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To Infinity and Beyond: Shifting the Space Regulatory Framework to Create Conservation-Minded Expansion

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ABSTRACT

The early days of American expansion were categorized by policies that emphasized resource extraction and utilization. In turn, these policies created major conflicts with overuse, ownership, and rehabilitation−many of which continue to this day. Now, the United States has begun to shift its focus to the next untapped frontier: outer space. As resource extraction in space grows more feasible, the United States has begun to shape a regulatory framework. In doing so, the United States is copying early American resource policy, leaving open the same gaps for conflicts arising from overuse, ownership disputes, and restoration. This paper analyzes historical American resource policies, the issues created therein, and how the United States is currently poised to make the same mistakes on a much larger scale. Lastly, this paper identifies several current international models that could be used to mitigate conflicts before they happen.

INTRODUCTION

Konstantin Tsiolkovsky, a Russian rocket scientist and one of the founding fathers of cosmonautics, once said, "Earth is the cradle of humanity, but one cannot remain in the cradle forever."[1] Carl Sagan, the American astrophysicist, took a blunt approach when he expressed his view that "all civilizations either become spacefaring or extinct."[2] Regardless of the poetic differences, both men agree on the same basic idea: humankind's future is in space. In the 64 years since the launch of Sputnik, humans have continuously improved space exploration technology and set

1. *Konstantin E. Tsiolkovsky*, NASA, https://www.nasa.gov/audience/foreducators/rocketry/home/konstantin-tsiolkovsky.html (last visited Mar. 16, 2022).

2. CARL SAGAN, PALE BLUE DOT: A VISION OF THE HUMAN FUTURE IN SPACE (1994) ("Since, in the long run, every planetary civilization will be endangered by impacts from space, every surviving civilization is obliged to become spacefaring–not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive . . . If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds.").

the stage for outward growth.[3] The United States has a wide range of motivations for space expansion, but one rising to the forefront is the massive wealth of natural resources space has to offer. Hydrocarbons, natural gases, and even water are now viewed as key energy components for future exploration.[4] As a result, current American space policies have focused on encouraging the development and use of resources.

Replicating the only mindset it has ever known, the United States is creating a regulatory framework for space resource extraction that mirrors early American expansionist sentiment. In doing so, it views space as the latest untapped wilderness. Unfortunately, early American emphasis on resource extraction created conflicts with overuse, ownership, and restoration that are still being dealt with today. To avoid making the same mistakes twice, the United States must reconstruct its policies for space resource extraction with an emphasis on conservation and international cooperation.

Although space remains the final frontier for human expansion, many scholars have already explored its projected legal and resource conflicts. Some scholars have identified the problems arising from a weak international regulatory framework,[5] some have focused on lessons learned from international maritime laws and their potential application in space,[6] and others have analyzed the need for conservation in space.[7] Each piece of literature probes at the central theme of regulation in space, agreeing that space resource extraction needs immediate attention. However, these explorations are broad, looking more at international conflicts and global use of resources than a single framework. This paper focuses the analysis on the United States' existing policies and the problems arising therein.

Part I of this paper provides data and background for the various energy resources that can be found on other planets and moons. Part II analyzes the problems created by early American resource extraction and how the current space extraction regulatory framework is poised to create the same issues. Part III looks at several potential frameworks that could encourage expansion while preemptively negating future conflicts. American resource policies have historically favored resource development, a trend that policymakers are set to continue in outer space despite the recurring problems with overuse, ownership, and restoration. By addressing the regulatory shortcomings now, the United States can transform policies and avoid making the same errors on a much bigger scale.

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3. *Space Exploration-Timeline*, NAT'L ARCHIVES, https://www.archives.gov/research/alic/reference/space-timeline.html#time (last visited Mar. 31, 2022).

4. NASA, *We Are Going*, YOUTUBE (May 14, 2019), https://www.youtube.com/watch?v=vl6jn-DdafM&list=LL&index=1&t=2s&ab_channel=NASA.

5. *See* Senjuti Mallick & Rajeswari Pillai Rajagopalan, *If Space is 'the Province of Mankind', Who Owns its Resources*, OBSERVER RSCH. FOUND. OCCASIONAL PAPER No. 182 (2019).

6. *See* Jonathan Koch, *Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining*, 16 ASTROPOLITICS THE INT'L J. OF SPACE POL. AND POL'Y 1 (2018).

7. *See* Martin Elvis & Tony Mulligan, *How much of the Solar System should we leave as Wilderness?*, 162 ACTA ASTRONAUTICA 574 (2018).

PART I: PRIMER ON RESOURCES IN SPACE

There is no known limit to outer space or the resources it contains. Humans have discovered galaxies 13.7 billion light years away and find more every year.[8] While these far reaches may be explored and used one day, expansion is limited by today's technology for the foreseeable future. Any consideration of resource extraction in space must be constrained to our minuscule solar system and its various celestial bodies.[9] Even still, some may believe that resource extraction in space is a distant future that belongs in science fiction—not science articles.

In reality, space resource extraction is a timely topic. Countries, companies, and scientists have already identified the major energy sources that will power future expansion, despite present limitations on technology needed to bring such resources back to Earth.[10] This section will explore the importance and location of the three most likely energy resources to be used in future solar system expansion.

A. Helium-3

Helium-3 is a natural gas that many researchers and scientists believe is the future of nuclear fusion energy production.[11] Unlike nuclear fission reactors that split nuclei apart, nuclear fusion reactors create energy by fusing nuclei.[12] Nuclear fusion reactors typically use tritium and deuterium and do not produce long-lived radioactive nuclear waste like their counterparts.[13] When Helium-3 is substituted for tritium, nuclear fusion reactors become much more efficient, and the by-products are normal helium and a proton.[14] Helium-3 could provide a clean nuclear energy source, but it is exceedingly rare on Earth.[15]

Solar winds carry Helium-3 outward through space and are the primary source for the gas. While the atmosphere shields Earth from most solar winds, the Moon does not have the same protection.[16] As a result, the Moon has an abundance

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8. *The Farthest Visible Reaches of Space*, NASA: IMAGINE THE UNIVERSE!, https://imagine.gsfc.nasa.gov/features/cosmic/farthest_info.html (last visited Mar. 16, 2022).

9. Jerry Coffey, *Diameter of the Solar System*, Universe Today (July 16, 2008), https://www.universetoday.com/15585/diameter-of-the-solar-system/. Although some may consider the solar system immense, it is vital to note the different distance scales at play. The furthest observable object under the Sun's influence is Sedna, which is 84 billion miles away. However, objects inside the solar system are typically measured in AU's (astronomical units), where each AU is 93 million miles. Larger still is a light year at 5,878,600,000,000 miles. Thus Sedna, the furthest object in the solar system, is about 90 AU, or .0014 light years away.

10. Mallick & Rajagopalan, *supra* note 5, at 5.

11. Florian Vidal, *Helium-3 from the lunar surface for nuclear fusion?*, POLYTECHNIQUE INSIGHTS (Dec. 1, 2021), https://www.polytechnique-insights.com/en/columns/energy/helium-3-from-the-lunar-surface-for-nuclear-fusion/.

12. *Fusion – Frequently asked questions*, IAEA, https://www.iaea.org/topics/energy/fusion/faqs (last visited Mar. 16, 2022).

