Chapter 13:

Spacepower and the Environment

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This chapter focuses on the unique environmental concerns that can both inhibit and enhance space as a domain of national security power. A number of concerns are examined, including the links between space and the environment on Earth, the orbital environment, and the environment of space beyond the orbital paths of space assets. Within this context, several important questions are raised:

- What roles will space play in the advancement of life on Earth and the future of humanity?
- How susceptible are civil, commercial, and military space assets to interference, disablement, and destruction from environmental threats in space?
- What is the importance of spacepower to scientific exploration?
- What are the political and legal paths to spacepower projection as a result of dealing with space and environmental concerns?

The first part of the chapter investigates the "global dimension" of space and environment. It begins with a discussion of environmental security and reviews a number of global environmental dangers. The environmental degradation of the Earth and anthropogenic influences on global climate change directly relate to the advancement of life on Earth and the future of humanity. The exploitation of natural resources is linked to economic stress, instability, and conflict. Earth observations from space play a role in monitoring and helping to assess changes in the Earth's environment that are applicable to security issues.

Although there is little agreement among scholars and practitioners on the definition of *environmental security*—just as there is little coherence on the definitions of *spacepower*, as this book makes clear—environmental security involves the issues of conflict and its prevention and state authority or control over sovereignty as they are linked to national, regional, and global environmental factors.[1] The second part of the chapter probes these issues of environmental security. How conflicts are prevented is first examined through the role of international and regional environmental agreements and the role of Earth observation satellites in monitoring the global environment. State authority is scrutinized through an assessment of Earth observations in the civil and commercial sectors and of implications for national security in terms of a loss of state control over sovereignty.

The third part of this chapter analyzes the issues of space situational awareness (SSA) and the use of space to project power and to provide for national, regional, and international security. Specific to the focus of space and the environment are the threats to space assets as a result of orbital debris and near Earth objects (NEOs) that may impact

Earth (potentially hazardous NEOs). The evolution of the orbital debris issue is surveyed, and the political measures by which it is managed are explained. The issue of NEOs is one of providing for planetary defense, an important end for the advancement of life on Earth. Planetary defense is investigated within the scope of spacepower as it applies to detection and mitigation strategies to deal with potentially hazardous NEOs.

Finally, spacepower deals with control of the space environment to achieve superiority there. This suggests a relationship between spacepower and protecting the environment in space. Protection of the environment concerns SSA and orbital debris as well as making sure that harmful contamination in space, on planetary bodies, or on Earth resulting from the introduction of extraterrestrial matter is managed and prevented. This problem of harmful contamination, which is discussed in the last part of the chapter, is one of planetary protection.

Environmental Security and Global Environmental Dangers

There are several noteworthy views regarding environmental security. One view is represented by United Nations (UN) programs and associated nongovernmental organizations dealing with the environment and development.[2] These organizations stress the state of environmental degradation on a global scale, and they see that degradation as a security threat. The very nature of the global environmental dangers that exist imperils national security by undermining natural support systems on which all human activity depends. Table 13–1 lists a selected set of global environmental dangers.

Table 13–1. Global Environmental Dangers

- Ozone layer depletion
- Global climate change due to greenhouse gas emissions
- Extreme weather events
- Sea level rise
- Retreating glaciers
- Spread of life-threatening diseases
- Radioactive spills from leaking nuclear submarines or nuclear waste storage tanks
- Nuclear bomb tests
- Accidents in nuclear plants
- Environmental impacts of and modification during war
- Spills from stockpiles of old weapons
- Oil spills and pollution
- Food security
- Water scarcity and pollution including ground water contamination
- Increasing international river usage
- Soil erosion and salinization
- Deforestation and desertification
- Human migration
- Human population growth
- Loss of biodiversity

- Habitat shifts
- Industrial development and contamination of air and oceans
- Fishery depletion due to over-fishing
- Transplantation of alien species into new ecosystems
- Disposal of hazardous and toxic wastes
- Destruction of coral reefs

A second view on environmental security emerges from scholarly work on the subject. Since the 1970s, scholars have argued that environmental concerns should be incorporated into the national security calculations of the state.[3] The argument is that ecological integrity plays a role in the economic, social, and political stability of states. Environmental scarcity, as a result of many of the environmental dangers listed in table 13–1, is inextricably linked to socioeconomic and sociopolitical instability, which can engender conflicts between states.

Scholarly attention to the globalization phenomenon further links the issue of ecology into the national security equation. Globalization represents the integration of capital, technology, trade, and information across national borders.[4] This integration manifests itself as a set of complex interdependencies characterized by linkages among politics, national security, cultures, markets, technology, and ecology. National security power projection as viewed through the lens of globalization is about maintaining the stability of the international system, which is linked to maintaining the ability to cope with and adapt to global environmental changes. This can be conceptualized through the national security notion of systems administration.[5] This aspect of national security power is the basis of one significant view of environmental security within the national security establishment in the United States.

Global environmental dangers can undermine the stability of the international system and lead to political, economic, and violent conflicts. To illustrate, a North Atlantic Treaty Organization (NATO) study from 1996 and a report published by the CNA Corporation (CNAC)[6] in 2007 that was authored by a number of retired flag officers identified several problem areas of environmental conflict.[7] The NATO study assessed potential conflicts over natural resource scarcities, which are a cause for intrastate and interstate migrations that trigger political, ethnic, and cultural conflicts. In addition, scarcities are tied to poverty and health problems due to limited food supplies, unavailability of fresh water, famine, and the spread of infectious diseases. Anthropogenic global environmental change and degradation—for example, greenhouse gas pollution, ozone depletion, climate change, loss of biodiversity, desertification, and deforestation—alter the availability and distribution of natural resources. In this perspective on environmental security, the systems administrator must deal with cooperative paths to power projection. The cooperative paths entail collective action and collective security arrangements.

The CNAC report examined climate change as an issue for national and international security. Climate change as a cause for many of the global environmental dangers listed in table 13–1 leads to "sustained natural and humanitarian disasters that will likely foster instability where societal demands exceed the capacity for governments to cope."[8] In this

regard, climate change is a threat multiplier for instability and conflict. The threat multiplier manifests itself as "geostrategic" and regional implications analogous to what was assessed with the NATO study. The CNAC report recommends that climate change be fully integrated into national defense strategies and that the United States commit to a role as systems administrator to help stabilize climate change and to help other governments cope with global environmental dangers. This indicates that spacepower calculations, as part of national defense strategies, need to account for climate change and that a U.S. leadership role on the issues of climate change is part and parcel of the national and international security equations. One central concern that flows from these suggestions, denoted with the NATO study as well, has to do with conflict prevention. Spacepower is a factor that can facilitate conflict prevention.

Conflict Prevention

Collective action as a basis for power projection is a consequence of the fact that the global environment and the environment in outer space are each a commons. These environmental commons lie outside the jurisdiction and sovereignty of any individual state and are valued resources globally. In the case of the global environment, agreed upon commons include the global climate system and the stratospheric ozone layer. In the case of outer space, they are free space itself, orbital paths around the Earth, and celestial bodies. These environmental resources are in joint supply and nationally nonappropriable. *Joint supply* signifies equal potential availability to the commons by all states. *Nonappropriability* specifies that states cannot extend their jurisdiction and sovereignty to the commons. It is impossible to exclude states from sharing in the benefits of the commons or from suffering the consequences caused by damage to the commons. Together, joint supply and nonappropriability constitute free access and free use and, as it concerns spacepower, the policy of freedom of action in space.

A commons that is unregulated can result in a "tragedy of the commons."[9] This situation is rooted in the rational self-interested state behavior regarding commons resources. It is a function of damage to the environment caused by free access and free use, like the release of greenhouse gases into the Earth's biosphere, the proliferation of orbital debris, or the possibility of harmful contamination of outer space or celestial bodies. To mitigate these tragedies, collective action is necessary. The environmental commons posits a collective action problem as to how to formulate and implement international cooperation to regulate at some level free access and free use.

This point in the chapter focuses on the global environment and international cooperation directed at managing the root causes of environmental change that lead to instability and conflict. The collective action response as observed in international environmental laws and laws that limit military activities in space portends for a collective "rules of the road" approach to spacepower as one way to mitigate tragedies of the commons, such as orbital debris proliferation and other harmful contamination of space (the rules of the road theme is discussed in chapter 20 of this book).[10] Later in this chapter, collective action and freedom of action in space are explored in the cases of orbital debris, planetary defense, and planetary protection.

