HOW THE REST WAS WON: CREATING A UNIVERSALLY BENEFICIAL LEGAL REGIME FOR SPACE-BASED NATURAL RESOURCE UTILIZATION

> With the passage of centuries, new conditions create a new form of beings, and the artificiality that surrounds them is gradually weakened and may finally vanish. Was it not thus when the creatures of the sea first crawled out onto dry land and became amphibians and then land-dwellers, some of which in turn became creatures of the air: birds, insects, bats? Having conquered air, is the next step not the conquest of space? Will not the creatures of the air become creatures of space, natives of the realm of pure sunshine and the infinite reaches of the universe?
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> K.E. Tsiolkovskiy, *The Exploation of the Universe with Reaction Machines: The "Rocket" Reaction Machine of K. E. Tsiolkovskiy*[1]

INTRODUCTION

History has demonstrated the United States' ability to assert rapid control over vast areas of land in a sweeping manner. In 1803, Thomas Jefferson acquired the Louisiana Purchase, doubling the size of the country.[2]

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1. K.E. TSIOLKOVSKIY, *The Exploration of the Universe with Reaction Machines: The "Rocket" Reaction Machine of K. E. Tsiolkovskiy*, *in* 2 COLLECTED WORKS OF K. E. TSIOLKOVSKIY: REACTIVE FLYING MACHINES 118, 164 (A.A. Blagonravov ed.,1954).

2. THOMAS MAITLAND MARSHALL, A HISTORY OF THE WESTERN BOUNDARY OF THE LOUISIANA PURCHASE, 1819-1841 10 (1914).

Over a century later, Congress passed the Outer Continental Shelf Lands Act of 1953, asserting control over 1.76 billion acres of submerged land.[3] And on September 10, 2014, a subcommittee in the House of Representatives sat down to discuss what could be the beginning of a new era of American property acquisition. The American Space Technology for Exploring Resource Opportunities in Deep Space Act (Asteroids Act) strives to "facilitate the commercial exploration and utilization of asteroid resources to meet national needs," as well as "promote the right of United States commercial entities to explore and utilize resources from asteroids in outer space, in accordance with the existing international obligations of the United States, free from harmful interference, and to transfer or sell such resources."[4] More recently, the Federal Aviation Administration (FAA) has mirrored some of Congress's intentions. The agency plans to "leverage the FAA's existing launch licensing authority to encourage private sector investments in space systems by ensuring that commercial activities can be conducted on a non-interference basis."[5] In doing so, the FAA acknowledged "the private sector's need to protect its assets and personnel on the moon or on other celestial bodies."[6]

Still in its preliminary stages, space law's scope has yet to be defined. With private space industry on the rise, the need to define space law's scope is increasingly apparent. Companies like Planetary Resources, with high profile investors including James Cameron and Richard Branson, are already envisioning a "new paradigm for resource discovery and utilization that will bring the Solar System into humanity's sphere of influence."[7] Yet this new paradigm—largely influenced by highly developed countries and affluent individuals—tends to focus on the desires of a select few private actors within the industry. These self-interested notions run contrary to traditional principles of space law, which provide for space exploration benefitting all mankind.[8] These competing ideals beg questions concerning property rights allocation in outer space and how to distribute acquired resources from space exploitation.

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3. 43 U.S.C. § 1332 (2012); INST. FOR ENERGY RESEARCH, *Outer Continental Shelf*, http://instituteforenergyresearch.org/topics/policy/ocs/? (last visited Nov. 19, 2015).

4. American Space Technology for Exploring Resource Opportunities in Deep Space Act, H.R. 5063, 113th Cong. § 51301 (2014).

5. Irene Klotz, *Exclusive—The FAA: Regulating Business on the Moon*, REUTERS (Feb. 3, 2015, 8:08 AM), http://www.reuters.com/article/2015/02/03/us-usa-moon-business-idUSKBN0L715F20150203.

6. *Id.*

7. PLANETARY RESOURCES, http://www.planetaryresources.com (last visited Sept. 16, 2015).

8. G.A. Res. 1472 (XIV) A, (Dec. 12, 1959).

Part I of this Note will look at the issue of scarcity and its applicability to natural resources in outer space. Part II briefly discusses the types of resources available in outer space. Part III analyzes the current regime of federal and international space-related laws and how they may interact with current systems of property and resource development. In addition, this section explores how current federal public lands paradigms, and other analogous areas of the law, may cooperate with evolving space law. Lastly, Part IV provides recommendations on how space law can ultimately promote not only a deeper understanding of the cosmos, but also the knowledge of how to garner resources responsibly, benefitting humankind from the depths of a little-known frontier.

I. SCARCITY & NATURAL RESOURCES

Scarcity is typically at the heart of resource management issues. In fact,

> [s]carcity is perhaps the most basic feature of any natural resource conflict for the simple reason that if the resource were not scarce there would be no need for law, i.e., there would be plenty to go around. As soon as there is scarcity, competing interests arise over use of the resource . . . .[9]

Consequently, competing interests interact in various ways. Scarcity creates markets,[10] encourages competition, and promotes innovation.[11] Unchecked scarcity can lead to violent conflict and has historically been a decisive factor in the downfall of early civilizations.[12] As a result, "the

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9. JAMES RASBAND ET AL., NATURAL RESOURCES LAW AND POLICY 36 (Robert C. Clark et al. eds., 2nd ed. 2009).

10. Indeed, water scarcity in the Western United States has inspired the creation of water markets as one potential solution. Victor Brajer et. al., *The Strengths and Weaknesses of Water Markets as They Affect Water Scarcity and Sovereignty Interests in the West*, 29 NAT. RESOURCES J. 489, 490 (1989) ("[A]s conditions relevant for the productivity of water change through time, the market provides a mechanism for shifting water use from low to high valued uses, with water use remaining *efficient* through time."); Peter Debaere et. al., *Water Markets as a Response to Scarcity*, 16 WATER POL'Y 625, 626 (2014) ("Many market advocates suggest that markets allocate existing water supplies more productively and coordinate the various demands on water resources more flexibly.").

11. Daron Acemoglu, *When Does Labor Scarcity Encourage Innovation?*, 118 J. POL. ECON. 1037, 1070 (2010) (concluding that labor scarcity can induce technological innovation under certain circumstances); Gregory Unruh, *Scarcity, Fountain of Innovation*, FORBES (Sept. 16, 2010, 3:00 PM), http://www.forbes.com/sites/csr/2010/09/16/scarcity-fountain-of-innovation (discussing how "self-imposed" scarcity can force entrepreneurs to innovate).

12. James A. Brander & M. Scott Taylor, *The Simple Economics of Easter Island: A Ricardo-Malthus Model of Renewable Resource Use*, 88 AM. ECON. REV. 119, 132 (1998) ("Rather than being the

increasing scarcity of particular resources fosters discovery or development of alternative resources, not only equal in economic quality but often superior to those replaced."[13]

Scarcity is also multidimensional. First, scarcity contains a temporal element. Resources that are limited at one point in time may increase in availability in the future. For example, in the early 2000s, many energy experts predicted that the world supply of oil would soon peak.[14] At that time, the world was producing about 78 million barrels of oil per day.[15] That number steadily rose over the next thirteen years—without even a hint of an impending crash.[16] Today, the world is pumping approximately 93 million barrels per day.[17] This prescient failure to predict the level of global oil production is largely attributed to the rise of new technology. Analysts did not realize that hydraulic fracturing would allow oil exploration in previously impractical areas. Due to these advances in technology, the United States is now the largest source of oil and natural gas in the world, surpassing both Russia and Saudi Arabia.[18] Thus, the ideas of time and technology become intertwined. Indeed,

> [r]esources can only be defined in terms of technology. Half a century ago the air was for breathing and burning; now it is also a natural resource of the chemical industry. Two decades ago Vermont granite was only building and tombstone material; now it is a potential fuel, each ton of which has a useable energy content (uranium) equal to 150 tons of coal.[19]

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cause of decline, violent conflict is commonly the result of resource degradation and occurs after the civilization has started to decline . . . .").

13. HAROLD J. BARNETT & CHANDLER MORSE, SCARCITY AND GROWTH: THE ECONOMICS OF NATURAL RESOURCE AVAILABILITY 10 (2d ed. 1967).

14. *See* KENNETH S. DEFFEYES, HUBBERT'S PEAK: THE IMPENDING WORLD OIL SHORTAGE 149 (2001) ("The resulting estimate gives a peak production year of 2003 and a total eventual oil recovery of 2.12 trillion barrels . . . . Other published estimates . . . give peak years from 2004 to 2009.").

15. *International Energy Statistics: Petroleum*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=53&aid=1&cid=regions&syid=2000&eyid=2013&unit=TBPD (last visited Sep. 12, 2015).

16. *Id.*

17. *Short-Term Energy and Winter Fuels Outlook: STEO Report: Global Petroleum and Other Liquids,* U.S. ENERGY INFO. ADMIN., http://www.eia.gov/forecasts/steo/report/global_oil.cfm, (follow "Global Petroleum and Other Liquids" under "STEO Report" menu) (last visited Sept. 9, 2015).

18. *Outer Continental Shelf*, Institute for Energy Research http://instituteforenergyresearch.org/analysis/u-s-overtakes-saudi-arabia-russia-worlds-biggest-oil-producer (last visited Oct. 23, 2014).

19. BARNETT & MORSE, *supra* note 13, at 7.

As time progresses, our idea of what constitutes a natural resource changes along with our needs and ability to harness such a resource. Resource predictions therefore contain an inherent risk of miscalculation due to our inability to fully predict the capabilities of future technology. Additionally, "[t]he notion of an absolute limit to natural resource availability is untenable when the definition of resources changes drastically and unpredictably over time."[20]

Technology can also expand natural resource exploration's scope. Thus, there is a spatial element to scarcity. When entities are faced with resource constraints, they diversify the geographic scope of potential resource exploitation. For example, much of the energy industry's recent exploration focus has been in East Africa.[21] While it is no secret that hydrocarbon resources have existed for decades in this part of the world, political realities and projection limitations have hindered past projects.[22] In the Rovuma Basin off the coast of Tanzania and Mozambique, however, recent natural gas discoveries have uncovered vast potential for production.[23] The same principle applies in the United States. Up until a few years ago, Pennsylvania was not considered overly abundant in natural resources. The discovery of the Marcellus Shale play in 2008 drastically changed this notion.[24] "From 2011 to 2012, Pennsylvania's marketed natural gas (which includes natural gas plant liquids) production grew by 72%, moving it from the seventh-largest to the third-largest marketed gas-producing state in the United States . . . ."[25] The location of resources thus contributes to scarcity as much as time and technological innovation.

When faced with resource scarcity, the United States has often paired technological advancements and expanding geographic scope with legal mechanisms. In the early 1900s, the United States faced the consequences of

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20. *Id.*

21. *Emerging East Africa Energy*, U.S. ENERGY INFO. ADMIN., (May 23, 2013) http://www.eia.gov/beta/international/regions-topics.cfm?RegionTopicID=EEAE.

22. *Id*. at 1 ("In the past there were doubts about the amount of recoverable resources in the region, along with regional and civil conflicts that presented challenges and risks to foreign companies. Consequently, exploration activities in East Africa have evolved at a much slower pace relative to other African regions.").

23. *Id*. at 6.

24. Hobart King, *Marcellus Shale-Appalachian Basin Natural Gas Play*, GEOLOGY.COM http://geology.com/articles/marcellus-shale.shtml (last updated Apr. 3, 2015).

25. Mike Kopalek, *Pennsylvania is the Fastest-Growing Natural Gas-Producing State*, U.S. ENERGY INFO. ADMIN., (Dec. 17, 2013), http://www.eia.gov/todayinenergy/detail.cfm?id=14231.

uninhibited timber exploitation during the previous century and a half.[26] Techniques used in American timber exploitation led to a 50% reduction in original forest cover by 1920.[27] In response, Congress passed The Weeks Act of 1911 and The Clarke-McNary Act of 1924. Both pieces of legislation were aimed at increasing the amount of timber on public lands available for use by agriculture and other industries.[28] This was accomplished by encouraging states to transfer forest lands from private and state ownership into federal hands.[29] While this program was a spatial expansion of where the country could obtain its timber resources, it would not have been possible without congressionally granted legal authority. Thus, legal elements essentially justify spatial expansion.