13. *Id*.

14. *Helium-3: Lunar Gold Fever*, OPENMIND BBVA (Mar. 14, 2019), https://www.bbvaopenmind.com/en/science/physics/helium-3-lunar-gold-fever/.

15. *Id*.

16. Thomas Simko & Matthew Gray, *Lunar Helium-3 Fuel for Nuclear Fusion: Technology, Economics, and Resources*, 6 WORLD FUTURE REV. 158, 160 (2014).

of Helium-3, currently estimated to be at least one million metric tons.[17] Researchers believe that 44 tons of the Moon's Helium-3 could meet the United States' energy demands for one year, making a single ton worth up to $3 billion.[18] Countries like India, China, and the United States have programs currently working towards mining Helium-3 from the Moon, each hoping to capitalize on the energy and economic benefits.[19]

B. Water

Water is another key resource for solar system expansion. First and foremost, water is vital for human survival. Second, water can be turned into hydrogen, a fuel source that already powers space-bound missions. With the highest efficiency in relation to the amount of propellant consumed, liquid hydrogen is the signature fuel for NASA and several other countries.[20] Using a process known as electrolysis, water can be effectively split into separate hydrogen and oxygen molecules.[21] The hydrogen is then liquefied and turned into rocket fuel.[22] Rocket propellant comprises most of a rocket's mass. Using a hydrogen/oxygen combination, a rocket's weight is 83% propellant.[23] If a hydrogen refueling station was built in orbit or off-Earth, rockets could use less propellant, thereby becoming cheaper and lighter.[24]

New discoveries of water in our solar system are regularly made. Launched in 2008, an Indian probe known as Chandrayaan-1 became the first probe to conclusively show the presence of water ice on the Moon.[25] NASA's Lunar Reconnaissance Orbiter (LRO) has since confirmed Chandrayaan-1's findings, estimating that the Moon has 660 million tons of water ice with potential for another 10-20% in permanently shadowed regions.[26] In 2020, NASA's Stratospheric

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17. *Id*. at 159.

18. *Id*. at 165.

19. Anurag Kotoky, *The Quest to Find a Trillion Dollar Nuclear Fuel on the Moon*, BLOOMBERG (June 28, 2018), https://www.bloombergquint.com/technology/the-quest-to-find-a-trillion-dollar-nuclear-fuel-on-the-moon.

20. *Liquid Hydrogen – the Fuel of Choice for Space Exploration*, NASA,https://www.nasa.gov/topics/technology/hydrogen/hydrogen_fuel_of_choice.html (last visited Mar. 13, 2022).

21. Jamie Carter, *Can We Really Use The Moon's Billion-Year Old Water To Make Rocket Fuel And Open Up The Cosmos*, FORBES (Nov. 1, 2019), https://www.forbes.com/sites/jamiecartereurope/2019/11/01/can-we-really-use-the-moons-billion-year-old-water-to-make-rocket-fuel-and-open-up-the-cosmos/?sh=452b04cd4658.

22. *Liquid Hydrogen – the Fuel of Choice for Space Exploration*, *supra* note at 20.

23. Don Pettit, *The Tyranny of the Rocket Equation,* NASA (May 1, 2012), https://www.nasa.gov/mission_pages/station/expeditions/expedition30/tryanny.html.

24. Neel Patel, *Mining the Moon for Fuel*, MIT TECHNOLOGY REVIEW (May 19, 2020), https://www.technologyreview.com/2020/05/19/1001857/how-moon-lunar-mining-water-ice-rocket-fuel/.

25. Elizabeth Howell, *Chandrayaan 1: India's First Mission to the* Moon, SPACE.COM (Mar. 28, 2018), https://www.space.com/40114-chandrayaan-1.html.

26. Jatan Mehta, *Your Guide to Water on the Moon*, THE PLANETARY SOC'Y (Nov. 23, 2020), https://www.planetary.org/articles/water-on-the-moon-guide.

Observatory for Infrared Astronomy (SOPHIA) confirmed water ice on the sunlit surface of the Moon for the first time.[27]

The Moon is not the only celestial body in our solar system with water. Mars has long been known to have frozen polar ice caps, with some ice sheets estimated to be the size of California and Texas combined.[28] The search for liquid water on Mars has taken longer. In 2015, NASA used a spectrometer from the Mars Reconnaissance Orbiter (MRO) to detect the ebb and flow of hydrated minerals on the surface of Mars, confirming surface water for the first time.[29] In 2018, researchers using data from the European Space Agency's (ESA) Mars-orbiting spacecraft discovered the presence of a large underground lake beneath the ice on Mars' south pole.[30] In 2020, data from the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) confirmed the ESA's finding and discovered three more underground lakes.[31]

The last notable source for water in our solar system has long been a focal point for science fiction authors and scientists alike: Europa.[32] One of Jupiter's 79 moons, researchers have theorized that Europa has an ice shell anywhere from 10 to 15 miles thick, resting on an ocean 40 to 100 miles deep.[33] In 1979, the two Voyager spacecraft became the first to provide evidence of the liquid ocean beneath the surface.[34] Then, in 2019, a NASA-led research team announced that water plumes had been detected above the surface of Europa for the first time.[35] Between the massive amounts of water ice and mounting evidence that Europa has liquid water, Europa will prove to be a key energy source.[36]

27. Press Release, NASA, NASA's SOPHIA Discovers Water on Sunlit Surface of Moon (Oct. 26, 2020), https://www.nasa.gov/press-release/nasa-s-sofia-discovers-water-on-sunlit-surface-of-moon.

28. Nola Taylor Redd, *Water on Mars: Exploration and Evidence*, SPACE.COM (Aug. 18, 2018), https://www.space.com/17048-water-on-mars.html.

29. Press Release, NASA, NASA Confirms Evidence that Liquid Water Flows on Today's Mars (Sept. 28, 2015), https://www.nasa.gov/press-release/nasa-confirms-evidence-that-liquid-water-flows-on-today-s-mars.

30. Jonathan O'Callaghan, *Water on Mars: discovery of three buried lakes intrigues scientists*, NATURE (Sept. 28, 2020), https://www.nature.com/articles/d41586-020-02751-1.

31. *See* Sebastian Lauro et al., *Multiple subglacial water bodies below the south pole of Mars unveiled by new MARSIS data*, 5 NATURE ASTRONOMY 63 (2021).

32. *Europa-In Depth Europa*, NASA SOLAR SYSTEM EXPLORATION, https://solarsystem.nasa.gov/moons/jupiter-moons/europa/in-depth/ (last visited Mar. 16, 2022).

33. *Id*.

34. *Id*.

35. Lonnie Shekhtman, *NASA Scientists Confirm Water Vapor on Europa*, NASA GODDARD (Nov. 18, 2019), https://astrobiology.nasa.gov/news/nasa-scientists-confirm-water-vapor-on-europa/#:~:text=Now%2C%20an%20international%20research%20team,world's%20biggest%20telescopes%20in%20Hawaii.

36. O'Callaghan, *supra* note 30. It should be noted that Europa is also likely to be one of the first celestial bodies visited after Mars. Europa may be one of the best locations to look for extraterrestrial life due to (1) the presence of a liquid ocean combined with (2) tidal effects from Jupiter's gravity that may create undersea volcanic activity. Although Ganymede, one of Jupiter's other moons also has ice and a liquid ocean, the ice crust is estimated to be 95 miles deep.