International environmental law regulates how states and their entities interact with the environmental commons. The onset of the development of international environmental law dates back to the UN Conference on the Human Environment held in Stockholm in 1972. This conference elevated the environment to a major issue at the international level. Stockholm focused on the degradation of the biophysical environment of the Earth due to human activities. The conference led to the establishment of the UN Environmental Program, which is at the forefront globally in calling for sustainable development—that is, human and economic development that mitigates further degradation of the environment and natural resources.[11]

Within the context of sustainable development, the World Commission on Environment and Development issued a report in 1987 entitled *Our Common Future*.[12] The report offered a definition of *sustainable development* as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," and highlighted global warming and ozone layer depletion as environmental problems. Following this, in 1992, under the auspices of the UN Conference on the Environment and Development, an Earth Summit was held in Rio de Janeiro, Brazil. The summit led to the Rio Declaration on the Environment and Development and an action plan, called Agenda 21, to realize the ideas of sustainable development therein.[13] Agenda 21 is the most significant and influential political instrument in the environmental field, serving as the blueprint for environmental management throughout the world. The whole notion of sustainable development and its implementation and management is in part a security issue in that it addresses the root cause of environmental security issues discussed earlier.

Two areas of development in international environmental law dealing with ozone depletion and global warming are examples of how global environmental dangers can result in collective paths to agreement and management. The paths to the respective agreements, the Montreal Protocol on Substances that Deplete the Ozone Layer and the Kyoto Protocol to the United Nations Framework Convention on Climate Change, are a story of how the state of knowledge—that is, science on the global issues—influences states to act in collective ways to manage global environmental problems.[14] Earth observation satellites, which play a critical role in monitoring the state of global environmental dangers, resulted in many of the advances in knowledge. Table 13–2 maps the cooperative path in the case of the Montreal Protocols and highlights the role of Earth observation satellites.

Table 13–2. Cooperative Paths to the Montreal Protocols

Year	**Event**
1956	First Antarctic ozone measurements
1971	Congress terminates Supersonic Transport funding
1973	Space shuttle exhaust linked to ozone destruction (chlorine loading)
1974	Chlorofluorocarbons (CFCs)-ozone depletion hypothesis published in *Nature*
1974	Antarctic measurements regularly conducted

1975	National Aeronautics and Space Administration (NASA) conducts upper atmosphere research as directed by U.S. Congress
1976	First discussion of ozone at United Nations Environmental Program (UNEP)
1977	UNEP and World Meteorological Organization (WMO) establish coordinating committee on ozone
1977	U.S. Congress amends Clean Air Act to report on status of ozone
1978	U.S. Congress bans CFCs in aerosol sprays
1978	**Nimbus-7 launched, Total Ozone Mapping Spectrometer (TOMS) (returned data to 1993)**
1978	First CFC replacement announced (replacements economically profitable)
1981	International negotiations begin on ozone issue
1985	Vienna Convention (precautionary principle collective action)
1985	UNEP Ozone Secretariat established
1985	British Antarctic Survey publishes ozone hole data in *Nature*
1985–1989	**Nimbus-7 TOMS data transmitted to public (record ozone hole in 1987 and 1989)**
1986	**Comprehensive report on ozone depletion (NASA and WMO); 85 percent restriction**
1987	Alignment of U.S.–European Community (EC) positions on CFC reductions
1987	Montreal Protocol; 50 percent restriction (compromise solution); in force 1989
1988	United States, Europe, and Japan ratify Montreal Protocol
1988	**Report on ozone trends (NASA, UNEP, WMO); more stringent control measures**
1988	DuPont agrees on phaseout of CFCs (industry agreement with problem)
1988	UNEP workshops that resolved modeling discrepancies in relation to ozone
1988-89	Global climate change on the U.S. political agenda (Global Change Research Program in 1989)
1989	EC calls for phasing out CFCs
1989	Synthesis Report (chlorine-loading issue); revisions in Montreal Protocol
1990	London Amendment to Montreal Protocol (scientific consensus, equity, controls); in force 1992
1990	U.S. Environmental Protection Agency (EPA) issues further restrictive CFC guidelines
1990-92	Brazil, China, and India accessions to Montreal Protocol
1991	**NASA announced severe ozone depletion, lowest values in 13 years of monitoring**
1991-92	U.S. Senate calls for CFC phaseout; 1992 Executive order to end use of CFCs
1991	**NASA launches Upper Atmosphere Research Satellite (returned data to 2005)**
1992	**NASA announced severity of problem for Arctic (up to 30 percent ozone loss)**
1992	Copenhagen Amendments to Montreal Protocol (controls); in force 1994; CFC phaseout by 1995

1993	Trade sanctions against nonsignatory countries
1994	**NASA indicates conclusive evidence of ozone depletion-chlorine link**
1996	**NASA report shows concentrations of ozone depleting chemicals beginning to level off**
1997	Montreal Amendments to Montreal Protocol (licensing system for trade issue); in force 1999
1998	Sweden first country to ban all CFC uses
1999	Beijing Amendments (control measures, bromide loading issue); in force 2002
2000	Largest ever Antarctic ozone hole detected
2001	UNEP reports results in nearly eliminating production of CFCs
2002	**European Space Agency launches Envisat with ozone measuring sensors**
2004	**NASA launches Aura to study ozone (Earth atmospheric chemistry)**

In addition to the examples of international environmental law discussed above, there are international laws that place specific limits on military uses of space. These laws constrain the means a state can use to realize freedom of action in space and spacepower projection. The relevant laws and constraints include:

- the *Limited Test Ban Treaty of 1963* and the *Comprehensive Test Ban Treaty of 1996* (which supplanted the 1963 one), which prohibit the conduct of nuclear weapons tests in outer space. Neither the United States nor China has signed or ratified the Comprehensive Test Ban Treaty as of 2009.
- the *Outer Space Treaty of 1967*, which prohibits the deployment of weapons of mass destruction in space and the stationing of military bases, but not military personnel, in space or on celestial bodies, and calls for "peaceful uses" of space, which is understood as no aggressive uses of space that harm or interfere with another state's access and use of space.
- the bilateral *Anti-Ballistic Missile (ABM) Treaty of 1972* between the United States and Russia, which many legal experts viewed as preventing a weaponization of space since it prohibited the deployment of space-based ABM systems, which do include most types of kinetic-kill space weapons that could be developed and deployed. The United States withdrew from this treaty in 2002.
- the *Convention on Registration of Objects Launched into Outer Space of 1974*, which requires states to register objects launched into space with the United Nations. This obligation helps to enable SSA and supports the view that such awareness should be shared and transparent to the extent possible without harming national security. This is the policy and practice of SSA in the United States.
- the *Environmental Modification Convention of 1980*, which prohibits military use of environmental modification techniques in space. The Outer Space Treaty also prohibits harmful contamination of the space environment.

- the *Moon Agreement of 1984*, which sought to demilitarize the Moon and celestial bodies and declare the Moon the "Common Heritage of Mankind."[15] It has little to no legal validity since no space powers have ratified it.

Earth Observation Satellites

The development of remote sensing satellite systems—Earth observation platforms—was driven initially by national security policies aimed at acquiring intelligence from the use of space assets. This led to the intelligence space program that is in place in the United States. At the same time, satellite use for weather monitoring emerged as a valuable asset for civil and military use. Beginning in the 1970s, remote sensing systems evolved to deal with environmental monitoring. The Landsat program in the United States began in 1972 with a focus on natural resource monitoring. The success of the Landsat program, which exists to this day with Landsat 7, and the issues associated with global change and global warming led to the U.S. Global Change Research Act of 1990. This act established an Earth observation program, the U.S. Global Change Research Program, aimed at understanding and responding to global change, including the cumulative effects of human activities and natural processes on the environment, and at promoting discussion toward international agreements in global change research.[16]

At the national level, the National Aeronautics and Space Administration (NASA) was tasked as the key implementing agency for the U.S. Global Change Research Program. This led to the development of NASA's Earth Sciences mission area and the Earth Observing System (EOS) that NASA implemented.[17] At the international level, agreements were reached on Earth observation data policies, which generally endorse open access to Earth observation data on the premises of nonexclusion and nondiscrimination. The 1986 UN Principles Relating to Remote Sensing of the Earth from Outer Space adopt such an open access policy. The principles state that as soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed state shall have access on a nondiscriminatory basis.[18] This very principle forms the basis for the data policy agreement reached through the Committee on Earth Observation Satellites (CEOS), established in 1984 to coordinate data management and policy issues for all spaceborne Earth observation missions. Membership in CEOS is open to all international and national organizations responsible for Earth observation satellites currently operating or in development phases.[19] The United States applies nondiscriminatory open access policies for Earth observation data at the national level through the Land Remote Sensing Policy Act of 1992 and the subsequent final rules issued by the U.S. Department of Commerce for Licensing of Private Land Remote Sensing Space Systems.

