, Section A.6(b); on sentences 3 and 4 of Article IX, see *supra*, Section A.6(c).

"harmful", as interpreted from the human-centred perspective,[114] could now be prohibited, even if they do not interfere with scientific, commercial or government uses of the Moon.

The onus to determine whether the existing balance of the environment has been disrupted rests with the States other than the one undertaking the allegedly disruptive activity because the undertaking State has no duty to consult even when it suspects that its activity may cause a disruption.[115] It is unclear whether any disruptive activity must be held in abeyance until a mutually acceptable settlement is reached. However, Article 15, para. 2 guarantees that any request for consultation must be honoured promptly and facilitates consultations by outlining a dispute resolution procedure.

[114] See *supra*, Section A.1 and text accompanying notes 66-68.

[115] However, sentence 3 of Article IX of the *Outer Space Treaty* is still applicable, thereby obliging the undertaking State to enter into consultations if it reasonably believes that any of its activities on the Moon could cause potentially harmful interference with activities of other States in outer space and on other celestial bodies, as well as on the Moon. See *supra*, text accompanying notes 89-92.

3. Article 3, para. 3 of the *Moon Agreement*

Article 3, para. 3 of the *Moon Agreement*[116] provides:

> States Parties shall not place in orbit around or other trajectory to or around the moon objects carrying nuclear weapons or any other kinds of weapons of mass destruction or place or use such weapons on or in the moon.

This provision contributes to the environmental protection of the Moon by prohibiting the placement of nuclear weapons in orbits around or in other trajectories to or around the Moon,[117] and on or in the Moon. Article 3, para. 3 addresses the fact that no reference was made to the Moon in the provision in the *Outer Space Treaty*[118] on the placement of nuclear weapons in outer space.[119]

C. Other Possible Sources of International Law relevant to Environmental Protection in Outer Space, on the Moon and on Other Celestial Bodies

Two other multilateral treaties, which contain provisions relevant to the protection of the outer space environment, are the *Partial Nuclear Test Ban Treaty* and the *Environmental Modification Convention*.

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[116] *Supra*, note 2.

[117] On Moon orbits and trajectories, see *supra*, text accompanying notes 108-110.

[118] *Supra*, note 1.

[119] See *supra*, Section A.7. See also, *infra*, Section C.1.

1. The *Partial Nuclear Test Ban Treaty*

Article I, para. 1(a) of the *Partial Nuclear Test Ban Treaty*[120] provides:

> Each of the Parties to this Treaty undertakes to prohibit, to prevent and not to carry out any nuclear weapon test explosion, or any other nuclear explosion, at any place under its jurisdiction or control in the atmosphere; beyond its limits, including outer space; or under water, including territorial waters or high seas.

This provision contributes to the environmental protection of outer space, the Moon and other celestial bodies with its prohibition against nuclear weapon test explosions in outer space. The prohibition complements the provisions in the *Outer Space Treaty*[121] and the *Moon Agreement*[122] regarding the placement of nuclear weapons in orbit around Earth and the Moon, or on the Moon and other celestial bodies.[123]

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[120] *Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and under Water*, 5 August 1963, 14 U.S.T. 1313, T.I.A.S. No. 5433 [hereinafter *Partial Nuclear Test Ban Treaty*] (entered into force 10 October 1963).

[121] *Supra*, note 1.

[122] *Supra*, note 2.

[123] See *supra*, Section A.4 and Section B.3.

2. The *Environmental Modification Convention*

The *Environmental Modification Convention*[124] prohibits military or other hostile uses of techniques which, through deliberate manipulation, could change the dynamics, composition or structure of outer space.[125] The effectiveness of this provision as a regulatory mechanism for protection of the outer space environment *per se* could be severely limited, if application of the *Environmental Modification Convention* is restricted to contracting States. If this were the case,

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[124] *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*, 18 May 1977, 31 U.S.T. 333, T.I.A.S. No. 9614, 610 U.N.T.S. 151 [hereinafter *Environmental Modification Convention*] (entered into force 5 October 1978).

[125] *Environmental Modification Convention*, *ibid.* at art. I, para. 1, and art. II, states:

> I.1 Each State Party to this Convention undertakes not to engage in military or other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.
>
> II. As used in article I, the term "environmental modification techniques" refers to any technique for changing -- through the deliberate manipulation of natural processes -- the dynamics, composition or structure of the earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space.

"Environmental modification techniques include changes in weather or climate patterns, ocean currents, the state of the ozone layer or ionosphere, or upsetting the ecological balance of a region." W.B. Wirin, "Constraints on Military Manned Activities in Outer Space", at 5. Paper prepared for presentation at Armed Forces Communications and Electronics Association Symposium on Man's Role in Space, Colorado Springs, Colo., August 1987.

the *Convention* would apply only to the territories of ratifying States, and not to the outer space environment *per se*.[126]

Another limitation on the prohibition against environmental modification techniques is that these techniques may be used for peaceful purposes, as permitted by international law[127].

D. Effects of Current Environmental Protection Provisions in International Space Law on the Application of International Environmental Law to Space Projects

The preceding sections indicate that what are considered to be the provisions for environmental protection in space law, notably Article IX of the *Outer Space Treaty*, have little to do with protecting and preserving biological entities-in-ecosystems and everything to do with ensuring the use of the outer space environment for space projects so as to avoid the loss of economically and politically valuable space assets.

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[126] D.E. Reibel, "Prevention of Orbital Debris", at 5. Paper prepared for presentation at 30th Congress, International Institute of Space Law, Brighton, October 1987.

[127] *Environmental Modification Convention*, *supra*, note 124, art. III, para. 1, states: "The provisions of this Convention shall not hinder the use of environmental modification techniques for peaceful purposes and shall be without prejudice to the generally recognized principles and applicable rules of international law concerning such use."

Despite their lack of sufficiently clear reference, the applicable environmental provisions of space law do not explicitly contradict the emerging principles of international environmental law. Consequently, the latter can be applied to space projects, given that Article III of the *Outer Space Treaty*[128] requires that States must "carry on activities in the exploration and use of outer space, including the Moon and other celestial bodies, in accordance with international law".

If anything, the provisions of Article IX of the *Outer Space Treaty* tend to support contemporary international environmental law, albeit in a very general and not particularly effective manner. The obligations to co-operate and provide mutual assistance are not only fundamental to Article IX,[129] but also represent customary international law, particularly in the field of international environmental law[130]. The further obligation in Article IX to conduct activities

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[128] See *supra*, note 90.

[129] See *supra*, text accompanying notes 69-70.

[130] "[T]he requirement of international cooperation underlies all international environmental law." A. Kiss & D. Shelton, *International Environmental Law* (Ardsley-on-Hudson, NY: Transnational Publishers, 1991) at 131. See also, *ibid.* at 107 and 131-132; T. Iwama "Emerging Principles and Rules for the Prevention and Mitigation of Environmental Harm" in E.B. Weiss, ed., *Environmental Change and International Law* (Tokyo: UN University Press, 1992) 107 at 116-118, and P.W. Birnie & A.E. Boyle, *International Law and the Environment* (Oxford: Clarendon Press, 1992) at 102-103. On mutual assistance, particularly in emergency situations, see Kiss & Shelton, *ibid.* at 106 and 132-133, Iwama, *ibid.* at 121-122 and Birnie & Boyle, *ibid.* at 108-109.

with "due regard to the corresponding interests of all other States Parties to the Treaty" places limits on the absolute freedom on the use by States of outer space.[131] This limitation acts as a deterrent against unrestricted use of the outer space environment in a manner analogous to the restriction that the principle of good neighbourliness places on the absolute freedom of States to use their natural "resources" as they wish.[132] The obligation to consult supports a similar requirement in international environmental law to address adverse effects occurring in more than one State[133].

However, the scope and content of these general obligations require expansion and additional detail so that they can be applied not only to space projects, but also to environmental concerns arising from these projects. In Article IX of the *Outer Space Treaty*, the interpretation of "corresponding interests"[134] should be broadened to include protection of the outer space environment. The subjective "reason to believe" test in Article IX should be amended so that it

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[131] See *supra*, text accompanying note 57.

[132] See Chapter III, *supra*, text accompanying notes 64-65.

[133] See Kiss & Shelton, *supra*, note 130 at 139-141 and Iwama, *supra*, note 130 at 119-121. See also, Chapter IV, *supra*, text accompanying notes 180-181.

[134] See *supra*, text accompanying notes 73-74.

becomes an objective test determined by independent experts.[135] The test should also be in conformity with the principle of precautionary measures to ensure prevention in cases of scientific uncertainty. Independently set international regulations should be developed for all adverse effects to the outer space environment, including standards for contamination[136].

Article 7, para. 1 of the *Moon Agreement*,[137] with its obligation on States to "take measures to prevent the disruption of the existing balance of its environment" for all space projects,[138] reflects the ecosystem management approach[139] by attempting to identify and mitigate any adverse effects of a project on the ecosystem. Here, too, space projects should be governed by independent international standards and the principle of precautionary measures. In view of their potentially catastrophic effect, consideration should

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[135] See *ibid.*, text accompanying notes 66-67.

[136] See *supra*, text accompanying notes 78-79.

[137] *Supra*, note 2.

[138] See *supra*, text accompanying notes 102-105.

[139] See Chapter IV, *supra*, text accompanying notes 8-12.

be given to the extent to which nuclear power sources and similarly ultra-hazardous materials should be permitted in outer space.[140]

What is most important is to ensure that measures for the protection and preservation of the outer space environment are taken by design, not by coincidence, as is currently the case.[141] To institute a planned, preventive biosphere management régime from the biocentric moral perspective will require a major adjustment in the current attitudes and thinking of political and technological elites. It is not, however, an impossible undertaking. Chapter VI sets out one effort to meet this challenge, with a proposal for incorporating the basic principles of international environmental law and biosphere management into international space law.

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140 See e.g., "Disposal of Nuclear Waste in Space" (13-19 February 1995) *Space News* 15 and "Astronomers in Two Camps over Topaz Protest" (14-20 December 1992) *Space News* 23.

141 See *supra*, text accompanying notes 66-68.

<u>CHAPTER VI: PROPOSAL FOR AN ENVIRONMENTAL PROTOCOL TO ARTICLE IX OF THE *OUTER SPACE TREATY*</u>

International space law and international environmental law are both relatively new branches of international law still in their formative years. On their separate paths, they seem to have lost sight of one another. The purpose of this chapter is to integrate the two legal fields so that international environmental law can be applied to any adverse effects to the Earth and outer space environments ("the planetary environment") arising from space activities.

Section A proposes a legislative format for environmental protection in the planetary environment and sets out its basic features. Section B applies the basic principles of international environmental law and the legal obligations of biosphere management to space projects.

<u>A. The Environmental Protocol</u>

The *Outer Space Treaty* is an international instrument, containing principles on which the law applicable to space projects is being progressively developed. For example, Article VII of the *Outer Space Treaty*[1] contains a general principle

[1] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 27 January 1967, Can. T.S. 1967 No. 19, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 [hereinafter *Outer Space Treaty*] (entered into force 10 October 1967).

with respect to liability, which was further elaborated in the *Liability Convention*[2]. Articles V and VIII of the *Outer Space Treaty*[3] set out general obligations, respectively, for the assistance to, and return of, astronauts and for the return of space objects; these are expanded upon in the *Rescue and Return Agreement*[4].

Similarly, given that Article IX of the *Outer Space Treaty* contains general obligations for protecting the outer space environment, a supplemental treaty instrument would expand upon those obligations. Such an arrangement is not without precedent. The *Madrid Protocol*[5] supplements the *Antarctic Treaty*[6] by enunciating elaborate principles for environmental protection in the Antarctic. Such a protocol would provide a means for applying contemporary principles

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[2] *Convention on International Liability for Damage Caused by Space Objects*, 21 November 1971, Can. T.S. 1975 No. 7, 24 U.S.T. 2389, T.I.A.S. No. 7762. 961 U.N.T.S. 187 [hereinafter *Liability Convention*] (entered into force 1 September 1972).

[3] *Supra*, note 1.

[4] *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space*, 22 April 1968, Can. T.S. 1975 No. 6, U.S.T. 7570, T.I.A.S. No. 6599, 672 U.N.T.S. 119 [hereinafter *Rescue and Return Agreement*] (entered into force 3 December 1968).

[5] *Protocol on Environmental Protection of the Antarctic*, 4 October 1991, ATS Doc. XI ATSCM/2/3/2 (1991), reprinted in 30 I.L.M. 1461 [hereinafter *Madrid Protocol*] (not yet in force).

[6] *Antarctic Treaty*, 1 December 1959, 12 U.S.T. 794, T.I.A.S. No. 4730, 402 U.N.T.S. 71 (entered into force 23 June 1961).

of international environmental law to space projects. The Protocol for the Protection and Preservation of the Planetary Environment to Article IX of the *Outer Space Treaty* ("Environmental Protocol") would be the first stage, setting out general principles and specific obligations. The second stage would address the regulation of particular projects as the need arises.

This two-stage approach conforms to an emerging trend in international environmental law for regulating human conduct in ecosystems. A framework or umbrella agreement is enacted, setting out an agreed statement of general principles and legal obligations, according to which the parties will be bound. The general instrument is then supplemented by protocols which mainly provide for the setting and implementation of technical standards.[7] General principles in the framework agreement are based on the nature of the activity and the constraints required to avoid adverse effects in a particular ecosystem. The protocol enacts the scientific and technical standards and compliance schedules, usually for specific substances and activities causing adverse effects.

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[7] See generally, G. Handl, "Environmental Security and Global Change: The Challenge to International Law" in W. Lang, H. Neubold & K. Zemanek, eds, *Environmental Protection and International Law* (London: Graham & Trotman, 1991) 59 at 61-63. See also, P.C. Szaz, "International Norm-making" in E.B. Weiss, ed., *Environmental Change and International Law: New Challenges and Dimensions* (Tokyo: UN University Press, 1992) 41 at 63-64.

The régime for protecting and preserving the ozone layer provides a particularly good illustration of the framework-protocol arrangement. The *Ozone Layer Convention*[8] sets out the general principles applicable to the regulation of any substances which States parties may agree could have adverse effects on the ozone layer. The *Montreal Protocol*[9] provides the specific control measures for substances with adverse effects on the ozone layer, particularly, but not limited to, chlorofluorocarbons. A major advantage of this system has been the flexibility provided by the ability of the ozone layer régime to adapt to rapid changes in scientific and technical information.[10] Flexibility in response to new information would be particularly advantageous in the relatively nascent field of space science and technology.

Protocols can be implemented when the need arises. Because they are mainly technical in nature, protocols can be designed to provide for easier

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[8] *Vienna Convention for Protection of the Ozone Layer*, 22 March 1985, UN Doc. UNEP/IG.535 (1985), reprinted in 26 I.L.M. 1516 [hereinafter *Ozone Layer Convention*] (entered into force 22 September 1988).

[9] *Montreal Protocol on Substances that Deplete the Ozone Layer*, 16 September 1987, reprinted in 26 I.L.M. 1550 [hereinafter *Montreal Protocol*] (entered into force 1 January 1989).

[10] W. Lang, "Environmental Treatymaking: Lessons Learned for Controlling Pollution of Outer Space" in John A. Simpson, ed., *Preservation of Near-Earth Space for Future Generations* (Cambridge: Cambridge University Press, 1994) 165 at 170-171.

negotiations, enactment, amendment and entry into force.[11] In the ozone régime, e.g., the *Montreal Protocol*[12] was opened for signature prior to the entry into force of the *Ozone Layer Convention*,[13] its framework convention.[14] When the standards in the *Protocol* were found to be insufficient for the satisfactory regulation of ozone-depleting substances, it underwent a "complete overhaul" in 1990, less than two years after its entry into force.[15] The framework-protocol arrangement can provide a forum for scientists to work without political, legal or other constraints[16] and is, overall, "less cumbersome and time-consuming"[17].

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[11] See Szaz, *supra*, note 7 at 64-65.

[12] *Supra*, note 9.

[13] *Supra*, note 8.

[14] Lang, *supra*, note 10 at 170.

[15] *Ibid.* at 171. See also, *Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer*, 29 June 1990, UN Doc. UNEP/OzL.Pro.2/3 (1990), reprinted in 30 I.L.M. 539 [hereinafter *London Adjustments*] (entered into force 10 August 1992).

[16] Lang, *supra*, note 10 at 178.

[17] Handl, *supra*, note 7 at 61.

In the space law context, the Environmental Protocol would represent the framework instrument, with its supplementary technical agreements designated as Annexes, in a manner similar in form to the Antarctic Treaty Series.[18]

B. Basic Principles and Legal Obligations

As a framework agreement, the Environmental Protocol would contain general principles applicable to space projects in the planetary environment. These provisions would be derived from the basic principles of international environmental law and the general obligations for biosphere management set out in Part Two. The purpose of this section is to enunciate these principles and obligations as they would apply to space projects.

1. Basic Principles of International Environmental Law in the Planetary Environment

The four basic principles of international environmental law developed in Chapter III represent a biocentric approach for addressing environmental issues on Earth and in outer space. In this subsection, these principles are

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[18] The five Annexes to the *Madrid Protocol*, *supra*, note 5, form an integral part thereof. The Annexes, which apply established methods of environmental protection to the special needs of the Antarctic, include Annex I on Environmental Impact Assessment, Annex II on Conservation of Antarctic Fauna and Flora, Annex III on Waste Disposal and Waste Management, Annex IV on the Prevention of Marine Pollution and Annex V on Area Protection and Management. Additional Annexes may be added to the *Madrid Protocol*. if necessary.

modified to account for the unique characteristics of the planetary environment.

(a) The Principle of Common Planetary Concern

> **The planetary environment is an ecosystem encompassing Earth, celestial bodies and the space plasma which surrounds them. Where humankind's space projects could have adverse effects on this environment which, for greater certainty, includes the biosphere, the prevention and protection of the planetary environment from these adverse effects is the responsibility of humankind through supranational action, whether these adverse effects arise within the jurisdiction and control of sovereign States or in *res communis* or other territories beyond their jurisdiction. Space projects involving natural "resources" in the planetary environment shall be subject to planetary management for the benefit of present and future generations of biokind.**

This principle incorporates the basic elements of the principle of common concern for the biosphere.[19] It is intended to apply to space projects rather than to the specific ecosystem called "outer space" because space projects as a rule affect several ecosystems in jurisdictions within and outside the control of States. Take, e.g., a project to place in orbit a satellite for maritime search and rescue purposes. This project includes the manufacture and production of at least three stages for the launch vehicle, the bus and operational components of the satellite and the fuel for both. Manufacturing these goods requires

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[19] See Chapter III, *supra*, Section A.

specialized process and production methods which may require clean technologies to prevent, or mitigate and control, if necessary, any adverse effects. Spaceports, located around the world, incorporate different methods for launching, tracking and recovering space objects and may have their own clean technology needs or other environmental concerns.

Once launched, the rocket and its payload may pass through several legal jurisdictions: national air space, international air space, the high atmosphere, including the ozone layer, and outer space. In outer space, the creation of space debris gives rise to a separate set of problems.[20] Some payloads and rocket stages may land or impact on the Moon or some other celestial body; satellite payloads placed in GEO may have orbital lifetimes of millions of years. Where components of the space object return to Earth, they may dissipate on re-entry, or re-enter and touch down on land or, more likely, in a marine ecosystem; on impact, they may be recovered or irretrievable.

Each of these phases in the life cycle of a space project may have its own adverse effects. Because each of these stages is related to the whole of the space project, they are subjects of the common planetary concern.

[20] See Chapter VII, *infra*.