C. Hydrocarbons

The third major space resource for energy production is already the basis for 69% of United States' energy consumption: hydrocarbons.[37] Hydrocarbons are chemical compounds that make petroleum and natural gas rich with energy potential.[38] Often referred to as fossil fuels, hydrocarbons produce energy through combustion, reacting with oxygen to create carbon dioxide, water, and heat.[39]

As the distance from the Sun grows, the environments, atmospheres, and composition of planets and moons change. Temperatures drop and compounds that may be a natural gas on Earth become liquids. Such is the case with the best potential source of hydrocarbons in space—Saturn's moon, Titan.[40] Out of more than 150 of the solar system's moons, Titan stands alone as having a substantial atmosphere and liquid rivers, lakes, and oceans on the surface.[41] However, Titan's rivers, lakes, and oceans are actually made from liquid methane and other hydrocarbons.[42] These hydrocarbons follow in a cycle similar to Earth's water cycle: raining, flowing, and evaporating across Titan's surface.[43]

Although only 20% of Titan was mapped by the space probe Cassini, researchers have already found several dozen lakes that are each estimated to contain more hydrocarbons than all of the oil and natural gas reserves on Earth.[44] When human expansion eventually reaches Saturn and its moons, Titan will undoubtedly prove a valuable source for energy production.

While Helium-3, water, and hydrocarbons are the three most likely energy resources for extraction, the solar system contains a wide range of other materials that could be used in human expansion. Thus, it is necessary to prime the space resource regulatory framework for future growth and transformations.

PART II: REPLICATING PROBLEMS FROM EARTH IN THE SPACE LEGAL REGIME

Much like outer space resources, early American settlers found ample resources on United States soil. Although property rights to outer space resources are not yet as concrete as those on American soil, the United States has not refrained from developing resource extraction policies in outer space like those on Earth.

37. U.S. ENERGY INFORMATION ADMINISTRATION, US ENERGY FACTS EXPLAINED, (2020), https://www.eia.gov/energyexplained/us-energy-facts/.

38. Francis Carey, *Hydrocarbon*, ENCYCLOPEDIA BRITANNICA (2020), https://www.britannica.com/science/hydrocarbon.

39. Bethel Afework et al., *Hydrocarbon Combustion*, ENERGY EDUCATION (Jan. 31, 2020), https://energyeducation.ca/encyclopedia/Hydrocarbon_combustion.

40. *Titan-Overview*, NASA SOLAR SYSTEM EXPLORATION, https://solarsystem.nasa.gov/moons/saturn-moons/titan/overview/ (last visited Mar. 16, 2022).

41. *Id.*

42. *See* A. Hayes et al., *Hydrocarbon lakes on Titan: Distribution and interaction with porous regolith*, 35 GEOPHYSICAL RESEARCH LETTERS, L09204 (2008).

43. *Titan-In Depth*, NASA SOLAR SYS. EXPL., https://solarsystem.nasa.gov/moons/saturn-moons/titan/overview/ (last visited Mar. 16, 2022).

44. *Titan's Surface Organics Surpass oil reserves on Earth*, THE EUR. SPACE AGENCY, http://www.esa.int/Science_Exploration/Space_Science/Cassini-Huygens/Titan_s_surface_organics_surpass_oil_reserves_on_Earth (last visited Mar. 16, 2022).

Unfortunately, the American policies that serve as the basis for space resource extraction are fraught with problems and oversights that lead to conflicts with overuse, ownership, and restoration. By replicating the legal regime in space, the United States is set to repeat these problems. This section explores the three major areas of conflict created by American resource extraction policy, and how the United States is currently on track to reiterate those conflicts in space.

A. Priority Resource Extraction, The Rule of Capture, and Overuse

The United States' expansion westward can be characterized as the culmination of several prominent social and economic theories. First, Manifest Destiny, which held that the United States was ordained to expand to the Pacific Ocean, remaking the west as the country grew.[45] Second, the concepts of a free market as defined by Adam Smith, which focused on self-interest as a benefit to societal goals.[46] Third, John Locke's labor theory of property, which held that the value and ownership of property was derived from improving upon nature.[47] Together, these ideologies combined to justify and encourage expansion, competition, and development. Given their influence, it should come as no surprise that American policies encapsulated these ideologies by prioritizing resource extraction.

1. Prioritization of Resource Extraction in the United States

The United States' regulatory framework and common law often give priority to resource extraction and use, generating a "first-come-first-serve mentality." One of the best examples is the Rule of Capture. Descended from English common law, the Rule of Capture is the basic principle that the first person to "capture" a particular resource has rightful ownership.[48]

Application of the Rule of Capture quickly followed the drilling of the first commercial oil well in 1859.[49] In 1889, the Supreme Court of Pennsylvania held that water, oil, and gas fell under the ferae naturae analogy—they have the power and tendency to escape without the volition of the owner.[50] Resources belong to the owner of the land, so long as they are found on or in the land, and are subject to the owner's control; but if the resources escape or come under another's control, the title of the former owner is gone.[51] If an adjoining, or distant, owner drills his own land and taps a property's resource—so that it comes into his well and under his control—

45. *See* ROBERT J. MILLER, NATIVE AMERICA, DISCOVERED AND CONQUERED: THOMAS JEFFERSON, LEWIS & CLARK, AND MANIFEST DESTINY 120 (2006).

46. *See* ADAM SMITH, AN INQUIRY INTO THE NATURE AND CAUSES OF THE WEALTH OF NATIONS Par.IV.2.9 (1776).

47. *See* JOHN LOCKE, TWO TREATIES OF GOVERNMENT Ch.V.27 (1689).

48. *See* Westmoreland Nat. Gas Co. v. Dewitt, 130 Pa. 235, 249 (1889).

49. Bruce Kramer & Owen Anderson, *The Rule of Capture – An Oil and Gas Perspective,* 35 ENV'T. L. 899, 900 (2005).

50. Westmoreland Nat. Gas Co., 130 Pa. at 249-50.

51. *Id.*

it is now his.[52] In the words of Daniel Plainview, a distant owner can drink the milkshake.[53]

The Rule of Capture is used in modern resource ownership disputes. In 2020, the Supreme Court of Pennsylvania held that the Rule of Capture can be applied in hydraulic fracturing ("fracking") scenarios, and that plaintiffs alleging trespass by invasion of property must aver something more than mere drainage of minerals from the subject property.[54] While oil and natural gas extraction methods have transformed since 1859, the governing policies have largely remained the same.