In the mid-1950s, the federal government utilized another pair of legislative actions in order to expand the area in which the government could legally explore and extract resources. Prior to 1953, the United States did not have jurisdiction over submerged lands beyond the country's coastal boundaries.[30] The Submerged Lands Act (SLA) granted states sovereignty over submerged lands extending three miles from their shores.[31] Congress defined *submerged lands* (or "lands beneath navigable waters") as "all lands within the boundaries of each of the respective States which are covered by nontidal waters that were navigable under the laws of the United States at the time such State became a member of the Union, or acquired sovereignty over such lands and waters thereafter . . . ."[32]

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26. MICHAEL WILLIAMS, DEFORESTING THE EARTH: FROM PRE-HISTORY TO GLOBAL CRISIS 317 (2003) ("From a mere 0.5 billion bf [board feet]. . . cut in 1801, the amount of lumber cut . . . reached 20 billion bf . . . in 1880 and peaked at nearly 46 billion bf . . . in 1906, an amount never reached since.").

27. RASBAND ET AL., *supra* note 9, at 1199.

28. *See* 16 U.S.C. § 569 (2012) (stating that the purpose of the act was to "enable owners of lands chiefly valuable for the growing of timber crops to donate or devise such lands to the United States in order to assure future timber supplies for the agricultural and other industries of the State or for other national forest purposes").

29. *Id.*

30. *See* United States v. California, 332 U.S. 19, 38–39 (1947) ("California is not the owner of the three-mile marginal belt along its coast, and . . . the Federal Government rather than the state has paramount rights in and power over that belt, an incident to which is full dominion over the resources of the soil under that water area, including oil."); United States v. Louisiana, 339 U.S. 699, 704 (1950) ("The marginal sea is a national, not a state concern. National interests, national responsibilities, national concerns are involved. The problems of commerce, national defense, relations with other powers, war and peace focus there. National rights must therefore be paramount in that area."); United States v. Texas, 339 U.S. 707, 719 (1950) ("[T]his is an instance where property interests are so subordinated to the rights of sovereignty as to follow sovereignty.").

31. 43 U.S.C. § 1301 (2012).

32. *Id.*

Almost concurrently, Congress enacted the Outer Continental Shelf Lands Act of 1953 (OCSLA) to assert federal jurisdiction over the coastal boundaries of the country. OCSLA gave the United States authority over submerged lands beyond three miles off the coast.[33] Arguably, the primary purpose of both SLA and OCSLA was to promote oil and mineral development. OCSLA's purpose explicitly states that "the outer Continental Shelf is a vital national resource reserve held by the Federal Government for the public, which should be made available for expeditious and orderly development, subject to environmental safeguards, in a manner which is consistent with the maintenance of competition and other national needs . . . ."[34] Moratoria issued by both Congress and the President have limited drilling in the Outer Continental Shelf (OSC) over the past two decades.[35] Since the passage of OSCLA, the political will to institute any OCS-wide drill agreement has been lacking.

In sum, three basic elements should be addressed when confronted with scarcity: spatial, temporal, and legal. The advent of space law results from the presence of these elements. The spatial element is clearly satisfied. As the world population continues to grow and natural resources inevitably dwindle, excess demand and limited supply will lead to the development of novel technologies and exploration of new natural resource frontiers. According to scholars, the current rate of growth has

> prompted recurring concern about whether the world's natural resource base is capable of sustaining such growth. To some degree, this concern is supported by simple mathematics: exponential physical growth in a finite world eventually generates absurd results. For example, any positive population growth rate eventually has the population completely covering the face of the [E]arth and expanding rapidly into space; any positive growth rate for petroleum consumption eventually results in annual production that is greater than the mass of the [E]arth.[36]

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33. *Id.* § 1332 (2012) ("It is hereby declared to be the policy of the United States that . . . the subsoil and seabed of the outer Continental Shelf appertain to the United States and are subject to its jurisdiction, control, and power of disposition . . . .").

34. *Id.*

35. Either the President, through authority granted under OSCLA, or Congress, via appropriation, can impose moratoria on OCS drilling. Thus, limitations on drilling are largely due to lack of political will as opposed to strict economic or environmental reasons. ADAM VANN, CONG. RESEARCH SERV., RL33404, OFFSHORE OIL AND GAS DEVELOPMENT: LEGAL FRAMEWORK at 4 (2014).

36. Jeffrey A. Krautkraemer, *Economics of Natural Resource Scarcity: The State of the Debate*, *in* SCARCITY AND GROWTH REVISITED 54, 54 (R. David Simpson et al. eds., 2005).

One may discern that certain resources—mineral and energy resources, for instance—will face increasing consumption pressures from a growing population. Governments and businesses will begin to look to previously unexplored areas in order to relieve this pressure. Outer space is an area within the spatial expansion necessary to satisfy the first element of natural resource scarcity.

Temporal scarcity issues mean the use of space-based natural resources will hinge upon technological developments. To date, we do not have the ability to mine an asteroid, exploit the Moon, or place solar panels into space in an economically viable manner. If we expand our temporal scope, however, it is likely that in the future these activities will not only be necessary, but technologically feasible and financially worthwhile.

As a final step, Congress or an international lawmaking body must create legal authority justifying the exploration and exploitation of new natural resource-rich areas. While the United Nations has a series of treaties governing outer space's uses, they do not explicitly consider mining and other related activities. The United States, on the other hand, has begun to contemplate these issues more seriously. As previously mentioned, a subcommittee in the House of Representatives sat down in 2014 to discuss what could be the beginning of a new era of American property acquisition. The Asteroids Act seeks to "promote the right of United States commercial entities to explore and utilize resources from asteroids in outer space, in accordance with the existing international obligations of the United States, free from harmful interference, and to transfer or sell such resources."[37] While the Asteroids Act is still early in the legislative process and not yet law, it is a clear indication that space-based natural resources are on Congress's radar.

II. SPACE-BASED NATURAL RESOURCES

Before discussing the allocation of resource and property rights, we must first determine the type of resources available in outer space. When the first samples of Moon rocks were brought back to Earth in 1969, there was an "expectant atmosphere in the Lunar Receiving Laboratory . . . like that in a medieval monastery as the monks awaited the arrival of a fragment of the

37. American Space Technology for Exploring Resource Opportunities in Deep Space Act, H.R. 5063, 113th Cong. § 51301(3) (2014).

True Cross."[38] The same anticipation is still felt when today's scientists and innovators consider the potential of space-based natural resources. But unlike the 1969 lunar rock analysis, our current understanding of what lies beyond Earth's atmosphere is drastically deeper.

To begin, the Moon, asteroids, and other celestial bodies throughout our solar system hold immense amounts of natural resources.[39] Some estimates suggest that outer space resources can support a high standard of living for a quadrillion people.[40] In particular, the Moon contains "vast amount[s] of mineral resources distributed uniformly across its surface and subsurface. . . . [T]he Moon is rich in aluminum, iron, silicon, oxygen, hydrogen, chromium, manganese, potassium, and other minerals."[41] Perhaps the most exciting resource on the Moon is Helium-3. Extremely scarce on Earth, this isotope of Helium results from solar wind and can fuel fusion power reactors.[42] Unlike typical uranium-based nuclear power, Helium-3 fusion power does not produce toxic waste byproducts.[43] The prospect of creating energy with little to no waste makes the idea of producing energy on the Moon feasible. The collection of resources available on the Moon could "form the basis of a space-based manufacturing industry that could build spaceships, human habitats and other structures"[44] independent of resource availability on Earth.

While there is economic potential in mining the Moon, most entrepreneurs have their sights focused on asteroid mining. Compared to the Moon, asteroid-based extractive resources are more cost-effective. For example, an asteroid that orbits within 194.5 million kilometers of Earth qualifies as a near-earth asteroid (NEA).[45] Over 300 NEAs are more easily accessible than the Moon.[46] They also contain similar elements, such as gold,

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38. Kenneth F. Weaver, *What the Moon Rocks Tell Us*, NAT. GEOGRAPHIC, http://ngm.nationalgeographic.com/1969/12/moon-landing/moon-rock-text (last visited Nov. 15, 2015) (original date of publication in Dec. 1969 issue).

39. 4 FABIO TRONCHETTI, *The Exploration of Natural resources of the Moon and Other Celestial Bodies: A Proposal for a Legal Regime*, *in* STUDIES IN SPACE LAW 1, 5 (F.G. von der Dunk et al. eds., 2009).

40. Mark Sonter, *Asteroid Mining: Key to the Space Economy*, SPACE.COM (Feb. 9, 2006, 6:51 AM), http://www.space.com/2032-asteroid-mining-key-space-economy.html.

41. TRONCHETTI, *supra* note 39, at 5.

42. *Id*. at 5–6.

43. *Id.* at 6.

44. Mike Wall, *Earth-Buzzing Asteroid Worth $195 Billion, Space Miners Say*, SPACE.COM (Feb. 12, 2013, 7:41 PM), http://www.space.com/19758-asteroid-worth-billions-2012-da14-flyby.html.

45. *Near Earth Asteroids*, INT'L ASTRONOMICAL UNION (Oct. 7, 2013), http://www.iau.org/public/themes/neo/nea.

46. Sonter, *supra* note 40.

platinum, and rhodium.[47] Moreover, asteroid resources tend to be of higher quality than their Earthly or Moon-based counterparts.[48] Indeed, "many stony and stony-iron meteorites contain Platinum Group Metals at grades of up to 100 ppm,"[49] whereas "open pit platinum and gold mines in South Africa and elsewhere mine ores of . . . 5 to 10 ppm . . . ."[50] This is because asteroids "are the undisturbed remains from the creation of the solar system. This leaves them relatively pristine and undisturbed in compositions that could have only formed and cooled in the microgravity of space, outside of a planet's gravitational pull."[51] As a result, investors are eager for opportunities to mine asteroids like 3554 Amum, an NEA that reportedly contains $8 trillion worth of iron and nickel, $6 trillion of cobalt, and $6 trillion of platinum-group metals.[52]

Lastly, there are opportunities for resource development outside of extractive industries. The Department of Energy has contemplated space-based solar power (SBSP) infrastructure. After all:

> On [E]arth, solar power is greatly reduced by night, cloud cover, atmosphere and seasonality. Some 30 percent of all incoming solar radiation never makes it to ground level. In space the sun is always shining, the tilt of the Earth doesn't prevent the collection of power and there's no atmosphere to reduce the intensity of the sun's rays. This makes putting solar panels into space a tempting possibility. Additionally, SBSP can be used to get reliable and clean energy to people in remote communities around the world, without relying on the traditional grid to a large local power plant.[53]

Thus, it is not necessary to focus on physical resource extraction in order to realize the benefits of outer space resources. By freeing solar panels from the inhibiting factors present on Earth, we could essentially create the

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47. William Steigerwald, *New NASA Mission to Help Us Learn How to Mine Asteroids*, NAT;'L AERONAUTICS & SPACE ADMIN., http://www.nasa.gov/content/goddard/new-nasa-mission-to-help-us-learn-how-to-mine-asteroids (last updated July 30, 2015).

48. Sonter, *supra* note 40.

49. *Id.*

50. *Id.*

51. *Asteroids: Composition*, PLANETARY RESOURCES, http://www.planetaryresources.com/asteriods/composition/ (last visited Sept. 16, 2015).

52. JOHN S. LEWIS, MINING THE SKY: UNTOLD RICHES FORM THE ASTEROIDS, COMETS, AND PLANETS 111–12 (1996).

53. *Space-Based Solar Power*, U.S. DEP'T OF ENERGY (Mar. 6, 2014), http://energy.gov/articles/space-based-solar-power.

ultimate renewable resource—the "total amount of power that could be produced is effectively infinite."[54]

While cost estimates to implement many of these projects are prohibitive, that should not discourage further research and investment. Advances in technology will eventually drive down the cost of celestial resource extraction, and "the rising cost of resource acquisition on Earth will surpass the falling cost of acquiring equivalent or substitute materials in space."[55] In other words, resource scarcity on Earth will drive us to explore space. Looking beyond economics, there are countless societal benefits that come with celestial resource extraction. Asteroid and moon mining could eliminate harmful environmental impacts of terrestrial mining;[56] cosmic natural resources could serve as an alternative and abundant source of certain metals and eventually contribute to ending resource conflicts;[57] and the opportunity presented from the lack of property rights in outer space could allow us to eliminate the issues surrounding tenure that plague conservation efforts in developing countries.[58] A discussion of the necessary consideration of these global benefits will follow.