The principle of common planetary concern ensures that all activities and substances, however connected with a space project, will be examined for possible adverse effects to any ecosystem, on or off Earth. In this manner, all environmental concerns connected with space projects may be canvassed. Jurisdictional disputes, such as the location of natural "resources" or whether an adverse effect occurred in national air space, international air space or outer space, can be avoided.[21] "Common planetary concern" also ensures that all biological entities-in-ecosystems are subjects of consideration when determining the adverse effects of space activities.

(b) The Principle of Good Neighbourliness

> **Every State shall bear international responsibility, in accordance with Article VI of the *Outer Space Treaty*, for ensuring that any space project, or element thereof, carried out in areas within the jurisdiction and control of a State, does not have adverse effects on any biological entities-in-ecosystems in the planetary environment.**

This principle sets out an international legal obligation for human conduct when undertaking space projects. It adapts the customary international law principle of good neighbourliness as stated in Principle 21 of the *Stockholm*

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[21] A particularly good example of transjurisdictional adverse effects of space projects is their contribution to depletion of the ozone layer from components of launch vehicle fuels. See "SDIO Hears Environmental Input" (2-8 March 1992) *Space News* 26; C.Q. Christol, "Stratosphere Ozone Problem and Space Activity" (1992) 35 Colloq. L. Outer Sp. 259, and M. Rothblatt, "Environmental Liability Issues of Rocket Exhaust under International Space Law" (1992) 35 Colloq. L. Outer Sp. 307.

Declaration and applies it to all biological entities-in-ecosystems in the planetary environment.[22] The principle of good neighbourliness applies to activities normally considered within the exclusive domain of sovereign States because space projects affect areas of common concern. Accordingly, uses of natural "resources" within State territory may be constrained to the extent that they may have adverse effects on the planetary environment, an area of common concern.[23]

Article VI of the *Outer Space Treaty*,[24] which provides for international responsibility of States for their space activities, is incorporated by reference. With Article VI, State responsibility for space projects is extended to projects undertaken by State nationals and by international organizations in which a State participates. Under Article VI, States are also responsible for the

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[22] See Chapter III, *supra*, Section B.

[23] See *ibid.*, text accompanying notes 64-65 and at 106.

[24] *Outer Space Treaty*, *supra*, note 1, art. VI, states: "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization."

authorization and continual supervision of the space projects of their nationals.

This adaptation of the principle of good neighbourliness is intended to ensure that space projects will not have adverse effects in any ecosystems whether within or beyond State jurisdiction and control. The ultimate effect of this principle is to require the development of international standards applicable to activities within States for those aspects of space projects which may have any adverse effects on any biological entities-in-ecosystems. The technical annexes to the *Chicago Convention*[25] provide a precedent for such international standards. Article 37 of the *Chicago Convention* provides for uniformity of regulation in order to "facilitate and improve air navigation".[26] Application of international standards to all space projects could result in safer and cleaner

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[25] *Convention on International Civil Aviation*, 7 December 1944, 15 U.N.T.S. 295 [hereinafter *Chicago Convention*] (entered into force 4 April 1947).

[26] *Chicago Convention*, *ibid.*, art. 37, states in part: "Each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organization in relation to aircraft, personnel, airways and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation. To this end, the International Civil Aviation Organization shall adopt and amend from time to time, international standards and recommended practices and procedures dealing with ... matters concerned with the safety, regularity, and efficiency of air navigation ... ." The subject matter of the annexes to the *Chicago Convention* include air traffic services, operation and airworthiness of aircraft, search and rescue, aeronautical communications, aeronautical information services and aircraft accident investigation. Of particular interest are Annex 16 on Environmental Protection and Annex 18 on The Safe Transportation of Dangerous Goods by Air.

rocket launches,[27] improved techniques for the production and waste management of materials used in the manufacture of launch vehicles and payloads[28] and cleaner ecosystems[29].

(c) The Principle of Precautionary Measures

> **Where scientific uncertainty exists about the possible adverse effects of an activity or substance connected with a space project in the planetary environment, including the biosphere, the implementation of the activity in, or introduction of the substance into, a planetary ecosystem should be prohibited unless the responsible State can demonstrate, with scientific certainty, that the activity or substance will have no adverse effect.**

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[27] See e.g., "China Disputes Casualty Claim" (4-10 March 1996) *Space News* 1: On 15 February 1996, a launch vehicle crashed into a hillside and exploded shortly after lift-off, approximately 1.5 km from the Zichang Satellite Launch Centre, reportedly resulting in six deaths, at least 57 injuries and extensive damage to the Chinese launch facility. See also, "Culture, Fish Shape Tanegashima Operations" (14-20 February 1994) *Space News* 11: The social and working habits of a 30-household farming village influenced both launch safety procedures at the Japanese launch facility on Tanegashima Island and the design of the H-2 launch vehicle.

[28] See e.g., "Rockwell Pleads Guilty" (9 April 1996) *The Globe and Mail* (National Edition) B6: Rockwell International paid US$6.5 million as compensation for the death of two men killed when a rocket engine exploded at its California testing grounds.

[29] See e.g., "Lawsuits Threaten ASRM Tests" (4-10 November 1994) *Space News* 4: Rural land-owners and environmentalists sought to enjoin the US National Aviation and Space Administration ("NASA") from testing rocket motors in Mississippi. Applicants were concerned about "toxic fallout" from the test firings; "Rocket Motors Tagged for Cleanup" (18-24 April 1994) *Space News* 17: US Pentagon officials sought "to cut cleanup costs and avoid environmental sanctions" by attempting to address pollution problems, and "American Company Tests New Hybrid Rocket Motor" (31 Oct - 06 November 1994) *Space News* 13: If successful, the motors are "expected to provide cheaper, safe and cleaner access to space ...".

This principle restates the biocentric adaptation of the principle of precautionary measures[30] and applies it to all space projects in the planetary environment which may cause any adverse effects to any biological entities-in-ecosystems. The priority in bringing space projects to fruition becomes prevention, not the cost of prevention. If it can be shown during the screening stage of the biosphere risk assessment process that the project is an appropriate one,[31] then economic incentives are available to assist in developing the space project[32]. Evaluation of space projects now focuses on the possibility of the risk of adverse effects, not the possibility of adverse effects.

Given the highly novel nature of many space projects, particularly those concerned with multi-satellite communication constellations, on-site construction of an international crewed space station and uncrewed missions to celestial bodies,[33] the principle of precautionary measures places severe constraints on space projects. These constraints include a low threshold for application of the principle -- "adverse effects";[34] a high standard of scientific

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[30] See Chapter III, *supra*, Section C.2.

[31] See Chapter IV, *supra*, Section C.3(b)(ii).

[32] See *ibid.* at Section C.2.

[33] See Chapter I, *supra*, text accompanying notes 10-17.

[34] See Chapter III, *supra*, text accompanying notes 127-129.

certainty, based on the statistical probability that a particular activity or substance will pose the risk of an adverse effect on an ecosystem;[35] and a burden of proof on the project developer to demonstrate that there is no probability of risk of an adverse effect[36]. Demonstrating adverse effects is a prime function of the biosphere risk assessment process.[37]

Precautionary measures in the planetary environment are to be taken for all space projects, including those already in progress. For this latter class of projects, it would be unfair to apply the test of scientific uncertainty, which could result in the suspension or termination of the project. In such cases, space project developers would be able to take all necessary interim measures to mitigate and control the adverse effects, while concurrently developing appropriate "degradation-free", or clean, technologies.[38]

(d) The Principle of Sustainable Development

> **Subject to the principle of precautionary measures, where the basic interests of any biological entities-in-ecosystems are in issue, space**

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[35] See *ibid.*, text accompanying notes 85-87.

[36] See *ibid.*, text accompanying notes 130-134.

[37] See Chapter IV, *supra*, Section C.3.

[38] See Chapter II, *supra*, text accompanying notes 119-126.

projects undertaken to fulfil these interests shall maintain a net level of consumption of all biological entities-in-ecosystems, including physical entities, in order to meet these basic interests.

This principle relegates the concept of sustainable development[39] to a subordinate function in its application to space projects. The principle of sustainable development is overarchingly anthropomorphic in its moral perspective;[40] it supports "development" over "environment";[41] it places limits on the application of the principle of precautionary measures,[42] and it stands in conceptual opposition to the principles of common planetary concern and good neighbourliness.

As applied to the planetary environment, the principle of sustainable development is modified in several ways. Given that the impetus for the concept of sustainable development was to meet the basic interests of humankind,[43] the principle is limited in its application to circumstances in which the basic interests of humankind are threatened and, at the same time, is broadened to apply to the basic interests of all biological entities-in-

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[39] See Chapter III, *supra*, Section D.

[40] See *ibid.*, text accompanying notes 186-189.

[41] See *ibid.*, text accompanying note 199.

[42] See *ibid.*, text accompanying notes 200-201.

[43] See *ibid.*, text accompanying notes 140-146.

ecosystems. Where conflicts arise in fulfilment of these basic interests, the principles of biocentric management are invoked[44] and applied during the screening stage of the biosphere risk assessment process[45].

Second, where it is conclusively demonstrated that a space project is necessary for sustainable development, the principle of precautionary measures is applied during the comprehensive review stage of the biosphere risk assessment process[46]. Third, in keeping with the biocentric aim of minimum impairment to any ecosystem,[47] the principle stipulates that interference with biological entities-in-ecosystems is limited, where possible, to a steady state level of consumption, not a growth level[48].

In the foreseeable future, it is difficult to conceive that space projects will be specifically designed to meet the basic interests humankind or, even less likely, the basic interests of biokind. Certain space projects, such as the development

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[44] See Chapter II, *supra*, Section C.2(b)(ii).

[45] See Chapter IV, *supra*, Section C.3(b)(i).

[46] See *ibid.* at Section C.3(b)(ii).

[47] See Chapter II, *supra*, Section C.2(b)(ii)(c).

[48] See Chapter III, *supra*, text accompanying notes 171-178.

of cheaper off-Earth energy sources,[49] could, of course, contribute to meeting the basic interests of the less fortunate populations. On a more optimistic note, however, the principle of sustainable development could, and perhaps should, be treated as an interim measure, designed to alleviate the suffering of all biological entities-in-ecosystems until such time as humankind alters its conduct sufficiently to meet the basic interests of all biokind.

2. Legal Obligations for Planetary Management

In the context of space projects, "biosphere management" becomes management for the protection and preservation of the planetary environment ("planetary management"). In this subsection, the three legal obligations for biosphere management, through which States acquire legal responsibility for their conduct and attract any resulting legal liability, are amended accordingly.

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[49] See e.g., "Exotic Fusion Energy Ideas Pushed by Helium-3 Fans" (30 August-5 September 1993) *Space News* 16: The Moon is believed to contain large amounts of helium-3 below the surface. If it could be extracted and exported to Earth, it could prove to be a relatively cheaper fuel source for fusion reactors. Unlike nuclear reactor fuels, helium-3 creates no radioactive wastes. See also, "SSI Report on NASA's Clean Energy Source, Lunar Study Now Available" (March 1990) *Spacewatch* 10, which refers to projects to use lunar materials to build solar power satellites and to convert the surface of the Moon into solar cells, both of which would transmit energy to Earth.

(a) Respect for Nature

> **States have an obligation to respect the inherent worth of the planetary environment, which includes all biological entities-in-ecosystems, and to maintain its natural processes.**

This obligation extends the central biocentric moral imperative to all components of the planetary environment, entitling outer space and all natural entities therein, including celestial bodies, as well as biological entities-in-ecosystems, to respect as part of nature. This entitlement is derived from the fact that all natural entities are outcomes of the universal forces released at the time of the "big bang" and, as such, constitute one ecosystem.

The "big bang" is the currently favoured cosmological theory for the creation of the universe.[50] It posits that all matter in the universe was concentrated in an infinitely small volume. When this matter became unstable, it exploded, began to expand and is still expanding. The material loosed during the "big bang" is the substance of all natural entities in the universe. Humankind should therefore respect nature as it appears in the planetary environment because it is the true cradle of the evolutionary history of civilization on

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[50] See S. Hawking, *A Brief History of Time: From the Big Bang to Black Holes* (Toronto: Bantam Books, 1988) at 35-51 and J.D. Barrow, *The Origin of the Universe* (New York: Basic Books, 1994) at 19-35. See also, S. Weinberg, *The First Three Minutes: A Modern View of the Origin of the Universe* (New York: Basic Books, 1977).

Earth.[51] In addition to sharing this common origin, humankind and all other natural entities have other characteristics in common,[52] which, arguably,[53] entitle them all to equal respect.

The obligation to have respect for nature acknowledges that the biosphere is merely one ecosystem among many in the planetary environment. The solar system, with its components ranging in size from the Sun and the planets to intergalactic plasma and simple molecular compounds,[54] evolves according to its own laws in a unique complex of interrelationships.[55] The Sun has its own

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[51] See also, Chapter I, *supra* at 11-12. "[T]he center of the universe resides in each of us as truly as it does in the Milky Way or in the constellation Andromeda." A.G. Haley, *Space Law and Government* (New York: Appleton-Century-Crofts, 1963) at 396. See also, G.S. Robinson and H.M. White, Jr., *Envoys of Mankind: A Declaration of First Principles for the Governance of Space Societies* (Washington, DC: Smithsonian Institution Press, 1986) at 3-6.

[52] (1) All natural entities share a common process of creation, characterized by the nature of quanta (matter/energy). See D. Bohm, *Quantum Theory* (Englewood Cliffs, NJ: Prentice-Hall, 1953) at 161-162; (2) All natural entities share a common structural basis, characterized as a system. See L. von Bertalanffy, *General Systems Theory: Foundations, Development, Applications* (New York: George Braziller, 1968) at 55-56; and (3) All natural entities have a self-organizing capacity, enabling them to account for differences and to adapt to changes in their surroundings. See I. Prigogene & I. Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Toronto: Bantam Books, 1984) at 160-171. See also, *ibid.* at 213-232.

[53] See Chapter II, *supra*, text accompanying notes 6-16.

[54] See Chapter I, *supra* at 10-11.

[55] See generally, I. Peterson, *Newton's Clock: Chaos in the Solar System* (New York: W.H. Freeman, 1993).

life cycle as a star, evolving according to its own nuclear actions.[56] The planets have sophisticated ecological systems, each processing universal materials in its own unique manner.[57]

None of the ecosystems in the planetary environment is self-contained. Their evolution is interdependent. Just as the biosphere forms a whole based on the sum of its parts and the relationships among them, the planetary environment is also an open system, each component ecosystem continually exchanging matter and energy with its neighbours. Primitive elemental materials become galaxies and solar systems. Waves of solar ultraviolet light chemically interact with oxygen to create the ozone layer and other elementary particles in Earth's atmosphere.[58] Incompletely understood physio-chemical relationships exist between the charged particles comprising the upper reaches of the atmosphere and near-Earth space, and the solar plasma accelerated toward Earth by the energy of the Sun.[59] The Sun not only provides the energy of life, but produces a solar wind containing elemental particulate matter which is

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[56] See Chapter I, *supra* at 12-13.

[57] See *ibid.* at Section B.3.

[58] See *ibid.* at 20-22.

[59] See *ibid.* at 22-23.

scattered to the far reaches of the solar system and beyond.[60] Even the oft-described lifeless and barren Moon not only affects water levels and, hence, numerous ecosystems on Earth, but also has a "flimsy atmosphere" which changes in composition according to chemical reactions originating below its surface.[61]

To give full meaning to the attitude of respect for nature during humankind's use and exploration of the accessible regions of the planetary environment, protection is extended to all natural entities in planetary ecosystems, including their interrelationships. Accordingly, all steps necessary should be taken to determine whether biological or analogous alien entities-in-ecosystems ("alien entities") exist. Where alien entities do exist, all possible efforts should be made to accord them the same respect as that conferred upon biological entities-in-ecosystems. Where there is scientific uncertainty as to whether alien entities exist, there should be a presumption in favour of their existence. All steps should be taken avoid any interference with the fulfilment of their

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[60] See *ibid.* at 13-14.

[61] G.J. Taylor, "Geological Considerations for Lunar Telescopes". Paper prepared for presentation at a NASA Workshop entitled, Space Environment on the Moon. Date approximately 1986-1987. On file with the author. See also, Chapter I, *supra*, n.40.

natural existence, including if necessary a prohibition on all space projects which could have adverse effects on such fulfilment.

(b) Protection and Preservation

> **States have an obligation to plan and conduct all space projects with the objectives of protecting and preserving both the planetary environment and its inherent worth, so as to avoid any effects adverse to the interests ("adverse effects") of the planetary environment, which includes the biosphere and all related ecosystems.**

This obligation gives effect to the means by which respect for nature is embodied in human conduct. Humankind has a legal duty to avoid harm to, or interference with, natural entities-in-ecosystems or, if that is not possible, to ensure that any impairment is minimal[62]. The requirement that all space projects be planned and conducted with these purposes in mind means that all such projects are subject to the principles of biosphere management, the basic method for rational ecosystem protection and preservation.[63] Biosphere management is intended to ensure uniformity and consistency of approach in efforts to avoid adverse effects in the planetary environment.[64]

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[62] See Chapter II, *supra*, text accompanying notes 53-78.

[63] See Chapter IV, *supra*, Section B.

[64] See *ibid.* at Section A.

Implementation of a biosphere management régime implicitly incorporates the principle of precautionary measures as the fundamental management premise[65] and implements biosphere risk assessment as the prime management technique[66]. The need for a supranational administrative institution to implement the biosphere risk assessment[67] is supported by the basic principles of Article IX of *Outer Space Treaty*, which call for co-operation with, and due regard for the interests of, other States. Supranational administration can also be an effective force for verifying that sovereign States respect the principle of good neighbourliness when dealing with allegations of exclusive sovereign use of "resources" in carrying out space projects.[68]

The obligation to prevent, by taking steps to avoid effects adverse to the interests of the planetary environment, draws attention to the distinctions made in the biocentric moral perspective between the differences in the interests of humankind and other biological entities-in-ecosystems, and among

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[65] See *ibid.* at 149-150.

[66] See *ibid.* at Section C.3.

[67] See *ibid.* at Section C.3(a).

[68] On other possible roles for a supranational administrative institution, see *ibid.*

the classes of human interests which may conflict with the interests of non-human biological entities-in-ecosystems.[69]

(c) Minimal Impairment

> **In conducting space projects States have an obligation to take all measures necessary to prevent or, if necessary, reduce and control, in as timely a manner as possible and to as great an extent as technologically feasible, any adverse effects to the planetary environment arising from space projects, including the introduction of any substance into, or the implementation of any activity in, the planetary environment, including the biosphere and all related ecosystems.**

This obligation expands upon the principle of protection and preservation by prescribing the means by which harm to, and interference with the fulfilment of, the existence of natural entities in the planetary environment are to be avoided when carrying out space projects. It clarifies that the meaning of "projects" includes both activities and substances in order to ensure that consideration is given both to environmental risk assessment for activities and to life cycle assessment for substances[70].

To achieve minimal impairment, all necessary measures must be taken. Given the tendency of States to show some bias in favour of their own interests, it

[69] See Chapter II, *supra*, text accompanying notes 81-89.

[70] See Chapter IV, *supra*, Section C.1.

will be necessary to have an objective determination of whether all possible measures and their implications have been considered. This determination is the purview of the biosphere risk assessment process, particularly during the comprehensive review stage.[71]

Techniques for minimal impairment are represented by the trilogy of prevent, reduce and control. "Prevent" is listed first because it is the preferred course of action according the principle of precautionary measures.[72] To stress that "prevent" is the priority option, it is set apart from "reduce and control" by the words "or if necessary". To reduce should be interpreted to mean "to remove the cause of the adverse effect"; to control, "to maintain the adverse effect at as low a level as possible". Because reduction may not, and control does not. eliminate adverse effects, States should be required to reduce and control adverse effects according to the best available technology and as quickly as possible.