Unchecked, the Rule of Capture creates a large-scale, zero-sum game. Each extracting entity is encouraged to withdraw as fast as possible to avoid losing out to competitors.[55] In the early 1900s, the town of Spindletop, Texas became a clear example of the negative incentives.[56] In January 1901, an oil company discovered an oil reserve that yielded 100,000 barrels per day. By September, the company had six successful wells.[57] As a result, land prices skyrocketed, the population of a nearby town quintupled, and other oil companies invested heavily in the area.[58] The increased competition quickly depleted the oil reserves. After yielding 17,500,000 barrels of oil in 1902, the Spindletop wells were reduced to 10,000 barrels a day by February 1904.[59]

Unrestrained, policies that favor the Rule of Capture motivate interested parties to extract the maximum amount of resources possible. Following the oil boom in Texas, some states recognized the need for constraint and regulation. Arkansas created legislation specifically designed to protect public and private interests from evils occurring in the production and use of oil by compelling ratable production.[60] To decrease the incentives created by the Rule of Capture, Arkansas' regulations set standards for wasteful drilling, including restrictions on the amount of oil a single drilling unit can produce.[61] The Arkansas Oil and Gas Commission also has the authority to regulate the number of wells that may be drilled within a single drilling unit and regulate the spacing of multiple wells placed in a single drilling unit.[62] Arkansas' solutions to the Rule of Capture are typical of conservation regulations, which include well spacing limits, proration, or pooling and unitization.[63]

However, the Rule of Capture and the first-come-first-serve mentalities are not limited to oil and natural gas. States have seen conflict over underground water

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52. *Id.*

53. THERE WILL BE BLOOD (Ghoulardi Film Company 2007).

54. Briggs v. Southwestern Energy Prod. Co., 224 A.3d 334, 352 (2020).

55. *Zero Sum Game,* MERRIAM-WEBSTER'S DICTIONARY, https://www.merriam-webster.com/dictionary/zero-sum%20game (last visited May 11, 2022).

56. Robert Wooster & Christine Moor Sanders, *Spindletop Oilfield*, TEX. STATE HIST. ASS'N, https://www.tshaonline.org/handbook/entries/spindletop-oilfield (last visited Mar. 16, 2022).

57. *Id.*

58. *Id.* By the end of 1902, there were more than 500 oil companies and 285 wells operating in Spindletop.

59. *Id.*

60. *See* ARK. CODE ANN., §15-6-72 (2018).

61. ARK. CODE ANN. §15-72-302(b)(2)(A) (2018) (defining a drilling unit as a single governmental section or the equivalent).

62. ARK. CODE ANN. §15-72-302(b)(2)(B) (2018).

63. Kramer & Anderson, *supra* note 49, at 903.

reservoirs as well. Texas, despite the lessons from Spindletop, still uses the Rule of Capture for groundwater reserves.[64] In *Houston & Texas Central Railway Co. v. East*, the Texas Supreme Court held that an owner may pump unlimited quantities of water from under his land, regardless of the impact that action may have on his neighbor's ability to obtain water on their own land.[65] As long as a landowner does not purposely or negligently injure a neighbor, the extraction and use of groundwater is unregulated.[66]

Neighboring states do not follow the same approach. By comparison, New Mexico's groundwater regulatory framework is incredibly strict.[67] The principal difference is that New Mexico treats all underground streams, reservoirs, or lakes as belonging to the public.[68] As such, it is unlawful for any person, firm, or corporation to drill a new well without license from the state.[69] Combined with a system that grants priority to older wells, ground water rights in New Mexico are antithetical to the Rule of Capture.

Unsurprisingly, the difference in state policies has created conflict between New Mexico and Texas, with continuing economic impacts. The Permian Basin, an area shared by both states, has seen a growth of fracking operations, which in turn has increased the demand for groundwater.[70] Due to the difference in state policies, oil companies have found groundwater harder to access in New Mexico.[71] Although both areas rely on the same aquifer, oil companies are building pipelines that carry groundwater from Texas to oil wells in New Mexico.[72] Texas' Rule of Capture allows oil companies to avoid water regulations in New Mexico, despite using the same resources. In 2018, the New Mexico State Land Commissioner accused Texas of stealing New Mexico's water, a situation that remains unresolved.[73]

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64. Douglas G. Caroom & Susan Maxwell, *The Rule of Capture – "If It Ain't Broke"*, 361 TEXAS WATER DEV. BD. REP. 41, 42 (2004).

65. Houston & Texas Central Ry. Co. v. East, 81 S.W. 279, 281-82 (1904).

66. Caroom & Maxwell, *supra* note 64, at 44. (citing City of Corpus Christi v. City of Pleasanton, 276 S.W.2d 798 (Tex. 1955); Friendswood Dev. Co. v. Smith-Southwest Indus., Inc., 576 S.W.2d 21, 30 (Tex. 1978)).

67. *Water Rights Applications and Forms*, N.M. OFF. OF THE STATE ENG'R, https://www.ose.state.nm.us/WR/forms.php (last visited Apr. 1, 2022). The Office of the State Engineer in New Mexico has 19 different permits regarding wells, ranging from simple modifications and well repair to applications to change a well's purpose.

68. N.M. STAT. ANN. §72-12-1 (1978).

69. N.M. STAT. ANN. §72-12-11 (1978).

70. Kameron B. Smith, *Subsurface Tension: The Conflicting Laws of Texas and New Mexico Over Shared Groundwater and New Mexico Desire for Regulation*, 7 TEX. A&M L. REV. 453, 455 (2020). Water is a key component for hydraulic fracturing, as water is pumped into the underlying bedrock, allowing for greater oil and natural gas extraction. The Permian Basin is an area that covers Southeast New Mexico and Western Texas.

71. Matt Weiser, *Oil boom in Southern New Mexico ignites groundwater feud with Texas*, N.M. POL. REP. (July 18, 2018), https://nmpoliticalreport.com/2018/07/18/oil-boom-in-southern-new-mexico-ignites-groundwater-feud-with-texas/.

72. *Id*.

73. Jay Root, *New Mexico official says Texas landowners are "stealing" millions of gallons of water and selling it back for fracking*, THE TEX. TRIB. (June 7, 2018), https://www.texastribune.org/2018/06/07/texas-landowners-new-mexico-stealing-water-fracking/.

The groundwater conflicts between New Mexico and Texas, as well as the oil and gas disputes in other states, reflect a large problem with the traditional resource regulatory framework of the United States. By choosing to favor industry development, the United States espoused policies that left little room for resource conservation. As resources became overused, traditional resource regulation policies enabled conflicts that continue today.

2. Prioritization of Resource Extraction in Space

Despite clear conflicts created by the Rule of Capture and the first-come-first-serve mentality, the United States' appears to be applying the same mentality to the legal framework in space. In 2015, the United States enacted the U.S. Commercial Space Launch Competitiveness Act (CSLCA).[74] First, Section 51302 declares that, "the President, acting through appropriate Federal agencies shall: 1) facilitate commercial exploration for and commercial recovery of space resources by U.S. citizens, and 2) discourage government barriers to the development in the United States of economically viable, safe, and stable industries for commercial exploration for and commercial recovery of space resources [. . .].[75] Second, Section 51303 states that, "a United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including the right to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with the applicable law, including the international obligations in the United States.[76]

The CSLCA's language is a clear continuation of the United States' prioritization of resource extraction. Section 51302 outlines the President's responsibilities as facilitating growth and discouraging government "barriers."[77] The statute's use of the word "shall" establishes a mandatory obligation for the president to carry out the CSLCA's stated goals.[78] Thus, if any regulation proposes a limitation on space resource extraction, the President is obligated to oppose it. Section 51303 of the CSLCA grants near unlimited rights to U.S. citizens over any asteroid or space resource.[79] Although the provision requires that United States citizens adhere to international obligations, there is no consensus as to what international obligations are.[80] Moreover, the CSLCA's use of the phrase "space resources obtained" mirrors the typical Rule of Capture language denoting ownership once control is established.[81]

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74. Pub. L. No. 114-90, 124 Stat. 2806, 2820, and 124 Stat. 704-22 (codified as amended in scattered sections of 42 U.S.C and 51 U.S.C).