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54. Katie Jennings, *What If Giant Space-Based Solar Panels Could Beam Unlimited Power to the Earth?* BUS. INSIDER (Aug. 11, 2014, 1:43 PM), http://www.businessinsider.com/space-based-solar-panels-could-power-earth-2014-7 (quoting Paul Jaffe, spacecraft engineer at the U.S. Naval Research Laboratory).

55. CHARLES L. GERLACH, PROFITABLY EXPLOITING NEAR-EARTH OBJECT RESOURCES 2 (2005).

56. *Id.* at 11.

57. There has been little scholarship that suggests the abundance of natural resources in outer space can be an alternative source of minerals that typically come from areas known for human rights abuses in the resource extraction industry. The basic premise, however, is that due to their excessive supply and incredibly high market barriers, these resources can serve as a more ethical option for consumers. Steigerwald, *supra* note 47. The higher supply will provide an abundant and cost-effective alternative to preexisting market options. Gold, for example, has been blamed as one of the "fundamental driver[s]of the conflict [in Congo], as brutal rebel groups commandeer mines and use the profits to fuel their murderous campaigns." Karen Attiah, *Going for Congo's Gold*, WASH. POST (Nov. 26, 2014), http://www.washingtonpost.com/blogs/post-partisan/wp/2014/11/26/going-for-congos-gold. Gold, however, is also plentiful in outer space. And the millions—if not billions—of dollars it requires to operate in an outer space market could ensure that a violent, authoritarian cabal does not take control. Moreover, the high market barriers and stringent job qualifications will ensure that only highly trained workers enter the market place. Businesses will have a strong interest in maintaining safe and humane operations in order to continue attracting a quality workforce and avoid backlash from regulators and the public in what is bound to be a closely scrutinized practice.

58. *See, e.g.,* BRYAN JOHNS, PES AND REDD+: THE CASE OF COSTA RICA 39–40 (2012) (equating the lack of clear land tenure as a barrier to effectively implementing carbon sequestration projects in the developing world).

III. THE LEGAL FRAMEWORK OF THE COMMONS

To properly create a functioning legal regime of space-based resource law, it is necessary to discuss multiple areas of the law and extract the applicable principles. This section will first discuss international space law. Then, an analysis of analogous natural resource frontiers where resource ownership and utilization are legally uncertain will follow. Lastly, the section will conclude with a discussion of pertinent American property law and federal natural resource management practices and how they can be applied to outer space natural resource management.

A. International Space Law

The concept of space law is not yet 60 years old. It is widely known that "practical legal questions arose immediately after the launch of the first Sputnik in 1957. Due to the vast political, military, and economic implications of the advent of space technology, a new [area of] law emerged in a historically short time span . . . ."[59] Consequently, the United Nations created multiple treaties, principles, and resolutions pertaining to space law beginning in the late 1950s. The first pertinent piece of space law is the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), developed in 1967. Article I of the Outer Space Treaty mandates that outer space activities "shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."[60] This language has subsequently been referred to as the Common Heritage doctrine. All of humankind must benefit from sharing the natural resources that are subject to this policy. Accordingly, when space-based activities are conducted, they are subject to equity-oriented limitations. For example, "[o]uter space, including the [M]oon and other celestial bodies, is not subject to national appropriation by claim of sovereignty . . . ."[61] Furthermore, the Moon, asteroids, and planets must be used "exclusively for peaceful

59. Judge Vladlen Stepanovich Vereshchetin, *The Law of Outer Space in the General Legal Field (Commonalities and Particularities)* (May 10, 2010), http://webtv.un.org/watch/judge-vereshchetin-icj-on-the-law-of-outer-space/2616999957001.

60. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, art. I, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

61. *Id*. art. II.

purposes."[62] Currently, there are 102 State Parties and 89 signatories to the Outer Space Treaty.[63] Generally, the United Nations sought to promote themes of cooperation and peaceful exploration—it recognized that our relationship with outer space is unique. Humanity shares a common curiosity regarding what lies beyond our terrestrial realm. The language in the Outer Space Treaty realizes this age-old commonality and proposes that it should be carried into the space age.

These provisions, however, are subject to two highly different interpretations. "For developing states, the [Common Heritage] doctrine means that outer space and its resources belong to all, and any benefit derived from outer space should be equitably distributed."[64] On the contrary, developed nations "view [the Outer Space Treaty] as a means of unfairly divesting them of the profits of their labor, making the investment in space development a risky and potentially unprofitable venture."[65] Resolving the differing interpretations is necessary to strike a balance between economic development and recognition of the rights and needs of nations unable to engage in space-faring activities.

The next significant treaty is the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty). Enacted in 1979, the Moon Treaty shares many of the goals advanced by the Outer Space Treaty. Although the Moon Treaty came 12 years later, the United Nations was still eager "to promote on the basis of equality the further development of co-operation among States in the exploration and use of the [M]oon and other celestial bodies."[66] In particular, the drafters were explicit in recognizing "the interests of present and future generations as well as . . . the need to promote higher standards of living and conditions of economic and social progress and development . . . ."[67] In order to account for the needs of developing States and future generations, the United Nations envisioned "an international régime, including appropriate procedures, to govern the exploitation of the natural resources of the [M]oon . . . ."[68] The establishment

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62. *Id.* art. IV.

63. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, U.N. OFFICE FOR DISARMAMENT AFFAIRS, http://disarmament.un.org/treaties/t/outer_space (last visited Nov. 15, 2015).

64. Lynn M. Fountain, *Creating Momentum in Space: Ending the Paralysis Produced By the "Common Heritage of Mankind" Doctrine*, 35 CONN. L. REV. 1753, 1762 (2003).

65. *Id.*

66. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, pmbl., Dec. 5, 1979, 1363 U.N.T.S. 3.

67. *Id*. art. 4.

68. *Id.* art. 11, para 5.

of this "international régime" is dependent upon the exploring country approaching the United Nations and disclosing what resources it would discover and use.[69]

Unlike the Outer Space Treaty, however, the Moon Treaty has received significantly less support—especially from space powers such as the United States and Russia.[70] This is because the Moon Treaty "appears to be antithetical to the commercial development of outer space. Without the security derived from ownership and sovereign control, entities that might be interested in the development of space resources will be reluctant to undertake this expensive and risky path."[71] Nevertheless, one cannot ignore that 12 years after the Outer Space Treaty and over 20 years after the launch of Sputnik I, the United Nations remained firm in its belief that outer space—and the Moon in particular—should be subject to the Common Heritage doctrine.

In addition to enacting the Outer Space and Moon Treaties, the United Nations also created five nonbinding legal principles that promote international cooperation and understanding in space activities,[72] two of which are pertinent here. The first principle, a Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, was enacted in 1963, prior to either of the treaties previously mentioned.[73] Along with a provision on asserting the need for a Common Heritage doctrine, the 1963 Principle also declared that "[o]uter space and celestial bodies are free for exploration and use by all States on a basis of equality and in accordance with international law."[74] Moreover, "[o]uter space and celestial bodies are not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[75] By denying any individual state from asserting sovereignty over a part or all of outer space, the United Nations sought to ensure that the resulting "co-operation will contribute to the development of mutual understanding and to the strengthening of friendly relations between nations and peoples . . . ."[76]

About three decades later, the United Nations reiterated the importance of treating outer space as a communal resource. In 1996, yet another

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69. *Id.* art. 11, para 6.

70. Fountain, *supra* note 64, at 1764.

71. *Id.*

72. *United Nations Treaties and Principles on Space Law*, UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, http://www.oosa.unvienna.org/oosa/SpaceLaw/treaties.html (last visited Sept. 16, 2015).

73. G.A. Res. 1962 (XVIII) (Dec. 13, 1963).

74. *Id.* para. 2.

75. *Id.* para. 3.

76. *Id.* prmbl.

Declaration promoted the Common Heritage doctrine along with principles of cooperation.[77] The United Nations recognized that the "experiences gained in international cooperative ventures" provide more utility to humankind as opposed to the individual efforts of any individual State.[78] Exploiting space-based natural resources on an "equitable and mutually acceptable basis" will not prohibit developing countries from benefiting from the potential wealth of outer space simply because they do not have the ability to access these minerals and energy sources.[79] Highly developed nations, "particularly those with relevant space capabilities and with [programs] for the exploration and use of outer space, should contribute to promoting and fostering international cooperation . . . ."[80] For countries that possess the ability to reach outer space and harvest its resources, the United Nations has imbued them with a sense of responsibility that cannot be abrogated in the face of an attractive economic investment.

Lastly, the United Nations also created multiple nonbinding resolutions to influence space-faring behavior. To date, there are over one hundred General Assembly Resolutions indicating the United Nations' stance on activities in space.[81] This is due to the United Nations revisiting and revising the 1959 Resolution on International Co-operation in the Peaceful Uses of Outer Space nearly every year since its inception.[82] In its original form, the first post-Sputnik I recognition of the need for a legal regime in outer space established the Common Heritage Doctrine, which was reiterated in later outer space principles and treaties.[83] The General Assembly strongly believed "that the exploration and use of outer space should be only for the betterment of mankind and to the benefit of States irrespective of the stage of their economic or scientific development . . . ."[84] The United Nations also adamantly encouraged space activities to be, above all things, peaceful.

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77. G.A. Res. 51/122, para. 1, Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (Dec. 13, 1996).

78. *Id.* pmbl.

79. *Id.* para. 3.

80. *Id.*

81. *Index of Online General Assembly Resolutions Relating to Outer Space,* UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, http://www.unoosa.org/oosa/documents-and-resolutions/search.jspx?&view=resolutions (last visited Sept. 16,, 2015).

82. *Id.*

83. *See* G.A. Res. 1472, *supra* note 8, A(1)(a–b) (formulating the Committee on the Peaceful Uses of Outer Space with the mandate to study feasible legal regimes to govern outer space exploration), G.A. Res. 34/68, pmbl. (Dec. 5, 1979) (identifying subsequent resolutions addressing principles for outer space).

84. G.A. Res. 1472, *supra* note 8, A.

There was a common desire "to avoid the extension of present national rivalries into" outer space.[85] Although the resolution on international cooperation in the peaceful uses of outer space has been revisited over fifty times, the rhetoric remains the same. Whether it was the support during the 1970s of space-related projects in India[86] or the concern during the 1980s of the global arms race extending into outer space,[87] the United Nations has staunchly stood by the Common Heritage doctrine. Even the most recent 2013 Resolution acknowledges that the United Nations is "[d]eeply convinced" that outer space should be treated "as the province of all humankind . . . ."[88]

From a jurisdictional perspective, the United Nations realized the practical difficulties in creating a legal regime for an area so vast. Two years after the first Resolution on the peaceful use of outer space, the United Nations refined the proposed legal regime.[89] While the exchange of information between governments, nongovernmental organizations, and the United Nations remained voluntary,[90] the United Nations saw itself as the "focal point" and regulator in a new area of international law.[91] Ultimately, the resolution sought to promote overarching themes of transparency and cooperation.[92]

After analyzing the United Nations' body of space law, a number of notable themes arise. First, from the creation of space law through today, the idea expressed in the Common Heritage doctrine—that the uses of outer space should benefit all of mankind—has not changed. Second, the United Nations acknowledges that, for a resource as vast as outer space, some sort of global institution is necessary to manage both the interested parties and the States. It has always seen itself as an arbiter of conflicts and information exchange, and will likely continue to do so. Lastly, the United Nations wants the mutual desires of all nations to encourage the "friendly relations between nations and peoples . . . ."[93] Outer space is more than a simple destination for natural resource exploitation; there is a unifying feature of outer space that all humanity shares.

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85. *Id.*

86. G.A. Res. 3388 (XXX), para. 16 (Nov. 18, 1975).

87. G.A. Res. 42/33, para. 11 (Nov. 30, 1987).

88. G.A. Res. 68/75, pmbl. (Dec. 16, 2013).

89. G.A. Res. 1721 (XVI), E (Dec. 20, 1961).

90. *Id.* B, para. 3(b).

91. *Id.* B, pmbl.

92. *Id.* B (calling for the Secretary-General to maintain a public record of information gathered, and requesting parties to voluntarily exchange information).

