Galactic gold rush:
lawfulness, lawlessness, and preservation of the outer space environment

By:

Matthew H. Ormsbee

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Abstract

Leading spacefaring powers plan to revisit the Moon, extract lunar resources, and someday springboard from the Moon to Mars and other celestial bodies. Against these ambitions, the core of space law was formulated in an era of two-State space competition with sometimes short-sighted notions of space exploration. This Thesis overlays the black-and-white space law paradigm of the Cold War with the technicolor reality of space aspirations in 2023 and beyond. It assumes that prevailing space laws permit lunar settlement and resource extraction to some extent. Yet, a vacuum of specific norms and regulations incentivizes a "galactic gold rush" that will foster destructive, unsustainable practices with irreversible effects.

This Thesis examines whether the current space law framework adequately protects against lunar resource depletion, land conservation, and preservation of historic sites on the Moon. It argues that legal protections cannot keep pace with technological advances. The methodology weighs potential environmental harms against legal safeguards while valuing an interchangeable menu of environmental concerns. Furthermore, because space laws are inadequate to protect these concerns, this Thesis assesses alternative legal measures to guide future space exploration and resource extraction. The Galactic Gold Rush must be disincentivized at all costs. With years remaining before national space programs and private companies can fulfill promises of lunar and Martian settlement, there is still time to formulate helpful norms and best practices in outer space, avoiding hasty lawlessness, environmental harm, and wasteland—legacies of the California Gold Rush.

Résumé

Les principales puissances spatiales prévoient de retourner sur la Lune, d'extraire des ressources lunaires et d'un jour se servir de la Lune comme tremplin pour se rendre sur Mars et d'autres corps célestes. Face à ces ambitions, le cœur du droit de l'Espace a été conçu à une époque de compétition spatiale entre deux États avec des idées parfois sans vision à long terme de l'exploration spatiale. Cette thèse oppose le paradigme sans contraste du droit spatial issu de la guerre froide à la réalité complexe des aspirations spatiales de 2023 et au-delà. Elle suppose que le droit de l'Espace en vigueur permette dans une certaine mesure l'établissement lunaire et l'extraction de ressources. Cependant, l'absence de normes et de réglementations spécifiques incite à une « ruée vers l'or galactique » qui favorisera des pratiques destructrices et insoutenables aux effets irréversibles.

Cette thèse examine si le cadre juridique actuel en droit spatial protège adéquatement contre l'épuisement des ressources lunaires, la conservation des terres et la préservation des sites historiques de la Lune. Elle soutient que l'encadrement juridique ne peut garder le rythme des avances technologiques. La méthodologie pondère les dommages potentiels sur l'environnement par rapport aux garanties juridiques tout en valorisant un menu interchangeable de préoccupations environnementales. De plus, puisque le droit de l'Espace est insuffisant pour assurer ces protections, cette thèse évalue les mesures juridiques alternatives pour guider l'exploration spatiale et l'extraction de ressources futures. La ruée vers l'or galactique doit être dissuadée à tout prix. Avec encore des années avant que les programmes spatiaux nationaux et les entreprises privées ne puissent tenir leurs promesses d'établissement sur la Lune et sur Mars, il est encore temps de formuler des normes utiles et des pratiques exemplaires dans l'espace extra-atmosphérique, évitant une illégalité précipitée, des dommages environnementaux et des terres dévastées—des héritages de la ruée vers l'or de Californie.

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List of Acronyms and Abbreviations

COPUOS	Committee on the Peaceful Uses of Outer Space
COSPAR	Committee on Space Research
DOD	Department of Defense
EIA	Environmental Impact Assessment
ET	Environmental Target
GEO	Geostationary Orbit
GSO	Geosynchronous Orbit
ICJ	International Court of Justice
LCROSS	Lunar Crater Observation and Sensing Satellite
LEO	Low Earth Orbit
LPA	Lunar Protected Area
MPA	Marine Protected Area
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
OOSA	Office for Outer Space Affairs
OST	Outer Space Treaty
PCALD	Permanent Court of Arbitration for Lunar Disputes
PRC	People's Republic of China
PSR	Permanently Shadowed Region
REE	Rare Earth Element
SpaceX	Space Exploration Technologies Company
U.K.	United Kingdom