75. 51 U.S.C. § 51302 (2015).

76. *Id*. § 51303.

77. *Id*. § 51302.

78. CHRISTINE COUGHLIN ET AL., A LAWYER WRITES: A PRACTICAL GUIDE TO LEGAL ANALYSIS 201 (3rd ed. 2018).

79. U.S. Commercial Space Launch Competitiveness Act § 51302.

80. Scot Anderson et. al, *The Development of Natural Resources in Space*, HOGAN LOVELLS ADG INSIGHTS, 6 (2019) (citing Pierfrancesco Breccia, "Article III of Outer Space Treaty and its Relevance in the International Space Legal Framework.").

81. *Id*. at 5.

Given the size of the solar system and the resources within it, many consider the concept of full solar system resource exploitation improbable.[82] However, mathematical models indicate that the global economy has maintained an average growth of 3.5% from the beginning of the Industrial Revolution to present day.[83] If the space economy matches a 3.5% baseline growth rate, then humans would have 400 years before the ratio between known asteroid reserves and annual production would be the same.[84] At that point, humans would only have 60 years before resource exhaustion.[85] If growth rates surpass the baseline world average as expected, the timeline for resource exhaustion could be even shorter.[86]

There is no question that, without regulation, a prioritization of resource extraction and development creates conflict and negative externalities. The United States' historical support of the Rule of Capture has created many issues with overuse, many of which are yet to be resolved. Nonetheless, the United States' current space resource extraction regulatory framework is on track to repeat the same mistakes. The United States' current attitude is encapsulated by the Space Foundation's CEO Elliot Pulham, who said, "There's no law that says you can't snag an asteroid. Knock yourself out."[87]

B. The Split Estate and Ownership Conflicts

Another unique American resource policy with long-lasting effects is the split estate, a situation where the surface rights and the mineral rights are owned by two separate parties.[88] In most countries, the state or crown holds title to all gas, oil, or mineral deposits, including those under private lands.[89] However, the United States created a system that allowed for the two estates to be held by different private parties.

1. The Split Estate and Ownership in the United States

Much like the Rule of Capture, the split estate was a product of the United States' push for frontier development.[90] The federal government incentivized westward expansion by selling public land surface rights to private parties while

82. Elvis & Milligan, *supra* note 7, at 1.

83. Elvis & Milligan, *supra* note 7, at 6.

84. Elvis & Milligan, *supra* note 7, at 15.

85. Elvis & Milligan, *supra* note 7, at 15.

86. Elvis & Milligan, *supra* note 7, at 7. A 10% growth rate is roughly the same as China's GDP growth over the last 30 years. If the space economy grew at 10% for a century, the result would be a cumulative growth factor of nearly 14,000 relative to the starting figure. After 200 years, the cumulative growth factor would be 190 million times the initial starting figure.

87. American Museum of Natural History, *Selling Space*, YOUTUBE (2014), https://www.amnh.org/explore/videos/isaac-asimov-memorial-debate/2014.

88. KENDOR JONES ET AL., *Split Estate and Surface Access Issues in* LANDMAN'S LEGAL HANDBOOK 181, 181 (2013).

89. *Id*.

90. Stacia Ryder & Peter Hall, *This is your land, maybe: A historical institutionalist analysis for contextualizing split estate conflicts in U.S. unconventional oil and gas development*, 63 LAND USE POL'Y 149, 152 (2017).

retaining mineral rights.[91] Mineral rights were transferred under the Mining Act of 1872, which allowed United States citizens to explore for minerals and establish mineral rights on federal lands without authorization from any government agency.[92] Under the Mining Act, if a site contained a deposit that could be profitably marketed, the claimant had the "right to mine" regardless of alternative uses, potential use, or non-use value of the land.[93] These various legislative policies "split" surface rights from mineral rights, creating different estates for private ownership.

At the same time, the common law was evolving to accommodate the split estate.[94] In 1854, the Pennsylvania Supreme Court decided that, "one who has the exclusive right to mine coal upon a tract of land has the right of possession even against the owner of the soil, so far as it is necessary to carry on mining operations."[95] This case, *Turner v. Reynolds*, is frequently cited as a justification of full possession and enjoyment to mineral rights below the surface.[96] As the common law evolved, mineral rights became dominant over surface rights.

There is an assumption that the creator of the split estate did not intend to give rights to the surface estate that would render the mineral estate worthless.[97] The Texas Supreme Court once stated that, "it is a well established [sic] doctrine from the earliest days of common law, that the right to minerals reserved carries with it the right to enter, to dig and carry them away, and all other such incidents thereto as are necessary to be used for getting and enjoying them."[98] The support from federal legislation and common law ensured that the split estate with mineral dominance was an early staple of American resource extraction.

Clearly, a separation of surface rights from subsurface rights generates conflict with ownership and use—forcing states to shift policy. The most common policy modification to mineral dominance is known as the accommodation doctrine.[99] Created by the Texas Supreme Court in 1971, the accommodation doctrine holds that the inconvenience to the mineral lessee of choosing an alternative method of operation must be measured against the surface owner's right to use the surface in a manner that did not unreasonably inhibit the mineral lessee's right to

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91. *See generally* Alan Collins & Kofi Nkansah, *Divided Rights, Expanded Conflict: The Impact of Split Estates in Natural Gas Production*, 2013 Annual Meeting, Agricultural and Applied Economics Association (2013). The Carey Act of 1859, the Homestead Raising Act of 1862, and the Stock-Raising Act of 1916 transferred or sold a combined 58 million acres of surface land rights to private owners.

92. David Gerard, THE MINING ACT OF 1872: DIGGING A LITTLE DEEPER, 11 PERC POL'Y SERIES, 2 (Dec. 1997).

93. *Id*.

94. Ryder & Hall, *supra* note 90, at 151.

95. Turner v. Reynolds, 23 Pa. 199, 199 (Pa. 1854).

96. Ryder & Hall, *supra* note 90, at 153.

97. JONES ET AL., *supra* note 88, at 183.

98. Cowan v. Hardeman, 26 Tex. 217, 222 (Tex. 1862).

99. *See* JONES ET AL., *supra* note 88, at 184.

develop the minerals.[100] For the accommodation doctrine to apply, the surface use must already exist as potential future uses are not considered.[101]

While the accommodation doctrine is now the rule in most states that have considered the question, there are several other state solutions in use.[102] Some states have passed laws explicitly protecting landowners from damage or loss of value caused by subsurface extraction, while others have used spatial and temporal development limits to accommodate other property and wildlife.[103] Like the Rule of Capture, federal and state remedies to conflicts created by the split estate developed slowly.[104]

Nonetheless, conflicts continue due to the split estate.[105] While early cases were typically private disputes, litigation has increased between federal agencies that manage surface estates and private parties that own mineral estates.[106] In 2009, the United States Forest Service denied access to several privately owned mineral rights in the Allegheny National Forest (ANF) and agreed as part of a settlement to analyze future drilling proposals pursuant to the National Environmental Policy Act (NEPA).[107] Following a challenge from several companies, the court found that any rules and regulations the Forest Service wanted to apply had to be a part of the original conveyance.[108] For the vast majority of the ANF properties owned by the federal government, the deeds did not provide the Forest Service with the regulatory authority to process oil and gas drilling claims.[109] This decision is a perfect example of the ongoing conflicts created by early American emphasis on development. Despite regulatory revisions, the split estate still generates issues between mineral estates and surface estates.