93. G.A. Res. 1962, *supra* note 73, pmbl.

B. Analogous Legal Regimes

However, there are other areas of the law that may provide guidance for how the world should proceed with resource-rich areas such as outer space. Some scholars analogize potential legal frameworks for outer space natural resource law with the current legal regimes for Antarctica and the Law of the Sea. These legal regimes draw from centuries-old principles of property law. Over time, "many different cultures and civilizations have developed and flourished. Most have recognized, in one form or another, public rights and interests in their society's natural resources."[94] Most scholars agree that the Romans pioneered public-oriented resource rights.[95] Under their view of natural law—defined as "that which all animals have been taught by nature; this law is not peculiar to the human species, it is common to all animals"—there are certain things that all of humanity inherently shares.[96] For example "by the law of nature, . . . the air, running water, the sea, and consequently the shores of the sea" are all considered common property.[97] It follows that "no man . . . is prohibited from approaching any part of the seashore, whilst he abstains from damaging farms, monuments, edifices, [et cetera], which are not in common as the sea is."[98] Consequently, the Romans viewed certain rights—such as "the right to load and unload cargo, to use the natural products of the sea and shore, to build cottages on the shore, to dry and keep nets on the shore, [and] to navigate in public waters"—as vested in every member of the public.[99] Moreover, private land adjacent to rivers was often subject to certain public-oriented contingencies designed to promote open access and use.[100] The particular focus of Roman public rights on the sea was "because the Roman civilization was almost completely dependent on navigation for economic survival."[101] Thus, the advent of the commons was based not only on legal practicalities, but on economic necessity as well.

After the fall of the Roman Empire, the next progression in the commons was the creation of the Magna Carta in 1215.[102] Although the charter

94. Lynda L. Butler, *The Commons Concept: A Historical Concept With Modern Relevance*, 23 WM. & MARY L. REV. 835, 840 (1982).

95. *Id.* at 846.

96. *Id.* at 846–47.

97. *Id*. at 849.

98. *Id.* at 849–50

99. *Id.* at 852.

100. *Id.*

101. *Id.* at 849.

102. *Id*. at 856. Although the Roman Empire fell around 476 AD, "the Roman common or public rights concept gradually fell into disuse in England" over the next few hundred years. *Id.* at 853. This accounts for the temporal gap between the fall of the Empire and the signing of the Magna Carta.

extended beyond Roman property law, importantly it reversed the course of increasing appropriation and privatization of forests, fisheries, seashores, pastures, and meadows by the Crown during the turn of the millennia.[103] In doing so, it established "the principle that the Crown was subject to the people."[104] Certain provisions within the charter "gave the people a legal foothold in their struggle to protect their rights from encroachment by the lords."[105] This struggle was further exemplified in the courts where "common law seized upon the spirit of the movement leading to the adoption of the Magna Carta to interpret its provisions broadly."[106] Thus, the idea of an open-access commons available to the public has survived over one thousand years, through the fall of an empire and the disappearance of an oppressive monarchy. Eventually, the rights of the public overcame the notion that property should only be subject to exclusive property rights.

Yet the commons encompasses multiple understandings of the public's right to access property and resources within the commons. Although these distinctions were developed hundreds of years ago, they nevertheless "are often overlooked when 'the commons' is carelessly categorized as one type of property."[107] Each type of nonexclusive property right lies on a continuum that varies in terms of rights surrounding access and use.[108] In the context of Antarctica, the sea, and outer space, two pertinent nonexclusive rights exist. At one end lies *res communis*. Here, the "character of some resources makes them incapable of 'capture' or any other act of exclusive appropriation."[109] No nation possesses an exclusive ownership interest in *res communis*.[110] Resources such as the sky and sea fall into this category.[111] Thus, "the sovereignty issue remains unresolved for [these areas, so resource] exploration and development may be possible only through multinational organizations."[112]

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103. *Id.* at 856.

104. *Id.* at 857.

105. *Id.*

106. *Id.* at 858.

107. Eleanor W. Brown, *A Common Morality: Toward a Framework for Designing Fiscal Instruments to Respond to Global Climate Change*, 15 WIDENER L. REV. 391, 401 (2010).

108. *See id.* (outlining a five-part continuum of rights the Romans developed for nonexclusive property).

109. Carol M. Rose, *Romans, Roads, and Romantic Creators: Traditions of Public Property in the Information Age*, 66 LAW & CONTEMP. PROBS. 89, 93 (2003).

110. *Id.*

111. *Id.*

112. Barbara E. Heim, Note, *Exploring the Last Frontiers for Mineral Resources: A Comparison of International Law Regarding Deep Seabed, Outer Space, and Antarctica*, 23 VAND. J. TRANSNAT'L L. 819, 820 (1990).

On the opposite side of the spectrum lies *res nullius*. *Res nullius* property consists of "things that are not by their nature nonexclusive; they have simply not yet been appropriated by anyone."[113] Unlike *res communis*, where possession of this type of *res* is difficult to conceptualize, *res nullius* is different in that the *res* is both accessible and subject to possession.[114] The property simply has not become subject to ownership.[115] In this case, governments assure open access to the *res nullius*. Within "this category the Romans placed things that might be reduced to private ownership but had not yet been so appropriated, such as unsettled land, and fish and wild game."[116]

When considering outer space and the two public commons analogs of the Law of the Sea and Antarctica, there are varying applications of the nonexclusive property interests. Antarctica is similar to outer space for multiple reasons: "each contains large quantities of valuable natural resources; each is an environment inherently inhospitable to humans; [and] each requires technological sophistication and significant financial backing to exploit . . . ."[117] From a legal perspective, no recognized sovereignty rights allow for development.[118] Technically, Antarctica may fit in the *res nullius* category; however, through multinational cooperation, it is now treated as *res communis*.

The Antarctic Treaty of 1959 was "[m]otivated by concerns to protect the fragile Antarctic environment, to preserve the area for scientific research, and to avoid potential sovereignty disputes arising from pre-existing claims . . . ."[119] Numerous subsequent international agreements and treaties

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113. Rose, *supra* note 109, at 92.

114. Brown, *supra* note 107, at 402.

115. *Id.*

116. *Id.*

117. Fountain, *supra* note 64, at 1769.

118. Prior to the 1959 Treaty, seven nations asserted territorial rights over parts of the continent. *The Antarctic Treaty*, SECRETARIAT ANTARCTIC TREATY, http://www.ats.aq/e/ats.htm (last visited Nov. 11, 2015). To date, Argentina, Australia, Chile, France, New Zealand, Norway and the United Kingdom all maintain these claims. *Id.* Some critics have argued that the Treaty did nothing "more, legally speaking, than preserve an opaque *status quo ante,* putting on ice the complex and contradictory rights and claims lodged earlier by the contracting parties." J. Peter A. Bernhardt, *Sovereignty in Antarctica* 5 CAL. W. INT'L L.J. 297, 297 (1975). While the Treaty does not in fact "constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica . . . ," it does prohibit any "new claim, or enlargement of an existing claim, to territorial sovereignty . . . ." The Antarctic Treaty art. 4, Dec. 1, 1959, 12 U.S.T 794, 42 U.N.T.S. 71. Furthermore, while the original Treaty did not mention Antarctic mineral development (most likely due to the fact that mining practices were not feasible in 1959), the subsequent Environmental Protocol includes a mining prohibition. Protocol on Environmental Protection to the Antarctic Treaty art. 7, Oct. 4, 1991-Oct. 3, 1992, 30 I.L.M. 1455.

119. Fountain, *supra* note 64, at 1770.

collectively comprise the Antarctic Treaty System.[120] Under the System, 28[121] parties "meet annually and make consensus-based decisions concerning activities in Antarctica."[122] This process guarantees that all parties to the treaty are considered in the decision making process. This System has the potential to act as a model legal regime because it "successfully squelched potential territorial disputes, ensured the peaceful use of the area, encouraged the proliferation of scientific research, and made strides in protecting the fragile environment . . . ."[123] One major discrepancy, however, is the absence of the Common Heritage doctrine. While both the original Treaty and the agreement between Consultative Parties on the 50th anniversary of the Treaty recognize that all of mankind has an interest in the preservation of Antarctica for peaceful purposes,[124] neither mention whether humans should share in any of the natural resource benefits potentially derived from Antarctica. The treaty does, however, encourage members to freely share all information gathered from scientific research.[125]

The Law of the Sea reflects similar characteristics: abundant natural resources[126] and the dilemma of their relationship with national autonomy.[127] This problem was seemingly resolved "in the 1960s when a boundary was established between the territorial sea and the high seas. This occurred after a number of States began unilaterally extending the breadth of their territorial sea to twelve miles, a practice that eventually was formalized in the Law of

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120. Heim, *supra* note 112, at 839.

121. These parties are referred to as "Consultative Parties." *The Antarctic*, BRITISH ANTARCTIC SURVEY, https://www.bas.ac.uk/about/antarctica/the-antarctic-treaty/ (last visited Nov. 11, 2015).

122. Fountain, *supra* note 64, at 1771.

123. *Id.*

124. The Antarctic Treaty, *supra* note 118, pmbl., art. 1; *Antarctic Treaty Consultative Meeting XXXII – Washington Ministerial Declaration on the Fifteenth Anniversary of the Antarctic Treaty,* SECRETARIAT ANTARCTIC TREATY (Apr. 6, 2009), http://www.ats.aq/documents/ATCM32/op/atcm32_op022_e.pdf.

125. The Antarctic Treaty, *supra* note 118, art. 3.

126. While there are obvious resources in such fisheries, some of the most sought after natural resources in the ocean are the minerals contained within the deep seabed. Heim, *supra* note 112, at 822. These include cobalt, copper, manganese, and nickel. *Id.* Oil in these areas is often overlooked "because the bulk of offshore oil production will continue within [the exclusive economic zones of nations] and at depths of less than 1,000 meters." *Id.* at 822 n.16. For instance, the world's largest manganese deposit exists in the Pacific Ocean and is estimated to contain 21 billion tons of manganese nodules alone. *Manganese Nodule Treasures*, WORLD OCEAN REV., http://worldoceanreview.com/en/wor-3-overview/mineral-resources/manganese-nodules (last visited Nov. 19, 2015).

127. Similar to outer space law, the current Convention has also faced "existential" questions surrounding definitions that create the foundation of the legal regime. Keith Johnson, *When is a Rock Not a Rock?*, FOREIGN POLICY (Apr. 4, 2014), http://foreignpolicy.com/2014/04/04/when-is-a-rock-not-a-rock. *See also infra* notes 215–33 and accompanying text.

the Sea Convention."[128] This boundary is known as the Exclusive Economic Zone (EEZ).[129] The EEZ creates a 200 mile buffer beyond the borders of individual countries.[130] Within the EEZ, countries can freely establish their own laws regarding the management of ocean resources; the laws of the Convention govern areas beyond the EEZ.[131] The boundary reflects a fine balance between the desires of resource-hungry nations and the broader ethical issue of how abundant natural resources that lie in the middle of the ocean should be utilized when many sovereigns lack the ability to access them.

Unlike the Antarctic Treaty System, the Convention reasserted the Common Heritage doctrine that is also seen in space law.[132] Through the use of nonexclusive rights, the Convention intended that natural resources of the high seas would not be abused.[133] If resources on the High Seas are utilized, the benefits accrued from such resources are equitably divided. Under the Convention, there are profit-sharing provisions mandating developed countries to share revenues from deep seabed mining with less developed nations. For example, "[u]nder article 82 of the Convention, States or individual operators who exploit the non-living resources of the outer continental shelf are required to contribute a proportion of the revenues they generate from such exploitation for the benefit of the international community as a whole."[134] This provision acknowledges all nations as communal "owners" of natural resources of the High Seas. Any benefit imbued in one nation is thereby distributed among others.

Even in the context of outer space, the application of nonexclusive property labels is nothing new. From the time Sputnik I launched, legal scholars grappled with the issue of whether state sovereignty could apply to outer space.[135] Today, it is "widely recognised that State sovereignty does not apply to outer space as a whole [nor can States] claim exclusive rights over

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128. RAM JAKHU, LEGAL ISSUES RELATING TO THE GLOBAL PUBLIC ISSUES IN OUTER SPACE 55–56 (2005).

129. United Nations Convention on the Law of the Sea, art. 55, Dec. 10, 1982, 1833 U.N.T.S. 397.

130. *Id.* art. 57.

131. *Id.* art. 55–58.