U.N.	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSC	United National Security Council
U.S.	United States of America

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I. Introduction

> *"About seven in the morning of January 24, 1848, James Marshall, a carpenter from New Jersey, was walking along part of the bed of the American River in Northern California a hundred or so crow-flying miles northeast of San Francisco. He was in charge of building a lumber mill for a Swiss émigré, John Sutter. To speed up the job, he had had a temporary dam built, then blasted so the released water would scour out the bed, and now he was investigating the results. He looked down, saw a sparkle, and picked up a shiny flake. By that afternoon, a few simple tests confirmed it was gold."*[1]

A. Historical Background

Fifty years after the first moon landing, the United States ("U.S.") declared plans in 2019 to send astronauts back to the Moon for "discovery, economic benefits, and inspiration for a new generation of explorers."[2] The mission to revisit the Moon serves as a test case for a sustained lunar presence and a potential stepping stone for Martian and deep space exploration.[3] The U.S. National Aeronautics and Space Administration ("NASA") named its ambitious lunar mission after Artemis, the twin sister of Apollo in Greek mythology.[4] NASA immediately sought a more than $1 billion increase in its budget to meet a 2024 deadline set by then-Vice President Mike Pence in March 2019.[5] Despite scrubbed launch attempts in the summer and autumn of 2022, NASA has demonstrated steady years-long progress in its Artemis campaign.[6] With a jaw-

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[1] Benjamin Mountford & Stephen Tuffnell, eds, *A Global History of Gold Rushes*, California World History Library (Berkeley: University of California Press, 2018) at 42, online: <https://doi-org.proxy3.library.mcgill.ca/10.1525/9780520967588>.

[2] Brian Dunbar, "NASA: Artemis" (last visited 5 September 2022), online: *NASA* <https://www.nasa.gov/specials/artemis/index.html> [*NASA*].

[3] See generally Robert Lea, "The Artemis plan: Why NASA sees the moon as a stepping stone to Mars" (24 August 2022), online: *Space.com* <https://www.space.com/artemis-1-moon-stepping-stone-mars> [*The Artemis plan*].

[4] Ashley Strickland, "NASA details Artemis moon missions, named after Apollo's twin sister" (24 July 2019), online: *CNN* <https://www.cnn.com/2019/07/24/us/nasa-artemis-program-scn/index.html>.

[5] Kenneth Chang, "For Artemis Mission to Moon, NASA Seeks to Add Billions to Budget", *The New York Times* (13 May 2019), online: <NYTimes.com> [https://www.nytimes.com/2019/05/13/science/trump-nasa-moon-mars.html].

[6] Kenneth Chang, "Why NASA Is Going Back to the Moon", *The New York Times* (28 August 2022), online: <NYTimes.com> [https://www.nytimes.com/2022/08/28/science/nasa-moon-rocket-launch.html].

dropping price tag of more than $100 billion to date, the U.S. believes that the Artemis mission is worth the investment.[7]

The U.S. is not alone in expressing renewed interest in lunar and Martian exploration. The Russian Federation and the People's Republic of China ("China" or "PRC") have pledged to cooperate on missions to the Moon and an asteroid.[8] This partnership comes as Russia notified parties of its intended withdrawal (effective 2024) from the International Space Station agreement, a long-standing joint undertaking by leading spacefaring states.[9] Despite its glory days in space exploration as the former Soviet Union, Russia now desires to hitch its wagon to the "world's new space power": China.[10] With blueprints for missions to the Moon and beyond, the PRC and Russia directly compete with the U.S. in what could become the new space race.[11] The stage is set for multiple spacefaring powers to follow through on promises to build lunar settlements, further explore the Moon, extract frozen water and minerals, and remake the Moon as a springboard for further space exploration.[12]

In addition to States, private companies intend to commercialize space exploration and outdo government projects thanks to nimble operations, minimized launch costs, and private investment.[13] While States were the spacefaring actors of the Cold War, super-wealthy individuals

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[7] *Ibid*.