The evolution of Earth observations in the civil sector resulted in the political and legal view that data acquired through remote sensing is a public good marked by nonexclusion and nondiscrimination. Data as a public good has implications for national security as to the control over knowledge and information. Historically, states controlled knowledge through the concept of sovereignty. Earth observation satellites make sovereignty "transparent" because data acquired on the natural resources of a state are public goods

that are available to any user either free of charge, as in the case of NASA's EOS program, or at a minimal processing fee per user request. This represents a constraint on the projection of national security power in the sense that the state is forced to sacrifice some control over knowledge about its territory in exchange for the benefits in use of that knowledge. Concomitantly, this "sovereignty bargain" can mitigate the constraints of sovereignty and national interests in trying to achieve cooperative paths to spacepower. Formulating rules of the road to preserve freedom of action in space so that the benefits of Earth observations can be attained is one example.

The theme of Earth observations and collective action is an important one. International cooperation pertaining to Earth observations by satellites directed at assessing global environmental change is represented by a collective action milieu (see table 13–3). The goal of this collaborative milieu is to advance scientific knowledge of the Earth's environment to understand and predict human-induced and natural global environmental change phenomena. Science serves as the end, while politics, a broad-based institutional structure of states, international organizations, and scientific communities, provides the means. One of the crucial factors in this case of international cooperation is the ability of transnational networks of Earth system scientists to work together in analyzing global change data and to translate those analyses into policy-relevant actions. This involves both coordinating missions and addressing data policy issues dealing with conditions and access to data, data pricing, periods of exclusive data use, and data archiving.[20] Cooperation aims to meet scientific and operational needs as well as satisfy data access and data exchange requirements for all parties as effectively as possible.

Table 13–3. Collective Action Milieu for Global Change Science

Level of Activity	Political Actors
Subnational ***(United States)***	American Meteorological Society; American Geophysical Union; Center for Global Change; Electric Power Research Institute; Environmental Defense Fund; Federation of American Scientists; Global Tomorrow Coalition; National Academy of Sciences; Goddard Institute for Space Studies; National Center for Atmospheric Research; Natural Resources Defense Council; National Climatic Data Center; Physicians for Social Responsibility; Sierra Club; Union of Concerned Scientists; World Resources Institute; Worldwatch Institute
National ***(United States)***	**U.S. Global Change Research Program—** **Subcommittee on Global Change Research** Department of Agriculture; National Oceanic and Atmospheric Administration; Department of Defense; Department of Energy; National Institute of Environmental Health Sciences; U.S. Geological Survey; Department of State; Environmental Protection Agency; National Aeronautics and Space Administration; National Science Foundation; Smithsonian Institution
Transnational	Greenpeace; International Council for Science (ISCU); International Geosphere Biosphere Program
International	UN Committee on the Peaceful Uses of Outer Space; UN Conference on Environment and Development; Economic and Social Commission of Asia and the Pacific; UN Education, Scientific and Cultural Organization (UNESCO); UN Environmental

	Program (UNEP); Food and Agricultural Organization (FAO); UN Framework Convention on Climate Change; Intergovernmental Oceanographic Commission (IOC); World Climate Research Program; World Commission on the Environment and Development; World Meteorological Organization (WMO)
Cross-Level ***(National, Transnational, International)***	**Committee on Earth Observation Satellites** Global Climate Observing System: ICSU, UNESCO, UNEP, IOC, WMO Global Ocean Observing System: ICSU, UNEP, WMO Global Terrestrial Observing System: ICSU, UNESCO, UNEP, FAO, WMO Intergovernmental Panel on Climate Change: UNEP, WMO

Political considerations concerned with data policy, national sovereignty, and national security issues influence collective action in the area of Earth observations.[21] The existence of disparate and incompatible data access policies among various satellite types and programs is reinforced in the retention of data by its producers, the requirement of licenses to use data, and the pricing of data above marginal costs of fulfilling user requirements. Harmonizing policies over these issues is one of the most difficult hurdles to surmount in fashioning international cooperation.[22]

The Committee on Earth Observation Satellites plays a central role in advancing the harmonization issue. The primary objectives of CEOS are to optimize the benefits of Earth observations through cooperation of its members in mission planning and in developing compatible data products, formats, services, applications, and policies; aid both its members and the international user community through international coordination of Earth observation activities; and exchange technical information to encourage compatibility among the different Earth observation systems.[23] CEOS data exchange principles have been adopted for global environmental change research use and for operational public benefit use with the agreement to make data available to each member in these user categories with no period of exclusive use and on a nondiscriminatory basis. There is a commitment to provide data at the lowest possible cost to bona fide researchers and to harmonize and preserve all data needed for long-term global change research and monitoring.

The concern with sovereignty and national security is that remote sensing data undercuts the ability of the state to control both the creation and the application of knowledge.[24] One important sovereignty concern is the proliferation of commercial remote sensing systems. This gives rise to the knowledge diffusion and sovereignty bargains mentioned earlier. Proliferation of high-resolution imagery has potential national security repercussions of particular concern since the events of September 11 and the ensuing global war on terrorism. First, increased certainty of an adversary's capabilities may negate the foundation for deterrence. Second, the possibility exists of misinterpretation and international deception leading to shifts in balances of power and conflict. And third, asymmetrical access to satellite imagery and processing capabilities could provide substantial advantages for some states over their neighbors—for example, developed states over developing ones—with destabilizing effects on the international system.

The development of a remote sensing commercial sector exacerbates the control of knowledge by advancing "global transparency." In the civil or public sector, it is well understood that remote sensing data primarily serves scientific research use and value-added uses for natural resource management. Further, such data is at relatively low spatial resolutions, limiting its utility for intelligence use. Data is an economic commodity in the commercial sector, which has developed and deployed systems with high spatial resolutions at less than 1 meter (m) that can be used for intelligence purposes. In fact, it is the policy of the U.S. Government, under the Land Remote Sensing Policy Act of 1992, Presidential Decision Directive (PDD) 23 issued by the Clinton administration, and the U.S. Commercial Remote Sensing Policy put forward by President Bush in 2003, to foster the development of commercial imagery systems with spatial resolutions of less than 1 m.

While the policies support the development of a remote sensing industry and mandate government data buyout contracts with commercial remote sensing operators in the United States, the threats that commercial systems pose to national security were recognized as well. After all, information dominance enables spacepower projection. This recognition was manifested in PDD 23 and reiterated in the 2003 Bush policy as "shutter control" directed to protect U.S. national security and foreign policy interests. Shutter control allows the Secretaries of Defense and State to determine when national security, international obligations, and/or foreign policy could be compromised as a result of commercial remote sensing and mandate specific restrictions as to where on Earth the commercial systems can acquire data. The shutter control policy attempts to mitigate the loss of control of knowledge that can harm national security. Despite this concern, shutter control is difficult to apply and for the most part has not proven to be a viable policy, although it remains a concern for the commercial interests of the remote sensing sector.