132. *Id.* pmbl. ("[T]he area of the seabed and ocean floor and the subsoil thereof, beyond the limits of national jurisdiction, as well as its resources, are the common heritage of mankind . . . .").

133. *Id.* art. 87 ("These freedoms shall be exercised by all States with due regard for the interests of other States in their exercise of the freedom of the high seas . . . .").

134. Secretary-General of the International Seabed Authority, *Report of the Secretary-General of the International Seabed Authority Under Article 166, Paragraph 4, of the United Nations Convention on the Law of the Sea*, ¶ 70, U.N. Doc. ISBA/16/A/2 (Mar. 8, 2010).

135. TRONCHETTI, *supra* note 39, at 10.

outer space or its parts . . . ."[136] The dispute rests largely on whether to define outer space's natural resources as *res nullius* or *res communis*.[137] On one hand, outer space remains an area devoid of any assertions of property, yet countries and individuals arguably have the ability to occupy and acquire celestial spaces and objects (*res nullius)*.[138] On the other hand, it is still disputed whether outer space "represents an area of common interest of all mankind."[139] The ultimate use of cosmic natural resources comes down to how the global community defines *property* in outer space.

In practice, whether one is dealing with the ocean floor or outer space, distinctions are often irrelevant in terms of how the world uses natural resources under both *res nullius* and *res communis* designations. From a policy perspective, *res nullius* is often described in terms of "[n]onexcludable open access."[140] This term is "virtually synonymous with the concept of a 'free marketplace' in capitalist economics [yet] has a categorical overlap with a term which defines the modern global commons."[141] Strangely enough, the terms *res communis* and *res nullius* have become interchangeable regarding a global natural resource commons. Even so,

> [i]f unlimited use is what defines common property in international law there would be no way to institute limits in this space. . . . It is as if *res communis* and *res nullius*, belonging to no-one and belonging to everyone, produce the same effect: both lead to nearly unlimited exploitation in international law.[142]

For example, even though the high seas used to be considered *res nullius*, "[n]inety percent of the world's fisheries are now enclosed in . . . coastal economic development zones. . . . [T]he current mismanagement of ocean fisheries has led to enormous biodiversity loss on ocean ecosystems. Fish stocks have collapsed in nearly one-third of all ocean fisheries."[143] This

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136. *Id.*

137. *Id.* at 10–12. Tronchetti uses the term "*res communis omnium*" to refer to areas that are the common heritage of mankind. For the purposes of this paper, there are few distinctions between *res communis omnium* and *res communis*, thus they will be used interchangeably.

138. *Id.* at 10–11.

139. *Id.* at 12.

140. KATHRYN MILUN, THE POLITICAL UNCOMMONS: THE CROSS-CULTURAL LOGIC OF THE GLOBAL COMMONS 58 (2011).

141. *Id.*

142. *Id.*

143. *Id.* at 5, n.7.

is what William Forster Lloyd and Garret Hardin defined as the "tragedy of the commons."[144]

Therefore, in order to avoid unlimited exploitation of outer space resources, we must create a legal framework that does not draw upon or conflate the traditional notions of *res communis* and *res nullius*. In doing so, we face the ontological dilemma of conceptualizing outer space not as a traditional *res*, but as a new form of property. Section IV discusses new and creative applications of the commons in the context of outer space.

C. American Natural Resource Law

Having established the existing framework of outer space law and the legal applications of nonexclusive property rights, this Note will now explore the current regime surrounding American natural resource law and how it may apply to the Asteroids Act or similar pieces of legislation in the future.

When the first settlers came to this country, they encountered a staggering amount of natural resources.[145] For example, when early European settlers reached America around 1630, "the estimated area of U.S. forest land was 1,023 million acres or about 46 percent of the total land area. . . . By 1910, the area of forest land had declined to an estimated 754 million acres,"[146] and only half of the country's virgin forest remained.[147] Throughout

144. Lloyd originally proposed this theory over a hundred years before Hardin. Lloyd was more interested in economic implications, while Hardin applied the theory to an ecological setting. *Compare* William Forster Lloyd, *W. F. Lloyd on the Checks to Population*, 6 POPULATION & DEV. REV. 473, 483 (1980) (postulating that a farmer grazing his cattle on a commons faces little disincentive to limit the number of cattle he grazes because the individual benefit she derives from the commons is greater than the shared impact she induces), *with* Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968) ("As a rational being, each herdsman seeks to maximize his gain . . . . Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited.").

145. UNITED STATES FOREST SERV., UNITED STATES DEP'T OF AGRIC., RESOURCE FACTS AND HISTORICAL TRENDS 7 (Aug. 2014).

146. *Id.*

147. WILLIAMS, *supra* note 26, at 317. Throughout this section, this Note will use forest lands as an analogy to outer space resources and as a proxy for many other resources managed under similar management principles. This is due to the rich history of this country's forests, their distribution (albeit uneven) across the United States, the evolution of the Forest Service, and the continuous demand of timber over the past four centuries. The lessons learned from managing this country's forests have been applied elsewhere, and this Note argues that they also can be applied to space-based natural resources. Moreover, this section will only analyze federal forests as opposed to those in private hands. All federal forest lands are mandated to have a forest plan, 16 U.S.C. § 1601(d)(1) (2012) ("It is the policy of the Congress that all forested lands in the National Forest System shall be maintained . . . in accordance with land management plans."), and "[r]ecent studies show that only 8 percent of the families and individuals who [privately] own U.S. forest land have a written management plan." UNITED STATES FOREST SERV., *supra* note 145, at 16. Thus, due to the consistency and availability of information, the focus will be on federal forests.

this period of rapid natural resource utilization, the United States went through two distinct eras: acquiring lands further to the west, and subsequently disposing of those lands to individuals willing to settle on America's seemingly endless frontier, in order to promote settlement and raise revenue.[148] Federal land polices that essentially gave away land "to anyone brave enough to take the risk led to extensive migration and many people began to move west to settle in the cheap land available there."[149] From the time of American independence through 1860, the size of the country more than tripled through purchases and treaties,[150] while the population grew nearly eightfold.[151] As this nation expanded, so did the desire to conquer the frontier. Eventually, "[t]his perennial rebirth, this fluidity of American life, this expansion westward with its new opportunities, [and] its continuous touch with the simplicity of primitive society, furnish[ed] the forces dominating American character."[152]

Yet with this rapid expansion arose problems of how the government could manage the natural resources within these immense boundaries. Because of "perceived over-exploitation and wanton abuse of public lands by the private sector resulting from the disposal era," the federal government entered into the final era of land use policies: the era of retention.[153] Beginning in 1849, "[t]he Federal Government began to designate and set aside areas of great natural beauty to be reserved for all future Americans to enjoy."[154] The first step came when the federal government created the Department of the Interior (DOI) "to be the custodian of the Nation's vast federally owned lands and natural resources"[155] that had yet to be disposed to settlers. Next, Congress established this country's first National Park, Yellowstone, in 1872;[156] the first Federal forest reserves in 1891;[157] and the first wildlife refuge in 1902.[158] Then, between 1901 and 1917, there was a

148. Jan G. Laitos & Thomas A. Carr, *The Transformation on Public Lands*, 26 ECOLOGY L.Q. 140, 147–48 (1999); Scott K. Miller, *Missing the Forests and the Trees: Lost Opportunities for Federal Land Exchanges*, 38 COLUM. J. ENVTL. L. 197, 208 (2013).

149. *History*, U.S SENATE COMM. ON ENERGY & NAT. RES., http://www.energy.senate.gov/public/index.cfm/history (last visited Nov. 16, 2015).

150. U.S. CENSUS BUREAU, STATISTICAL ABSTRACT OF THE UNITED STATES 8 (2012), http://www2.census.gov/library/publications/2011/compendia/statab/131ed/2012-statab.pdf.

151. *Id*.

152. FREDERICK JACKSON TURNER, THE FRONTIER IN AMERICAN HISTORY 2–3 (1953).

153. Laitos & Carr, *supra* note 148, at 149.

154. U.S SENATE COMM. ON ENERGY & NAT. RES., *supra* note 149.

155. *Id.*

156. *Id.*

157. *Id.*

158. *Id.*

"concerted Congressional movement towards conservation of natural resources and the protection and preservation of forests, wilderness areas, wildlife refuges, and historic areas of the Nation."[159] It was not until this nation's resources were largely exploited that the government realized the pressing need to manage what remained in a more responsible manner.[160]

With increased intervention from the federal government came the need to delegate responsibilities more efficiently.[161] At first, concerns were mostly with the survey and disposal of western lands.[162] These tasks were divided between Congress, the Department of the Treasury, the War Department, and the DOI.[163] These fragmented responsibilities continued through the late 1800s, when "the Interior Department continued dutifully disposing of the public lands without much thought for the natural resources on them."[164] However, in 1878, early American explorer John Wesley Powell completed his Report on the Lands of the Arid Region.[165] In this report, Powell "recommended that, for the first time, the public lands be inventoried and then classified according to their best use—whether for timber, mining, or pasturage—and that after classification, management policies should be designed for each type of land."[166] Powell believed that science-driven natural resource management would produce the most efficient results.[167] The Report called on Congress to reflect on data gathered by land managers and eventually "establish broad policy objectives that could then be turned into practical, on-the-ground policies by expert scientists and managers working for federal agencies."[168] Initially, Powell and the Report were largely ignored.[169] Over time, however, they "laid the groundwork for the

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159. *Id.*

160. In no way does this section try to argue that a resource management regime is necessary because we may someday exploit all of outer space. This author is hesitant to speak in absolutes, but due to the fact that "we live on an insignificant planet of a humdrum star lost between two spiral arms in the outskirts of a galaxy which is a sparse cluster of galaxies, tucked away in some forgotten corner of a universe in which there are far more galaxies than people," total exploitation —let alone exploration—is impossible. CARL SAGAN, COSMOS 193 (1980). Due to limits in technology and the laws of physics, we are inevitably restricted in our scope of natural resource utilization. Thus, in the boundaries that we *can* explore, it is imperative to learn from our mistakes of uninhibited natural resource utilization, and manage space-based natural resources responsibly for the billions of individuals on Earth.

161. RASBAND, *supra* note 9, at 210.

162. *Id.*

163. *Id.*

164. *Id.*

165. *Id.*

166. *Id.*

167. *Id.*

168. *Id*. at 211

169. *Id*.

move toward expert agency management of natural resources."[170] In doing so, Powell instilled "the belief that public ownership and scientific management of important natural resources would best insure their conservation."[171]

At its core, expert-oriented decision making is designed to promote rational and efficient natural resource management, insulated from political whims.[172] Because these choices of how to allocate natural resources are essentially "technical in nature, . . . technicians, rather than legislators, should deal with them."[173] When conflicts do arise, the political arena is not suited to resolving them. Instances such as "[p]ressure group action, logrolling in Congress, or partisan debate [can] not guarantee rational and scientific decisions. Amid such jockeying for advantage with the resulting compromise, concern for efficiency would disappear."[174] These sentiments lead to the establishment of the Forest Service, the National Park Service, and the Bureau of Reclamation in the early 1900s. Agencies like the Bureau of Ocean Management, the Fish and Wildlife Service, and the United States Geological Service followed. Under authority granted by the Property Clause in the Constitution,[175] federal agencies manage over 614 million acres of federal lands.[176] While these agencies have their own independent bureaucracies and the authority to create rules, "Congress has established management guidelines and constraints for the existing agencies to use in conjunction with their existing missions and purposes."[177]

Powell's idea that natural resource management decisions should be in the hands of experts and insulated from political activity dovetails nicely with the notion that resource management should also satisfy the desires of many stakeholders. If management decisions instilled benefits largely on one faction of society, then a great deal of utility—and ultimately efficiency—would be lost. The idea gained stronger footing under Gifford Pinchot and his fledging Forest Service. Pinchot

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170. *Id*.

171. *Id*.

172. SAMUEL P. HAYS, CONSERVATION AND THE GOSPEL OF EFFICIENCY: THE PROGRESSIVE CONSERVATION MOVEMENT, 1890–1920, at 2 (1959).

173. *Id.* at 2–3.

174. *Id.*

175. U.S. CONST. art IV, § 3, cl. 2.

176. ROSS W. GORTE ET. AL., CONG. RESEARCH SERV., R42346, FEDERAL LAND OWNERSHIP: OVERVIEW AND DATA 8 (2012). This amounts to 95% of all public land and roughly 28% of the 2.27 billion acre American land base. *Id.* at 3, 8.