[8] Andrew E Kramer & Steven Lee Myers, "Russia, Once a Space Superpower, Turns to China for Missions", *The New York Times* (15 June 2021), online: <NYTimes.com> [https://www.nytimes.com/2021/06/15/world/asia/china-russia-space.html].

[9] *Ibid*.

[10] *Ibid*.

[11] *Ibid*.

[12] Francis Lyall & Paul Larsen, *Space Law: A Treatise*, 2d ed (New York: Routledge, Taylor and Francis Group, 2018) at 177.

[13] Svetla Ben-Itzhak, "Companies are commercializing outer space Do government programs still matter?" (11 January 2022), online: *The Washington Post* <https://www.washingtonpost.com/politics/2022/01/11/companies-are-commercializing-outer-space-do-government-programs-still-matter>.

now wield unthinkable resources that outstrip the capabilities of entire States.[14] In 2021, Richard Branson and Jeff Bezos, owners of Virgin Galactic and Blue Origin, respectively, stole headlines with their private space race as each trumpeted plans to commercialize space tourism.[15] Paul Allen of Stratolaunch Systems and Elon Musk of SpaceX also vie for headlines with their spacefaring corporations.[16] With each ambitious development in the private sector, humanity approaches the point at which travel by spacecraft will seem as mundane as travel by aircraft. In addition to space tourism, private enterprises have ambitions to mine the Moon and other celestial bodies for water and minerals.[17]

Against this backdrop, competing States and companies are bound by international law drafted in the era of the Sputnik and Apollo missions, which is well-intended but as antiquated as the spacecraft from that era. The foundational legal document governing outer space is the Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("OST").[18] The OST was drafted in 1967 and boasts 111 State ratifications (including all significant spacefaring States) and 23 signatories.[19] It

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[14] *Ibid*.

[15] Kenneth Chang, "Richard Branson Will Try to Beat Jeff Bezos to Space With July 11 Flight", *The New York Times* (7 February 2021), online: <NYTimes.com> [https://www.nytimes.com/2021/07/01/science/richard-branson-jeff-bezos-space.html].

[16] Eric Johnson & Joey Roulette, "Exclusive: Space firm founded by billionaire Paul Allen closing operations - sources" (31 May 2019), online: *Reuters* <https://www.reuters.com/article/us-space-exploration-stratolaunch-exclus/exclusive-space-firm-founded-by-billionaire-paul-allen-closing-operations-sources-idUSKCN1T12FD>.

[17] Christian Davenport, "A dollar can't buy you a cup of coffee but that's what NASA intends to pay for some moon rocks" (3 December 2020), online: *The Washington Post* <https://www.washingtonpost.com/technology/2020/12/03/moon-mining-contracts-named/>.

[18] *Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, (entered into force 27 January 1967) [*OST*].

[19] *Ibid*; see also *ibid*; see also Sophie Goguichvili, Alan Linenberger & Amber Gillette, "The Global Legal Landscape of Space: Who Writes the Rules on the Final Frontier?" (1 October 2021), online: <https://www.wilsoncenter.org/article/global-legal-landscape-space-who-writes-rules-final-frontier> [*The Global Legal Landscape of Space*].

declares outer space "the province of all mankind"—a public commons free from claims of State sovereignty—yet provides little in the way of detailed rules or procedures for conduct, mining entitlements, and environmental protection.[20] The nebulous and aspirational terms of space law harkening from another era are directly at odds with a sweeping wave of State agencies and for-profit activists gearing up for aggressive space exploration.

B. Research Rationale

This Thesis overlays the black-and-white space law paradigm of the Cold War with the technicolor reality of space ambitions in 2023 and beyond. It presumes that space laws permit lunar mining or are sufficiently silent on the matter, and States will proceed with lunar mining operations without substantial resistance. However, the Thesis argues that a vacuum of specific norms and regulations incentivizes a "galactic gold rush" that will foster reckless and environmentally unsustainable practices.[21] Particularly, the critical piece of outer space law, the OST, addresses outer space environmental concerns very little, thus not providing clear legal boundaries for spacefaring parties.

It has been said that the "law never seeks to regulate technology, but rather aims to place an order in the competing human interests that result from that technology."[22] This could not be truer for the space race currently unfolding. The rationale for this Thesis stems from the overwhelming State and private ambition to explore and exploit outer space assets and the lack of detailed legal guidance.[23] This could place humanity on a crash course for an environmental

[20] *OST*, *supra* note 18.