While prevention is the *prima facie* course of action to be taken for new space projects, it is possible to describe at least two situations in which prevention

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[71] See *ibid.* at Section C.3(b)(ii).

[72] See Chapter III, *supra*, Section C.1.

could be waived. Certain conflicts of interest may require actions that result in adverse effects.[73] However, even in these circumstances, the adverse effects should be as minimal as possible and should be accompanied by appropriate restitution.[74] The second situation arises where changes must be made to aspects of existing space projects due to government regulation. Reduction and control measures should be permissible as interim measures until the appropriate clean technologies are in place. States should be obliged to ensure that the development of the required technology is made in a timely fashion.

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[73] See Chapter II, *supra*, Section C.2(b)(ii)(B).

[74] *Ibid.*

CHAPTER VII:
A PLANETARY RISK ASSESSMENT OF SPACE DEBRIS[1]

Today the greatest hazard facing humankind's space projects in the planetary environment is space debris. It poses dangers to spacecraft and mission crews, and could have adverse effects on other ecosystems in the planetary environment, including the space plasma and the ozone layer. The space debris hazard has introduced new safety issues for consideration by the nations active in outer space and has been the subject of numerous workshops, conferences, consultations and publications.[2]

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[1] Several portions of this chapter appeared previously in H.A. Baker, "Space Debris: Law and Policy in the United States" (1989) 60 U. Colo. L. Rev. 55 at 55-68, and will be so indicated when they are used. These excerpts are reprinted with permission of the University of Colorado Law Review. Amendments have been made to the text in order account for significant changes since original publication. Otherwise, these portions remain unchanged because they represent the first technical analysis of space debris from a legal perspective and were written before any of the now-standard technical references on the subject were available. The basic facts and conclusions have not changed; if anything, the space debris hazard is worse now.

[2] The major publications are: United States National Research Council, *Orbital Debris: A Technical Assessment* (Washington, DC: National Academy Press, 1995) [hereinafter *NRC Assessment*]; European Space Agency, *Proceedings of the First European Conference on Space Debris* (Darmstadt, Ger: European Space Operations Centre, 1993) [hereinafter *Darmstadt Proceedings*]; J.A. Simpson, ed., *Preservation of Near-Earth Space for Future Generations* (Cambridge: Cambridge University Press, 1994); United States National Security Council, *Report on Space Debris* (Washington, DC: National Security Council, February 1989); United States Congress, Office of Technology Assessment, *Orbiting Debris: A Space Environmental Problem -- Background Paper* (Washington, DC: US Government Printing Office, September 1990), and European Space Agency, *Space Debris: Report of the ESA Space Debris Working Group* (Noordwijk, The Netherlands: ESA, November 1988).

Space debris presents a significant hazard to current space systems. It has been given comprehensive consideration in the development of new space systems, such as the international space station and the "little LEO" constellations of telecommunications satellites, and could now be rendering certain portions of near-Earth space unusable.[3]

Without space projects, space debris would not exist. It was largely unforeseen and, consequently, unplanned for when the first satellites were placed in orbit. Nor were biocentric ethical theories developed or adequate future planning techniques available to apply to the problems being posed by the creation and subsequent proliferation of space debris.

The purpose of this chapter is to apply the techniques of biosphere risk assessment to space projects in the planetary environment ("planetary risk assessment") as a means of remedying, from an environmental law perspective, the risks posed by space debris, the first major adverse effect to the planetary environment arising from space projects. To accomplish this purpose, the

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[3] For an overview of the current international consensus on the hazards to space assets from space debris, see NRC Assessment, *ibid.* at 1-9.

applicable components of screening stage and the comprehensive review stage of the planetary risk assessment process[4] will be applied.

A. The Screening Stage

Prior to reviewing space projects for their space debris implications, all such projects are screened to ascertain the human interests they represent, to determine whether these interests raise conflicts with the basic interests of natural entities-in-ecosystems and to decide whether the project can be undertaken.[5]

The basic human interests are classified as basic, non-exploitive non-basic ("non-exploitive") and exploitive non-basic ("exploitive").[6] In the planetary environment, the basic interests of alien entities are taken into account by adding an extra step at the beginning of the screening process to account for the possibility of the existence of alien entities-in-ecosystems and their basic interests.

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[4] See Chapter IV, *supra*, Section C.3.

[5] See *ibid.* at Section C.3(b)(i).

[6] See *ibid.* See also, Chapter II, *supra*, text accompanying notes 81-104.

According to the legal obligation of respect for nature, the existence of alien entities is presumed to be the case until the question of their existence is no longer scientifically uncertain.[7] In order to commence a space project, the project director must first demonstrate, with scientific certainty, that alien entities-in-ecosystems do not exist. If they do exist, the project is prohibited until it can be determined what constitutes the basic interests of alien entities-in-ecosystems ("basic alien interests").

Ascertaining basic alien interests could present a daunting challenge because the survival and well-being of alien entities-in-ecosystems may be based on totally different physio-chemical factors.[8] But respect for nature requires that their interests be established. Where it can be demonstrated with scientific certainty what are the basic alien interests, the project can proceed through the screening stage. Where the purpose of a space project is to determine the existence of alien entities-in-ecosystems or their basic interests, the project proceeds through the remainder of the screening stage.

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[7] See Chapter VI, *supra* at 266-267.

[8] See e.g., Chapter I, *supra*, text accompanying note 42.

Most space projects in the near future will likely fall within the category of non-exploitive interests because their predominant purpose will be for the public benefit: exploring our solar system; learning to live in the planetary environment; improved telecommunication services. Determining whether a space project represents a non-exploitive interest has subjective and objective components. It must first be decided whether the project represents values of central importance to the community.[9] With the principle of common planetary concern, the "community" is the community of humankind as represented by its political and technological elites. Depending on their structure and objectives, space projects with a predominantly public purpose could include the development of cheaper and safer fuel and other energy sources[10] or the production of oxygen from lunar soil for life support or rocket fuel[11].

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[9] See Chapter IV, *supra*, text accompanying notes 143-144. See also, Chapter II, *supra*, text accompanying note 91.

[10] See e.g., "Japanese to Seek Funds to Study Lunar Helium-3" (19-25 July 1993) *Space News* 15; "Exotic Fusion Energy Ideas Pushed by Helium-3 Fans" (30 August-5 September 1993) *Space News* 16; "Scientists Discuss Herding Asteroids for Raw Materials" (5-11 April 1993) *Space News* 12, and "SSI Report on NASA's Clean Energy Source, Lunar Study Now Available" (March 1990) Spacewatch 10.

[11] See e.g., "Lunar Oxygen Facility Tested Aboard Russian Moon Rover" (29 August - 4 September 1994) *Space News* 10 and "Lunar Oxygen Venture Begins" (24 February - 1 March 1992) *Space News* 3.

Nor is it reasonably foreseeable that space projects to ensure the basic interests of humans for food, water and shelter will be necessary, unless, of course, it is predicted with scientific certainty that life on Earth will perish, by internal combustion, humankind's conduct or meteorite impact.

The problematic space projects are those designed to fulfil exploitive interests. Depending on the extent of their purely private benefit, such projects could include the orbiting of human remains for cremation on re-entry;[12] use of LEO and payloads for advertising;[13] use of the Moon as a theme park or other kind of entertainment;[14] and use of LEO for tourism[15]. Where the purpose of a space project is predominantly exploitive, it would be prohibited.

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[12] "Celestis To Offer Commercial Space Memorial Service" (2-8 October 1995) *Space News* 10.

[13] See e.g., "Columbia Drops Plan To Hype 'Hero' on Comet" (6-12 September 1993) *Space News* 4 and "Senate Panel Quashes Advertising in Space" (15-28 August 1994) *Space News* 2.

[14] See e.g., "This Lunar Rover Would Have a Theme-Park Attitude" (14-20 February 1994) *Space News* 17 and "ISE Unveils Lander Model for 1997 Moon Launch" (28 March -3 April 1995) *Space News* 13.

[15] See e.g., "X" Prize Seeks $10 Million To Jump-Start Space Tourism" (3-9 July 1995) *Space News* 19 and "NASA Begins Space Tourism Enterprise Assessment" (18-24 September 1995) *Space News* 17.

From these criteria, it becomes apparent that predominantly commercial space projects, particularly those involving the exploitation of celestial bodies, are most likely to be forestalled during the screening stage. The current dearth of knowledge about the possible existence of alien entities and the ecosystems of celestial bodies, in combination with the principle of common planetary concern,[16] the principle of precautionary measures[17] and the obligations to respect nature[18] and to protect and preserve the planetary environment,[19] may be viewed as tantamount to a prohibition on commercial space projects.

Yet these safeguards for avoiding adverse effects by humankind to the planetary environment are more like a moratorium than a prohibition because they are based on a lack of knowledge and an assessment requiring scientific certainty. There is, therefore, no need to legislate a prohibition, as was done for mining in the Antarctic in the *Madrid Protocol*[20]. In practical terms, this

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[16] See Chapter VI, *supra*, Section B.1(a).

[17] See *ibid.* at Section B.1(c).

[18] See *ibid.* at Section B.2(a).

[19] See *ibid.* at Section B.2(b).

[20] *Protocol on Environmental Protection of the Antarctic*, 4 October 1991, ATS Doc. XI ATSCM/2/3/2 (1991), reprinted in 30 I.L.M. 1461 [hereinafter *Madrid Protocol*] (not yet in force), art. 7, states: "Any activity relating to mineral resources, other than scientific research, shall be prohibited."

prohibition is a moratorium on Antarctic mining activity for at least 50 years.[21] Any amendment to allow mining after 50 years must be adopted by a majority of all the Parties to the *Antarctic Treaty*[22] and then ratified by three-fourths of the Consultative Parties[23]. If such an amendment has not entered into force within three years of its adoption, any Party may give notice to withdraw and then withdraw two years later.[24] Effectively, "[a]ctual mining operations could ... begin two years after notification of withdrawal".[25] It is interesting to speculate whether the Article 7 prohibition was put in the *Madrid Protocol* to appease the environmentalists, who believed that the 50-year moratorium, along with an agreement to adopt a mineral development régime on expiry of the moratorium, "constituted a clear victory":[26] no major oil and mineral

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[21] *Madrid Protocol, ibid.*, art. 25, para. 2, provides that after 50 years from the date of entry into force of the *Protocol*, a conference will be held if so requested by a Consultative Party to the *Antarctic Treaty*, 1 December 1959, 12 U.S.T. 794, T.I.A.S. No. 4730, 402 U.N.T.S. 71 (entered into force 23 June 1961).

[22] *Madrid Protocol, ibid.*, art. 25, para. 3.

[23] *Ibid.*, art. 25, para. 4.

[24] *Ibid.*, art. 25, para. 5(b).

[25] W.B. Welch, "The Antarctic Treaty System: Is It Adequate to Regulate or Eliminate the Environmental Exploitation of the Globe's Last Wilderness?" (1992) 14 Hous. J. Int'l L. 597 at 644.

[26] F. Francioni, "The Madrid Protocol on the Protection of the Antarctic Environment" (1993) 28 Tex. Int'l L. J. 47 at 69.

companies had shown an interest in exploring the continent, most likely because there are no indications of any oil, gas or mineral deposits in Antarctica of commercial value and appropriate mining technology is not yet available.[27]

Effective planetary risk assessment of commercial space projects does not require a prohibition because, by virtue of the principle of precautionary measures, a *de facto* moratorium is placed on commercial space projects until the appropriate level of knowledge is available. Where a commercial space project developer believes that he has adequate knowledge and can demonstrate to the world community that the project has a predominantly public purpose, the project can proceed to the comprehensive review stage.

B. The Comprehensive Review Stage

1. The Project[28]

All space projects, crewed and uncrewed, generate human-made materials orbiting in outer space ("space debris").[29] For the purposes of comprehensive

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[27] See Welsh, *supra*, note 25 at 648.

[28] Material in this section originally appeared in Baker, *supra*, note 1 at 55-58.

[29] While meteoroids are a natural source of orbital debris, space debris poses a much greater risk of harm to space activities. See D.J. Kessler, "Earth Orbital Pollution" in

review, it is convenient to divide space debris into four categories: inactive payloads, operational debris, fragmentation debris and microparticulate matter. There are currently some 7800 trackable objects in GEO, MEO and LEO ("near-Earth space").[30] In April 1988, inactive payloads accounted for 20 per cent of the trackable space debris population; operational debris, 26 per cent, and fragmentation debris, 49 per cent.[31] Microparticulate populations can only be estimated because they are untrackable.

E.G. Hargrove, ed., *Beyond Spaceship Earth: Environmental Ethics and the Solar System* (San Francisco: Sierra Club Books, 1986) 47 at 48-49.

[30] "Star Dreck" (January 1996) Sci. Am. 22. This figure is close to the June 1988 figure of 7110 trackable objects. "Space Becoming Earth's Junkyard" (12 June 1988) *The* [Montreal] *Gazette* F4. Excluding inactive payloads, about 57 per cent of space debris has been generated by the United States, 40 per cent by Russia and the former Soviet Union, and 3 per cent by a combination of the United Kingdom, the European Space Agency ("ESA"), France, West Germany, India, Japan and the People's Republic of China; E. Marshall, "Space Junk Grows with Weapons Tests" (1985) 20 Sci. 424 at 424.

[31] "Orbital Space Debris Threatens Future of Scientific and Commercial Missions" (18 July 1988) *Satellite News* 2 at 3. A reduction of fragmentation debris to 42 per cent is the major difference in recent figures. See NRC Assessment, *supra*, note 2 at 22. The change is likely due to the voluntary halt placed on deliberate payload explosions and the venting of fuel in first- and second-stage rocket bodies.

Inactive payloads are those former active payloads which can no longer be controlled by their operators. Of the more than 1000 inactive payloads now orbiting Earth,[32] most are spent Earth-orbiting satellites and space probes[33].

Operational debris are those objects associated with space activities, which remain in near-Earth space. While more than 7500 of these mission-related objects have been deposited in near-Earth space since 1957,[34] many have re-entered the Earth's atmosphere and disintegrated. Mostly launch hardware, operational debris also includes items placed in near-Earth space, either accidentally or by design, by humankind during crewed missions.[35]

Fragmentation debris is produced when space objects break up as a result of explosions, collisions and possibly other unknown phenomena. Fragmentation debris from nearly 100 identified satellite breakups accounts for 46 per cent of all catalogued space objects in near-Earth orbit, and is found at altitudes

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[32] N.L. Johnson, "Preventing Collisions in Orbit" (May-June 1987) SPACE 17 at 17.

[33] W.B. Wirin, "The Sky Is Falling: Managing Space Objects" (1984) 27 Colloq. L. Outer Sp. 147 at 151.

[34] Johnson, *supra*, note 32 at 7.

[35] Operational debris objects include rocket bodies and apogee kick motors, payload shrouds, separation hardware and packing devices, empty fuel tanks and insulation, window and lens covers, raw propellant and frozen sewage.

mainly below 2000 km where many application satellites function and where all crewed operations take place.[36]

Explosions, either deliberate or accidental, have contributed more than 36,000 kg of debris fragments to the near-Earth space environment.[37] Deliberate explosions were detonated to prevent recovery of certain satellites and to test weapons.[38] Accidental explosions are generally the result of propulsion system failures, although engine failures during operations have also resulted in satellite explosions.[39] The cause of several recorded explosions has yet to be

[36] Johnson, *supra*, note 32 at 17.

[37] "Debris -- The Pollutant of Outer Space", at 3-4 (Webster University, Colo., February 1987) Unpublished research paper. On file.

[38] On explosions to prevent recovery, see e.g., N.L. Johnson, "Artificial Satellite Breakups (Part 1): Soviet Ocean Surveillance Satellites" (1983) 36 J. Brit. Interplanetary Soc. 51. Weapons tests included the anti-satellite ("ASAT") programmes of the United States and the former Soviet Union and the US Strategic Defense Initiative ("SDI"). See e.g., M.L. Stojak, Legally Permissible Scope of Current Military Space Activities in Space and Prospects for Their Future Control (D.C.L. dissertation, McGill University, 1985) at 32-33, 39-41 and 43, and N.L. Johnson, "Artificial Satellite Breakups (Part 2): Soviet Anti-Satellite Program" (1983) 36 J. Brit. Interplanetary Soc. 357.

[39] Johnson, *supra*, note 32 at 17. Old US and Soviet rocket bodies whose fuel tanks have exploded are a prime source of this type of debris. O.J. Frederick, "Litter in Space Increasing: Orbiting Trash Can Proposed" (March 1985) Sp. World 17 at 17.

determined. Alternative explanations include deliberate destruction, malfunction of a satellite sub-system and collision.[40]

Collision-induced fragmentation debris poses a greater threat to active payloads than do breakup fragments from explosions because the former is produced in greater quantities, travels at greater speeds and is generally too small to be tracked.[41] In addition, certain incidents of debris fragmentation cannot be attributed to a specific cause.[42]

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[40] Examples of such debris fragmentation include the suspected breakup of two Soviet space stations and the unexplained disintegration of two Soviet ASAT target satellites. See M.S. Smith, "Protecting the Earth and Outer Space Environment: Problems of On-Orbit Space Debris" (1982) 25 Colloq. L. Outer Sp. 45 at 46 and Johnson (Breakups Part 1), *supra*, note 38 at 361, respectively.

[41] Johnson, *supra*, note 32 at 18. On collisions, see also, *infra*, Section B.3(a).

[42] Examples of such fragmentation include the breakups of Transit 4A [Johnson, *ibid.* at 17]; Kosmos 954 [see "Fallen Nuclear Satellite Poses No Danger" (1978) 30 Current Dig. Soviet Press (1 March) and "Intensive Analysis Under Way on Cosmos Debris in Canada" (13 February 1978) *A.W.S.T.* 22-23]; SNAP-10A ["Radioactive Space Debris Study Cites Hazards to Satellites, Earth" (22 September 1986) *A.W.S.T.* 19 at 20], and Kosmos 1275 [see D. McKnight, "Determining the Cause of a Satellite Breakup: A Case Study of the Kosmos 1275 Breakup", at 1 and 7. Pre-print of a paper prepared for presentation at 38th Congress, International Astronautics Federation, Brighton, October 1987 and N.L. Johnson, "History and Consequences of On-Orbit Breakups" (1985) 5 Advances Sp. Research 11].

Microparticulate m… ter varies in size from 1-100 microns[43] and consists of particles, gases and spaceglow. It has been estimated that trillions of microparticulates are present in near-Earth space.[44] This class of space debris is created by solid-propellant rocket motors ("SRMs"),[45] surfaces of orbiting objects[46] and crewed spacecraft[47].

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[43] D.J. Kessler, "More Than Meets the Eye" (June 1987) Sky & Telescope 587. One micron is one millionth of a metre.

[44] M.G. Wolfe and L.P. Temple III, "Department of Defense Policy and the Development of a Global Policy for the Control of Space Debris", at 3. Pre-print of a paper prepared for presentation at 38th Congress, International Astronautics Federation, Brighton, October 1987.