177. *Id.* at 13.

> and his successors ordered that the national forests be managed according to the multiple-use concept, primarily emphasizing timber harvesting and watershed protection. In Pinchot's view, reflected in official Forest Service policy for several decades, multiple use was best accomplished when the forest was 'used' for its principal economic commodity—the harvesting of trees.[178]

These practices were officially codified in 1960 in the form of the Multiple Use and Sustained Yield Act.[179] *Multiple use* became a pillar of natural resource management that was eventually mirrored in other natural resource-oriented legislation.[180] Modern forest management under the National Forest Management Act (NFMA) still applies this principle, but accounts for a larger variety of interests due to an increasingly diverse user base.[181]

In order to successfully implement multiple-use management, agencies must properly determine which uses to emphasize. To do so, agencies develop a sense of what the public and the government desire. There are multiple vehicles for determining which uses to manage. The first is through the Administrative Procedure Act (APA). Under the APA, agencies are mandated to "give interested persons an opportunity to participate in the rule making through submission of written data, views, or arguments . . . ."[182] Upon receipt of such submissions, the agency must consider "the relevant matter presented"[183] by the public and "incorporate in the rules adopted a concise general statement of [the rules'] basis and purpose."[184] It is important to note that agencies are by no means directed to regulate based on popular opinion expressed through the public's comments. They are, however, required to *consider* such comments and explain how the public's opinion influenced the particular regulation.[185]

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178. Laitos & Carr, *supra* note 148, at 150–51.

179. Multiple-Use and Sustained Yield Act of 1960, Pub. L. No. 86-517, 74 Stat. 215.

180. *See* Federal Land Policy Management Act, 43 U.S.C. § 1701(a)(7) (2012) ("The Congress declares that it is the policy of the United States that . . management be on the basis of multiple use and sustained yield unless otherwise specified by law."). Multiple use is defined as "the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people . . . ." 43 U.S.C. § 1702(c) (2012).

181. 16 U.S.C. § 528 (2012) ("It is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes.").

182. 5 U.S.C. § 553(c) (2012).

183. *Id.*

184. *Id.*

185. *See* South Carolina *ex rel.* Tindal v. Block, 717 F.2d 874, 885 (4th Cir. 1983) ("The purpose of allowing comments is to permit an exchange of views, information, and criticism between interested

Citizen influence can even extend beyond the detailed regulations that agencies promulgate. For instance, individuals can persuade the Forest Service to shift how individual forests are managed. Through regulations promulgated pursuant to NFMA, the Forest Service is required to "provide opportunities to the public for participating in the assessment process" and the planning process.[186] These regulations are far more detailed than the APA and ensure that the Forest Service encourages private landowners,[187] Native American Tribes,[188] "[y]outh, low-income populations, and minority populations"[189] to all participate in the crafting of forest plans. The diversity of input should ultimately show in the Forest Service's multiple-use management schemes. Admittedly, there are drawbacks to this system. Most of the criticisms, however, are a result of public choice theory and not necessarily the structure of public participation mechanisms or the folly of independent agencies.[190]

The idea that the federal government should manage some land for the benefit of the public was—and to some extent still is—uniquely American. This country pioneered the concept of public lands with Yellowstone, the world's first national park.[191] At the time, many subscribed to Gifford Pinchot's utilitarian belief that the forests and rangelands should simply be utilized in a more sustainable manner.[192] Yet a growing faction wanted to preserve the remaining untouched landscape for preservation's sake and for the enjoyment of future generations.[193] These wilderness advocates "link[ed]

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persons and the agency. There is no requirement for the Secretary to discuss every fact or opinion contained in the public comments." (citing Home Box Office, Inc. v. FCC, 567 F.2d 9, 35 (D.C. Cir. 1977); Gen. Tel. Co. v. United States, 449 F.2d 846, 862 (5th Cir. 1971))).

186. 36 C.F.R. § 219.4(a) (2014).

187. *Id.* at (a)(1)(iii).

188. *Id.* at (a)(1)(v).

189. *Id.* at (a)(1)(ii).

190. Public choice theory "treats legislative, regulatory, and electoral institutions as an economy in which the relevant actors . . . exchange regulatory 'goods,' which are 'demanded' and 'supplied' according to the same basic principles governing the demand and supply of ordinary economic goods." Steven P. Croley, *Theories of Regulation: Incorporating the Administrative Process*, 98 COLUM. L. REV. 1, 34 (1998). Consequently, in the case of independent agencies, "trades" in the form of regulations occur "because they further the (private) economic interests of those on the demand side and the (private) political interests of those on the supply side." *Id.* at 35. Thus, pure public opinion may not be represented and general interests are rarely advanced because many individuals do not have the resources to participate in the regulatory market. Instead, the only actors left in the market are the regulators and self-interested rent-seekers.

191. *Yellowstone: History & Culture*, NAT'L PARK SERV., http://www.nps.gov/yell/learn/historyculture/index.htm (last visited Nov. 11, 2015).

192. Laitos & Carr, *supra* note 148, at 150.

193. DOUGLAS W. SCOTT, CAMPAIGN FOR AMERICA'S WILDERNESS, A WILDERNESS-FOREVER FUTURE: A SHORT HISTORY OF THE NATIONAL PRESERVATION SYSTEM 1 (2001).

the existence of ecological wholeness to human well-being and to American culture."[194] This blend of ideals contributed to how the government has managed public lands. Furthermore, although the statutes that established early national parks and forest reserves dictated the management mandates, underlying the entire framework was the doctrine calling for governments to manage land as a commons in trust for the public.[195]

The public trust doctrine imposes three restrictions on the government's ability to manage land as a traditional fee owner would. To begin,

> the property subject to the trust must not only be used for a public purpose, but it must be held available for use by the general public; second, the property may not be sold, even for a fair cash equivalent; and third, the property must be maintained for particular types of uses.[196]

Sax's definition draws heavily on the Roman idea of a commons described earlier in this Note.[197] Where Sax differs in his interpretation is that he "unhooked [the doctrine] from its traditional moorings on or around water bodies and applied it to dry land as well."[198] Some scholars have even taken Sax's public trust doctrine and interpreted it as a cognizable, defendable interest and form of property.[199] Nevertheless, no matter the legal interest

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194. *Id.* at 2.

195. The Doctrine was first expressed in American federal common law in 1892. Ill. Cent. R.R. v. Illinois, 146 U.S. 387 (1892). In *Illinois Central*, the Court invalidated a conveyance of land by the Illinois legislature to Illinois Central Railroad. The State had planned to deed nearly the entire waterfront of Chicago to the Railroad. The Court, however, held in favor of the city. In doing so, the Court proclaimed that "[t]he ownership of the navigable waters of the harbor and of the lands under them is a subject of public concern to the whole people of the State." *Id.* at 455. The trust that the Court spoke of "is governmental and cannot be alienated, except in those instances mentioned of parcels used in the improvement of the interest thus held . . . ." *Id.* Importantly, the interest held by Illinois "is a title held in trust for the people of the State that they may enjoy the navigation of the waters, carry on commerce over them, and have liberty of fishing therein freed from the obstruction or interference of private parties." *Id.* at 452.

196. Joseph L. Sax, *The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention*, 68 MICH. L. REV. 471, 477 (1970). *See also* Hayes v. Bowman, 91 So. 2d 795, 799 (Fla. 1957) (noting that State title to lands under tidal navigable waters are "held in trust for the people for the purposes of navigation, fishing, bathing and similar uses. Such title is not held primarily for purposes of sale or conversion into money. Basically it is trust property and should be devoted to the fulfillment of the purposes of the trust, towit: the service of the people").

197. *See supra* text accompanying notes 94–106.

198. Carol M. Rose, *Joseph Sax and the Idea of the Public Trust*, 25 ECOLOGY L.Q. 351, 352 (1998).

199. When faced with such standing dilemmas, courts have allowed claims to proceed, particularly in cases of conservation easements that are found to imbue a public benefit. *See* Jessica E. Jay, *Third-Party Enforcement of Conservation Easements*, 29 VT. L. REV. 757, 779 (2005) ("[T]he public

expressed by the public trust, the doctrine is useful. Here it reiterates the idea that when certain forms of property are necessary for broad, society-based benefits, the government has a responsibility to prevent privatization and manage the parcel for the public good.[200]

The foundation of multiple tenets of American natural resource management that still exist today arose from the need for responsible natural resource management, coupled with our historical relationship with the continuous settlement of new lands. That tenet is expert-driven, multiple-use management that not only strives to efficiently oversee this nation's natural resources, but also reflects the public's desires and confirms the government's role as the trustee of public land. As mentioned in Part II of this Note, however, prior to allowing the management of natural resources, it is equally important for the United States or the United Nations to first assert sovereignty over an area. The same should be true for outer space in order to remove legally questionable use of natural resources. Furthermore, an expert agency will necessarily need to manage the natural resources that exist in this new territory. They should follow a management structure similar to that of an agency such as the Forest Service, where resources are managed for multiple uses—not simply for natural resource entrepreneurs, but scientists, recreationists, and other countries. Lastly, there should be some mechanism, similar to the public comment forum present in the APA, which allows for the public's input when putting forth management plans or standards.

Thus, while the Asteroids Act may be exciting in that it expresses the United States' desire to commercialize the resources in outer space, it is not the first time this country has considered such a feat. The Forest Service, the Bureau of Ocean and Energy Management, and the Bureau of Land Management, among others, have all faced similar management responsibilities—albeit on a much smaller scale. Regardless of Congress' views on the commercial potential of outer space, there are myriad tenets of natural resource management that the United States has operated under for over one hundred years, and they should be considered in the next stage of expansion.

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trust doctrine potentially provides standing for attorneys general, citizens, the general public, or any beneficiaries of the 'public trust' to enforce conservation easements, provided that the conservation easement at issue covers property defined by the doctrine as 'public trust' property.").

200. Carol Rose, *Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U. CHI. L. REV. 711, 711–14 (1986).

IV. THE NEED FOR THE COMMON HERITAGE DOCTRINE

The Asteroids Act is an exciting development in the realm of outer space law. Unfortunately, the strong overtones of privatization and commercialization of outer space are unsettling in light of international law's focus on the Common Heritage doctrine. While some commentators argue that this doctrine hinders cosmic development, this Note argues that the Common Heritage doctrine and successful exploitation of outer space natural resources are not necessarily mutually exclusive. There are multiple reasons to encourage natural resource development while simultaneously promoting the needs of humanity.

A. Policy Arguments for the Common Heritage Doctrine

The first reason concerns legislative intent. Since the inception of outer space law, and continuing through the most recent reiteration of outer space law principles in 2013, the United Nations has never wavered in its support of the Common Heritage doctrine. Moreover, the United Nations has included identical provisions in other areas of the law with success. In the context of deep-sea mining, the majority of the world has operated under the doctrine since 1982. As mentioned above, under the United Nations Convention on the Law of the Sea, profit-sharing provisions mandate that developed countries to share revenues from deep seabed mining with less developed nations.[201] Even in the private sector, outside of the watch of international regulation, there is precedent for equitable sharing of revenues when multinational corporations engage in the exploration and extraction of natural resources belonging to developing countries.[202] Unlike the United States or the United Kingdom, where drilling practices are often regulated by "an almost mind-numbing set of detailed, command-and-control statutes,"[203] developing countries often lack these social, human rights, and environmental protections.[204] Historically, companies took advantage of this lax regulatory regime and they "have left a painful legacy of pollution and poverty . . . especially for the local communities living near the operation

201. Secretary-General of the International Seabed Authority, *supra* note 134.

202. JACQUELINE L. WEAVER, ROCKY MOUNTAIN MINERAL LAW FOUNDATION, INTERNATIONAL PETROLEUM TRANSACTIONS 798–812 (3d ed. 2010).

203. *Id.* at 799.

204. *Id.* at 800 ("A survey of petroleum agreements in more than 100 developing countries done in the early 1990s revealed a contractual pattern of referencing a broad principle of environmental protection, but with no substantive or systematic requirements imposed.").

sites."[205] Today, however, practices have evolved and many companies adopt a "'triple bottom line' approach to development which meshes their business strategy with the three legs of the sustainable development tripod: economic progress, environmental progress, and social progress."[206] Accordingly, companies such as ExxonMobil, in cooperation with the World Bank and NGOs, have negotiated plans with governments in Africa to share the benefits derived from the company's activities.[207] Shell engaged in similar practices in Peru.[208] Thus, if we can accept that developing nations have an equal interest in outer space as compared to developed nations, it is not so farfetched that natural resource extraction companies would share benefits with those who do not have the ability to obtain these resources.