100. *See* Getty Oil Co. v. Jones, 470 S.W.2d 618 (Tex. 1971) (determining when the mineral rights must accommodate surface uses, the court created a three-part test, stating that the mineral estate must accommodate existing surface uses when (1) the proposed mineral use would completely preclude or substantially impair the existing surface use; (2) the surface owner has no reasonable alternative method by which to continue that use; and, (3) there are reasonable, customary, and industry-accepted alternative methods available to the mineral owner for mineral extraction).

101. JONES ET AL., *supra* note 88, at 184.

102. JONES ET AL., *supra* note 88, at 184.

103. Tara Righetti, *Liberating Split Estates*, 14 INT'L J. OF THE COMMONS 638, 643 (2020) (citing C. Kulander, *Split Estate Remediation issues on tribal lands*, 2 TEX. J. OF OIL, GAS, AND ENERGY LAW 125 (2007)).

104. *See* Ryder & Hall, *supra* note 90, at 151-54. The accommodation doctrine, which is now the common split estate policy, was created over 100 years after the split estate.

105. *See* Andrew Mergen, *Surface Tension: The Problem of Federal/Private Split Estate Lands*, 33 LAND & WATER L. REV. 419, 420 (1998) (citing Reno Livestock Co. v. Sun Oil Co., 638 P.2d 147 (Wyo. 1981) and Gerrity Oil & Nat. Gas Corp. v. Magness, 946 P.2d 912 (Colo. 1997)).

106. *Id*. at 420-21.

107. Minard Run Oil Co. v. U.S. Forest Service, 2009 WL 4937785, at *1 (W.D. Penn. 2009). The federal government owns the majority of the ANF's surface estates, while over 93% of the mineral estates are privately owned. Approximately 48% of the mineral estates are "reserved mineral estate," which are categorized at the time the federal government acquired the surface rights. Accordingly, the vast majority of reserved mineral estates in the ANF are "1911 reserved mineral estates."

108. *Id*. at *29.

109. *Id*.

2. The Split Estate and Ownership in Space

Despite the contentious history of the split estate, the United States is taking the same approach to resources in the solar system. However, where recent conflicts have been between the federal government and private parties, the space split estate is set to generate conflict between countries. The primary international agreement for regulation in outer space is the 1967 United Nations *Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (the Outer Space Treaty).[110] The Outer Space Treaty is particularly notable for the concept that outer space is a common interest, focusing on a push for peace and illustrating outer space as "the province of all mankind."[111] Under Article II, "outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by any means of use or occupation, or by any other means."[112]

Despite being original signatories to the Outer Space Treaty, the United States' current space resource policies are taking a contradictory stance.[113] As noted previously, one of the primary American regulations for resources in space is the Commercial Space Launch Competitiveness Act, which focuses on the prioritization of space resource extraction and encourages private acquisition.[114] Although the CSLCA's declaration of private rights over space resources appears to contradict the Outer Space Treaty, the United States has argued that exclusive ownership over the resources in outer space is not the same as claiming sovereignty over an area of outer space.[115] In effect, the United States' position on space resources is creating mineral rights in the resources of a celestial body, while leaving the sovereignty under international authority; a clear example of the split estate.

The United States reiterated the stance that space resource extraction does not constitute appropriation in October 2020 under the *Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets and Asteroids for Peaceful Purposes* (Artemis Accords).[116] Although the Artemis Accords are, "built in compliance with the Outer Space Treaty,"[117] Section 10 states that, "Signatories affirm that the extraction of space resources does not inherently

110. Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

111. Mallick & Rajagopalan, *supra* note 5, at 11.

112. Outer Space Treaty, *supra* note 110, at art. II.

113. *See generally* Outer Space Treaty, *supra* note 110.

114. U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, 129 Stat 704 (2015).

115. *See id.* at § 51303; *see also* Mallick & Rajagopalan, *supra* note 5, at 11 (discussing that popular arguments reference maritime law, regarding space resources as comparable to fish and shellfish, but celestial bodies like the Moon and asteroids are not, like the high sea).

116. *See generally* The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets and Asteroids for Peaceful Purposes, NASA, Oct. 13, 2020, https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf [hereinafter Artemis Accords].

117. *Id*. at 1.

constitute national appropriation under Article II of the Outer Space Treaty."[118] In short, the Artemis Accords restate the argument that resource extraction does not constitute appropriation of celestial bodies or violate the Outer Space Treaty.[119]

The CSLCA and the Artemis Accords are clear continuations of early American emphasis on resource extraction and use, and the language used in the regulations indicate an attempt by United States policymakers to separate mineral and resource rights from the surface rights on celestial bodies. In fact, these regulations have already generated international conflict over the ownership of resources in space. In response to the Artemis Accords, the deputy director for the Russian Space Agency stated that American, "attempts to expropriate outer space and aggressive plans to actually take over other planets," go against the principles of international cooperation.[120]

C. Restoration After Resource Extraction

Ostensibly, the Rule of Capture and split estates are only important if there are resources on the estate. Once the resources are exhausted, the mineral estate is worthless and extracting parties have no incentive to continue operations. Without regulations governing land restoration after the owners finished extracting resources, companies would often abandon empty mines or drilling sites, which in turn created long lasting environmental and economic repercussions.[121]

1. Land Restoration on Earth

Despite the heavy environmental impacts of mining and resource extraction, most American policies largely ignored the issue until the 1960s.[122] As a result, United States mining operations were conducted for roughly 200 years without any clean-up requirements. This oversight created massive environmental and economic challenges that continue today. For example, as of 2000, United States mining had contaminated stream reaches in the headwaters of more than 40% of American watersheds.[123] Between 1998 and 2007, taxpayers spent $2.6 billion on hardrock mine cleanup alone.[124] In 2008, the Government Accountability Office

118. *Id.* at 4. As of the writing of this article, the Artemis Accords currently has nine signatories: Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, the United Kingdom, Ukraine, and the United States.

119. *Id*. at 1. Notably, the Artemis Accords also state that the Signatories commit to the creation of safety zones that encourage safe extraction and utilization of space resources.

120. Namrata Goswami, *The Strategic Implications of the China-Russia Lunar Base Cooperation Agreement*, THE DIPLOMAT (Mar. 19, 2021), https://thediplomat.com/2021/03/the-strategic-implications-of-the-china-russia-lunar-base-cooperation-agreement/.

121. *See* U.S. GOV'T ACCOUNTABILITY OFF., GAO-20-238, ABANDONED HARDROCK MINES: INFORMATION ON NUMBER OF MINES, EXPENDITURES, AND FACTORS THAT LIMIT EFFORTS TO ADDRESS HAZARDS (2020). It is estimated that there are over 500,000 abandoned hardrock mines in the United States.

122. *Id*.