[45] SRMs produce effluent from the rocket exhaust plume during firing, from the rocket nozzle during the postfire period and from auxiliary motor hardware. While most of this effluent is solid aluminum oxide (0.25-5.5 microns), carbon particles as well as molten potassium, phosphorus, chlorine and sodium are present. Carbon dioxide and nitrogen gas, with smaller amounts of oxygen and various hydrocarbons, are also emitted. While all postfire phase effluent has not been identified, the major contaminants are oil and grease. See P.T. Girata, Jr. and W.K. McGregor, "Particle Sampling of Solid Rocket Motor Exhausts in High Altitude Test Cells" in R.A. Roux and T.D. McCay, eds., *Spacecraft Contamination Sources and Prevention* (New York: American Institute of Aeronautics and Astronautics, 1984) 293 at 293-294, and P.T. Girata, Jr. and W.K. McGregor, "Postfire Sampling on High Altitude Test Cells" in Roux and McCay, eds. *ibid.*, 312 at 325-326.

[46] Various coatings and materials used in spacecraft, notably paints and their binder agents, leave bits of space debris behind. This coating degradation and chipping is due to exposure to ultraviolet radiation and atomic oxygen and to expansion and contraction stresses resulting from severe changes in temperature. See Frederick, *supra*, note 39 at 17-18.

[47] Cabin leakage, outgassing of heavy molecules, water dumps, flash evaporator system operation, reaction control system engine firings, particles and gases have been released from space transportation system (STS) orbiters. See H.K.F. Ehlers *et al.*, "Space Shuttle Contamination Measurements from Flights STS-1 Through STS-4" (1984) 21 J. Spacecraft & Rockets 306 at 306-307. The orbiters also exhibit a radiated glow

2. The Ecosystem[48]

In near-Earth space, space debris is found in orbit from altitudes of 200 to approximately 40,000 kilometres.[49] At least 45 rocket bodies and inactive payloads are in orbit around, or have landed or crashed on, the Moon;[50] at least 23, around or on Venus[51] and at least 43, around or on Mars[52]. Another four payloads are in the process of leaving the solar system.[53] On Earth, although there is by definition no space debris, space projects may have adverse effects on ecosystems of the biosphere.[54]

(spaceglow) which interferes with space-based optical measurements. See R.K. Cole *et al.*, "Atomic Oxygen Simulation and Analysis" (1987) 15 Acta Astronautica 887 at 887 and 889-891.

[48] See also, Chapter I, *supra*, Section B.

[49] Space debris found beyond GEO, i.e., at altitudes higher than 35,800 km, has two main sources: objects in highly elliptical orbits with perigees in LEO and apogees up to 40.000 km; and objects in disposal orbits from 50 to 1000 km above GEO. See NRC Assessment, *supra*, note 2 at 64-67 and 147-149. A space object's perigee is the point in its orbit closest to Earth; the apogee, the point furthest from Earth. *Ibid.* at 197-198.

[50] R. Maurer, *Junk in Space* (New York: Simon & Schuster, 1989) at 28.

[51] *Ibid.* at 38.

[52] *Ibid.* at 43.

[53] See Chapter I, *supra*, text accompanying notes 17-18.

[54] See Chapter VI, *supra*, Section B.1(a). See also, "Space Debris Study Explores Effect on Climate, Ozone" (18-24 October 1993) *Space News* 32.

3. Adverse Effects[55]

Collision and interference are the major risks space debris poses to human life and active payloads. More recently, concerns have been raised that both liquid and solid rocket-motor fuels are contributing to depletion of the ozone layer[56] and otherwise threatening the quality of the atmosphere[57].

A collision may result in loss of property or life, damage to persons or property, generation of further debris, misinterpretation, release of contamination or the need to alter space operations or space object design. Space debris also causes interference with scientific, commercial and military space projects. In addition, at least the possibility exists that space debris could be used for military purposes.

(a) Collision

A collision with space debris could result in the death of persons or destruction of property. With speeds averaging 10 km/sec (more than 35,000

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[55] Material in this section originally appeared in Baker, *supra*, note 1 at 58-68. See also, NRC Assessment, *supra*, note 2 at 79-99.

[56] See e.g., C.Q. Christol, "Stratosphere Ozone Problem and Space Activity" (1992) 35 Colloq. L. Outer Sp. 259.

[57] See e.g., M. Rothblatt, "Environmental Liability Issues of Rocket Exhaust under International Space Law" (1992) 35 Colloq. L. Outer Sp. 307.

km/hour), a 0.5 mm-chip of paint could puncture a standard spacesuit, killing an astronaut engaged in an extravehicular activity.[58] The impact of an object 1 cm in diameter with a space station could penetrate the pressurized crew module, killing the crew and causing the station to break up; it could pierce the window of a space shuttle, killing its occupants and seriously damaging the spacecraft, or could disable or destroy a satellite in GEO.[59] The development and construction of the space station has already suffered serious delays due to design alterations to increase protection against space debris.[60] RADARSAT, Canada's first remote-sensing satellite, was the first satellite to undergo

[58] L.P. Temple III, "The Impact of Space Debris on Manned Space Operations", at 6 . Paper prepared for presentation at American Institute of Aeronautics and Astronautics Space Systems Technology Conference, San Diego, Cal., June 1986, and Wolfe & Temple, *supra*, note 44 at 3. The risk of such a collision has increased four orders of magnitude in 10 years. Temple, *ibid.*

[59] See "Station Likely To Be Hit by Debris" (17 September 1984) *A.W.S.T.* 16; D.S. Edgecombe, N.H. Fischer and R.C. Reynolds, "Space Craft Design Alternatives to Accommodate the Collision Threat Posed by Orbiting Man-Made Debris" in G.W. Heath, ed., *Space Safety and Rescue 1982-83* (San Diego, Cal: Univelt, 1984) 223 at 226; A. Oberg, "Trashing the Orbital Frontier" (October 1984) Sci. Dig. 41 at and S. Wiessner, "The Public Order of the Geostationary Orbit: Blueprints for the Future" (1983) 9 Yale J. World Pub. Ord. 217 at 226-227. There is also an escalating risk of damage to the Hubble Space Telescope. "Hubble Trouble?" (January 1987) Sky & Telescope 31.

[60] See *eg* United States General Accounting Office, *Space Station: Delays in Dealing with Space Debris May Reduce Safety and Increase Costs* (Washington, DC: USGAO, June 1992).

changes at an advanced stage of design in order to protect it against space debris.[61]

Collisions with space debris could also cause varying degrees of damage. "Graceful" degradation of spacecraft capability could occur, due to pitting or fracturing of optical surfaces, solar cell cover glasses or special thermal coatings; the skin of a spacecraft (shielded or unshielded) could be penetrated, leading to damage or destruction of secondary sub-systems (e.g., computers and communication equipment) or even more robust subsystems (e.g., propulsion system components and high-pressure fuel tanks).[62] In addition, launching upper stages with SRMs near US shuttle orbiters leaves open the possibility of damage to thermal protection tiles and crew observation windows from the high velocity cloud of small particles.[63]

Evidence indicating that space debris has struck active payloads abounds. An early indication was obtained from Explorer 46. Analytical results of the 43

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[61] See H.R. Warren and M.J. Yelle, "Effects of Space Debris on Commercial Spacecraft -- the RADARSAT Example" in Simpson, ed., *supra*, note 2 at 77.

[62] Edgecombe *et al.*, *supra*, note 59 at 226.

[63] Girata & McGregor (Particle sampling), *supra*, note 45 at 294.

impacts with the satellite could only be explained by man-made objects.[64] The first real proof that space debris was striking active payloads was provided by the Skylab cosmic dust experiment, S-149.[65] A widely discussed collision occurred in June 1983 when the windshield of the Challenger shuttle orbiter was struck by a particle of thermal paint about 0.2 mm in diameter estimated to be travelling at a speed in the range of 3-6 km/sec. This impact represented the first confirmed damage to an operational spacecraft by space debris.[66] More recently, examination of materials recovered from the Solar Maximum Mission satellite ("Solar Max") and the Long Duration Exposure Facility ("LDEF") have revealed hypervelocity impacts with meteoritic materials, paint particles and particles of unknown origin. Analysis indicates that possibly 70 per cent of the impacts on Solar Max resulted from space debris.[67]

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[64] Kessler, *supra*, note 29 at 57-58.

[65] See Wolfe & Temple, *supra*, note 44 at 3-4 and Kessler, *ibid.* at 57.

[66] At first believed to be a micrometeorite impact, the paint chip left a crater 2.0-2.4 mm across and 0.63 mm deep and damaged the glass out to a diameter of 4 mm. Due to the severity of the impact, the windshield could not be reused. See "Strike Craters Shuttle Windshield, Forces Replacement" (11 July 1983) *A.W.S.T.* 18; Frederick, *supra*, note 39 at 18; R. DeMeis, "Cleaning Up Our Space Act" (February-March 1987) Aerosp. Am. 10 at 10; Kessler, *supra*, note 43 at 587, and Kessler, *supra*, note 29 at 57.

[67] On Solar Max, see Kessler, *supra*, note 29 at 58; Wolfe & Temple, *supra*, note 44 at 4, and F.J.M. Rietmeijer *et al.*, "An Inadvertent Capture Cell for Orbital Debris and Micrometeorites: The Main Electronics Box Thermal Blanket of the Solar Maximum Satellite" (1986) 6 Advances Sp. Research 145 at 147-148. The source of the particles of unknown origin remains enigmatic. On LDEF analyses, see e.g., S. Mullen, J.A.M. McDonnell, & C. Tarrantino, "A Study of Meteoroids and Debris Impacts on the LDEF

In several cases where the cause of loss or damage to active payloads is unknown, collision has been put forward as a possible explanation. In these instances, analysts have concluded that, but for a collision, the incident would not have occurred.[68]

The cascade effect is perhaps the most serious consequence of collisions with space debris. At present, the space debris population increases according to the quantity of new man-made objects placed in space. It is hypothesized that, when the space debris population reaches a certain threshold, collisions between existing debris objects will create new debris and therefore obviate the

UHCRE Thermal Blankets" in Darmstadt Proceedings, *supra*, note 2 at 153; J.A.M. McDonnell, "The LEO Microparticulate Environment: LDEF's 5.75 Year Perspective on Orbital Space Debris and Meteoroids" in Darmstadt Proceedings, *ibid.* at 171, and R. Bernhard *et al.*, "Composition and Frequency of Impact Residues Detected on LDEF Surfaces" in Darmstadt Proceedings, *ibid.* at 189.

[68] Such incidents include the US communications reflector balloon PAGEOS [J. Schefter, "The Growing Peril of Space Debris" (July 1982) Pop. Sci. 48 at 51 and N.L. Johnson *et al.*, *History of On-Orbit Satellite Fragmentation*, 2d ed. (Colorado Springs. Colo: Teledyne Brown Engineering, 1986) I-47]; Soviet target satellites, Kosmos 839 and Kosmos 880 [Johnson (Breakup Part II), *supra*, note 38 at 361-362]; Soviet ocean surveillance satellite Kosmos 954 [see Marshall, *supra*, note 30 at 425 and V. Riche, "The Facts About Kosmos-954" (1978) 271 Nature 497 at 498]; ESA's magnetospheric satellite (Geos-2) [G. Wrenn, "Geos 2 in Space Collision?" (1978) 274 Nature 631 at 631]; Kosmos 1275 [see Johnson, *supra*, note 42 at 14; Marshall, *ibid.* at 425; Kessler, *supra*, note 29 at 51-52, and Johnson (History), *ibid.* at I-276]; Tracking and Data Relay Satellite A ["TDRS Orbital Shift Delayed Pending Study" (18 April 1983) *A.W.S.T.* 26-27], and the third stage of an Ariane rocket in November 1986 [see "Ariane Booster Fragments in Space" (February 1987) Satellite Telecommunic. 11; "Used Ariane Stage Explodes, Creating Space Debris Hazard" (1 December 1986) *A.W.S.T.* 34, and DeMeis, *supra*, note 66 at 11].

need for the introduction of new man-made objects to increase the debris population. It is possible that cascading has already begun and that this self-generation will create a debris belt around Earth, despite the implementation of launch constraints, related operational procedures and design alterations.[69] The significance of the cascade effect is three-fold: the occurrence of a few collisions could increase dramatically the severity of the space debris problem; collisions and any ensuing cascading may make this problem unmanageable because space debris is virtually impossible to remove; and the near-Earth environment could become so full of space debris that certain regions of LEO would become unusable, especially at its lower limits.[70]

Although collisions with space debris are inevitable, the intent of these impact events could be misinterpreted easily. For example, if a collision resulting in a

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[69] See NRC, *supra*, note 2 at 6-7. See also, D.J. Kessler, "Collisional Cascading: The Limits of Population Growth in Low Earth Orbit" (1991) 11 Advances Sp. Research 63 and D.J. Kessler & B.G. Cour-Palais, "Collision Frequency of Artificial Satellites: Creation of a Debris Belt" in H.B. Garrett and C.P. Pike, eds, *Space Systems and Their Interactions in the Earth's Space Environment* (New York: American Institute of Aeronautics and Astronautics, 1980) 707 at 707 and 724.

[70] See R.C. Reynolds, N.H. Fischer and D.S. Edgecombe, "A Model for the Evolution of On-Orbit Man-Made Debris Environment" (1983) 10 Acta Astronautica 479 at 481; R.C. Reynolds, E.E. Rice and D.S. Edgecombe, "Man-Made Debris Threatens Future Space Operations" (September 1982) Physics Today 9 at 116, and W.W. Mendell and D.J. Kessler, "Limits to Growth in Low-Earth Orbit", at 1. Paper IAA-87-574 prepared for presentation at 38th Congress, International Astronautics Federation, Brighton, October 1987.

loss of life were to lead to hostility and suspicion among nations, plans for a rapidly expanding human presence in near-Earth space could be frustrated for decades, possibly generations, to come.[71] If space debris were to strike an active payload, that collision could be mistaken for an armed attack or some other deliberate attempt to cause damage. The risk of a dangerous interpretation could only increase if weapons-related tests involving collisions with targets are resumed.[72] Misinterpretation could also occur on the re-entry of a collision-induced fragment into the Earth's atmosphere because the final trajectory of a decaying, large space object is similar to that of a re-entering ballistic missile.[73]

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[71] Wolfe & Temple, *supra*, note 44 at 2.

[72] See B. Jasani, "Military Uses of Outer Space" in Stockholm International Peace Research Institute, *SIPRI Yearbook 1987: World Armament and Disarmament* (London: Oxford University Press, 1987) 57 at 67 and *Physical Nature and Technical Attributes of the Geostationary Orbit*, UN COPUOS, 1983, para. 36, UN Doc. A/AC.105/203/Add.4 (1983) [hereinafter *1983 Physical Nature*].

[73] J.A. Howell, "The Challenge of Space Surveillance" (June 1987) Sky & Telescope 584 at 588. As early as 1970, there have been instances when objects in orbit could have confused defense radars guarding against surprise missile attack. See C.S. Sheldon II and B.M. DeVoe, "United Nations Registry of Space Vehicles" (1970) 13 Colloq. L. Outer Sp. 127 at 130.

Collisions between space debris and active payloads with nuclear power sources ("NPS") on board pose the hazard of radioactive contamination.[74] More than four dozen satellites carrying in excess of one tonne of radioactive materials were orbiting Earth in 1987. In February 1995, it was reported that more than two-dozen NPS Russian military satellites were leaking reactor coolant which could have "a very slight, residual radioactivity".[75] By the end of this century, it is estimated that there will be more than three tonnes of toxic fuels and fission products in orbit, unless there are reductions in NPS programmes.[76] If the active payload population continues to grow at present rates, the chance of a collision between a crewed or uncrewed spacecraft and an NPS satellite before re-entry from its storage orbit is a "virtual certainty".[77] Moreover, due to natural orbital decay, NPS satellites or their radioactive

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[74] Other various wastes products which a collision with space debris could release include unusable waste by-products destined for Earth, quarantined microbiological organisms and used or contaminated material (e.g., stored gases and rocket motor lubricant leakage). These materials would increase the quantity of space debris and cause hazards to navigation, communication and health. P. McGarrigle, "Hazardous Biological Activities in Space" (1984) 18 Akron L. Rev. 103 at 114; M.J. Mackowski, "Safety on the Space Station" (March 1987) Sp. World 22 at 22-23, and Girata and McGregor (Postfire sampling), *supra*, note 45 at 326.

[75] "Russian Satellites Suspected as Space Debris Source" (13-19 February 1995) *Space News* 19.

[76] N.L. Johnson and D. McKnight, *Artificial Space Debris* (Malabar, Fla: Orbit Books, 1987) at 90-91. As of October 1988, about 70 NPS were in orbit. "Atom Power in Orbit: A Fear of Debris" (19 October 1988) *Intern'l Herald Tribune* 1.

[77] N.L. Johnson, "Nuclear Power Supplies in Orbit" (1986) 2 Sp. Pol'y 223 at 231.

component parts could collide with a large space structure, when they begin to enter lower altitudes after several hundred years.[78] In addition, release of radioactive materials into the space environment could affect the performance of proposed space-based radars, by disrupting the propagation of electromagnetic waves in the atmosphere.[79]

The risk of collision with space debris is given serious consideration today in planning space operations. Space traffic management programmes have already been altered to avoid the risk of collision.[80] New spacesuits are being designed to give greater protection against collision impacts, while the risk of such an impact is considered by designers of large structures such as the international space station and the advanced X-ray astronomy facility.[81]

(b) Interference

Space debris can interfere with scientific, commercial and military space projects. Interference with these projects could also result in conflict-creating

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[78] *Ibid.* at 230-231.

[79] "DNA Models Nuke Effects for Space Radars" (12 October 1987) *Military Space* 4.

[80] See NRC Assessment, *supra*, note 2 at 125-128.

[81] See Temple, *supra*, note 58 at 4, 6 and 8; DeMeis, *supra*, note 66 at 10. and "Space Station Likely To Be Hit by Debris" (17 September 1984) *A.W.S.T.* 16.

misinterpretation.[82] Space debris may interfere with the space-based acquisition of scientific data by causing damage to the surface of optical instruments and solar panels or by impairing the accuracy of the scientific data. Gases, solid particles and spaceglow released as by-products of STS orbiter operations could also affect future scientific observations from vehicles orbiting in space.[83]

Earth-based space activities also suffer from interference with space debris. Inactive payloads and rocket fragments may disturb the frequency bands in which sensitive instruments (e.g., radio telescopes) operate, thereby preventing clear reception of celestial radio signals. Space debris regularly disfigures photographs of distant stars and galaxies, taken with ground-based telescopes, and has prompted false discoveries.[84] In the future, threats of interference may

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[82] See *supra*, text accompanying notes 71-73.

[83] Of special interest are the exhaust clouds of aluminum oxide released when second-stage SRMs are fired. These clouds, existing for as long as two weeks after the rocket firing, affect significantly meteoroid measurements in near-Earth orbit and stratospheric cosmic dust collection experiments. See Marshall, *supra*, note 30 at 425, and A.C. Mueller and D.J. Kessler, "The Effects of Particulates from Solid Rocket Motors Fired in Space" (1985) 5 Advances Sp. Research 77 at 77.

[84] See e.g., M. Benkö, W. de Graff and G.C.M. Reijnen, *Space Law in the United Nations* (Dordrecht, The Netherlands: Martinus Nijhoff, 1985) 140 and "Orbiting Junk Threatens Space Missions" (4 August 1987) *The New York Times* C1 at C3.

come from space-based projects which fail to account for scientific interests.[85] Concerned scientists have formed an organization to counter the proliferation of space debris.[86]

Interference with commercial space activities by space debris is dominated by the problem of congestion, or crowding, in LEOs and in GEO. Early crewed missions confirmed the existence of congestion in LEO.[87] A US shuttle orbiter, at an altitude of about 270 km on a four-day mission, is expected to come within 200 km of some 67 space objects larger than 1 m.[88] In GEO, satellites sharing the same nominal orbital position come close together periodically at

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[85] One plan was to launch a ring of 6-m diameter aluminum-coated spheres into an 800-km orbit. Such a ring of light would do incalculable harm to astronomy. Another proposal was to place in space a highly reflective sail with a surface of 1800 sq m. Its brightness could have blotted out the faint stars and distant galaxies, both of which are of great concern to many astronomers. See S. van den Bergh, "Century 21: The Age of Space Junk?" (July 1987) Sky & Telescope 4 at 44.