Since the emergence of commercial uses of remote sensing, resolution limitations imposed to protect national security have lessened. In the late 1970s, the Carter administration lowered the spatial resolution limit on nonmilitary remote sensing systems to 10 m. After the U.S. Congress passed the Land Remote Sensing Policy Act of 1992 directed to end the Federal monopoly on remote sensing technology and data distribution, numerous commercial interests began to apply for remote sensing satellite licenses and lobbied for lower spatial resolution restrictions. PDD 23 removed spatial resolution restrictions on commercial remote sensing satellites, making the resolution limit a decision to be made by the Department of Commerce, the authority licensing the system, on a case-by-case basis. This stood in stark contrast to the previous national security protection elements of imposing spatial resolution limits and access to remotely sensed data.[25]

U.S. Government authorities have continuously debated shutter control since PDD 23 was issued. In an attempt to further clarify when and how shutter control might be implemented, the Department of Commerce signed a memorandum of understanding (MOU) with the U.S. Departments of State, Defense, and Interior and the Intelligence Community as to how they would work together during the licensing process to make certain that all the elements of national security are taken into consideration. The MOU

discussed when and how shutter control restrictions could be placed upon a system. In response to the concern of commercial satellite operators, the MOU makes the shutter control decision occur at the highest levels of the respective governmental departments. If they cannot agree, the issue is sent to the President for a decision.[26]

In the aftermath of September 11 and during subsequent military operations in Afghanistan, the United States opted not to exercise shutter control as specifically described in PDD 23 and the MOU. However, it did make use of alternative means to control the use of remotely sensed data. In October 2001, the National Imagery and Mapping Agency (NIMA) signed a contract with Space Imaging, whose Ikonos satellite was the only U.S. commercial high-resolution satellite operating at the time, for the exclusive rights to Ikonos imagery collected over Afghanistan and the surrounding areas.[27] This arrangement established a way to control data distribution from U.S. commercial operators and data providers, albeit via methods other than what was originally intended with the shutter control policy.

During the blackout on the distribution of high-resolution Ikonos data outside the U.S. Intelligence Community, ImageSat International, an Israeli firm, sold high-resolution imagery to news media and other organizations on the open market. As the U.S. war efforts in Afghanistan continued, NIMA discontinued the imagery buyout of Ikonos data. Furthermore, DigitalGlobe successfully launched and continues to operate QuickBird and Worldview 1 at lower panchromatic spatial resolutions than Ikonos (0.6 m for Quickbird and 0.5 m for Worldview versus 1 m for Ikonos).

Commercial remote sensing systems also existed prior to Ikonos, such as Spot Image in France, ImageSat, and commercial remote sensing entities and commercial data products in Canada, Europe, India, and Russia. These developments further indicate that shutter control may not be a viable policy, and that global transparency and the associated factor of loss of control over sovereignty represent new international norms with which national security power and spacepower projection must contend. For spacepower, this implies that true information dominance cannot be achieved, and counterspace operations or applications of force aimed at preserving freedom of action in space would not be applied to commercial assets absent a global scale conflict. As a result, the state is forced into a sovereignty bargain that reiterates the theme of collective action and cooperation as ways to further spacepower interests.[28]

Orbital Debris

The fact that space is legally defined as a commons underlies freedom of action there—that is, the free use of and free access to the space environment for peaceful purposes that include military uses for self-defense and for collective defense as stipulated in the Outer Space Treaty and the UN Charter. Free access to and free use of the space commons, not unlike the global environment, can lead to a potential tragedy of the commons in that a resource that people share can become exploited to the detriment of all users.

Space is subject to joint use and availability. Therefore, any user may exploit the resource since exclusion is impossible or impractical. As a consequence, the resource value of space may diminish as a result of overuse or misuse. The costs and benefits associated with commons' use are likely to be distributed asymmetrically, and it is even conceivable that those who benefit may not pay a use cost.[29] For space, the problem of the commons is perhaps most notable in the growing problem of space debris.

The U.S. Air Force Space Command, through the Space Surveillance Network, routinely tracks and catalogues all human-made debris objects. This information is provided to and used by the civil, commercial, and military space sectors. For example, NASA uses the data on every space shuttle flight and has made numerous orbital corrections over the years to avoid collision. The same holds true for the International Space Station even though the ability for orbital correction is more limited. The space environment is populated by millions of pieces of orbital debris from a range of sources, such as inactive spacecraft, spent rocket bodies, operational debris from satellites and other payloads, fragmentation debris as a result of debris collisions, paint flakes, and particulates from propellant fuels. Collisions with pieces of debris greater than 10 millimeters (mm) in size can produce catastrophic damage to spacecraft. Even smaller debris ranging from 1 mm to 10 mm can be destructive as it can produce impact damage that can be serious depending upon system vulnerabilities and defensive design provisions against debris. Orbital debris smaller than 1 mm can cause surface pitting and erosion of materials; for example, 0.1 mm debris can potentially penetrate a spacesuit. The International Space Station is shielded to protect from smaller debris, and military space assets are hardened in many cases for such protection.

The millions of debris particles smaller than 1 mm are beyond detection capabilities from satellite or ground-based radar observing systems. Despite the fact that technical capabilities exist to systematically track debris at about 50 mm in size, the U.S. Air Force Space Command nominally tracks and catalogues debris of about 100 mm or greater in size.[30] This discrepancy between what is possible and what is accomplished is one of the key political issues facing SSA and the need for additional budgetary allocations to upgrade capabilities. Space Command's SSA mission also aims at information transparency and "deconfliction."[31] To these ends, Space Command shares debris data with space users worldwide in the civil, commercial, and military sectors and provides space users with modeling and predictions for debris avoidance. Information transparency is a tool to deconflict any potential national security issues or threats that the debris issue may posit. Deconfliction implies diplomatic and cooperative paths to address problems.

The larger issue here is one of space as a commons for peaceful and cooperative purposes versus contested space scenarios that involve spacepower projection in the space medium. The functional necessity of dealing with the space debris problem to ensure free access to and use of space and the civil, commercial, and military benefits that space offers advances a cooperative approach to maintain the peaceful uses of space as the status quo. All this is made clear when one considers that fragmentation debris shifts linear debris growth patterns to exponential ones assuming no active mitigation measures

are implemented. The Chinese antisatellite (ASAT) weapons test conducted in January 2007, which destroyed a Chinese satellite, and the February 2009 collision between an operational Iridium satellite and a dysfunctional Russian Cosmos communications satellite resulted in thousands of additional debris fragments that can potentially threaten space assets. The seriousness of the debris issue is compounded when one realizes the time it takes debris to deorbit. For instance, the last debris from U.S. ASAT tests in the 1980s only deorbited in 2004.

Though the majority of operational and active satellites are impacted by debris, impact has occurred without consequence except for the Iridium/Cosmos case mentioned above and one additional documented case in 1996 that involved a French satellite and Ariane upper rocket body. Modeling of the debris threat has also shown low risk of debris impacts on large spacecraft that could cause harm—for example, there is a 1 in 100,000 chance of debris impact with the space shuttle. This is not to undercut the argument that debris is a potential commons problem. The failure to prevent debris proliferation in low Earth orbit (LEO) could severely restrict use of the more commonly used orbital paths and inclinations. Most experts have indicated that some degree of mitigation is needed in LEO and that there is a need for improved detection and modeling of the risks.[32] The latter issue is one very central to spacepower as manifested in freedom of action in space and SSA and the need to upgrade debris tracking capabilities as denoted earlier. Further, the debris issue in geostationary orbit (GEO) is potentially serious and costly, due to the relative permanency of orbit (no passive debris removal through orbital decay), narrow orbital bands, and the high economic values of GEO slot allocations with lucrative footprints on Earth for telecommunications.