[21] John Wrench, "Non-Appropriation, No Problem: The Outer Space Treaty Is Ready for Asteroid Mining" (2019) 51:1 Case W Res J Int'l 437.

[22] Michel Bourbonniere, "National-Security Law in Outer Space: The Interface of Exploration and Security" (2005) 70 J Air L & Com 3 at 3.

[23] Ram S Jakhu, Joseph N Pelton & Yaw Otu Mankata Nyampong, *Space Mining and Its Regulation*, New Space Ventures (Switzerland: Springer International Publishing, 2017) at 113 (stating that "[t]he term "space exploration"

disaster in outer space. Without clarity and reliable legal provisions, the lunar environment is as vulnerable as the untamed California environment of the early nineteenth century.

C. Research Objectives

This Thesis examines whether the OST and other sources of space law offer sufficient legal safeguards to protect against the most immediate environmental threats: lunar pollution, resource depletion, and degradation of historic areas on the Moon. It argues that space law is insufficient to protect vital environmental interests based on vague and outdated notions in treaty law. To conduct this evaluation, the Thesis sets forth a methodology for weighing the effects of lunar mining against space law protections to determine if specific environmental concerns on the Moon are adequately protected. With this methodology, the Thesis evaluates whether space law adequately protects enumerated environmental goals on the Moon.

After arguing and demonstrating that legal safeguards are insufficient, this Thesis next puts forth proposals to preserve these critical environmental objectives. The space law context is uniquely challenging and, at times, unprecedented because actors struggle to find relevant guidance due to inarticulate space law and conflicts between international and national laws. Without clear laws, States will revert to a "galactic gold rush," in which the first to arrive on a celestial body will wreak environmental havoc without concern for future generations or environmental preservation. States and policymakers must disincentivize this at all costs.

Perhaps there is no more significant objective in our lifetime than extending our Earth-based best practices to the black void, where the law has not kept pace with technology. Another wave of space exploration may crest soon. Legal regimes must stay abreast of launch technology

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refers to all activities related to discoveries in outer space and natural resources of the planets [.] and space 'exploitation on the other hand means extraction and refinement of natural resources essentially for commercial purposes').

to avoid environmental calamity. The California Gold Rush of 1848 is particularly apt, demonstrating the risks of an unbridled race to largely untouched land bearing vast natural riches.

Without a guiding methodology and sturdy legal framework to constrain commercial interests, a wave of modern forty-niners may depart this world unbound by legal constraints and notions of environmental well-being. There is still time to formulate priorities, norms, and best practices in outer space, avoiding hasty lawlessness and wasteland—regrettable legacies of the California Gold Rush.

II. Comprehensive Literature Review

> *"Nothing set the world in motion like gold. Between 1848 and the turn of the twentieth century, the global rush to find and extract precious metal from the earth in previously unimaginable quantities inspired a dramatic burst of movement and energy, affecting the course of world history. In California, and then across the Pacific Rim and parts of Africa, gold discoveries and the rushes that followed birthed new territories and states; triggered short-term booms and busts; provoked violent conflict with local indigenous and other resident communities; sparked entrepreneurship of all kinds; reordered production, trade, and labor; exposed humankind's capacity to alter the natural world; and created new hierarchies of difference and disconnection. These transformations took place on a global stage, as capital, people, and raw materials connected distant areas of the world in a spontaneous, contagious search for gold."*[24]

This Thesis joins an ongoing dialogue among practitioners and scholars about the capacity of space laws to regulate harmful human activities in outer space. Two notable characteristics of the field of relevant literature are worth noting at the outset. First, the field of space law is undoubtedly much smaller than other more broadly applicable fields of law, such as contract law. While the rights and obligations of contracting parties may stretch back as far back as humans have relied on each other's promises (resulting in a proportionately larger body of literature), space

[24] Mountford & Tuffnell, *supra* note 1 at 3.

law per se crystalized in the 1960s and 1970s. Therefore, the body of literature on space law is substantially smaller than many other bodies of law.