[86] "Debris in Space Presents an Increasingly Difficult New Dilemma for Scientists" (10 August 1987) *Satellite News* 7 at 8.

[87] R.C. Hall, "Comments on Traffic Control of Space Vehicles" (1965) 31 J. Air L. & Com. 327 at 329. As LEOs are the easiest region of near-Earth space to reach, they host a wide variety of telecommunication activity, serve as warehouses for space objects prior to their transfer to higher orbits and provide temporary domicile for humans.

[88] R.T. Swenson, "Pollution of the Extraterrestrial Environment" (1985) 25 A.F. L. Rev. 70 at 72 and Schefter, *supra*, note 68 at 50.

the borders of their slots.[89] Space debris congestion in heavily used regions of space could also lead to interference with transmissions from telecommunication satellites and could disrupt other space-based activities.[90] The military are also concerned that space debris could seriously interfere with their planned space projects.[91]

(c) Military Use

Due to its destructive nature, the possibility exists that space debris could be harnessed for military purposes. In the United States, near-Earth space is a medium in which military operations in support of national security are currently taking place and which could be used in the future for as yet untested purposes.[92]

[89] In a sample of GEO encounters for 21 satellites during a six-month period in 1981, there were 120 predicted encounters in a 50-km "near-miss" distance. Several close approach predictions were in the 1-5 km range, necessitating collision avoidance manoeuvres. 1983 Physical Nature, *supra*, note 72, para. 33.

[90] *The Feasibility of Obtaining Closer Spacing of Satellites in the Geostationary Orbit*, UN COPUOS, 1985, para. 50, UN Doc. A/AC.105/340/Rev.1 (1985).

[91] See e.g., "Contamination Threatens USAF Payload" (24 May 1982) *A.W.S.T.* 63 and "DNA Models Nuke Effects for Space Radars" (12 October 1987) *Military Space* 4.

[92] See Wolfe & Temple, *supra*, note 44 at 7 and "The Orbiting Junkyard" (April 1982) 16 Futurist 77. See also, Jasani, *supra*, note 72 at 66-67.

Both individual space debris objects and space debris clouds could have military applications, depending on the objective of the military action. Individual objects have the advantage of size; debris clouds have the advantage of density, making them useful not only for inflicting damage, but also for interference and camouflage purposes. Space debris would be an effective countermeasure, both militarily and economically, against space platforms in polar orbits because each piece of space debris has an energy potential of more than 15 times that of dynamite.[93] Space debris could also be introduced deliberately into near-Earth space either to deny access to a particular orbital region which is perceived to be particularly valuable to an enemy, or to interfere with surveillance activities.[94]

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[93] The realization that space debris might be used as an offensive weapon would necessitate expansion of platform bumper shields to ensure that any space debris would hit them. At the same time, this additional weight would make the platform less manoeuvrable, leaving its unshielded areas more vulnerable to impacts. See J.R. Michener, "Orbital Weapons Systems: Requirements, Countermeasures and Offensive Capabilities Creating a Cost-Effective (?) Defense?", at 7-9 (1987). Unpublished paper. On file.

[94] On denying access, see Reynolds *et al.* (Debris threat), *supra*, note 70 at 117 and Oberg, *supra*, note 59 at 43. Following the explosion of an Ariane third-stage rocket in November 1986, it was thought that the United States was concerned that the resulting debris was in the path of its only photo-reconnaissance satellite. Jasani, *supra*, note 72 at 66. On 26 October 1987, the US Air Force launched a "classified military payload" which was most likely a similar photo-reconnaissance satellite. "Successful Launch Ends 18-Month Grounding" (2 November 1987) *Satellite News* 12.

4. Mitigation

For a space project is to pass through a comprehensive review, the project developer will be required to demonstrate that all necessary steps have been taken to reduce or control, in as timely a manner as possible and by using the best technology available, the potential adverse effects which could be caused by space debris.[95]

When the space nations became aware of the adverse effects of space debris on their space operations, efforts began on an *ad hoc* basis in the late 1980s to determine the best methods for mitigating these effects. With the publication in 1995 of the NRC Assessment on space debris,[96] an orchestrated, international approach for mitigation of space debris was initiated. The NRC Assessment is for the most part a consensus document, written by the NRC Committee on Space Debris ("NRC Committee"), with contributions from individuals and organizations from around the world having expertise in space debris science, technology, law and policy.

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[95] See Chapter IV, *supra*, text accompanying notes 159-162.

[96] *Supra*, note 2. On the contributions of individual States to the mitigation of space debris, see Canadian Space Agency, *The Report of the ICS Subcommittee on Space Debris* (Montreal: Canadian Space Agency, July 1996) Appendix.

The significance of the NRC Assessment is that it will likely establish the parameters for voluntary international standard-setting by those States with major interests in space projects. Currently, these States are the ones which manufacture launch vehicle components and payloads, and which launch the vast majority of spacecraft: the United States, Russia, the European Space Agency, Japan and China. By agreeing on technical standards outside the diplomatic and legal constraints of the international space law-making body, the United Nations Committee on the Peaceful Use of Outer Space ("COPUOS"), these stakeholders hope to set any future agenda for standard-setting in the technical and legal sub-committees of COPUOS.

In a related matter, NASA has for the last few years, in consultation with the other space nations, been developing a handbook of guidelines, designed for use by US industry in limiting space debris generation.[97] The handbook is likely to be modified to incorporate the recommendations of the NRC Assessment and could serve as an international benchmark for space debris mitigation.

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[97] R.C. Reynolds *et al.*, "A Handbook to Support the NASA Policy to Limit Orbital Debris Generation -- A Progress Report" in Darmstadt Proceedings, *supra*, note 2 at 619.

The first recommendation of the NRC Committee is to form an "expanded international group to advise" on future areas of research and research methods.[98] Action on this proposal could mark the commencement of efforts to create a supranational body to oversee space debris standard-setting and to lobby for, and otherwise encourage, States to implement these standards. This display of international co-operation to address a matter of common concern is evidence of the regard the spacefaring nations have for the interests of other States, as required by Article IX of the *Outer Space Treaty*[99]. This attitude supports the principles of good neighbourliness[100] and precautionary measures[101], and endorses, albeit in a limited manner,[102] the various elements of the comprehensive review.

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[98] NRC Assessment, *supra*, note 2 at 176.

[99] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 27 January 1967, Can. T.S. 1967 No. 19, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 [hereinafter *Outer Space Treaty*] (entered into force 10 October 1967). See also, Chapter V, *supra*, text accompanying notes 69-74.

[100] See Chapter VI, *supra*, Section B.1(b).

[101] See *ibid.* at Section B.1(c).

[102] See *infra*, criticisms of NRC Committee recommendations for mitigation, waste management and monitoring.

The principal recommendation of the NRC Committee for reducing and controlling space debris is to prevent accidental explosions, which create most fragmentation debris, by removing fuel and other pressurized materials from rocket bodies and payloads at the end of their functional lifetimes and by dissipating energy in batteries and other storage systems.[103] Another recommendation is to reduce, where possible, the release of mission-related objects, the redesign of which is fairly easy and not significantly expensive.[104] Space debris arising from crewed missions and from the exhaust products of SRMs are not considered for mitigation. The former "will not reduce the overall long-term debris hazard"; the "potential damage that [the latter] can cause to functional spacecraft [is] small".[105] It is also recommended to space project developers to attempt to develop paints and thermal materials that do not chip, in order to avoid "surface degradation" to "unprotected spacecraft components such as optics windows and tethers".[106]

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[103] See NRC Assessment, *supra*, note 2 at 180. See also, *ibid.* at 136-142.

[104] See *ibid.* at 181. See also, *ibid.* at 136-137.

[105] See *ibid.* at 137.

[106] See *ibid.* at 18. See also, *ibid.* at 142.

Removal of non-functional rocket stages and payloads from orbit is seen as an important method for avoiding adverse effects on space activities. The NRC Committee recommends that in LEO space objects such as these be removed by deorbiting, through use of the spacecraft's propulsion system, or by reducing the orbital lifetime of the space object by accelerating its natural decay.[107] While the NRC Committee could not reach agreement on the exact limitation of lifetime for a rocket body or non-functional spacecraft in LEO, it supported a NASA guideline for removal "no longer than 25 years after mission completion.[108] Disposal orbits were rejected as an option in LEO because it is possible to remove space debris from orbit and "there is a lack of sufficiently unpopulated regions" for the allocation of disposal orbits.[109]

In GEO, deorbiting or reduced orbital lifetimes were not considered as a method of removal because the necessary manoeuvres would be "prohibitively costly".[110] The alternative is boosting the space debris to "disposal orbits", although consensus could not be reached on the altitude of these orbits above

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[107] See *ibid.* at 182. See also, *ibid.* at 143-145.

[108] See *ibid.* at 182.

[109] See *ibid.* at 152.

[110] See *ibid.* at 148.

GEO "or on whether the use of disposal orbits is the optimal strategy for containing the GEO debris hazard".[111] Until a strategy is agreed upon, the NRC Committee recommended that non-functional spacecraft, "if they are capable of safely performing a reorbiting maneuver," should re-orbit to at least 300 km in altitude above the geostationary band.[112] Active removal of space debris from LEO or GEO by either a dedicated spacecraft or other, as yet technically unproven means, is considered uneconomical for the foreseeable future.[113]

While this voluntary international effort to agree on mitigation measures and standardized procedures is commendable, in the context of planetary risk assessment the conclusions in the NRC Assessment are too narrow on three separate grounds. First, the scope of the recommendations does not include all adverse effects from space debris, as required from the legal obligation of minimal impairment,[114] which underlies the comprehensive review. Second, mitigation measures are limited to collisions with space debris, with no

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[111] See *ibid.* at 182. See also, *ibid.* at 147-152.

[112] See *ibid.* at 182.

[113] See *ibid.* at 153-154.

[114] See Chapter VI, *supra*, Section 2.C.

consideration given to the actual and potential adverse effects on ground-based activities,[115] to the ozone layer,[116] or to the space plasma and the upper atmospheric regions of the biosphere[117].

Third, the mitigation measures are limited in their scope of application because the NRC Committee only considered the extent to which a mitigation "method will actually reduce the debris hazard to space operations".[118] The Committee discounted the potential adverse effects of operational debris released from crewed space missions and from exhaust products of SRMs because they will not cause sufficient damage to functional spacecraft.[119] Restricting its considerations to the effect of space debris on "space operations" further limits possible mitigation measures by focusing on space projects in LEO and GEO, in disregard of the potential adverse effects of space debris (i) on the surfaces of, and in orbits around, the Moon and other celestial bodies; (ii) to the biosphere, particularly the atmosphere, from the launch and re-entry of space objects; and (iii) on the surface of the biosphere

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[115] See *supra*, text accompanying notes 84-86.

[116] See *ibid.*, text accompanying notes 56-57.

[117] See Chapter I, *supra*, text accompanying notes 32-35.

[118] NRC Assessment, *supra*, note 2 at 135.

[119] See *ibid.* at 187.

caused during the manufacture, launch and retrieval of spacecraft. These limitations do not reflect the general principles of common planetary concern[120] and of good neighbourliness,[121] nor do they conform to the legal obligations to protect and preserve the planetary environment[122] and to ensure that all space projects result in minimal impairment of that environment[123].

Perhaps the major weakness of the proposed mitigation measures arises from the high priority given by the NRC Committee to the "cost of implementing the debris reduction measures".[124] These costs include development costs for new technology and lost opportunities "of any revenue lost or performance sacrificed in implementing the method".[125] The cost factor appears to have provided the most fundamental constraint on the mitigation analysis, particularly in the NRC Committee's considerations of removal of space debris in order to avoid collisions.[126] But cost cannot be the prime mover of

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[120] See Chapter VI, *supra*, Section B.1(a).

[121] See *ibid.* at Section B.1(b).

[122] See *ibid.* at Section B.2(b).

[123] See *ibid.* at Section B.2(c).

[124] See e.g., NRC Assessment, *supra*, note 2 at 135-136.

[125] *Ibid.* at 136.

[126] See *ibid.* at 143-145.

planetary management. According to the principle of precautionary measures,[127] and as restated in the legal obligations to protect and preserve,[128] and to minimally impair,[129] prevention of adverse effects -- not the cost of prevention-- should be the priority.[130] If economic incentives, technological breakthroughs and creative alternatives are not forthcoming, then space projects with potentially adverse effects should not be initiated.

5. Waste Management

Waste management is an organized system for disposing of unwanted by-products created in the manufacture, production and use of goods. A major weakness of the NRC Assessment is the absence of firm plans to manage the disposal of newly created space debris or to clean up existing waste sites. Such management plans are necessary in order to minimize adverse effects on planetary ecosystems and to avoid interference with their inherent worth[131].

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[127] See Chapter VI, *supra*, Section B.1(c).

[128] The legal obligation to protect and preserve extends to any adverse effect in any ecosystem. See *ibid.*, text accompanying notes 62-64.

[129] The legal obligation to minimally impair ecosystems is to be carried out in a timely manner and with the best available technology. See *ibid.* at [24].

[130] See *ibid.*, text accompanying notes 30-32.

[131] See Chapter IV, *supra*, text accompanying notes 163-165.

In near-Earth space, the recommended disposal strategies vary according to altitude. In LEO, disposal would not apply to existing space debris, but would be limited to the removal of rocket bodies and payloads placed in orbit in the future, within a proposed maximum of 25 years after placement.[132] For GEO, the NRC Committee could not reach a consensus on disposal, but agreed that removal would be quite costly, in terms of both fuel requirements, which would reduce the functional lifetime of the spacecraft, and the research, development and operation costs for a retrieval vehicle.[133] However, using a disposal orbit, the NRC Committee notes, "only moves the hazard to a slightly wider band" and "does not completely eliminate the hazard the objects pose to spacecraft" in GEO.[134] Interestingly, disposal in MEO, which is expected to host a multitude of new-generation global positioning and telecommunications satellites by the year 2000, is not addressed.

These efforts are unsatisfactory for meeting the conditions of the planetary risk assessment process. Minimally, space debris interferes with the inherent worth

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[132] See NRC Assessment, *supra*, note 2 at 182.

[133] See *ibid.* at 182 and 150-152.

[134] See *ibid.* at 153.

of near-Earth space[135] and is analogous to terrestrial littering, a practice increasingly frowned-upon in the biosphere. As well, it interferes with scientific endeavours with a considerable public interest function.[136] The practice of not disposing of space debris is contrary to the principle of good neighbourliness, a principle of customary international law,[137] which requires that States take steps to avoid adverse effects in areas outside their jurisdiction and control. States cannot waive this principle for reasons of expedience. Failure to give consideration to the disposal of all space debris also breaches the legal obligation of minimal impairment. If the litter is produced, States have the responsibility to remove it.

The orbital lifetime of a spacecraft is determined primarily by the altitude of its orbit. In LEO, most space debris is found at an altitude of 2000 km and below.[138] At 200 km, a spacecraft has an average lifetime of 1-4 days; at 600 km, 25-30 years; at 1000 km, 2000 years; and at 2000 km, 20,000 years.[139] In

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[135] See Chapter VI, *supra*, Section B.2(a).

[136] See *supra*, Section B.3(b).

[137] See Chapter III, *supra*, text accompanying notes 61-63.

[138] Spatial density in LEO is greatest near altitudes of 1000 and 1500 km. W. Flury and D. McKnight, "Options for Controlling Space Debris" in Darmstadt Proceedings, *supra*, note 2, 633 at 634.

[139] See *ibid.* at 635.

GEO, with an altitude of 35,800 km, the typical lifetime for spacecraft is in the order of tens of thousands of years or more.[140]

Rocket bodies and non-functional payloads below 2000 km in LEO could be removed within three months, with no new technology development, only by "changes in hardware or operational procedures".[141] Rocket upper stages in GTOs and other highly elliptical orbits could be removed within 10 years.[142] Techniques for the disposal of space debris objects at altitudes above 2000 km will require new technology. Proposals to date include orbiting manoeuvring vehicles, drag and tether devices, destruction by laser and debris catcher/sweepers, none of which is currently technologically feasible or cost-efficient.[143] Alternative, more efficient propulsion methods are also being explored.[144] States which manufacture and launch spacecraft have a duty to pursue the development of these methods, as well as others for disposal of the smaller-sized space debris, in fulfilment of their obligation of minimal

[140] NRC Assessment, *supra*, note 2 at 153.

[141] Flury & McKnight, *supra*, note 138 at 640.

[142] *Ibid.*

[143] *Ibid.*

[144] See e.g., *infra*, text accompanying notes 158-162.

impairment. As with technology development for mitigation measures, appropriate cost incentives should be made available.

In near-Earth orbit, the requirement in the waste management plan for cleaning up existing disposal sites and abandoned work sites basically corresponds to need for developing comprehensive mitigation strategies, given the physical nature of the near-Earth ecosystem. Site cleanups on the surfaces of celestial bodies, including the Moon, Venus and Mars, have been given no consideration in the NRC Assessment. Any future crewed mission to these celestial bodies should include a priority commitment to dispose of previously discarded materials. In anticipation of any such mission, the Earth-made objects on each celestial body should be catalogued to determine whether these objects can be usefully re-used or recycled in order to reduce both mission costs and the cost of final disposal. As to the disposal of wastes created by mission crews, whether in orbit or on the surface of a celestial body, future crewed missions should be required to follow the first rule of the wilderness camper and bring back everything that has not been consumed. Body wastes should be recycled, where possible.

A legal impediment to the removal of space debris, particularly the identifiable larger items such as rocket stages and non-functional payloads, arises under

Article VIII of the *Outer Space Treaty*[145]. Article VIII allocates jurisdiction and control over space objects to the State of registry of the space object. Article VIII further provides that ownership of a space object is not affected in outer space. One negative consequence of this provision is that the State of registry has the exclusive right to make and enforce law in relation to any space object and personnel under its jurisdiction and control. A significant implication of ownership is that consent of an owner is required for the possession, use or disposal of the owner's property.[146]

Assuming that the space debris to be removed can be characterized as a "space object",[147] the State of registry will have to agree, and the owner consent, to the removal of any space debris in orbit or on the surface of a celestial body. Provisions for waiving the requirement of consent for removal of space debris

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[145] *Outer Space Treaty*, *supra*, note 99, art. VIII, states in part: "A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the earth."

[146] On the analysis of Article VIII of the *Outer Space Treaty* as it applies to space debris, see H.A. Baker, *Space Debris: Legal and Policy Implications* (Dordrecht, The Netherlands: Martinus Nijhoff, 1989) at 67-71.

[147] On the question whether "space objects" includes "space debris", see Baker, *ibid.* at 79-80.

could be negotiated among space project stakeholders. Such an agreement could determine the classes of space debris to which it applied, could restate the principles of jurisdiction and control in the context of space debris removal and could prescribe the conditions for removal. Implementation of this agreement could be by means of an Annex to the Environmental Protocol to Article IX of the *Outer Space Treaty*.[148]

6. Clean Technology

The development and application of clean technologies are a basic means for remedying the problem of space debris, which may be characterized as an industrial externality arising from the unplanned, adverse effects of space projects on near-Earth ecosystems. Under the polluter pays principle, the costs of clean technologies should be "internalized" into the cost of production and passed on to the consumer.[149]

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[148] See Chapter VI, *supra*, Section A.