The evolution in policy as it relates to orbital debris in the United States emphasizes the need to prevent debris proliferation and to take measures, such as SSA enabling debris avoidance maneuvers based on potential impact predictions, to reduce the harm that debris causes.[33] In 1982, NASA and the U.S. Department of Defense (DOD) initiated debris mitigation practices, such as passivation of upper rocket bodies and the placement of end-of-lifetime GEO satellites in parking orbits outside the GEO orbital band. Since 1987, DOD policy has been to minimize or reduce accumulation of space debris and to mitigate the impact of space debris on missions and operations in space. NASA formed a space debris research group in 1993 with the aim of limiting debris generation, and U.S. national space policy has also stated positions on the debris issue. Ronald Reagan called for all space sectors to prevent debris proliferation, and George H. W. Bush said the United States would encourage other spacefaring nations to prevent proliferation. Congress has taken this stance since 1991, laying the groundwork for international cooperation on debris mitigation guidelines. Bill Clinton called for an extension of debris mitigation guidelines to the commercial sector, leading to a requirement in the U.S. licensing process for commercial space launch vehicles and commercial remote sensing for operators to submit and adhere to debris mitigation plans. George W. Bush reiterated all these positions in his 2006 national space policy.[34]

The functional necessity of addressing the debris issue advances collective action. This is no better illustrated than by the information transparency and deconfliction goals of the

U.S. Air Force Space Command. In addition to this, the U.S. Government and foreign governments have convened working groups, in particular the Inter-Agency Space Debris Coordination Committee (IADC), to identify, plan, and assist in the implementation of cooperative activities in space debris research and mitigation options.[35] The approach taken by the IADC encompasses alternatives ranging from the promulgation of voluntary actions that states and industries can take to reduce debris—passivation, parking orbits, hardware designs like shielding and fasteners—to the establishment of guidelines and standards to govern launch vehicles and their payloads. The IADC has also been successful in drawing attention to the issue before the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) Legal Subcommittee, which has made it an agenda item, and there is international interest in formulating orbital debris principles in international space law.[36] Such a formulation is important as the Outer Space Treaty regime deals with space objects that are registered as a legal remedy for dealing with liability issues. Hence, questions remain as to how one would determine a legal definition of debris, how registration of debris is to be dealt with, and whose debris is causing harm, especially if that harm is in the space environment and under a fault-based liability regime per the Convention on Registration of Objects Launched into Outer Space of 1974.

Planetary Defense

Planetary defense deals with the detection and possible mitigation of potentially hazardous NEOs. This is central to the question of what role space will play in the advancement of life on Earth and in the future of humanity. Planetary defense is ultimately about providing for the security of Earth similar to avoiding nuclear war and global environmental destruction. The focus in this section is on the link between the space enterprise and planetary defense.

Near Earth objects were first discovered in 1932, and the first photographic surveys began in the 1960s and 1970s. Of particular concern are potentially hazardous asteroids. These are asteroids of 150 m in diameter and larger that approach within 7.5 million kilometers (km) of Earth and have the potential for impacting it. The type of event caused by a collision between NEOs and Earth is determined by the diameter of the asteroid impactor. In the 1980s, geologists established the fact that impacts with global effects (asteroids that are 300 m in diameter or larger) have occurred in the past and do take place in intervals of as little as 25,000 years.[37] Given the typical pattern of collisions that scientists have discovered in the history of Earth, the statistical risk of death from NEO impacts is the same as that of dying in a passenger aircraft accident and greater than that of death from natural disasters like floods and tornados.[38]

Most of the potentially hazardous NEOs travel in predictable orbits and can be detected decades in advance. One important issue surrounding NEOs deals with political support for detection and surveying efforts and with governance and authority over them. An arrangement aimed at more systematic detection and surveying began in 1988 with the Spacewatch survey, which involved detection efforts ongoing at NASA and a network of amateur astronomers. In 1989, detection efforts documented a NEO near-miss with Earth.

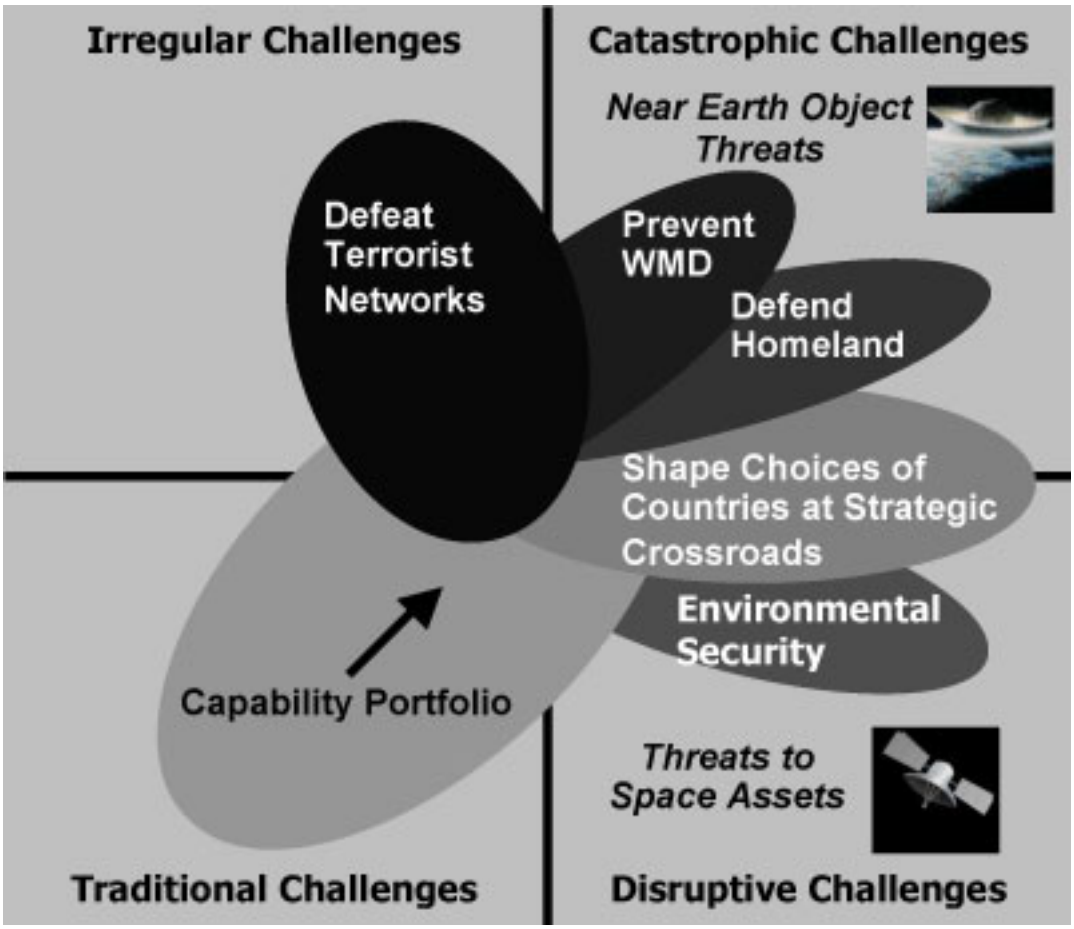
This led to political advocacy before the U.S. Congress that resulted in a NASA Multiyear Authorization Act of 1990 that called for NASA to increase the detection rate of NEOs on an international basis. Following this, in 1991, the House Committee on Science and Technology directed NASA to conduct workshops and studies on the issue. The findings of the workshops were presented to Congress, and in 1994 the Committee on Science and Technology amended the NASA Authorization Act and called for NASA to cooperate with DOD and foreign national space agencies to identify and catalogue within 10 years potentially hazardous NEOs greater than 1 km in diameter.

The plan to carry out identification and cataloguing, known as the Spaceguard survey, was initiated by NASA in 1998 in cooperation with U.S. Space Command Space Surveillance Networks. As of May 2009, NASA had identified 6,242 NEOs and the orbits of 1,047 potentially hazardous asteroids.[39] However, NEOs between 150 m and 1 km can have global effects.[40] As such, a new program was called for in the NASA Authorization Act of 2005 to detect, track, catalogue, and characterize the physical characteristics of NEOs larger than 140 m in size, with the goal to achieve 90 percent completion of the survey by 2020. In 2007, NASA studied the option of such a program and determined that at current budgetary allocations, it can continue to fund the Spaceguard program through 2012, but it cannot initiate a new program as suggested in the 2005 Authorization Act.[41] Obviously, budgetary allocations and priorities are not congruous with what is directed by policy and what is needed to provide for a more robust planetary defense mission. This also begs the question of who is in charge of such a mission.

The political evolution of the NEO issue demonstrates problems of authority and governance. NASA has taken the lead on this and cooperates with DOD for detection, but no one has authority over the problem.[42] No U.S. agency—not NASA, DOD, Air Force Space Command, or the Department of Homeland Security—has been assigned the mission of planetary defense. There are no formal plans or procedures to deal with the NEO issue as it relates to mitigation or to counter the fallout from an impact. This raises the concern of whether planetary defense should be a DOD mission.[43] In other words, should DOD assume a mission to secure the global commons in relation to NEOs, as figure 13–1 below suggests? If this was the case, then should this be part of the calculus with spacepower projection? Is it logical to include in counterspace operations the possible deployment of space weapons, even the use of standoff nuclear weapons, for planetary defense? These are questions that require answers within the context of spacepower theory development.