Second, while much is written on space law, the bulk of writings have centered on orbital debris and other popular "centers of gravity" in space law rather than the particular considerations of lunar mining, which is the focus of this Thesis. This is not to undervalue the importance of space law writing on topics other than orbital debris, which receives considerable attention. On the contrary, new topics are exceptionally deserving of attention. Nevertheless, lunar preservation is perhaps a niche topic within the greater niche subject matter of outer space law. The following literature review is guided accordingly.

The objectives of the literature review are two-fold. First, to evaluate the strength of the space law regime, this Thesis will determine what scholars have written about the OST's efficacy in environmental law. Therefore, the literature review will focus, for example, on scholarly determinations regarding whether the OST's provisions have the regulatory and enforcement power to meaningfully stop a State from polluting on the Moon. Notably, the focus will be on whether scholars believe that the status quo legal framework is sufficient to restrict commercial actors that wish to appropriate swaths of the Moon, mine the lunar surface, and operate close to the original Apollo 11 landing site.

Second, this Thesis will describe proposals to shore up the space law framework. Thus, the literature review will examine what other scholars have proposed as supplementary measures to bolster the OST. Many writers have taken the stance that the OST is too vague and aspirational to offer significant deterrence or leverage for those seeking unfettered commercial access to the Moon. In that case, the Thesis will examine what can complement earlier proposals to strengthen

the OST. This Thesis will join the conversation of past authors to arrive at original and compelling proposals.

The relevant literature for the Thesis falls into discrete groupings and academic stances. First, the Thesis will address the adequacy of existing space laws, concluding that existing laws are, on the whole, inadequate to prevent lunar pollution, resource depletion, and the destruction of historic areas. This stance is consistent with most past scholarly writings on this subject. Haroun, for example, maintains that the "current international legal regime regulating space activities has proven to be incapable" of addressing space pollution.[25] In support, other authors agree that the existing space law regime is ineffectual at halting pollution and preserving resources and historical sites.[26]

Indeed, the literature review reveals only a few scholars who believe the current legal regime is adequate, and even those authors still propose steps to strengthen the space law regime.[27] Since the earliest publications relevant to the Thesis, scholarship has centered on the relative

[25] Fawaz Haroun, "Toward the Sustainability of Outer Space: Addressing the Issue of Space Debris" (2021) 9:1 New Space 63 at 69.

[26] M Deva Prasad, "Relevance of the Sustainable Development Concept for International Space Law: An Analysis" (2019) 47:166 Space Policy at 168; Rutwik Navalgund, "Reduce, Reuse and Recycle: An Environmental Law Approach to Long-term Sustainability of Outer Space" (2020) 45:1 Air & Space Law 285 at 289; Daniel Capper, "What Should We Do with our Moon?: Ethics and Policy for Establishing International Multiuse Lunar Land Reserves" (2022) 59:1 Space Policy 148 at 155; David Tan, "Towards a New Regime for the Protection of Outer Space as the 'Province of All Mankind'" (2000) 25:145 Yale Journal of International Law 149 at 147; Jean-Frederic Morin & Benjamin Richard, "Astro-Environmentalism: Towards a Polycentric Governance of Space Debris" (2021) 12:4 Global Policy 2 at 2; Vishakha Gupta, "Critique of the International Law on Protection of the Outer Space Environment" (2016) 14:1 Astropolitics 20 at 20–43; Scot Anderson, Julia La Manna & Korey Christensen, "The Development of Natural Resources in Outer Space" (2021) 51:10 Envtl L Rep 10835 at 10836.

[27] Molly Macauley, "Environmentally Sustainable Human Space Activities: Can Challenges of Planetary Protection be Reconciled?" (2007) 5:3 Astropolitics 209 at 209–236; Branislav Turcina, "International Law Obligations of States Authorizing Persons and Entities to Mine in Outer Space" (2018) McGill University Publications (LLM Thesis) at 28.

weakness of the space law regime to confront unforeseen environmental challenges.[28] While there is generally a consensus that space laws are ineffective in constraining environmental harms, the literature review reveals a modern shift from space debris to newer forms of environmental concern.