123. U.S. ENV'T PROT. AGENCY, LIQUID ASSETS 2000: AMERICA'S WATER RESOURCES AT A TURNING POINT, 10 (2000) (estimating that total cleanup costs could exceed $35 billion).

124. U.S. GOV'T ACCOUNTABILITY OFF., GAO-08-574T, INFORMATION ON ABANDONED MINES AND VALUE AND COVERAGE OF FINANCIAL ASSURANCES ON BLM LAND, at 4 (2008).

estimated that at least 33,000 sites had degraded the environment.[125] In Pennsylvania, an estimated 133,000 acres of pre-1970 mines remain inadequately stabilized.[126]

The federal government began to enact environmental protection and rehabilitation laws in the 1960s. Between 1960 and 1977, the federal government enacted the Clean Air Act (CAA),[127] Clean Water Act (CWA),[128] and the Surface Mining Control and Reclamation Act (SMCRA).[129] These three acts placed an increased focus on future environmental protection and rehabilitation. In 1980, the United States enacted the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA).[130] CERCLA, also known as the federal "superfund" statute, establishes a plan for the cleanup of a contaminated site and provides rights of recovery associated with the cleanup of hazardous waste and hazardous substances.[131] Together, these policies reflect an attempt to address decades of environmental oversight from American resource extraction.

Despite these regulations, contamination and clean up continue 40 years later. For instance, in 2005, the U.S. Forest Service began reclamation on a cyanide heap leach mine after the parent company filed for bankruptcy. [132] As of 2018, the U.S. Forest Service's final reclamation costs for the single cyanide heap leach mine were estimated to be $40,530,139 + $400,000 per year for long term water treatment.[133] Despite the advancements made by the CWA, CAA, SMCRA, and CERCLA, land restoration remains a contentious and expensive subject. Restoration will most likely continue for the foreseeable future. As of March 2022, CERCLA's National Priorities List has 1,322 sites.[134] Each one of these sites could see rising cleanup costs or restoration disputes before being fully resolved.

2. Restoration in Space

Given the increased attention to the impact of resource extraction on Earth, it seems likely that the importance would carry over to future space restoration. However, like resource extraction technologies, the United States' regulations are currently confined to Earth. For example, CERCLA states that claims asserted and

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125. *Id*. at 5.

126. William Toffey et. al., *Two Decades of Mine Reclamation: Lessons Learned from One of the Nation's Largest Biosolids Beneficial Use Programs*, PA. DEP'T OF ENV'T PROT. (1998).

127. 42 U.S.C. § 7401 *et. seq.* (1963).

128. 33 U.S.C. § 1251 *et. seq.* (1972).

129. 30 U.S.C. § 1201 *et. seq*. (1977).

130. 42 U.S.C. § 9601 *et. seq*.

131. J.B. RUHL ET. AL., THE PRACTICE AND POLICY OF ENVIRONMENTAL LAW 377 (4th ed. 2017). Substantively, CERCLA constitutes a legal framework for the identification of sites in need of remediation, the remediation necessary, and the parties that should bear the costs of remediation. When a site has been selected for hazardous waste cleanup under CERCLA, the site is placed on the National Priorities List (NPL).

132. Perry Backus, *Cleanup Costs Mount at Beal Mountain Mine Site*, INDEP. REC. (Dec. 30, 2005), https://helenair.com/news/state-and-regional/cleanup-costs-mount-at-beal-mountain-mine-site/article_99b32fbe-351b-5fe6-9651-caeb10c14260.html.

133. LAURA ZANOLLI, TRACK RECORD - MONTANA MODERN HARDROCK MINING - WATER QUALITY IMPACTS AND RECLAMATION BONDING 6 (2018).

134. Superfund: National Priorities List, Env't Prot. Agency, https://www.epa.gov/superfund/superfund-national-priorities-list-npl (last visited Mar. 12, 2022).

compensable can be asserted against the fund, "*Provided, however*, [t]hat any such claim may be asserted only by the President as trustee, for natural resources over which the United States has sovereign rights."[135] But the United States does not "assert sovereignty . . . or exclusive rights or jurisdiction over, or the ownership of, any celestial body."[136] Because the United States maintains the stance that resource extraction in space does not count as exercising sovereignty, any statute dependent on sovereign authority does not apply.

There are currently general guidelines for space debris, but the policies are outdated and unable to address contemporary issues.[137] Internationally, space debris is not defined in any United Nations space treaty or agreement, and all the instruments directly addressing space debris are simply guidelines for participating countries.[138] The American mitigation framework is not much better. In fact, the CSLCA directly states "that an improved framework may be necessary for space traffic management of United States . . . assets . . . in outer space and space debris mitigation."[139] The Artemis Accords simply state that the signatories commit to plan for the mitigation of space debris and "to limit, to the extent practicable, the generation of new, long-lived harmful debris released through normal operations."[140] NASA's orbital debris mitigation standards also need refining. According the mitigation standard practices, debris larger than 5 mm that remains in orbit for more than 25 years must be evaluated and justified.[141] Spacecraft or rocket upper stages can be disposed of by three methods: 1) atmospheric reentry, 2) maneuvering to a "storage orbit", or 3) direct retrieval.[142] The mitigation standards are inadequate as they only apply to debris with extended orbital periods, and spacecraft like satellites can simply be pushed into another orbital altitude instead of being removed. Put simply, current debris policies create a landfill in the sky.

Because concrete regulations regarding space conservation do not exist, space debris is already an issue in Earth's atmosphere. As of March 2022, the European Space Agency estimates Earth's orbit contains over 131,036,500 pieces of debris.[143] It is estimated that a continuing trend, without explosions or disposal, will

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135. 42 U.S.C. § 9611(b)(1).

136. U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 51303(403), 124 Stat. 2806, 2820 (2015).

137. Fawaz Haroun et al., *Toward the Sustainability of Outer Space: Addressing the Issue of Space Debris*, 9 NEW SPACE 63, 65 (2021). Space debris is defined as "artificial material orbiting Earth but is no longer functional." Erik Gregersen, *Space Debris*, ENCYCLOPEDIA BRITANNICA, https://www.britannica.com/technology/space-debris (last visited Jan. 31, 2022).

138. Haroun et al., *supra* note 137, at 65 (citing Article IX of the UN Outer Space Treaty, which mandates states refrain from "harmful contamination" of outer space. The Outer Space Treaty does not define or clarify further.).

139. U.S. Commercial Space Launch Competitiveness Act § 50914(109).

140. Artemis Accords, *supra* note 116, at 6.

141. *Orbital Debris Mitigation Standard Practices*, NASA, § 1-1 (2021), https://www.orbitaldebris.jsc.nasa.gov/library/usg_od_standard_practices.pdf.

142. *Id.* § 4-1. Option three includes maneuvering the spacecraft outside of Earth's orbit into a heliocentric orbit. *Id*.

143. *Space debris by the numbers*, EUROPEAN SPACE AGENCY, https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers (last visited Mar. 12, 2022). 36,500 pieces of debris greater than ten centimeters, 1,000,000 objects between one and ten centimeters, and 130 million objects between one millimeter and one centimeter.

lead to a 1.5 times growth in fragments over 20 centimeters over 200 years, and a 3.2 times growth in fragments ranging from 10 to 20 centimeters.[144] Because these fragments travel at speeds up to 17,500 miles per hour, even relatively small fragments can damage satellites or spacecraft.[145] As space resource extraction grows, mitigation and restoration will become a more prevalent issue unless clear regulations are put into place.