The second reason supporting the Common Heritage doctrine focuses on funding. Over the past decade, the American space industry has become largely privatized.[209] Yet the capital funding these private companies does not come solely from typical venture capitalists and savvy investors. It comes from taxpayers. In an effort to create "a competitive market, NASA [the National Aeronautics and Space Administration] has pumped an additional $7 billion into contracts with two companies—SpaceX and Boeing—to build spaceships to take American astronauts to the International Space Station by 2017."[210] Yet it is many of these same companies that seek to capitalize on what they deem to be natural resources subject to privatization. For space exploration companies to overlook the public's investment in the private sector's recent developments is akin to denying the public any benefits in the future.

The third reason concerns the benefit a boon of natural resources would provide to many developing countries throughout the world. Often times, countries that have the ability to exploit natural resources lack the resource itself within their sovereign boundaries and thus go elsewhere to satisfy their needs. While on their quest for natural resources, developed countries can

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205. *Id.* at 713.

206. *Id.*

207. The Revenue Management Plan between ExxonMobil and Chad's President Derby stipulated that "10% of all oil revenues would be held in trust for future generations, 80% would be earmarked for health, education and rural development, and 5% would go to communities around the oil fields . . . ." *Id.* at 811.

208. The Land Use Transfer Agreement between Shell and the Camisea community in Peru created a payment plan consisting of "physical goods . . . to be used as infrastructure for health, education, communication, water supply and the social well-being of the community . . . ." *Id.* at 808.

209. Kristyn Martin, *The Business of Space: Exploring the New Commercial Space Economy*, AL JAZEERA (Dec. 2, 2014, 6:00 PM), http://america.aljazeera.com/watch/shows/real-money-with-alivelshi/articles/2014/12/2/the-business-of-spaceexploringthenewcommercialspaceeconomy.html.

210. *Id.*

take advantage of lax health, safety, and environmental regulations in host countries, which are often classified as "developing." This can result in human rights violations, unsafe working conditions, and environmental degradation. Conversely, through natural resource exploitation in space, developed nations have the ability to end the conflicts that tend to surround global demand for resources. Through the process of

> exploring other worlds we safeguard this one. By itself, this fact more than justifies the money our species has spent in sending ships to other worlds. It is our fate to live during one of the most perilous and one of the most hopeful chapters in human history.[211]

Compliance with the Common Heritage doctrine could eventually eliminate the abuses that occur around many of our current natural resource extraction industries.

Fourth, when considering other forms of the global commons, the Common Heritage doctrine is not a high standard to begin with. We should learn from the failures of our current approach to global commons natural resource management. Unfortunately, "[e]ven when the global commons do remain outside the territorial governance of states and individuals, international law has not succeeded in protecting them from devastating exploitation."[212] The United States should learn from these mistakes to create an equitable legal regime for outer space natural resources. At the very least, if the United States defies international law and refuses to acknowledge the Common Heritage doctrine, the American public should have input into how activities are conducted in space and some of the benefits derived from the natural resources garnered from outer space. Like many natural resource extraction industries, exploiting outer space resources has many impacts—both terrestrial and extraterrestrial.[213] The impacts that occur on Earth could arguably implicate the public participation process in NEPA.[214] Consequently, individuals could have a say in how these industries act.

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211. Carl Sagan *in Cosmos: Who Speaks for Earth?* (PBS television broadcast Dec. 21, 1980).

212. MILUN, *supra* note 140, at 5.

213. *See generally* 3 LOTTA VIIKARI, *The Environmental Element in Space Law: Assessing the Present and Chartering the Future*, *in* STUDIES IN SPACE LAW 29–52 (Frans G. von der Dunk ed., 2008) (highlighting the various environmental impacts of outer space activities such as health problems associated with individuals living around launch sites, space debris, and nuclear contamination).

214. Under NEPA, all "major Federal actions significantly affecting the quality of the human environment," require the preparation of an environmental impact statement that reflects input from the public. 42 U.S.C. § 4332 (2012); 40 C.F.R. § 1503.1(a)(4) (2014). "Federal actions" constitute not only projects in which the government is the actor, but also projects where the federal government exercises some level of control. United States v. S. Fla. Water Mgmt. Dist., 28 F.3d 1563, 1572 (11th Cir. 1994)

B. A New Era of Property

The final reason to utilize the Common Heritage doctrine involves the practical difficulty in assigning rights or claims of sovereignty to different areas of space. This is the crux of this Note. Multiple scholars have remarked that the legal analogs of Antarctica and the Law of Sea are quite dissimilar. To begin, "'the concept of contiguous space based on the analogy of territorial waters' . . . 'is incorrect, unnecessary and not susceptible to implementation.'"[215] It is worth noting at length that

> [t]hose who qualify the space as a *res nullius* and those who qualify it as a *res communis* . . . render an arbitrary qualification because they proceed from the principle that space is a "res" and then attempt to qualify this "res" according to the effects due to this qualification . . . . [T]here is perhaps an ego-centric (or rather terra-centric) conception which makes our planet the center of the universe. The Earth, however, should be considered from a more

("The touchstone of major federal activity constitutes a federal agency's authority to influence nonfederal activity."). Assuming for a moment that either NASA or the FAA take some part in the regulation of outer space activities, the only remaining legal element to satisfy is whether the environmental impacts are *significant*. Given the severity of some of the impacts discussed by Viikari, this will unlikely be a difficult burden to meet. For example, "the levels of endocrine disease and blood disorders in children [living below flight paths of rockets] are reported to be over twice the regional average. This is due to highly toxic propellants . . . which are dumped onto the land located along flight trajectories . . . ." VIIKARI, *supra* note 213, at 29. The fact that activities are conducted, initiated, or have an impact outside of the geographic boundaries of the United States does not bar NEPA jurisdiction. Courts interpreting NEPA have consistently found the need to consider environmental impacts despite geographic boundaries. Wilderness Soc'y v. Morton, 463 F.2d 1261, 1261 (D.C. Cir. 1972) (allowing intervention "of a nonresident Canadian citizen and a Canadian environmental organization . . . in litigation aimed at testing whether the Secretary of the Interior has complied with the procedures of the National Environmental Policy Act prior to deciding whether to issue a permit for the trans-Alaska pipeline."); Nat. Res. Def. Council v. Hodel, 865 F.2d 288, 297 (D.C. Cir. 1988) (invalidating an FEIS that "did *not* consider the effect of simultaneous *inter*-regional development on migratory species") (emphasis added); Swinomish Tribal Cmty. v. Fed. Energy Regulatory Comm'n, 627 F.2d 499, 503–04, 510, 512 (D.C. Cir. 1980) (holding that FERC's FEIS was adequate, but assuming that impacts to a reservoir entering into Canada must be analyzed, and allowing Canadian intervenors to defend such interests). Moreover, courts have "also assumed that NEPA requires analysis of major federal actions that take place entirely outside of the United States but could have environmental effects within the United States." Memorandum from Kathy A. McGinty, Chair, Council on Envtl. Quality, to Heads of Agencies (July 1, 1997) (on file with the Council on Environmental Quality). As a result, the public would have a chance to comment on the responsible agency's actions and how they pertain to environmental impacts.

215. MILUN, *supra* note 140, at 130 (quoting Stephen Gorove, *On the Threshold of Space: Toward a Cosmic Law*, 4 N.Y.L.F. 305, 321–22 (1958)).

> objective point of view, [i.e.], that the Earth is not the center of the universe but an insignificant part of it.[216]

There is also far more to consider than simple legal qualifications. "The parceling of land into real estate," or in this case the parceling of outer space, "is not, as we might be tempted to suppose, a simple geometrical affair. Real estate is a complex historical product of interaction between human beings, political, legal and economic and sometimes religious institutions, and the physical environment."[217] Property frameworks subsequently hold "a central place in arrangements surrounding social life, a place so central that some writers have claimed that it is impossible to imagine anything [that] could be called a society without some property institution."[218] The current systems of property developed by individual countries are unique because of the varying factors that exist within their political boundaries. We do not have the same political barriers in outer space; thus, the legal regime must be a reflection of the commonalties the globe shares in relation to the cosmos.[219] Accordingly, it becomes clear that Congress and legal scholars will need to analyze outer space sovereignty outside of the traditional forms of property—and traditional notions of culture—that have typically been applied to other forms of natural resources.

The primary needs are for definition and flexibility. The Outer Space Treaty and similar international laws and principles distinguish between outer space and the celestial bodies that exist throughout.[220] Yet this body of law does not provide a definition of *celestial body*. As a whole, outer space "hosts innumerable variations of matter in widely varying physical configurations, ranging from infinitesimal particles of dust and gaseous substances to vast land masses with solid surfaces that make up the stars and

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216. Modesto Seara-Vázquez, *The Functional Regulation of the Extra-Atmospheric Space*, *in* SECOND COLLOQUIUM ON THE LAW OF OUTER SPACE 139, 140 (1959) (emphasis added).

217. Barry Smith & Leo Zaibert, *The Metaphysics of Real Estate,* 20 TOPOI 161, 166 (2001).

218. Andrew Reeve, *Property*, *in* 2 A COMPANION TO CONTEMPORARY POLITICAL PHILOSOPHY 719, 719 (Robert E. Goodin et al. eds., 2007).

219. Some actors have referred to the need for the "democratization of space." Dave Baiocchi & William Welser IV, *The Democratization of Space: New Actors Need New Rules*, 94 FOREIGN AFFAIRS 98, 98 (May/June 2015). Outer space exploration is a crowded field with rapid changes in technology allowing for even more countries and private actors to readily participate. At this point, "12 countries host a total of 26 public and private launch facilities," and "53 countries are responsible for over 1,300 active satellites; even Ghana has a space agency." *Id.* at 101, 103.

220. *See, e.g.*, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, *supra* note 60, art. 4 (differentiating between installing nuclear weapons on celestial bodies and stationing them in outer space); *see* Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, *supra* note 66, art. 5 (distinguishing between activities carried out on celestial bodies and in outer space in general).

planets."[221] One could argue that an asteroid is not a celestial body simply because it is immensely dissimilar to the Moon, or to Mars, or to a gaseous corona.[222] Yet to subvert the prohibition on appropriation by limiting the definition of celestial body would be to defeat the purpose of the body of United Nations space law and the overarching Common Heritage doctrine. On the other hand, to lump all objects in outer space under the same title of celestial body does not provide the flexibility to efficiently manage natural resources, nor does it provide the incentive and framework for investment.

The International Institute of Space Law has continuously wavered in their definition of celestial body and "concluded that there is no absolute answer to that question."[223] Without a concrete definition of celestial body, it is difficult to create a starting point with which to create a property regime. Thus, the rest of this Note will attempt to create a definition of celestial body and construct a property framework around it.

1. Defining a Celestial Body

The first step in creating a property-centric definition for something one can own "is to appeal to the age-old distinction between movable and immovable things."[224] Immoveable, or real, property has two "special characteristics which distinguish it from all other commodities known to commerce."[225] First, the law does not recognize the ability to physically transfer land from one owner to another.[226] Second, it is perpetual; the property owner cannot destroy the legal rights to the property.[227] Their "power is limited to the enjoyment or disposition of rights in or over it."[228] Applied to the situation at hand, "asteroids and comets . . . do not have these characteristics; with the appropriate technology, they could be moved; and

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221. Philip De Man, *The Exploitation of Outer Space and Celestial Bodies – A Functional Solution to the Natural Resource Challenge* 5 (Leuven Ctr. for Glob. Governance Studies, Working Paper No. 54, 2010).

222. Virgiliu Pop, *A Celestial Body Is a Celestial Body Is a Celestial Body . . .* (2001), http://www.spacefuture.com/archive/a_celestial_body_is_a_celestial_body_is_a_celestial_body.shtml.

223. *The 44th International Colloquium on the Law of Outer Space*, INT'L INST. SPACE L., http://www.iislweb.org/docs/2001%20IISL%20REPORT%20TOULOUSE.pdf (last visited Nov. 14, 2015).