Figure 13–1. Challenges of the Security Environment

Source: Developed by Eligar Sadeh; adapted and updated from Department of Defense, Quadrennial Defense Review Report (Washington, DC: Department of Defense, 2006), 19.



The nature of space as a commons does set up the NEO issue as one of collective action. Evidence of this exists with international efforts on the issue. For example, in 1995 and 1999, the United Nations hosted workshops on NEOs. The Spacewatch and Spaceguard survey programs noted above entail international efforts, and Europe has put forward a long-term policy commitment on NEOs. More recently, in April 2009, the International Academy of Astronautics held a planetary defense conference.[44] Although these international efforts lack any formal mechanism for cooperation, they do not attempt to coordinate a common or collective view to planetary defense. The NEO subject has also been discussed at UNCOPUOS meetings,[45] and the space preservation treaty efforts that have been part of the UN Prevention of an Arms Race in Outer Space process through the UN Conference on Disarmament have at times made the point that one caveat should be to allow for space weapons for planetary defense.[46]

This possible caveat raises interesting tensions among space weapons use, orbital debris, and planetary defense. Earlier, the rational argument was that mitigating orbital debris demands that weapons not be deployed, limiting spacepower projection and counterspace operations. Here, the argument is that space weapons may in fact be one option to provide for planetary defense. If this option is realized, can space weapons technologies be managed as to provide for a "common good?" Could this common good notion be extended to legitimize the use of space weapons for collective security? And is it

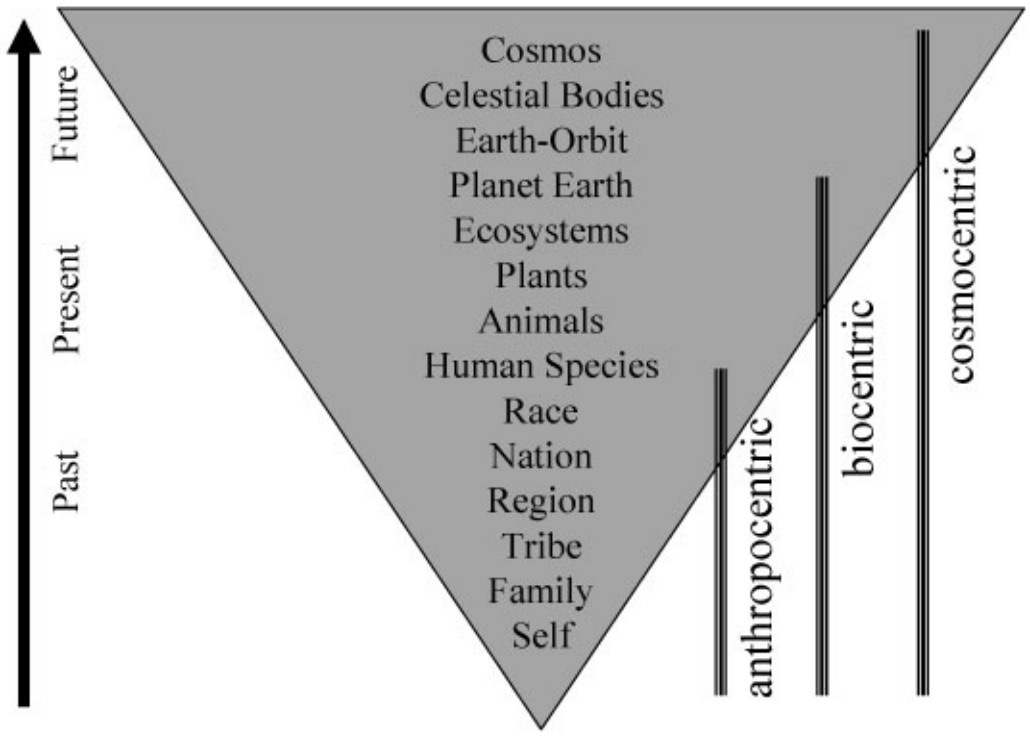
legitimate for the United States to deploy space weapons to facilitate its role as a systems administrator?

These questions deal with the search for schemes to manage space weapons technologies as part of any spacepower calculus. Philosophical debates on the problems associated with managing technology emanate from a schism between *techne* and *logos*. Ideally, *technology*—as a combination of *logos*, meaning reason or study, and *techne*, meaning the production of something, the skill or the method—implies an articulate thinking turned toward production and making. In these terms, technology is the thinking of technique, while technique is the productive transformation of that thinking. What is obvious with technique is that it may be lacking *logos* or reason and thinking. Since the technique (that is, the operational understanding and application) for space weapons exists, an interesting question that requires answers emerges. Will space weapons techniques become the driving power for space weapons development and use, or will a *logos* guide the use and development of space weapons technologies to the benefit of humankind?[47]

Planetary Protection

An important issue within the context of the environmental theme of this chapter is to spread life in a responsible fashion throughout the solar system. A failure to take environmental considerations into account could lead to a scenario whereby civil, commercial, and military uses of space produce a new extraterrestrial environmental crisis. A useful way of ascertaining the evolution of environmental considerations in space is illustrated in figure 13–2. There is a continuous evolving system in which concepts of environmental protection beyond humans are extended to all animals, plants, entire ecosystems, the Earth, and finally to the entire cosmos. In this regard, three distinct views on planetary protection are identified and discussed: anthropocentric, biocentric, and cosmocentric.

Figure 13–2. Space and Environmental Considerations



In the anthropocentric view, humans are treated as ends in and of themselves and act as moral agents in relation to the environment. Nature is of instrumental value in that it contributes to human life. Anthropocentrism is rooted in the principle of nature as a utility for human ends. In this vein, the environment can be both exploited and protected to safeguard and further human interests and the persistence of human civilization.

The exploitation-of-nature argument is based on the exploitation of the environment to enhance human well being. This view allows humans to extract resources from space and planetary bodies and to create human-supported biospheres in space and on planetary surfaces and terraform celestial bodies. In the realm of national security, such a view suggests spacepower projection without regard for the contamination of the space environment. This is the unregulated view that can lead to a tragedy of the commons of space. The perpetuation of the human species that is linked to spacepower considerations suggests that extending a human presence in space takes place without regard for environmental protection.[48]

The exploitation-of-nature argument underlies the view on spacepower discussed in chapter 9 in this book, which examines the use of the Moon's resources for national economic development. Indicative of this is the new U.S. policy "to incorporate the Solar System in our economic sphere," with the fundamental goal of exploration being to advance scientific, security, and economic interests through a robust space exploration program.[49]

The protection-of-nature argument begins to limit the extent to which resources in space can be incorporated exclusively into the U.S. economic sphere. The argument is that the environment needs to be protected, not because it has intrinsic value of its own, but to safeguard human ends. Environmental protection of some sort is consequently promoted due to instrumental ends that include preventing contamination of planets hospitable to life forms for scientific inquiry;[50] conserving natural resources in space for economic development purposes (that is, a measured distribution of resources so that all can partake and benefit); preserving resources for future generations; preserving aesthetics of planetary surfaces and interplanetary space for human enjoyment; and mitigating environmental contamination, such as orbital debris, to ensure freedom of action in space. International space law is in congruence with these views and designates space and celestial bodies as common resources to be protected from contamination by anthropogenic activities.

Indicative of international space law and environmental protection are the planetary protection provisions advanced by the International Council for Science Committee on Space Research (COSPAR), with the first formal guidelines established in 1969 and most recently updated in 2005. COSPAR planetary protection policies are directed at fulfilling the provisions of the 1967 Outer Space Treaty to avoid the harmful contamination of the Moon and other celestial bodies, with foremost thought given to preserving the scientific integrity of planetary bodies. These policies set the context for NASA's planetary protection policies that establish formal guidelines for planetary protection and stipulate that NASA will not participate in international missions unless all partners agree to follow COSPAR's planetary protection policies. COSPAR also formed a panel on planetary protection that is concerned with the development, maintenance, and promulgation of planetary protection knowledge, policy, and plans to prevent the harmful effects of biological contamination on celestial bodies.