Among the environmental harms is orbital space debris, which comprises defunct rocket parts, satellites, tools, and miscellany that indefinitely orbit the Earth.[29] Orbital debris now receives overwhelming attention and scholarship in space law literature. For instance, Popova and Schaus address debris remediation as what they believe to be the primary environmental concern in outer space.[30] Their paper echoes numerous other papers that focus on space debris to the exclusion of various other forms of environmental harm.

In the last ten years, authors have increasingly addressed issues other than debris remediation envisioned in the Thesis. Capper, for instance, discusses "multiuse land reserves" to preserve land from mining operations.[31] His paper argues that large swaths of lunar land must be set aside from commercial development, lest commercial actors run rampant. Lixinski and Schreiber agree with Capper's proposal of land reserves. Still, they ground their proposal in

[28] Albert Gore, Jr, "Outer Space, the Global Environment, and International Law: Into the Next Century" (1990) 57:329 Tenn L Rev at 341; Nicolas Mateesco Matte, "Environmental Implications and Responsibilities in the Use of Outer Space" (1989) 14:419 Annals Air & Space L at 433; DE Reibel, "Environmental Regulation of Space Activity: The Case of Orbital Debris" (1991) 10:97 Stan Envtl LJ at 99.

[29] NASA, "What is Orbital Debris?" (8 June 2010), online: *NASA Knows* <https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbital-debris-58.html>.

[30] Rada Popova & Volker Schaus, "The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space" (2018) 5:2 Aerospace Journal 2 at 35.

[31] Capper, *supra* note 26 at 155.

protecting cultural heritage, whereas Capper grounded his proposal in the preservation of the natural beauty of the Moon.[32]

Lixinski and Schreiber are more motivated to preserve "traces of human existence" with archaeological and natural contexts on the Moon.[33] As they explain, beginning with the Apollo 11 landing, humans have marked the surface of the Moon, and several of those historical sites are deserving of protection from other lunar activities with less significance for humankind.[34] To be sure, land protection through landmarking and preserved areas would secure the untouched nature of broad swaths of the Moon. Still, it would also serve an important anthropological purpose for the lunar areas where humans first impacted and explored the Moon.

Spennemann similarly urges humankind to recognize and protect the extraterrestrial heritage of the Apollo program, noting that the Moon's lack of atmosphere has preserved Neil Armstrong's first bootprints on the lunar surface.[35] Yet, Spennemann's proposal is rooted in "management ethics" that he believes should apply on the lunar surface. Such non-legal ethics principles are mainly outside the scope of the Thesis. Still, they find a valid and worthy objective: preserving lunar historical remnants at all costs—legal or extralegal.

Losch joins Spennemann to form a minority of scholars looking beyond space debris remediation. Losch zooms out and writes about "planetary sustainability," focusing on macro-level initiatives to preserve entire planetary ecosystems.[36] While his expanded scope is laudable, the Thesis will find an appropriate scope between a narrow focus on space debris remedies and

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[32] Lucas Lixinski, MM Losier & Hanna Schreiber, "Envisioning a Legal Framework for Outer Space Cultural Heritage" 45:1 J Space L at 1.

[33] *Ibid*.

[34] *Ibid*.

[35] Dirk HR Spennemann, "The Ethics of Treading on Neil Armstrong's Footprints" (2004) 20:279 Space Policy at 282.

[36] Andreas Losch, "The Need for an Ethics of Planetary Sustainability" (2019) 18:259 Intl J Astrobiology at 266.

Losch's vast scope of planetary protection. Indeed, a vital aspect of the literature review and this Thesis is the breadth of the scope of inquiry. This Thesis restricts its scope to outer space mining on the Moon only, yet analysis and aspects of this Thesis may later be broadened to other celestial bodies in our universe.

A final category of interest focuses on the legal proposals to address shortcomings in space law. The Thesis concludes that the existing space law framework must be revised to safeguard environmental interests. Thus, the Thesis proposes measures to bolster the space law framework as a logical next step. It argues that States are unlikely to ratify a new multilateral agreement or agree to a treaty amendment today based on their unwillingness to sign significant, progressive space treaties since the OST of 1967.[37] Instead, a voluntary regulatory framework based on regime-building or adjudication by the International Court of Justice ("ICJ") is required.