[149] See Chapter IV, *supra*, text accompanying notes 63-67.

For the reduction and control of space debris, clean technologies are required for the purposes of mitigation[150] and waste management[151]. Possible clean technologies include reusable and multipurpose launch vehicles;[152] devices for removing orbital space debris;[153] hardware to reduce operational debris;[154] systems for controlled payload re-entry; paints, thermal coatings and binder agents which do not break down in the near-Earth space environment;[155] systems for recycling and re-using waste products and gases produced during crewed missions,[156] and devices or systems for disposal of debris on the surface of celestial bodies[157].

Perhaps the most promising clean technologies are in the field of propellants and propulsion systems. Propellants to replace SRM fuels are being developed

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[150] See *supra*, Section B.4.

[151] See *ibid.* at Section B.5.

[152] See e.g., "X-33 Hurdles: After Hardware, Find the Money" (28 August - 3 September 1995) *Space News* 1: Preliminary work is under way to design a "reusable launch vehicle with near airliner-like operations".

[153] See e.g., Flury & McKnight, *supra*, note 138 at 640.

[154] See *supra*, text accompanying notes 34-35.

[155] See *ibid.* at n.46.

[156] See *ibid.* at n.35.

[157] See *ibid.*, text accompanying notes 50-53.

to eliminate aluminum oxide and hydrogen chloride, which not only pollute outer space, but are considered to be contributing factors to degradation of the ozone layer and the reduction in quality of the atmosphere. Cleaner fuel substitutes in varying stages of development include cryogenic fuels, which consist of super-cooled liquid hydrogen and oxygen, and hybrid fuels which combine solid fuels with a liquid or gaseous oxidizer.[158] Alternative propulsion systems being proposed include antimatter propellants, which would result in reusable, horizontal space vehicles with greater carrying capacity and could eliminate most of the space debris in orbit as well as adverse effects associated with launch procedures.[159] Other proposed propulsion methods being explored

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[158] See e.g., "U.S. Defense Conversion Effort Buoys Amroc Hybrid Fuel Work" (4-13 February 1994) *Space News* 18 and "Hybrid Rocket Tests Impress NASA Skeptics" (20-26 June 1994) *Space News* 6. The NRC has "recommended that NASA pursue hybrid propulsion as a high-priority technology". *Ibid.*

[159] See e.g., "USAF Predicts Antimatter Propellants Could Be in Use by Early 21st Century" (21 March 1988) *A.W.S.T.* 19 and H.D. Froning, Jr., "Investigation of Antimatter Air-Breathing Propulsion for Single-Stage-to-Orbit Ships" (1988) 17 Acta Astronautica 853. "If a rocket could be built that would use hydrogen heated by the annihilation of antihydrogen mixed with it, the propulsive energy in one-hundredth of a gram would be equivalent to that of 109 tonnes of the fuel that fires NASA's space shuttle." "Filling Thermos Flasks for an Antimatter Picnic" (19 November 1994) *The Globe & Mail* (National Edition) D8.

include electromagnetic launch systems,[160] deuterium beam propulsion[161] and electric propulsion[162].

Because clean technologies are a means of reducing and controlling existing adverse effects of space debris, they are interim measures and should be supported by financial assistance in the form of cost incentives, in order to internalize more easily the environmental costs associated with the creation of space debris.[163] The approach of internalizing environmental costs would eliminate the repeated, familiar strategy of pleading the costs of research and development as a predominant justification for failing to take corrective action.[164] A particularly attractive form of cost incentive might be limited term, government subsidies or international consortia financing, with returns based on some combination of *pro rata* profit sharing and salvage rights to retrieved space debris.

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[160] See e.g., "NASA Studies Use of Magnetic Launch Pad" (19-25 September 1994) *Space News* 6.

[161] See e.g., "Deuterium Beam Possible Propulsion for Interstellar Probe" (12-18 September 1994) *Space News* 16.

[162] See e.g., "Eureca's Electric Propulsion Test Experiences Failure" (1-7 February 1993) *Space News* 5.

[163] See Chapter IV, *supra* at 163.

[164] See *supra*, text accompanying notes 124-130.

7. Monitoring

Monitoring space debris in orbit provides another example of international co-operation among the space-capable States to resolve a problem of growing common concern. Given the expense and sophistication of the technology required to detect, track and identify space debris and to predict with some accuracy its orbital behaviour, the thrust of international co-operation has been on sharing information, derived from the efforts of the major space project stakeholders.

Currently, the major techniques for monitoring the space debris environment in near-Earth space are the characterization of space debris,[165] the prediction of hazards it poses to space operations,[166] damage assessment and prediction,[167] modelling the future quantity and nature of space debris and analysing the effectiveness of debris reduction methods[168]. The means for the characterization of space debris include tracking and cataloguing of space debris by ground-based radar and optical sensors operated by the military in

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[165] See NRC Assessment, *supra*, note 2 at Chapter 2.

[166] See *ibid.* at Chapter 2.

[167] See *ibid.* at Chapter 5.

[168] See *ibid.* at Chapter 8.

the United States and Russia;[169] and by sampling space debris both statistically from ground- and space-based sensors and in the laboratory by studying space debris captured, advertently or inadvertently, on the surfaces of spacecraft[170].

Comprehensive monitoring of space debris is hampered by several factors, perhaps the most significant being that only a small percentage of space debris can be tracked, due mainly to the size of the debris objects and their location and attitude in near-Earth space.[171] The NRC Committee was aware of these shortcomings and has recommended that "[t]he creation of an international system for collecting, storing, and distributing data on orbital debris should be explored", based on a "unified data base" from all sources;[172] that "models of the future debris environment should be further improved";[173] that currently uncatalogued "medium-sized and large" space debris in LEO "should be

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169 See *ibid.* at 31-37.

170 See *ibid.* at 37-49.

171 See *ibid.* at 31 and 35. In LEO, space debris with a cross-section of 10-30 cm can be sensed by ground-based sensors; in GEO, the minimum size is 1 m. *Ibid.* at 34-35. The attitude of a space object is the position of the space object relative to the siting sensor.

172 See *ibid.* at 177-178.

173 See *ibid.* at 177.

carefully studied" because of its potential to damage spacecraft;[174] and that all space debris in GEO should be studied due to the commercial value of GEO and the active payloads in it[175].

The thrust of these techniques and the recommendations for their improvement basically conform with the monitoring requirements for planetary risk assessment, i.e., to ascertain and assess space debris risk events, both on a routine and emergency basis, and to predict and assess unforeseen risk events and their consequences.[176] Clearly, an effort is being made for co-operative supranational planning for effective monitoring. However, as with mitigation techniques,[177] monitoring activities are restricted by their limited application to space operations occurring in near-Earth space and by cost, particularly for development of sensors[178].

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[174] See *ibid.* The NRC Committee considered large space debris to be greater than 10 cm in diameter; medium-sized space debris, between 1 mm and 10 cm in diameter; and small debris, less than 1 mm in diameter. *Ibid.* at 2.

[175] See *ibid.* at 177.

[176] See Chapter IV, *supra*, text accompanying notes 167-169.

[177] See *supra*, text accompanying notes 114-130.

[178] See e.g., NRC Assessment, *supra*, note 2 at 42.

8. Post-Project Analysis

For orbiting space debris, the requirements for post-project analysis are contained in the monitoring function.[179] A combination of sensing devices and computer modelling techniques have been designed to anticipate unforeseen adverse effects, to monitor future mitigation practices, to verify past computer modelling predictions and to deal effectively with accidents.[180] The limitations on the effectiveness of post-project analysis are the same as those for monitoring space debris: coverage of too few debris objects, a limited application to near-Earth space operations and an overriding importance accorded to cost-effectiveness.[181] The adherence by post-project analyses to the basic principles of international environmental law and the legal obligations for planetary management also suffer to the same extent as do mitigation practices.[182]

As to celestial bodies, no evidence is available of any post-project analyses by the space launching nations of the space debris deposited either in orbit

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[179] See *supra*, Section B.7.

[180] See Chapter IV, *supra*, text accompanying note 170.

[181] See also, *supra*, text accompanying notes 114-130.

[182] See *ibid.*, text accompanying notes 120-123.

around or on those bodies, particularly for the detection of unforeseen effects and early warnings of potential accidents. Future missions should be mandated to collect required post-project information, which could not only prevent adverse effects in alien ecosystems, but could also assist in understanding the effect of alien environments on Earth-based materials and their potential re-use.

9. Restitution

Restitution is necessary in circumstances where a space project is justifiable and minimal adverse effects are unavoidable.[183] Restitution is not, however, a compensation mechanism arising from legal liability for damage. Restitution is anticipatory, based on the expectation of harm to biological entities-in-ecosystems,[184] and applies to new projects and alterations to existing ones[185]. For space projects, restitution will be required for any adverse effects to planetary ecosystems caused by space debris.

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[183] See Chapter II, *supra*, text accompanying notes 144-146.

[184] See Chapter IV, *supra*, text accompanying notes 171-173.

[185] See *ibid.*, text accompanying notes 133-134.

In the biosphere, restitution should be required for any adverse effects to biological entities-in-ecosystems arising from the re-entry of space debris, including general pollution of an ecosystem. Because the project developer agrees to the terms and conditions of restitution prior to project implementation, the question of liability in international space law does not arise.[186]

In near-Earth space, restitution for adverse effects of space debris would be required for the death or injury of mission crew members and non-human biological entities[187] and for interference with the ecosystems of near-Earth space and celestial bodies[188]. Restitution for interference should be made by the removal of space debris.

Restitution should take into account the possibility of the existence of alien entities.[189] Even if there is *prima facie* no likelihood that a space project might adversely affect alien entities-in-ecosystems,[190] the possibility of the need for

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[186] On legal liability in the planetary management régime, see *infra*, Section B.10.

[187] See Chapter IV, *supra*, text accompanying note 172.

[188] See *ibid.*, text accompanying note 174.

[189] See *supra*, text accompanying notes 6-8.

[190] See Chapter VI, *supra* at 266-267.

restitution should not be ignored. Accordingly, a preliminary requirement of any space project should be to take all measures to gain a comprehensive understanding of the alien ecosphere, its components and the interrelationships among them; and of the effects which the project may have on the alien ecosphere. In this manner, appropriate plans for restitution will likely be available, should they be needed.

10. Liability

The planetary management régime applies the principle of precautionary measures[191] and imposes the legal obligation to protect and preserve[192] so that adverse effects on ecosystems from space projects may be avoided. Unless scientific uncertainty as to the risk of adverse effects has been overcome, a space project should not be implemented.[193] Any justifiable adverse effects of a space project are to be compensated for by means of restitution.[194] In the context of planetary risk assessment, considerations of legal liability are therefore limited to adverse effects arising from events unforeseen or

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[191] See *ibid.* at Section B.1(c).

[192] See *ibid.* at Section C.2(b) .

[193] See *supra*, text accompanying notes 127-130.

[194] See *ibid.* at Section B.9.

overlooked during the course of the preparation and evaluation of the comprehensive review ("unforeseen adverse effects").

For any unforeseen adverse effect on natural entities-in-ecosystems from space projects, the State actor will be responsible on the basis of strict liability for all costs, including damage to persons, property and ecosystems, and costs of mitigation, control, clean up and restoration. Strict liability for unforeseen adverse effects is based on the polluter pays principle, which views these effects as externalities, to be built into future product costs.[195] The purpose of strict liability is to ensure that immediate and comprehensive action can be taken to ensure that harmed ecosystems are minimally impaired. Whether the unforeseen adverse effect arose from negligent or criminal conduct is a matter between the State actor and the space project developer.

The rule of strict liability for unforeseen adverse effects is not consistent with the liability régime established under the *Liability Convention*,[196] which governs liability for damage caused by space objects. The *Liability Convention* is fairly

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[195] See Chapter IV, *supra*, Section C.2(a).

[196] *Convention on International Liability for Damage Caused by Space Objects*, 21 November 1971, Can. T.S. 1975 No. 7, 24 U.S.T. 2389, T.I.A.S. No. 7762, 961 U.N.T.S. 187 [hereinafter *Liability Convention*] (entered into force 1 September 1972).

restrictive in its coverage. Damage is limited to harms to persons and to property caused by space objects.[197] It is generally agreed that damage does not include adverse effects in near-Earth space,[198] nor is it likely that "damage" would apply to alien entities-in-ecosystems. Further, the definition of "space objects" is not broad enough to include all classes of space debris.[199]

For damage caused on earth or to "aircraft in flight", liability is absolute, with the launching State responsible for compensation.[200] Absolute liability would exclude damage to areas of common planetary concern[201] such as the atmosphere, including the ozone layer, given that damage means loss or

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[197] *Liability Convention*, *ibid.*, art. I(a), states: "The term 'damage' means loss of life, personal injury or other impairment of health, or loss of or damage to property of States or of persons, natural or juridical or property of international intergovernmental organizations;"

[198] Baker, *supra*, note 146 at 79. On the meaning of "damage", see *ibid.* at 79-80. See also, B.A. Hurwitz, *State Liability for Outer Space Activities in Accordance with the 1972 Convention on International Liability for Damage Caused by Space Objects* (Dordrecht, The Netherlands: Martinus Nijhoff, 1992) at 12-20.

[199] See Baker, *ibid.* at 62-67.

[200] *Liability Convention*, *supra*, note 196, art. II, states: "A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight." On strict liability in the *Liability Convention*, see Hurwitz, *supra*, note 198 at 27-32.

[201] See Chapter VI, *supra*, Section B.1(a).

damage to property of States,[202] and is restricted in air space to aircraft in flight. To base a claim on strict liability, proof of damage and identification of the launching State[203] of the space object would be required.

For damage caused in the planetary environment, other than on the surface of Earth and to "aircraft in flight", liability is based on negligence.[204] If the damage falls within the scope of Article I(a) of the *Liability Convention* and if the space debris is considered a "space object", a successful claim for liability in negligence will require the claimant to prove on a balance of probability that (i) the damage occurred; (ii) the damage was caused by the space debris object; (iii) the space debris object is connected to a launching State; and (iv) the launching State breached the due diligence standard, i.e., the launching State did not take all reasonably foreseeable steps to avoid the event resulting in the

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[202] See *supra* at n.197.

[203] A launching State includes the State which launches or attempts to launch a space object; the State which procures the launch or attempted launch of a space object; the State from whose territory the space object is launched or attempted; and the State from whose facility a space object is launched or attempted. *Liability Convention*, *supra*, note 196, art. I(b) and I(c).

[204] *Liability Convention*, *ibid.*, art. III, states: "In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible." On fault liability in the *Liability Convention*, see Hurwitz, *supra*, note 198 at 32-36.

damage.[205] This is an extraordinarily onerous burden in near-Earth and other planetary ecosystems and should prompt a claimant to consider self-insurance for several reasons. First, the location of the alleged incident may make it impossible to prove a causal connection. Second, the current tracking technology may foreclose on detecting the space debris object, let alone identifying the launching State. Third, no standard of care has been established for space projects as a basis for evaluating the reasonableness of the launching State's diligence. Fourth, existing levels of technology make avoidance of collisions with space debris, the principle adverse effect, impossible.[206] Therefore, recovery for damage in the planetary environment triggered by an unforeseen adverse event would be extremely unlikely.

To provide adequate liability in the planetary environment for unforeseen adverse effects from space projects will require a régime distinct from that of the *Liability Convention*, which could be implemented by means of an Annex to the Environmental Protocol to the *Outer Space Treaty*.[207] Application of the Annex would be limited to unforeseen adverse effects to any natural entities-

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[205] See Baker, *supra*, note 146 at 84.

[206] *Ibid.*

[207] See Chapter VI, *supra*, Section A.

in-planetary-ecosystems from space projects. Where the adverse effect and the identity of the launching State are proved on a balance of probability, the launching State would be strictly liable for costs on the basis of the polluter pays principle. Where the adverse effect is proved, but the identity of the launching State is not, a space project insurance pool would provide the compensation. The pool would have two ponds. A shallow pond would provide compensation up to a specified fixed limit, with money provided by launching States and other space project owners in proportion to their project activities. A deep pond would provide compensation for costs which spilled over from the first pond, with contributions from space project users in proportion to their participation in space projects.

A precedent for such a compensation fund is found in the régime for the protection of the marine environment from oil pollution. Together, the *Oil Pollution Convention*[208] and the *Fund Convention*[209] provide strict liability for oil

[208] *International Convention on Civil Liability for Oil Pollution Damage*, 29 November 1969, 12 U.S.T. 2989, 973 U.N.T.S. 3 [hereinafter *Oil Pollution Convention*] (entered into force 19 June 1975).

[209] *Convention on the Establishment of an International Fund for Compensation of Oil Spill Damage*, 18 December 1971, 1110 U.N.T.S. 57 [hereinafter *Fund Convention*] (entered into force 16 October 1978).

pollution and full compensation to oil pollution victims.[210] Shipowners provide the money for compensation under the *Oil Pollution Convention*. With the *Fund Convention*, the economic burdens and the risks of liability are shared with oil importers. The importers provide the money for the Fund, which covers compensation in excess of that available under the *Oil Pollution Convention*, through a levy based on their anticipated annual commitments for oil.[211] This system "has functioned rather well. Compensation has been paid relatively quickly -- bearing in mind the frequently complex issues involved -- and the claimants have in most case received adequate compensation".[212]

11. Third Parties

Given that space debris is located in an area of common planetary concern, all States should have the opportunity to review and comment upon those aspects

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[210] See D. Wilkinson, "Moving the Boundaries of Compensable Environmental Damage Caused by Marine Oil Spills: The Effect of Two New International Protocols" (1993) 5 J. Env. L. 71 at 75-76. For an overview of the maritime liability régime for damage caused by oil pollution, see M. Jacobsson, "The International Conventions on Liability and Compensation for Oil Pollution Damage and the Activities of the International Oil Pollution Compensation Fund" in C.M. de la Rue, ed., *Liability for Damage to the Marine Environment* (London: Lloyd's of London Press, 1993) 3; P. Wetterstein, "Trends in Maritime Environmental Impairment Liability" [1994] 2 Lloyd's Mar. & Com. L.Q. 230, and Wilkinson, *ibid.* For the US perspective, see M.K. Cooney, "The Stormy Seas of Oil Pollution Liability: Will Protection and Indemnity Clubs Survive?" (1993) 16 Hous. J. Int'l L. 343.

[211] Wetterstein, *ibid.* at 235.

[212] *Ibid.* at 231-232.

of a space project relating to the potential adverse effects of space debris and to the proposed remedies.[213] While all States may able to comment on whether all potential adverse effects have been explored, the most effective criticism should come from States with the relevant experience, scientific knowledge and technological expertise.

[213] See Chapter IV, *supra*, text accompanying notes 176-177.

CONCLUSION

The prime motivating force for this study was a desire to develop an approach to international environmental law that would provide a remedy for environmental degradation on Earth and would at the same time avoid similar problems in outer space. The study proposes such a remedy by developing a biocentric (life-centred) approach to international environmental law and by applying the principles based on that approach to human activities in the entire planetary environment.

Having examined the basic moral perspectives applicable to environmental protection, the study argues that a biocentric perspective provides a more appropriate basis for international environmental law both on and off Earth because it reflects an environmental ethic which goes beyond human self-interest. This ethic is grounded in the biological nature of humankind and as such it accords equal respect to all biological entities and obliges humans to avoid harming or interfering with the natural existence of these entities. With a management régime for preserving non-human biological entities, the biocentric ethic places constraints on the contemporary human tendency to overwhelm and incapacitate natural systems.