PART III: POTENTIAL FRAMEWORKS FOR THE AMERICAN SPACE REGULATORY REGIME

Given its current trajectory, the American space resource regulatory framework needs revision to prevent repetition of previous mistakes throughout the solar system. The positive news is that the United States has time to make these changes. This section explores several possible existing regulatory frameworks or agreements that the United States could use as models for sustainable space exploration and focuses on internationally cooperative solutions because space is considered the province of all mankind.

A. Frameworks for Overuse

In some ways, overuse is one of the easiest corrections for United States space resource policy. Although the Rule of Capture and the first-come-first-serve mentality were initially dominant, the visible conflicts eventually led to statutory change. States like Arkansas began to place limits on the Rule of Capture to prevent rampant zero-sum games.[146] Thus, the United States has multiple examples of effective limitations it can use in space.

One theoretical solution is to place a "one-eighth" principle on resources in outer space.[147] Under this concept, resource development would be limited to one-eighth of the total resources available in the solar system, leaving the rest as wilderness.[148] Although it may seem extremely restrictive, the one-eighth principle only prevents unconstrained or runaway growth; if growth is stabilized or other constraining methods are created, the restriction would be readily set aside.[149] Even with such constraints, the solar system has plenty of resources for growth until other means can be found.[150] However, this theory is limited by the current lack of an enforcing entity and the lack of knowledge regarding the total amount of resources in the solar system.

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144. N.N. Smirnov et al., *Space traffic hazards from orbital space debris mitigation strategies*, 109 ACTA ASTRONAUTICA 144, 145 (2015).

145. Mark Garcia, *Space Debris and Human Spacecraft*, NASA, https://www.nasa.gov/mission_pages/station/news/orbital_debris.html (last visited May 26, 2021).

146. *See* ARK. CODE ANN., § 15-6-72 (2018).

147. Elvis & Milligan, *supra* note 7, at 574.

148. Elvis & Milligan, *supra* note 7, at 576-577. Wilderness is defined by the 1964 Wilderness Act as areas where "man himself is a visitor that does not remain" (citing U.S. Congress, §2(c) (1964)). *Id*. at 578.

149. *See* Elvis & Milligan, *supra* note 7, at 576.

150. *See* Asterank.com, a scientific and economic database of over 600,000 asteroids and provides the basic value and cost effectiveness for each.

Another potential framework for consideration is the International Seabed Authority (ISA). Created under the 1982 *United Nations Convention on the Law of the Sea*, the ISA is an organization where member states organize and control all mineral-resources-related activities for the benefit of all mankind.[151] The ISA has a framework in place for the Economic Planning Commission, an expert body that would examine the potential impact from sea-bed mining on developing countries.[152] Although the Legal and Technical Commission currently exercises these functions,[153] the concept of impact analysis and control could be a solution for the United States to prevent rampant overuse. Furthermore, the cooperation inherent in the ISA would be a key component to prevent international conflict.

B. Frameworks for Ownership

Ownership will be a central focus for international space development as countries try to exercise authority over resources. Although agreements regarding ownership may be more complicated due to conflicting national policies and incentives, there are several functioning predecessors that can serve as foundation.

The first example of collaborative ownership in space is the International Space Station (ISS).[154] Launched in 1998, the ISS extends "the national jurisdiction of each participating state to an attributed compound or area of the station."[155] The partners involved in the ISS each sign memoranda of understandings outlining implementation and management structures, and have the ability to rent or sell any portion of their allocation.[156] By following the example set by the ISS, the United States could set up joint bases on the Moon and other celestial bodies.[157] Countries could then have rights to the resources equivalent to their allocation in the bases. By setting up space resource extraction outposts in conjunction with other countries, the United States could reduce ownership conflicts while lowering costs and fostering future cooperation.

Another proposed framework for space resource extraction is based on the International Telecommunication Union (ITU), which regulates the allocation of orbital slots for geostationary satellites.[158] Because satellites require specific spacing for transmissions, the orbital slots are limited in number.[159] In essence, the ITU has created property rights in outer space, which some argue could be extended to outer space resources.[160] Although this framework is difficult to imagine working for

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151. United Nations Convention on the Law of the Sea, art. 140, 156-57, Dec. 10, 1982, 1833 U.N.T.S. 397.

152. *Id*. at 89-90.

153. Jonathan Koch, *Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining*, 16 ASTROPOLITICS 1, 16 (2018).

154. *Id.* at 6.

155. *Id.* Participating states include the United States, Russia, Canada, Japan, and various European countries.

156. *Id.*

157. *Id.* at 6-7.

158. *Id*. at 6. Currently, the ITU has 193 members and 800 private entities serving as advisors.

159. *Id.*

160. *See* J. D. Scheraga, *Establishing Property Rights in Outer Space*, 6 CATO J. 889, 902 (1987).

planets, it could be realistically applied to asteroid belts. Countries and companies would pay for sole access over a specific part of the asteroid belt, thereby gaining title to all the resources therein. This system could favor wealthy countries with more resources to buy rights, but the ownership conflicts would be eliminated.

C. Frameworks for Restoration

The United States' regulatory framework made the mistake of overlooking restoration for most of its history—a mistake that should not be repeated.[161] Fortunately, restoration will be simplified by fixing the other two areas of conflict. For example, alterations to the Rule of Capture will offset many overuse externalities, thereby reducing restoration needs. Furthermore, cooperative ownership frameworks like the ISS could extend beneficial restoration acts like CERCLA. Many of the gaps from the United States framework could close without undue complications. However, outer space restoration will have unique challenges. For example, the wind and atmosphere on Mars ensure that contamination at a single area will eventually have at least some global impact on the planetary surface.[162] Any proposed regulations for restoration after resource extraction will need to account for the unique challenges posed by the particular celestial body.

Another distinct problem that restoration policies must face is contamination in orbit, like the amount of space debris currently circulating Earth.[163] Although the American mitigation policies previously discussed could be expanded, those policies are not actually a solution. Pushing space debris into a specific orbit is simply saving the problem until it reaches a breaking point. One solution that the United States could incorporate into international agreements is the creation of salvage rights. Currently, neither the Outer Space Treaty or the Registration Convention acknowledge the existence of salvage rights in space.[164] By incorporating salvage rights to any agreement, the United States and participating countries would automatically create a monetary incentive to reduce orbital debris.

CONCLUSION

Mankind is primed to take the next giant leap. With space resource extraction on the horizon, the United States is continuing a history of regulations that prioritize resource development and use. In doing so, the United States is poised to recreate conflicts regarding overuse, ownership, and restoration on a much larger scale. To avoid replicating the same mistakes from the first frontier to the final frontier,[165] the United States must rework its regulatory framework with a focus on international cooperation and conservation.

161. *See* 42 U.S.C. § 7401 *et. seq*. (1963).
162. Elvis & Milligan, *supra* note 7, at 575.
163. Haroun et al., *supra* note 137, at 65.
164. Haroun et al., *supra* note 137, at 65. As a result, it is illegal to move or remove an object in space without permission from the launching site.
165. STAR TREK (Desilu Productions 1966-1968, Paramount Television 1968-1969).