224. Smith & Zaibert, *supra* note 217, at 164. In the common law system, this distinction is between real and personal property. For the purposes of this note, however, it is easier to visualize and discuss outer space resource in terms of movable and immovable.

225. Pop, *supra* note 222 (quoting S. R. SIMPSON, LAND LAW AND REGISTRATION 5 (1976)).

226. *Id.*

227. *Id.*

228. *Id.* (quoting S. R. SIMPSON, LAND LAW AND REGISTRATION 6 (1976)).

they can be destroyed, i.e. consumed in their totality. Thus, they may qualify as movables."[229] Alternatively, larger objects such as the Moon or other planets fall squarely into the immoveable category, thus leaving us in the untenable position of defining things differently but wanting to use them similarly. But because this distinction is largely a legal fiction,[230] we can strive for a more refined definition to support the exploration and use of outer space natural resources and avoid conflicts in the future.

There are "two main schools of thought [that] have formed, namely the spatialist and the functionalist one."[231] To begin, the spatialist approach seeks to define a celestial body based on size alone. We would define objects in outer space over a specified size as celestial bodies, while objects smaller than this specified size would fail to qualify as a celestial body. Consequently, "[t]he practical problem is to quantify that size, and to reach a consensus over that. . . . Difficult as it is, lawyers have the ability to find the mythical 'straw that broke the camel's back.'"[232] Unfortunately, whatever dividing line is drawn, it will ultimately do little to clarify the ambiguity that currently exists. To further this point, there have been attempts to define where the dividing line between air space and outer space lies under the spatialist approach. There were 49 proposals, "ranging from 12 km to 38,400 km and *ad infinitum*."[233] The same difficulties exist when defining objects in outer space. Arguably, particles of dust are excluded from the celestial body definition, while the Moon and Jupiter are clearly included. But the problem of creating a dividing line for everything that falls in between still remains.

The second approach for a definition is functionalist. The functional approach is quite simple. It defines objects in outer space based on what the actual use of the object is, such as the extraction of natural resources or the construction of an extraterrestrial colony.[234] Thus, it would follow that any "objects that are sufficiently large to allow for manned [or] unmanned landing and which cannot be deviated from their orbit" could qualify as celestial bodies.[235] This definition is attractive because it is flexible. Unlike the spatialist definition, it does not set some arbitrary dividing line based on

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229. *Id.*

230. "Immovability" is largely a positive legal concept. Indeed, "the law does not envisage the possibility of movement with the same rigor as mechanics." It follows then, that "the elements which compose the soil, rocks, sand, minerals, may be displaced." Yet the law does not define them as such. Smith & Zaibert, *supra* note 217, at 165 (quoting MARCEL PLANIOL, TREATISE ON THE CIVIL LAW 301 n.5 (Louisiana State Law Institute, trans.) (1939)).

231. Pop, *supra* note 222.

232. *Id.*

233. *Id.*

234. *Id.*

235. De Man, *supra* note 221, at 8.

size, and it can acclimatize to the ever-innovating technological capabilities of spacecraft. Moreover, this definition can easily comply with the letter and the spirit of the Outer Space Treaty and the Common Heritage doctrine. It would deny the subversion of the Treaty and the Doctrine for purposes of appropriation and exploitation, but it could still allow the United Nations—or any other international body—to regulate *functional* celestial bodies for the purpose of garnering research and natural resources. It would also create a compromise: outer space objects that are not large enough for a manned or unmanned landing could still be exploited if companies had the ability to bring such objects out of orbit and into use without landing on them. The functionalist definition of celestial body is used for the rest of this Part.

2. Managing Outer Space Resources

Now that we have established a definition, we must envision a potential management and regulatory framework. The majority of the space our solar system occupies is filled with energy and not planets or asteroids.[236] The natural resources that we are interested in exploiting exist on objects that are in continuous orbit through this emptiness. Therefore, it would be difficult to assign rights over regions of outer space that allow for practical resource extraction. Celestial objects, such as asteroids or the Moon, are continuously moving and will only pass through a region periodically while in orbit. This practical difficulty leads us to the possibility of assigning orbital rights. To some extent, this has already occurred. A

> [g]eostationary orbit is a band 36,000 kilometers above Earth's equator where a satellite orbits the Earth at the same speed the Earth rotates. Therefore, a satellite in GEO stays over a fix [sic] point on the Earth's surface. Satellites in GEO are why you have satellite TV and some of the large scale weather pictures . . . . Because there are only 360 degrees of orbit can be used [sic], and satellites must be several degrees apart to avoid interference, satellite positions—called "orbital slots"—in GEO are limited.[237]

236. Bob Berman, *The Nature of Empty Space: Let's Talk About Nothing*, ASTRONOMY, June 2015, at 30, 33 ("It's as if the entire cosmos, despite the appearance of emptiness, seethes with so much energy that it can barely contain itself.").

237. Dan St. John, *The Bogotá Declaration and the Curious Case of Geostationary Orbit*, DENV. J. INT'L L. & POL'Y (Jan. 31, 2013), http://djilp.org/3494/the-bogota-declaration-and-the-curious-case-of-geostationary-orbit.

This limited space has led to countries leasing and auctioning their "orbital slots."[238] This practice has "essentially amount[ed] to the temporary use of a non-depletable spatial resource that does not significantly deteriorate after intensive use."[239] While it is a practical market-based solution, it is dissonant with the Common Heritage doctrine due to the cost barriers imposed on developing counties. Under international law, countries are granted equal footing in the benefits they share. This concept exists only in the orbital slot above a country's boundaries. A more extensive system based on orbital rights would not be hinged to the geographic area of a particular state. Imagine a track around a football field with the Earth lying at the center of the track. Orbital rights could allow nations to own one "lane" of the track and be able to exploit every object that travels within that lane. Unfortunately, this may be impractical due to the inevitable overlapping of these lanes. A viable, resource-rich asteroid may not follow a perfect circular orbit, and thus may risk crossing through multiple other orbital paths.

This Note proposes a more viable regulatory model, which combines what Pop refers to as the *space object*[240] approach and what this author calls the *value-based* approach. This object/value framework would approach all objects in outer space, whether or not they are celestial bodies, as "space objects."[241] These space objects would subsequently be studied, assigned a quantifiable value according to the natural resources that they contain and any research or recreation value they possess, and catalogued in a database. Private companies or state-run space programs could then apply for a license to obtain an interest in a particular space object. The acquirable interests would vary based on whether the space object was defined as a celestial body. If it was a celestial body, it would be subject to the Outer Space Treaty and the interests would only extend as far as the rights to use the space object for mining or other similar activities. If the object was not a celestial body and not subject to the Treaty, however, the interested party could apply for appropriation or ownership rights.

An institution analogous to the International Seabed Authority or the Organization of the Petroleum Exporting Countries (OPEC) would manage

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238. De Man, *supra* note 221, at 16–17.

239. *Id.*

240. Pop, *supra* note 222 (envisioning *space objects* as products of human intervention and potentially "used as a shell for a space station, losing its natural appearance, together with its legal status of 'celestial body' by becoming a manmade structure."). This section takes on a broader definition of "space object" to include any object in space that we may derive some economic use from. Remember, however, that a "space object" only qualifies as a *celestial body* when it is large enough to land a manned or unmanned spacecraft.

241. *Id.*

this proposed catalogue.[242] The management institution would ensure compliance with the Common Heritage doctrine by equitably limiting the aggregate value each Treaty party could acquire. If a state wanted to acquire a value that exceeded its initial investment, it would be subject to a profit-sharing mechanism similar to that imposed by the International Seabed Authority. The profits could then be used to fund both the resource management institution and specified purposes within developing countries. These limitations would allow countries such as India, which has long been an interstellar minnow, to advance their technology to the point where they could compete with other developed nations in the resource extraction industry.

The object/value approach complies with many of the difficulties of outer space law expressed throughout this Note. First, the functionalist definition eliminates much of the ambiguity surrounding the current definition of celestial body. Second, the definition and the framework comply with the nonappropriation principle and the Common Heritage doctrine, both present in the Outer Space Treaty. Third, it creates a management institution that can proactively manage outer space resources; it should not be forced to react to past resource abuses of the commons, similar to what happened in early American history. The object/value framework is practical, equitable, efficient, and, best of all, legal.

CONCLUSION

This Note has established that outer space is an area abundant in natural resources that have only recently become attainable. Due to advances in technology and pressures resulting from global resource scarcity, the United States and other developed nations are poised to take advantage of what the cosmos has to offer. Its geographic orientation and its lack of sovereignty qualify outer space as a commons accessible to many around the world. Our current commons management regime, however, results in unsustainable

242. While OPEC is a "closed agreement, meaning membership is limited," it is a successful example of a "state-centered model for collective resource management." Benjamin D. Hatch, *Dividing the Pie in the Sky: The Need for a Lunar Resources Regime*, 24 EMORY INT'L L. REV. 229, 282 (2010). A space resource manager could act in a similar manner by unifying markets through the creation of a quota system and limiting how many resources may enter the market. *Id.* at 284. Similarly, "[b]y regulating how much energy enters the international petroleum market, OPEC is able to adjust oil prices against the natural trends of the market." *Id.* at 283. This power, with all of its potential for abuse, can still be effective "insofar as it [can allow] members to utilize their natural resources to become enriched in ways that would otherwise not be possible . . . ." *Id.* Accordingly, if a model like OPEC were utilized for space-based natural resources, it could equitably allocate revenues and ensure the enrichment of the less developed member states. *Id.* at 284.

natural resource use. Thus, we must strive to define a new form of property that natural resource management experts should manage. Such experts could include NASA, whose decisions evoke efficiency and the public's desires, similar to American natural resource law.

Our relationship with space is one of awe and wonder. There is also a "strange agential character which allows [outer space] to 'possess us,'" unlike our relationship with the sea, where the ocean "become[s] an object possessed by us."[243] No matter what race, class, age, religion, or sexual orientation, we all look up to the sky at night and share a similar sense of curiosity. When Neil Armstrong stepped off the ladder of the *Eagle* and acknowledged that America's space-faring actions were "one giant leap for mankind,"[244] he was not simply referring to the citizens of the United States.[245]

The relationship humanity has with space should not be commandeered simply because a few wealthy men now have the ability to pilfer $20 trillion asteroids like the lords of yesteryear did to early American grasslands and forests. Not only do we owe it to humanity to develop an equitable and comprehensive legal regime, but we also owe this to the companies who will lead the world into a new era of natural resource exploitation. It is improbable that an outer space resource company will "spend the millions, perhaps billions, of dollars it would take to travel to the ends of the solar system and develop a mine, a factory, and a colony, if the governing law is unclear . . . ."[246]

Moreover, we should not be hindered by old notions of property when considering a vastly new-age resource. The Asteroids Act is simply a reflection of a puerile and xenophobic notion of "finders keepers." Even outer space firms have acknowledged the current "wild west . . . mentality and approach . . . ."[247] Regardless of these companies' views on international outer space law, they still must be cognizant of United States outer space policy principles that "enable others to share in the benefits provided by the use of space," and recognize uses of outer space "for the benefit of all

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243. MILUN, *supra* note 140, at 131.

244. Transcript of *The Eagle Has Landed – 1969*, NAT'L ARCHIVES AND RED. ADMIN, http://www.archives.gov/social-media/transcripts/transcript-eagle-has-landed-1969-45017.pdf (last visited Nov. 14, 2015).

245. Indeed, NASA's involvement in a proposal for an international flag of Earth is an implicit agreement with this notion. Brian Wu, *The Earth Now Has a Flag to Plant on Mars*, SCIENCE TIMES (May 20, 2015), http://www.sciencetimes.com/articles/6503/20150520/earth-now-flag-mars.htm.

246. Ezra J. Reinstein, *Owning Outer Space*, 20 NW. J. INT'L L. & BUS. 59, 71 (1999).

247. Klotz, *supra* note 5.

humanity . . . ."[248] We have the ability to conceptualize a new form of commons management and discover a way for it to benefit everyone: the scientists, the developing nations, the entrepreneurs, the United Nations, the United States, and other space-faring nations. It's time for a higher order of legal thinking.

—Ian Hedges[*]

248. EXEC. OFFICE OF THE PRESIDENT OF THE U.S., NATIONAL SPACE POLICY OF THE UNITED STATES OF AMERICA 3 (2010).

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