Both the biocentric and cosmocentric views are informative for what they may imply for the use of space. However, they are theoretical in that the anthropocentric view dominates space policy and spacepower projection calculations. This is due in part to the fact that the further one departs from anthropocentrism toward biocentrism and cosmocentrism, the greater is the constraint on human freedom of action within the space environment.[51] The biocentric dimension is based on maximizing the well being of the totality of living existence. With this approach, value is assigned to all of living biology. From this vantage point, humanity has a direct obligation to the welfare of that biology. By way of illustration, the need to maintain and value extraterrestrial indigenous life forms would take precedence over the right of life from Earth to exploit and destroy those life forms. This notion is rooted in the principle of the value of life. Humans have a responsibility to respect and support the interests of life whether animal, biota, or microbes. This is an extension of the aim to preserve the scientific integrity of planetary bodies discussed above, but with a value or ethical commitment to that end that transcends the anthropocentric view.

The logical extension of biocentrism is a cosmocentric ethic characterized by the entirety of the cosmos as an environmental priority. An intrinsic value permeates all levels of

both ecological and geomorphological hierarchies; all "named" features and those yet to be discovered have an inherent right to exist. This view is rooted in the principle of the sanctity of existence. Behavior under such a system involves nonviolation of the extraterrestrial environment and the preservation of its existing state, whether that state is biological, ecological, or geomorphological. On a more practical level, a cosmocentric ethic implies that environmental considerations directly inform and determine the planning for the exploration and development of the solar system and any spacepower projection considerations. An extension of the concept of environmental security to spacepower is one practical implication of this view.

Conclusion

The conclusion of this chapter highlights the implications of viewing spacepower through the lens of environmental factors. One implication broadens the scope of spacepower from a focus solely on national concerns to include regional and global concerns. While global environmental dangers and their environmental security aspects—orbital debris, planetary defense, and planetary protection—are all issues that affect national security considerations, they are at the same time issues that posit a collective action problem and require collective action solutions. The collective action solutions discussed herein—international environmental laws, international laws that limit military activities in space, orbital debris mitigation guidelines, planetary defense detection programs, and planetary protection policies—offer paths for viewing spacepower through cooperation, rules of the road, and ultimately, collective security arrangements.

A second implication extends the scope of spacepower through the incorporation of environmental factors into spacepower projection. Remote sensing directed at Earth observations links spacepower to that of identifying, tracking, and assessing global environmental dangers that underlie environmental security. A role, then, for the projection of spacepower is to provide the means for global stability (that is, systems administration) by working to mitigate environmental factors that can cause instability and conflict between and within states. The example of orbital debris as it relates to the space situational awareness mission exemplifies an inclusion of environmental issues in spacepower. The extent to which space situational awareness can be tied to planetary defense is an issue for spacepower projection. Planetary protection plays a possible role in the spacepower calculus, since contamination is a topic that links to environmental security, especially if contamination of Earth occurs from space. It is also a subject that is tied to realizing freedom of action in space, since contamination of the space environment needs to be mitigated if free access to and free use of space are to be ensured.

The final implication within the context of the chapter relates to a strategic view on spacepower. From a strategic "high ground" perspective, spacepower is ultimately about space control that involves control of cislunar space. Due to geography, technological advantage, and global strategic and economic power positions, the United States historically has had far greater success in, reach to, and reliance on cislunar space than any other state. This suggests that space control is more than just a focus on Earth-bound, geocentric strategies like counterspace operations, responsive space, and control of low

Earth orbit, to an integrated strategy based upon building long-term, unconstrained security in cislunar space and in the solar system.[52] The development of spacepower to achieve this end would undoubtedly need to take into account the environmental issues that were the themes of this chapter.

Notes

1. This definition is derived by the author from Environmental Security Studies at <www.acunu.org/millennium/env-sec1.html>.
2. For a list of some of these groups, see table 13–3 in this chapter.
3. Gerald B. Thomas, "U.S. Environmental Security Policy: Broad Concern or Narrow Interests," *Journal of Environment and Development* 6, no. 4 (1997).
4. Thomas Friedman, *The Lexus and the Olive Tree* (New York: Farrar, Straus and Giroux, 1999).
5. Thomas P.M. Barnett, *The Pentagon's New Map* (New York: G.P. Putnam's Sons, 2004).
6. The CNA Corporation is a nonprofit research organization that operates the Center for Naval Analyses and the Institute for Public Research. See <www.cna.org>.
7. Alexander Carius, Melanie Kemper, Sebastian Overturn, and Detlef Sprinz, *Environment and Security in an International Context: State of the Art and Perspectives* (NATO/CCMS Pilot Study, October 1996); The CNA Corporation, *National Security and the Threat of Climate Change*, 2007, available at <http://securityandclimate.cna.org>.
8. *National Security and the Threat of Climate Change*, Executive Summary.
9. "Each man [actor] is locked into a system [an international system] that compels him [the individual actor] to increase his herd [to use, obtain collective good] without limit—in a world that is limited. Ruin is the destination toward which all men [actors] rush, each pursuing his own best interest [self-interest based on rational choice, actor model] in a society [an international system] that believes in the freedom of the commons [free access and free use of the commons]. Freedom in a commons brings ruin [tragedy] to all." Garrett Hardin, "The Tragedy of the Commons," *Science* 162 (1968).
10. See Theresa Hitchens, *Future Society in Space: Charting a Cooperative Course* (Washington, DC: Center for Defense Information, September 2004).
11. See <hwww.unep.org>.
12. Gro Harlem Bruntland, ed., *Our Common Future: The World Commission on Environment and Development* (Oxford, UK: Oxford University Press, 1987).
13. See <www.un.org/esa/sustdev/documents/agenda21/index.htm>.
14. See <http://ozone.unep.org> and <http://unfccc.int>.
15. The Outer Space Treaty declares space as the "province of all mankind." As a province, space is viewed as *res nullius*, that is, belonging to no one (non-appropriable), open to free use and access, and subject to limited claims, like right of use for specific orbital slots for telecommunications purposes. The Moon Agreement's declaration of the Moon as the "Common Heritage of Mankind" differs in that it establishes the natural resources of the Moon as a common property resource for all mankind. If this is accepted, the Moon Agreement requires that lunar resources, once exploitation commences, be shared equitably through an international arrangement, such as an international regime. For an analogous approach that is an accepted part of international law, see the International Seabed Authority at <www.isa.org.jm/en/home>.
16. See <www.gcrio.org/gcact1990.html> and <www.usgcrp.gov/usgcrp>.
17. See <http://eos.nasa.gov>.
18. United Nations, Article XII, *Principles Relating to Remote Sensing of the Earth from Outer Space*, adopted December 3, 1986.
19. The membership of CEOS includes national space agencies and space-based research organizations of Australia, Brazil, Canada, China, France, Germany, India, Italy, Japan, Russia, Sweden, Ukraine, United Kingdom, and the United States. Belgium, Canada, New Zealand, and

Norway are observers; and affiliates include the Economic and Social Commission of Asia and Pacific, Food and Agricultural Organization, Global Climate Observing System, Global Ocean Observing System, Intergovernmental Oceanographic Commission, International Council of Scientific Unions, International Geosphere-Biosphere Program, United Nations Environmental Program, United Nations Office of Outer Space Affairs, World Climate Program, and World Meteorological Organization.