The study, further, modifies the four basic principles of international environmental law necessary for adequate protection of the planetary environment to better reflect the biocentric approach. Because there already exists an internationally recognized need for management of the biosphere, a régime, reflecting a biocentric approach to management of the biosphere, is recommended. It features an international legal obligation to respect the inherent worth of all biological entities and to protect and preserve the biosphere by avoiding adverse effects on ecosystems, as well as the requirement to take all measures necessary to minimally impair the biosphere. These principles provided the basis for suggesting a comprehensive, two-stage biosphere risk assessment procedure for managing the adverse effects of humankind's projects on all biological entities-in-ecosystems.

While generally supportive of international environmental law, the corresponding provisions of international space law represent a human-centred approach which would severely restrict the application of the biocentric perspective to management of the planetary environment. To overcome these restrictions, the study recommends a draft of a "Protocol for the Protection and Preservation of the Planetary Environment" to Article IX of the *Outer Space Treaty*. The Protocol takes the form of a framework instrument, setting out in the context of the planetary environment general principles and legal obligations derived from the biocentric interpretation of the basic principles of international environmental law and the legal obligations for biosphere management. With the Protocol as its basis, the biocentric risk assessment process developed in Chapter IV of the study is applied to remedy, from an environmental law perspective, the problem of space debris.

International environmental law and international space law are relatively young branches of international law. When taken together, they still exhibit sufficient flexibility to contribute significantly to the creation of forward-looking, innovative and practical law -- law that not only recognizes the human needs to explore and create, but also acts upon the biological reality that humankind is a part of nature, not above it. Enactment of the Environmental Protocol to the *Outer Space Treaty* would represent substantial movement in this direction. If the international community of nations could demonstrate the collective will to avoid in outer space the problems that overindulgent, human self-interest has spawned in the biosphere, the Environmental Protocol, with its new principles of international environmental space law and régime for planetary environmental management, could provide a model for human conduct on Earth as well as in outer space.

BIBLIOGRAPHY

A. TREATIES

Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, 29 June 1990, UN Doc. UNEP/OzL.Pro.2/3 (1990), reprinted in 30 I.L.M. 539 (entered into force 10 August 1992).

Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 18 December 1979, 1363 U.N.T.S. 3 (entered into force 11 July 1984).

Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, 22 April 1968, Can. T.S. 1975 No. 6, 19 U.S.T. 7570, T.I.A.S. No. 6599, 672 U.N.T.S. 119 (entered into force 3 December 1968).

Antarctic Treaty, 1 December 1959, 12 U.S.T. 794, T.I.A.S. No. 4730, 402 U.N.T.S. 71 (entered into force 23 June 1961).

Convention on Biological Diversity, 5 June 1992, UN Doc. UNEP/Bio.Div/N-7-INC.5/4 (1992), reprinted in 31 I.L.M. 818 (entered into force 29 December 1993).

Convention on Environmental Impact Assessment in a Transboundary Context, 25 February 1991, ECE Doc. E.ECE.1250, reprinted in 30 I.L.M. 800 (not yet in force).

Convention on the Establishment of an International Fund for Compensation of Oil Spill Damage, 18 December 1971, 1110 U.N.T.S. 57 (entered into force 16 October 1978).

Convention on International Civil Aviation, 7 December 1944, 15 U.N.T.S. 295 (entered into force 4 April 1947).

Convention on International Liability for Damage Caused by Space Objects, 21 November 1971, Can. T.S. 1975 No. 7, 24 U.S.T. 2389, T.I.A.S. No. 7762, 961 U.N.T.S. 187 (entered into force 1 September 1972).

Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, 18 May 1977, 31 U.S.T. 333, T.I.A.S. No. 9614, 610 U.N.T.S. 151 (entered into force 5 October 1978).

Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, GA Res. 18/1962, UN GAOR, 18th Sess., Item No. 28, UN Doc. A/5656 (1963).

Declaration of the United Nations Conference on the Human Environment, 16 June 1972, UN Doc. A/CONF.48/144 (1972), reprinted in 11 I.L.M. 1416.

International Convention on Civil Liability for Oil Pollution Damage, 29 November 1969, 12 U.S.T. 2989, 973 U.N.T.S. 3 (entered into force 19 June 1975).

International Convention on Oil Pollution Preparedness, Response and Co-operation, 30 November 1990, reprinted in 30 I.L.M. 735.

International Responsibility of States in regard to the Environment, GA Res. 27/2996, UN GAOR, 27th Sess., Item No. 47, UN Doc. A/8901 (1972).

Ministerial Declaration on Sustainable Development in the ECE [United Economic Commission for Europe] *Region*, 16 May 1990, reprinted in H. Hohmann, ed., *Basic Documents of International Environmental Law*, vol. 1 (London: Graham & Trotman, 1992) at 558.

Montreal Protocol on Substances that Deplete the Ozone Layer, 16 September 1987, reprinted in 26 I.L.M. 1550 (entered into force 1 January 1989).

Protocol on Environmental Protection of the Antarctic, 4 October 1991, ATS Doc. XI ATSCM/2/3/2 (1991), reprinted in 30 I.L.M. 1461 (not yet in force).

Rio Declaration on Environment and Development, 14 June 1992, UNCED Doc. A/CONF.151/5/Rev. 1 (1992), reprinted in 31 I.L.M. 874.

Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and under Water, 5 August 1963, 14 U.S.T. 1313, T.I.A.S. No. 5433 (entered into force 10 October 1963).

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 27 January 1967, Can. T.S. 1967 No. 19, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 (entered into force 10 October 1967).

United Nations Charter, 26 June 1945, 16 U.S.T. 1134 (entered into force 24 October 1945).

United Nations Convention on the Law of the Sea, 7 October 1982, UN Doc. A/CONF.62/122 and Corr. 1 to 11 (1982), reprinted in 21 I.L.M. 1261 (entered into force 16 November 1994).

United Nations Framework Convention on Climate Change, 9 May 1992, UN Doc. A/AC.237/18 (Part II)/Add.1 and Corr.1 (1992), reprinted in 31 I.L.M. 851 (entered into force 21 March 1994).

Vienna Convention for Protection of the Ozone Layer, 22 March 1985, UN Doc. UNEP/IG.535 (1985), reprinted in 26 I.L.M. 1516 (entered into force 22 September 1988).

World Charter for Nature, GA Res. 37/7, UN GAOR, 34th Sess., Item No. 21, UN Doc. A/37/L.4 and Add.1 (1982), reprinted in 22 I.L.M. 455.

B. BOOKS

Baker, H.A., *Space Debris: Legal and Policy Implications* (Dordrecht, The Netherlands: Martinus Nijhoff, 1989).

Barrow, J.D., *The Origin of the Universe* (New York: Basic Books, 1994).

Barry, R.G. & R.J. Chorley, *Atmosphere, Weather and Climate*, 5th ed. (New York: Routledge, 1987).

Bates, M., *The Forest and the Sea: A Look at the Economy of Nature and the Ecology of Man* (New York: Vintage Books, 1960).

Baugher, J., *On Civilized Stars: The Search for Intelligent Life in Outer Space* (Englewood Cliffs, NJ: Prentice Hall, 1985).

Benkö, M., W. de Graff & G.C.M. Reijnen, *Space Law in the United Nations* (Dordrecht, The Netherlands: Martinus Nijhoff, 1985).

Billingham, J., ed., *Life in the Universe* (Cambridge, Mass: MIT Press, 1981).

Birnie, P.W. & A.E. Boyle, *International Law and the Environment* (Oxford: Clarendon Press, 1992).

Bohm, D., *Quantum Theory* (Englewood Cliffs, NJ: Prentice-Hall, 1953).

Brunnée, J., *Acid Rain and Ozone Layer Depletion: International Law and Regulation* (Dobbs Ferry, NY: Transnational Publishers, 1988).

Brownlie, I., *Principles of Public International Law*, 4th ed. (Oxford: Clarendon Press, 1990).

Burhenne, W.E. & W.A. Irwin, *The World Charter for Nature: A Background Paper* (Berlin: Erich Schmidt Verlag, 1983).

Burrows, W.E., *Exploring Space: Voyages in the Solar System and Beyond* (New York: Random House, 1990).

Cairns-Smith, A.G., *The Life Puzzle* (Toronto: University of Toronto Press, 1971).

Campiglio, L. *et al.*, eds, *The Environment after Rio: International Law and Economics* (London: Graham & Trotman, 1994).

Cayley, D., *The Age of Ecology: The Environment on CBC Radio's Ideas* (Toronto: James Lorimer, 1991).

Chipman, R., ed., *The World in Space: A Survey of Space Activities and Issues* (Englewood Cliffs, NJ: Prentice Hall, 1982).

Christol, C.Q., *The Modern International Law of Outer Space* (New York: Pergamon Press, 1982).

Cohen, M., ed., *Law and Politics in Space* (Montreal: McGill University Press, 1964).

Couper, A. & E. Gold, eds, *The Marine Environment and Sustainable Development: Law, Policy, and Science* (Honolulu: Law of the Sea Institute, 1993).

Damon, T.D., *Introduction to Space: The Science of Spaceflight* (Malabar, Fla: Orbit Books, 1989).

de la Rue, C., ed., *Liability for Damage to the Marine Environment* (London: Lloyd's of London Press, 1993).

Devall, B. & G. Sessions, *Deep Ecology* (Salt Lake City, Utah: Peregrine Smith Books, 1985).

Disch, R., ed., *The Ecological Conscience: Values for Survival* (Englewood Cliffs, NJ: Prentice-Hall, 1970).

Dolman, A.J., *Resources, Regimes, World Order* (New York: Pergamon Press, 1981).

Ehrenfeld, D., *The Arrogance of Humanism* (New York: Oxford University Press, 1985).

European Space Agency, *Proceedings of the First European Conference on Space Debris* (Darmstadt, Ger: European Space Operations Centre, 1993).

European Space Agency, *Space Debris: Report of the ESA Space Debris Working Group* (Noordwijk, The Netherlands: ESA, 1988).

Evernden, N., *The Natural Alien: Humankind and the Environment* (Toronto: University of Toronto Press, 1985).

Feinberg, G. & R. Shapiro, *Life beyond Earth* (New York: William Morrow, 1980).

Garrett, H.B. & C.P. Pike, eds, *Space Systems and Their Interactions in the Earth's Space Environment* (New York: American Institute of Aeronautics and Astronautics, 1980).

Haley, A.G., *Space Law and Government* (New York: Appleton-Century-Crofts, 1963).

Hargrove, E.G., ed., *Beyond Spaceship Earth: Environmental Ethics and the Solar System* (San Francisco: Sierra Club Books, 1986).

Hart, D., *The Encyclopedia of Soviet Spacecraft* (London: Bison Books, 1987).

Hawking, S.W., *A Brief History of Time: From the Big Bang to Black Holes* (Toronto: Bantam Books, 1988).

Heath, G.W., ed., *Space Safety and Rescue 1982-83* (San Diego, Cal: Univelt, 1984).

Herscovici, A., *Second Nature: The Animal-Rights Controversy* (Montreal: CBC Enterprises, 1985).

Holgren, C.J., ed., *Private Investments Abroad -- Problems and Solutions in International Business in 1992* (New York: Matthew Bender, 1992).

Hossain, K. & S.R. Chowdhury, eds, *Permanent Sovereignty over Natural Resources in International Law: Principles and Practice* (New York: St. Martin's Press, 1984).

Hurwitz, B.A., *State Liability for Outer Space Activities in Accordance with the 1972 Convention on International Liability for Damage Caused by Space Objects* (Dordrecht, The Netherlands: Martinus Nijhoff, 1992).

International Union for the Conservation of Nature and Natural Resources, *World Conservation Strategy* (Gland, Switzerland: IUCN, 1980).

Jackson, F. & P. Moore, *Life in the Universe* (New York: W.W. Norton, 1987).

Jasani, B., ed., *Outer Space: A Source of Conflict* (Stockholm: International Peace Research Institute, 1987).

Jasentuliyana, N. & R.S.K. Lee, eds, *Manual on Space Law*, vols I-IV (Dobbs Ferry, NY: Oceana Publications, 1979).

Jenks, C.W., *Space Law* (London: Stevens & Sons, 1965).

Johnson, N.L. & D. McKnight, *Artificial Space Debris* (Malabar, Fla: Orbit Books, 1987).

Johnson, N.L. *et al.*, *History of On-Orbit Satellite Fragmentation*, 2d ed. (Colorado Springs, Colo: Teledyne Brown Engineering, 1986).

Kindred, H.M. *et al.*, *International Law Chiefly as Interpreted and Applied in Canada*, 4th ed. (Toronto: Emond Montgomery, 1987).

Kiss, A. & D. Shelton, *International Environmental Law* (Ardsley-on-Hudson, NY: Transnational Books, 1991).

Lang, W., H. Neubold & K. Zemanek, eds, *Environmental Protection and International Law* (London: Graham & Trotman, 1991).

Leclerc, I., *Whitehead's Metaphysics: An Introductory Exposition* (Bloomington, Ill.: University of Indiana Press, 1958).

Leiss, W., *The Domination of Nature* (Boston: Beacon Press, 1974).

Livingston, J.A., *The Fallacy of Wildlife Conservation* (Toronto: McClelland & Stewart, 1981).

Livingston, J.A., *One Cosmic Instant: Man's Fleeting Superiority* (Boston: Houghton Mifflin, 1973).

Lovins, A., *Soft Energy Paths: Towards a Durable Peace* (Harmondworth: Penguin, 1977).

Macdonald, R.St.J. & D.M. Johnson, eds, *The Structure and Process of International Law: Essays in Legal Philosophy, Doctrine and Theory* (Dordrecht, The Netherlands: Martinus Nijhoff, 1986).

Maurer, R., *Junk in Space* (New York: Simon & Schuster, 1989).

McDougall, W.A., ... *The Heaven and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985).

McRobie, G., *Small Is Possible* (New York: Harper and Row, 1981).

Meadows, D. *et al.*, *The Limits to Growth* (New York: Signet/New American Library, 1974).

Oates, D., *Earth Rising: Ecological Belief in a Scientific Age* (Corvallis, Or: Oregon State University Press, 1989).

Odum, E.P., *Ecology* (New York: Holt, Rinehart & Winston, 1963).

Peterson, I., *Newton's Clock: Chaos in the Solar System* (New York: W.H. Freeman, 1993).

Prigogene, I. & I. Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Toronto: Bantam Books, 1984).

Regan, T., *The Case for Animal Rights* (Berkeley: University of California Press, 1983).

Ricklefs, R.E., *Ecology*, 3d ed. (New York: W.H. Freeman, 1990).

Robinson, G.S. & H.M. White, Jr., *Envoys of Mankind: A Declaration of First Principles for the Governance of Space Societies* (Washington, DC: Smithsonian Institution Press, 1986).

Rolston III, H., *Philosophy Gone Wild: Essays in Environmental Ethics* (Buffalo, NY: Prometheus Press, 1986).

Roux, R.A. & T.D. McCay, eds., *Spacecraft Contamination Sources and Prevention* (New York: American Institute of Aeronautics and Astronautics, 1984).

Sagan, C., *Cosmos* (New York: Random House, 1983).

Sagan, C. & A. Druyan, *Comet* (New York: Pocket Books, 1986).

Saunders, O.J., ed., *The Legal Challenge of Sustainable Development: Essays from the Fourth Institute Conference on Natural Resources Law* (Calgary: Canadian Institute for Resources Law, 1990).

Schumacher, E.F., *Small Is Beautiful* (London: Abacus, 1974).

Shepard, P., *Nature and Madness* (San Francisco: Sierra Club Books, 1982).

Shepard, P., & D., McKinley, eds, *Environ/mental: Essays on the Planet as a Home* (Boston: Houghton Mifflin, 1971).

Shepard, P., & D. McKinley, eds, *The Subversive Science: Essays Toward an Ecology of Man* (Boston: Houghton Mifflin, 1969).

Shklovskii, I.S. and C. Sagan, *Intelligent Life in the Universe* (New York: Dell, 1966).

Simmonds, K.R., *The Antarctic Conventions* (London: Simmonds & Hill Publishing, 1993).

Simpson, J.A., ed., *Preservation of Near-Earth Space for Future Generations* (Cambridge: Cambridge University Press, 1994).

Singer, P., *Animal Liberation* (New York: New York Review Books, 1990).

Taylor, P.W., *Respect for Nature: A Theory of Environmental Ethics* (Princeton, NJ: Princeton University Press, 1986).

United States Congress, Office of Technology Assessment, *Orbital Debris -- A Space Environmental Problem* (Washington, DC: US Government Printing Office, 1990).

United States National Research Council, *Orbital Debris: A Technical Assessment* (Washington, DC: National Academy Press, 1995).

United States National Security Council, *Report on Space Debris* (Washington, DC: National Security Council, 1989).

von Bertalanffy, L., *General Systems Theory: Foundations, Development, Applications* (New York: George Braziller, 1968).

Weinberg, S., *The First Three Minutes: A Modern View of the Origin of the Universe* (New York: Basic Books, 1977).

Weiss, E.B., ed., *Environmental Change and International Law: New Challenges and Dimensions* (Tokyo: UN University Press, 1992).

Weiss, E.B., *In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity* (New York: Transnational Publishers, 1989).

Wilson, E.O., *The Diversity of Life* (Cambridge, Mass: Belknap Press of Harvard University Press, 1992).

World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987).

World Commission on Environment and Development, Experts Group on Environmental Law, *Environmental Protection and Sustainable Development: Legal Principles and Recommendations* (London: Graham & Trotman, 1987).

Worster, D., *Nature's Economy: The Roots of Ecology* (San Francisco: Sierra Club Books, 1977).

C. ARTICLES and PAMPHLETS

Ackerman, F., "Waste Management -- Taxing the Trash Away" (June 1992) Env. 2.

Adelman, B., "The Question of Life on Mars" (1986) 39 J. Brit. Interplanetary Soc. 256.

"Agora: What Obligation Does Our Generation Owe to the Next? An Approach to Global Environmental Responsibility" (1990) 84 Am. J. Int'l L. 190.

Angelini, J. & A. Mansfield, "A Call for U.S. Ratification of the Protocol on Antarctic Environmental Protection" (1994) 21 Ecology L.Q. 163.

Baker, H.A., "Protection of the Outer Space Environment: History and Analysis of Article IX of the Outer Space Treaty" (1987) 12 Ann. Air & Sp. L. 143.

Baker, H.A., "Space Debris: Law and Policy in the United States" (1989) 60 U. Colo. L. Rev. 55.

Boyle, A.E., "Marine Pollution under the Law of the Sea Convention" (1985) 79 Am. J. Int'l L. 347.

Bragdon, S.H., "National Sovereignty and Global Environmental Responsibility: Can the Tension Be Reconciled for the Conservation of Biodiversity?" (1992) 33 Harv. Int'l L.J. 381.

Brennan, A., "The Moral Standing of Natural Objects" (1984) 6 Env. Ethics 35.

Brunnée, J., "'Common Interest' -- Echoes from an Empty Shell?" (1989) 49 Heidelberg J. Int'l L. 791.

Cameron, J. & J. Abouchar, "The Precautionary Principle: A Fundamental Principle of Law and Policy for Protection of the Global Environment" (1991) 14 B.C. Int'l & Comp. L. Rev. 1.

Canadian Space Agency, *The Report of the ICS Subcommittee on Space Debris* (Montreal: Canadian Space Agency, 1996).

Charney, J.I., "Universal International Law" (1993) 87 Am. J. Int'l L. 529.

Cheng, B., "The Legal Regime of Airspace and Outer Space: The Boundary Problem, Functionalism versus Spatialism: The Major Premises" (1980) 5 Ann. Air & Sp. L. 323.