20. For the issues of mission coordination and the relevant actors and data policy issues, see Eligar Sadeh, "Harmonization of Earth Observation Data: Global Change and Collective Action Conflict," *Astropolitics*: *International Journal of Space Politics and Policy* 3, no. 2 (2005).
21. Gerald B. Thomas, James P. Lester, and Willy Z. Sadeh, "International Cooperation in Remote Sensing for Global Change Research: Political and Economic Considerations," *Space Policy* 1, no. 2 (1995).
22. Sadeh, "Harmonization of Earth Observation Data."
23. *Committee on Earth Observation Satellites toward an Integrated Global Observing Strategy, 1997 Yearbook* (Surrey, UK: Smith System Engineering Limited, 1997).
24. Earth remote sensed data have the potential to engender sovereignty transparency and the "unbundling of territoriality." For a further discussion on this unbundling concept and international relations, see John G. Ruggie, "Territoriality and Beyond: Problematizing Modernity in International Relations," *International Organization* 47, no. 1 (1993).
25. Michael R. Hoversten, "U.S. National Security and Government Regulation of Commercial Remote Sensing from Outer Space," *Air Force Law Review*50 (Winter 2001).
26. Attempting to clarify when shutter control might occur, the memorandum of understanding states: "Conditions should be imposed for the smallest area and for the shortest period necessary to protect national security [defense and intelligence], international obligations, or foreign policy concerns at issue. Alternatives to prohibitions on collection and/or distribution shall be considered such as delaying the transmission or distribution of data, restricting the field of view of the system, encryption of the data if available, or other means to control the use of the data." U.S. President, National Science and Technology Council, "Fact Sheet: Regarding the Memorandum of Understanding Concerning the Licensing of Private Remote Sensing Satellite Systems," November 1, 2001.
27. Orbimage acquired Space Imaging, and the company today is named GeoEye.
28. The facts suggest that there may be no choice but for the U.S. military to accept certain sovereignty bargains, which implies constraints and limits on the use of spacepower projection. An important argument that emerges from this conclusion has to do with what set of constraints is acceptable. For example, is the body of international space law and other international agreements that limit military uses of space as explained in this chapter a sufficient set of constraints, or will the sovereignty bargain force other constraints, like "rules of the road" that could impact the use of spacepower to preserve freedom of action in space?
29. Molly K. Macauley, "Economics of Space," in *Space Politics and Policy: An Evolutionary Perspective*, ed. Eligar Sadeh (The Netherlands: Kluwer Academic Publishers, 2002).
30. Hitchens, *Future Society in Space*; and author correspondence with General James E. Cartwright, USMC, Commander, U.S. Strategic Command, Space and Telecommunications Law Conference, University of Nebraska, Lincoln, Nebraska, March 2, 2007.
31. Author correspondence, General James E. Cartwright.
32. See, for example, *Technical Report on Space Debris* (New York: United Nations, 1999).
33. Attaining zero debris growth, or even cleaning up all debris to achieve zero debris, is likely to be prohibitively expensive and may well require cessation of doing *anything* in space. Further, it probably is not economically practical or technically feasible. Pinpointing a "livable" amount of debris requires a comprehensive social benefit and cost calculus, informed by engineering data about debris populations and their probable growth over time, to weigh the benefits of space activity against the costs of debris production and mitigation. Finally, debris issues, like all space activity, are inherently global. Choosing the best way to manage debris requires the consensus of all parties: those now using space, those who will use space in the future, and those who may never use space directly but who indirectly benefit from space activity. Macauley, "Economics of Space," in Sadeh, ed., *Space Politics and Policy*.

34. U.S. National Space Policy, August 31, 2006, available at <www.ostp.gov/html/US%20National%20Space%20Policy.pdf>, states:

    Orbital debris poses a risk to continued reliable use of space-based services and operations and to the safety of persons and property in space and on Earth. The United States shall seek to minimize the creation of orbital debris by government and non-government operations in space in order to preserve the space environment for future generations. Toward that end: Departments and agencies shall continue to follow the United States Government Orbital Debris Mitigation Standard Practices, consistent with mission requirements and cost effectiveness, in the procurement and operation of spacecraft, launch services, and the operation of tests and experiments in space; the Secretaries of Commerce and Transportation, in coordination with the Chairman of the Federal Communications Commission, shall continue to address orbital debris issues through their respective licensing procedures; and the United States shall take a leadership role in international fora to encourage foreign nations and international organizations to adopt policies and practices aimed at debris minimization and shall cooperate in the exchange of information on debris research and the identification of improved debris mitigation practices.

35. IADC members include British National Space Centre, *Centre National d'Etudes Spatiales*, China National Space Administration, European Space Agency, German Aerospace Center, Indian Space Research Organisation, Italian Space Agency, Japan, NASA, National Space Agency of Ukraine, and the Russian Federal Space Agency. Also see <www.iadc-online.org>.
36. One potential obstacle to any new formulation in international space law has to do with the U.S. concern that any "new" legal agreements could limit U.S. military options and spacepower projection. The National Space Policy issued in October 2006 clearly states that the "United States will oppose the development of new legal regimes or other restrictions that seek to prohibit or limit U.S. access to or use of space." See U.S. National Space Policy.
37. *Report of the Task Force on Potentially Hazardous Near Earth Objects*, September 2000, available at <www.nearearthobjects.co.uk/report/resources_task_intro.cfm>.
38. Clark R. Chapman, "The Hazard of Near-Earth Asteroid Impacts on Earth," *Earth and Planetary Science Letters* 222 (2004).
39. See <http://neo.jpl.nasa.gov>.
40. *Report of the Task Force on Potentially Hazardous Near Earth Objects*.
41. National Aeronautics and Space Administration, "Near-Earth Object Survey and Deflection Analysis of Alternatives," report to Congress, March 2007.
42. Peter Garretson and Douglas Kaupa, *Planetary Defense: Potential Department of Defense Mitigation Roles* (Colorado Springs: U.S. Air Force Academy, December 2006).
43. The U.S. Air Force recently conducted an interagency exercise dealing with a scenario of a near Earth object (NEO) impact with Earth. See AF/A8XC Natural Impact Hazard (Asteroid Strike) Interagency Deliberate Planning Exercise After Action Report (December 2008). The major insights of this effort include: the NEO impact scenario is not captured in existing plans; the NEO impact scenario should be elevated to higher level exercises with more senior government players; proper planning and response to a NEO emergency requires delineation of organizational responsibilities including lead agency and notification standards; government players were not able to achieve consensus on which agency should lead the NEO deflection/mitigation effort; there is a deficit in software tools to support senior decisionmaking and strategic communication for disaster response and mitigation for a NEO scenario; there are significant regional and global effects a NEO impact would generate that are not adequately captured in existing models; the public may be aware of an impending NEO impact before senior decisionmakers; lead time for evacuation requires decisions be made before best information is available; public safety and tranquility require that the U.S. Government be able to rapidly establish a single authoritative voice and tools to present critical information; and the preferred approach for short-notice NEO deflection was standoff nuclear.
44. See <www.congrex.nl/09c04/>. The 2009 conference discussed detecting and tracking NEO asteroids and comets that might be hazardous to Earth, physical characteristics of NEOs,

deflecting a threatening NEO should one be detected, the nature of impact disasters, and political, legal, and policy issues that must be considered as part of an overall mitigation strategy.

45. See <www.b612foundation.org>.
46. The use of any technology to counter the threat of NEO impacts has to consider the lead time before impact and the physical type and characteristics of the NEO. Whether a space weapon or another type of technology could be effective is a matter of debate in the space community.
47. Everett C. Dolman, in *Astropolitik: Classical Geopolitics in the Space Age* (London: Frank Cass, 2002), argues for spacepower projection by the United States to safeguard and advance its values of freedom and democracy.
48. Molly K. Macauley, "Environmentally Sustainable Human Space Activities: Can Challenges of Planetary Protection Be Reconciled," *Astropolitics: International Journal of Space Politics and Policy* 5, no. 3 (2007).
49. John Marburger, keynote address, 44th Robert H. Goddard Memorial Symposium, Greenbelt, MD, March 15, 2006, available at <www.spaceref.com/news/viewsr.html?pid=19999>.
50. NASA has addressed some of these issues by establishing a Planetary Protection Office and instituting policy guidelines regarding planetary protection. These guidelines incorporate both "forward" and "backward" contamination issues. Forward contamination seeks to prevent Earth organisms from contaminating another celestial body, and possible backward contamination is contamination forthcoming from another planet to Earth.
51. Eligar Sadeh, "Space and the Environment," in Sadeh, ed., *Space Politics and Policy*.
52. Thomas Cremins and Paul D. Spudis, "The Strategic Context of the Moon: Echoes of the Past, Symphony of the Future," *Astropolitics: International Journal of Space Politics and Policy* 5, no. 1 (2007). The cislunar perspective also informs the development of this spacepower theory project. Dennis Wingo argues in chapter 9 in this book that a geocentric mindset has become an embedded assumption in the development of national spacepower theory. *Geocentric* is defined as a mindset that sees spacepower and its application as focused primarily on actions, actors, and influences on Earthly powers, the Earth itself, and its nearby orbital environs. Wingo argues that this is a mindset and worldview that must be expanded in the development of spacepower theory. The expanded view can be defined as cislunar based on a "cosmographic" outlook. See presentation by Charles D. Lutes, "Towards a Theory of Spacepower," *The Influence of Spacepower on History and the Implications for the Future*, Institute for National Security Studies, National Defense University, Washington, DC, April 25–26, 2007.