Christenson, G.A., Book Review (1990) 1 Y.B. Int'l Env. L. 392.

Dooling, D., "Satellite Data Alters View on Earth-Space Environment" (1987) 29 Spaceflight (Supp. 1) 21.

Christie, E., "The Eternal Triangle: The Biodiversity Convention, Endangered Species Legislation and the Precautionary Principle" (1993) 10 Env. & Plan. L.J. 470.

Christol, C.Q., "Stratosphere Ozone Problems and Space Activity" (1992) 35 Colloq. L. Outer Sp. 259.

Cole, R.K. *et al.*, "Atomic Oxygen Simulation and Analysis" (1987) 15 Acta Astronautica 887.

Cooney, M.K., "The Stormy Seas of Oil Pollution Liability: Will Protection and Indemnity Clubs Survive?" (1993) 16 Hous. J. Int'l L. 343.

Dembling, P.G. & S.S. Kalsi, "Pollution of Man's Last Frontier: Adequacy of Present Space Environmental Law in Preserving the Resource of Outer Space" (1973) 20 Netherlands Int'l L.J. 125.

DeMeis, R., "Cleaning Up Our Space Act" (February-March 1987) Aerosp. Am. 10.

Desaussure, H., "Maritime and Space Law: Comparison and Contrasts (An Oceanic View of Space Transport)" (1981) 9 J. Sp. L. 93.

Dwyer, J.P., "The Use of Market Incentives in Controlling Air Pollution: California's Marketable Permits Program" (1993) 20 Ecology L.Q. 103.

Ehlers, H.K.F. *et al.*, "Space Shuttle Contamination Measurements from Flights STS-1 Through STS-4" (1984) 21 J. Spacecraft & Rockets 306.

Elder, P.S., "Sustainability" (1991) 36 McGill L.J. 832.

Fleming, D.J., "State Sovereignty and the Effective Management of a Shared Universal Resource: Observations Drawn from Examining Developments in the International Regulation of Radiocommunication" (1985) 10 Ann. Air & Sp. L. 327.

Flury, W., "Europe's Contribution to the Long Duration Exposure Facility (LDEF) Meteoroid and Debris Impact Analysis" (1993) 47 ESA Bull. 70.

Foreman, E.F., "Protecting the Antarctic Environment: Will a Protocol Be Enough?" (1992) 7 Am. U. J. Int'l L. & Pol'y 843.

Francioni, F., "The Madrid Protocol on the Protection of the Antarctic Environment" (1993) 28 Tex. Int'l L.J. 47.

Frederick, O.J., "Litter in Space Increasing: Orbiting Trash Can Proposed" (March 1995) Sp. World 17.

Froning, Jr., H.D., "Investigation of Antimatter Air-Breathing Propulsion for Single-Stage-to-Orbit Ships" (1988) 17 Acta Astronautica 853.

Galloway, E., "Agreement Governing Activities of States on the Moon and Other Celestial Bodies" (1980) 5 Ann. Air & Sp. L. 481.

Goldie, L.F.E., "Title and Use (and Usufruct) -- An Ancient Distinction Too Oft Forgot" (1985) 79 Am. J. Int'l L. 689.

Goodland, R.J.A., "The World Bank's Environmental Assessment Policy" (1991) 14 Hastings Int'l & Comp. L. Rev. 811.

Goodpaster, K., "On Being Morally Considerable" (1978) 75 J. Phil. 308.

Gorove, S., "Pollution and Outer Space: A Legal Analysis and Appraisal" (1972) 5 N.Y.U. Int'l L. & Pol. 53.

Grant, M., "A European View of Sustainable Development" (1991) 9 J. Energy & Nat. Resources L. 124.

Grossman, C. & D.D. Bradlow, "Are We Being Propelled Towards a People-centered Transnational Legal Order?" (1993) 9 Am. U. J. Int'l L. & Pol'y 1.

Hall, R.C., "Comments on Traffic Control of Space Vehicles" (1965) 31 J. Air L. & Com. 327.

Howe, C.W., "Tradable Discharge Permits: Functioning, Historical Applications, and International Potential" (1993) 4 Colo. J. Int'l Env. L. & Pol'y 370.

Howell, J.A., "The Challenges of Space Surveillance" (June 1987) Sky & Telescope 584.

"Hubble Trouble" (January 1987) Sky & Telescope 31.

Hunt, W.M., "Are Mere Things Morally Considerable?" (1980) 2 Env. Ethics 59.

Janis, M.W., "International Law?" (1991) 32 Harv. Int'l L.J. 363.

Jasentuliyana, N., "Environmental Impact of Space Activities: An International Law Perspective" (1984) 27 Colloq. L. Outer Sp. 390.

Johnson, N.L., "Artificial Satellite Breakups (Part 1): Soviet Ocean Surveillance Satellites" (1983) 36 J. Brit. Interplanetary Soc. 51.

Johnson, N.L., "Artificial Satellite Breakups (Part 2): Soviet Anti-Satellite Program" (1983) 36 J. Brit. Interplanetary Soc. 357.

Johnson, N.L., " History and Consequences of On-Orbit Breakups" (1985) 5 Advances Sp. Research 11.

Johnson, N.L., "Nuclear Power Supplies in Orbit" (1986) 2 Sp. Pol'y 223.

Johnson, N.L., "Preventing Collisions in Orbit" (May-June 1987) SPACE 17.

Joiner, C.J., "Legal Implications of the Concept of the Common Heritage of Mankind" (1986) 35 Int'l & Comp. L.Q. 190.

Kamaras, G., "Cumulative Impact Assessment: A Comparison of Federal and State Environmental Review Provisions" (1993) 57 Alb. L. Rev. 113.

Keiter, R.B., "Beyond the Boundary Line: Constructing a Law of Ecosystem Management" (1994) 65 U. Colo. L. Rev. 283.

Keiter, R.B., "NEPA and the Emerging Concept of Ecosystem Management on the Public Lands" (1990) 25 Land & Water L. Rev. 43.

Keller, S., "Ecology and Community" (1992) 19 Env. Aff. 623.

Kessler, D.J., "Collisional Cascading: The Limits of Population Growth in Low Earth Orbit" (1991) 11 Advances Sp. Research 63.

Kessler, D.J., "More That Meets the Eye" (June 1987) Sky & Telescope 587.

Kettlewell, U., "The Answer to Global Pollution? A Critical Examination of the Problems and Potential of the Polluter-Pays Principle" (1992) 3 Colo. J. Int'l Env. L. & Pol'y 429.

Kindall, M.P.A., "UNCED and the Evolution of Principles of International Environmental Law" (1991) 25 J. Mar. L. Rev. 19.

Kiss, A-Ch., "Will the Necessity to Protect the Global Environment Transform the Law of International Relations?" (The Josephine Onoh Memorial Lecture, 28 January 1992) Hull, England: University of Hull Press, 1992.

Kiss, A-Ch. & D. Shelton, "Systems Analysis of International Law: A Methodological Inquiry" (1990) 17 Netherlands Y.B. Int'l L. 45.

Klein-Chesivoir, C., "Avoiding Environmental Injury: The Case for Widespread Uses of Environmental Impact Assessments in International Development Projects" (1990) 30 Va. J. Int'l L. 517.

Kolossov, Y.M., "Legal Aspects of Outer Space Environmental Protection" (1980) 23 Colloq. L. Outer Sp. 103.

Kovar, J., "A Short Guide to the Rio Declaration" (1993) 4 Colo. J. Int'l Env. L. & Pol'y 119.

Kuhn, A.K., "The Trail Smelter Arbitration -- United States and Canada" (1937) 31 Am. J. Int'l L. 785.

Lang, W., "Environmental Protection: The Challenge for International Law" (1986) 20 J. World Trade L. 489.

Leigh, K., "Liability for Damage to the Global Commons" (1993) 14 Austl. Y.B. Int'l L. 129.

MacCormick, N., "Beyond the Sovereign State" (1993) 56 Mod. L. Rev. 1.

Mackowski, M.J., "Safety on the Space Station" (March 1987) Sp. World 22.

Mann, H., "The Rio Declaration" (1992) 86 Proc. Am. Soc. Int'l L. 405.

Marshall, E., "Space Junk Grows with Weapons Tests" (1985) 20 Sci. 424.

McGarrigle, P., "Hazardous Biological Activities in Space" (1984) 18 Akron L. Rev. 114.

McKnight, D., "Determining the Cause of a Satellite Breakup: A Case Study of the Kosmos 1275 Breakup". Pre-print of paper prepared for presentation at 38th Congress, International Astronautics Federation, Brighton, England, October 1987.

McConnell, M.L. & E. Gold, "The Modern Law of the Sea: Framework for Protection and Preservation of the Marine Environment?" (1991) 23 Case W. Res. J. Int'l L. 83.

Mendell, W.W. & D. J. Kessler, "Limits to Growth in Low-Earth Orbit". Paper IAA-87-574 prepared for presentation at 38th Congress, International Astronautics Federation, Brighton, England, October 1987.

M'Gonigle, R.M. *et al.*, "Taking Uncertainty Seriously: From Permissive Regulation to Preventative Design in Environmental Decision Making" (1994) 32 Osgoode Hall L.J. 99.

Minzi, M.L., "The Pied Piper of Debt-for-Nature Swaps" (1993) 17 U. Pa. J. Int'l Bus. 37.

Miklodi, M., "Some Remarks on the Status of Celestial Bodies and Protection of the Environment" (1982) 25 Colloq. L. Outer Sp. 13.

Mueller, A.C. & D.J. Kessler, "The Effects of Particulates from Solid Rocket Motors Fired in Space" (1985) 5 Advances Sp. Research 77.

Mushkat, R., "Environmental Sustainability: A Perspective from the Asi-Pacific Region" (1993) 27 U.B.C. L. Rev. 153.

Naess, A., "The Shallow and the Deep, Long-Range Ecology Movement. A Summary" (1973) 16 Inquiry 95.

Nicholson, J.B., "European Economic Community -- Envrionmental Policy -- Economic and Fiscal Instruments -- Report of the Working Group of Experts from the Member States Proposes the Use of Economic and Fiscal Instruments to Attain Community-wide Environmental Goals" (1991) 21 Ga. J. Int'l & Comp. L. 290.

Odum, E.P., "Great Ideas in Ecology for the 1990s" (1992) 42 Biosci. 542.

"Orbiting Junkyard, The" (April 1982) 16 Futurist 77.

Panjabi, R.K.L., "From Stockholm to Rio: A Comparison of the Declaratory Principles of International Environmental Law" (1993) 21 Den. J. Int'l L. & Pol'y 215.

Panjabi, R.K.L., "The South and the Earth Summit: The Development/Environment Dichotomy" (1992) 11 Dick. J. Int'l L. 77.

Perek, L., "The Scientific and Technical Aspects of the Geostationary Orbit" (1988) 17 Acta Astronautica 589.

Qizhi, H., "Towards International Control of Environmental Hazards of Space Activities" (1987) 30 Colloq. L. Outer Sp. 138.

Rehbinder, E., "Environmental Regulation Through Fiscal and Economic Incentives in a Federalist System" (1993) 20 Ecology L.Q. 57.

Reibel, D.E., "Prevention of Orbital Debris" (1987) 30 Colloq. L. Outer Sp. 147.

Reijnen, G.C.M., "Some Aspects of Environmental Problems in Space Law" (1977) 26 Zeitschrift Luft Weltraumrecht 23.

Reiterer, M., "The International Legal Aspects of Process and Production Methods" (1994) 17 World Comp. L. & Econ. Rev. 111.

Reitmeijer, F.J.M. *et al.*, "An Inadvertent Capture Cell for Orbital Debris and Micrometeorites: The Main Electronics Box Thermal Blanket of the Solar Maximum Satellite" (1986) 6 Advances Sp. Research 145.

Reynolds, R.C., N.H. Fischer & D.S. Edgecombe, "A Model for the Evolution of On-Orbit Man-Made Debris Environment" (1983) 10 Acta Astronautica 479.

Reynolds, R.C., E.E. Rice & D.S. Edgecombe, "Man-Made Debris Threatens Future Space Operations" (September 1982) Physics Today 9.

Richardson, E., "Prospects for the 1992 Conference on the Environment and Development: A New World Order" (1991) 25 J. Mar. L. Rev. 1.

Riche, V., "The Facts About Kosmos-954" (1978) 274 Nature 631.

Robinson, N.A., "International Trends in Environmental Impact Assessment" (1992) 19 Env. Aff. 591.

Rohrbough, E., "On Our Way to Ten Billion Human Beings: A Comment on Sustainability and Population" (1994) 5 Colo. J. Int'l Env. L. & Pol'y 235.

Rothblatt, M., "Environmental Liability Issues of Rocket Exhaust under International Space Law" (1992) 35 Colloq. L. Outer Sp. 307.

Saffo, P.L., "The Common Heritage of Mankind: Has the General Assembly Created a Law to Govern Seabed Mining?" (1979) 53 Tul. L. Rev. 493.

Sand, P.H., "Lessons Learned in Global Environmental Governance" (1991) 18 Env. Aff. 213.

Sand, P.H., "UNCED and the Development of International Environmental Law" (1992) 3 Y.B. Int'l Env. L. 3.

Sanwal, M., "Sustainable Development, the Rio Declaration and Multilateral Cooperation" (1993) 4 Colo. J. Int'l Env. L. & Pol'y 45.

Schefter, J., "The Growing Peril of Space Debris" (July 1982) Pop. Sci. 48.

Schnerre, M.G., "The Restructured World Bank Facility" (June-August 1994) ASIL Newsletter 14.

Sheldon II, C.S. & B.M. DeVoe, "United Nations Registry of Space Vehicles" (1970) 13 Colloq. L. Outer Sp. 127.

Sher, M.S., "Can Lawyers Save the Rain Forest? Enforcing the Second Generation of Debt-for-Nature Swaps" (1993) 17 Harv. Env. L.J. 151.

Smith, M.S., "Protection of the Earth and Outer Space Environment: Problems of On-Orbit Space Debris" (1982) 25 Colloq. L. Outer Sp. 46.

Sohn, L.B., "The Stockholm Declaration" (1973) 74 Harv. Int'l L.J. 423.

"Star Dreck" (January 1996) Sci. Am. 22.

Sterns, P.M. & L.I. Tennen, "Principles of Environmental Protection in the *Corpus Juris Spatialis*" (1987) 30 Colloq. L. Outer Sp. 172.

Stevens, C., "The OECD Guiding Principles Revisited" (1993) 23 Env. L.J. 607.

Stewart, R.B., "Models for Environmental Regulation: Central Planning versus Market-based Approaches" (1992) 19 Env. Aff. 547.

Stone, C.D., "Beyond Rio: Insuring against Global Warming" (1992) 86 Am. J. Int'l L. 445.

Supanich, G.P., "The Legal Basis of Intergenerational Responsibility: An Alternative View -- The Sense of Intergenerational Equity" (1992) 3 Y.B. Int'l Env. L. 94.

Swenson, R.T., "Pollution of the Extraterrestrial Environment" (1985) 25 A.F. L. Rev. 70.

Szilagyi, I., "Protection of the Outer Space Environment: Questions of Liability" (1982) 25 Colloq. L. Outer Sp. 53.

Tarlock, D., "The Nonequilibrium Paradigm in Ecology and the Partial Unravelling of Environmental Law" (1994) 27 Loy. L.A.L. Rev. 1121.

Temple III, L.P., "The Impact of Space Debris on Manned Space Operations". Paper prepared for presentation at American Institute of Aeronautics and Astronautics Space Systems Technology Conference, San Diego, California, June 1986.

United States General Accounting Office, *Space Station: Delays in Dealing with Space Debris May Reduce Safety and Increase Costs* (Washington, DC: USGAO, 1992).

van den Bergh, S., "Century 21: The Age of Space Junk?" (July 1987) Sky & Telescope 4.

van Traa-Engelman, H.L., "Environmental Hazards from Space Activities: Status and Prospects of Environmental Control" (1982) 25 Colloq. L. Outer Sp. 55.

Vlasic, I.A., "The Growth of Space Law 1957-65: Achievements and Issues" [1965] Y.B. Air & Sp. L. 365.

Wee, L.C.W., "Debt-for-Nature Swaps, A Reassessment of Their Significance in International Environmental Law" (1994) 6 J. Env. L. 57.

Weinberg, P., "Environmental Protection in the Next Decades: Moving from Clean Up to Prevention" (1994) 27 Loy. L.A.L. Rev. 1145.

Weiss, E.B., "Environmentally Sustainable Competitiveness: A Comment" (1993) 102 Yale L.J. 2123.

Weiss, E.B., "International Environmental Law: Contemporary Issues and the Emergence of a New World Order" (1993) 81 Geo. L.J. 675.

Weiss, E.B., "The Planetary Trust: Conservation and Intergenerational Equity" (1984) 11 Ecology L.Q. 495.

Welch, W.B., "The Antarctic Treaty System: Is It Adequate to Regulate or Eliminate the Environmental Exploitation of the Globe's Last Wilderness?" (1992) 14 Hous. J. Int'l L. 597.

Wetterstein, P., "Trends in Maritime Environmental Impairment Liability" [1992] 2 Lloyd's Mar. & Com. L.Q. 230.

Wiessner, S., "The Public Order of the Geostationary Orbit: Blueprints for the Future" (1983) 9 Yale J. World Pub. Ord. 217.

Wilkinson, D., "Moving the Boundaries of Compensable Environmental Damage Caused By Marine Oil Spills: The Effect of Two New International Protocols" (1993) 5 J. Env. L. 71.

Wirin, W. B., "Constraints on Military Manned Activities in Outer Space". Paper prepared for presentation at Armed Forces Communications and Electronics Association Symposium on Man's Role in Space, Colorado Springs, Colo., August 1987.

Wirin, W.B., "The Sky Is Falling: Managing Space Objects" (1984) 27 Colloq. L. Outer Sp. 147.

Wolfe, M.G. & L.P. Temple III, "Department of Defense Policy and the Development of a Global Policy for the Control of Space Debris". Pre-print of a paper prepared for presentation at 38th Congress, International Astronautics Federation, Brighton, England, October 1987.

Wood, A., "The Global Environment Facility Pilot Phase" (1993) 5 Int'l Env. Aff. 218.

Wood, Jr., H.W., "The United Nations World Charter for Nature: The Developing Nations' Initiative to Establish Protections for the Environment" (1985) 12 Ecology L.Q. 977.

Wren, G., "Geos 2 in Space Collision?" (1978) 274 Nature 631.

D. OTHER SELECTED DOCUMENTS

Organization for Economic Co-operation and Development, Environment Directorate and Trade Directorate, Joint Session of Trade and Environment Experts, *An Introduction to Concepts and Principles of International Environmental Law* (Draft), 17 November 1993, OECD Doc. COM/ENV/TD(93) 117.

Organization for Economic Co-operation and Development, Environmental Directorate and Trade Directorate, Joint Session of Trade and Environment Experts, *Environmental Principles and Concepts* (Draft), 25 May 1994, OECD Doc. COM/ENV/TD(93)117/REV1.

Report of the World Commission on Environment and Development: Our Common Future, UN GAOR, 42d Sess., Annex, Agenda Item 83(3), para. 1, UN Doc. A/42/427 (1987).

United Nations Environment Programme, Background Paper Number One, Environment and Trade, *Concepts and Principles in International Environmental Law: An Introduction* (Draft) September 1993.

United Nations Environment Programme, *Goals and Principles of Environmental Impact Assessment*, UNEP Dec. 14/25, UNEP Doc. GC.14/17/Annex III (1987).

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

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