This approach finds support from scholars in the literature review. For example, Kellman maintains that environmental issues in space are "an international legal matter for judicial resolution."[38] While his scholarship focuses exclusively on orbital debris, his approach consisting of ICJ adjudication of State responsibility for space debris conceptually applies to other forms of environmental harm. As a result, the ICJ provides one viable avenue for space debris remediation and conceivably for lunar pollution and resource depletion. Alternatively, other fora providing judicial or arbitration dispute settlement may offer viable routes to conflicts over the use or exploitation of regions of the Moon.

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[37] Peter Baker, "For Biden, an Era When Treaties Are More Likely to Be Broken Than Brokered", *New York Times* (10 April 2023), online: <https://www.nytimes.com/2023/04/10/us/politics/biden-good-friday-agreement-diplomacy.html>.

[38] Barry Kellman, "Space: The Fouled Frontier: Adjudicating Space Debris as an International Environmental Nuisance" (2014) 39:2 J Space L at 227.

Beyond the ICJ, Dallas proposes a regulatory framework for "environmental impact assessment" ("EIA") in space.[39] The EIA has historically been used to "assess the potential environmental consequences of a particular project or action" before executing a project.[40] Its success on Earth is well recognized, beginning in the United States in 1969 under the National Environmental Policy Act and finding adoption in many other States.[41] The Thesis will explore this concept in greater depth. The EIA or a similar idea would permit a regulatory body such as the United Nations ("U.N.") to review proposed changes to the lunar surface and seek public input before deciding whether to endorse outer space mining operations.

Besides ICJ enforcement and the EIA process, the literature review reveals more unique approaches. For instance, Altabef agrees with Kellman about ICJ enforcement but proposes "environmental personhood" to address contamination and resource exploitation.[42] Altabef asserts that there is no way to hold outer space polluters accountable because the existing international legal regime is too weak and unenforceable. Still, outer space environmentalists could seek to recognize celestial bodies as juridical persons and seek damages before an international tribunal.[43] Yet, very little has been written about recognizing the Moon as a juridical person. Moreover, while environmental personhood is a singular concept, it is also relatively undeveloped and somewhat experimental.

Although the above literature sometimes addresses ineffectual space laws and pending threats to the space environment, only a few publications address the unique threats of lunar

[39] JA Dallas, S Saydam & AG Dempster, "An Environmental Impact Assessment Framework for Space Resource Extraction" (2021) 57:101441 Space Policy at 442.
[40] *Ibid*.
[41] *Ibid*.
[42] William B Altabef, "The Legal Man in the Moon: Exploring Environmental Personhood for Celestial Bodies" (2020) 21:476 Chicago Journal of International Law 479 at 480.
[43] *Ibid*.

mining. Fewer still connect legal proposals to the existing legal framework. This Thesis will join a minority of authors like Losch and Spennemann writing about environmental issues beyond orbital debris. Commercial lunar mining is an existential challenge but is absent from the legal discussion.

The Thesis will fill a gap in the literature by linking the "due regard" requirement under Article IX of the OST to Dallas's EIA framework. Finally, the Thesis will recognize the possibility for land perseveration as proposed by Losch and Spennemann. However, it will examine pursuing this aim via regime-building from leading spacefaring states or ICJ litigation rather than a new convention.

III. Research Methodology

> *"What happened? First, an environmental apocalypse. Indians lived by a hunting-gathering-fishing culture that supported a surprisingly high standard of living but required unfettered access to a large and relatively undisturbed area. Undisturbed, however, is not a word anyone would apply to the site of a gold rush. Professional hunters quickly depleted populations of anything four-legged and edible. Miners wrote of 'poor Indians . . . driven to actual starvation' on lands 'as sterile as a sandbar,' with 'no wild animals except Indians, lizards, and black-tailed hares.' […] Simply by being there, residents of the camps disrupted the migrations of animals and interrupted the Indians' intricate, carefully choreographed annual rounds. The Native world of day-to-day survival unraveled."*[44]

The methodology of the Thesis is structurally guided by the problem described in the introduction and the progress in the academic field as framed by the comprehensive literature review. The methodology is practical because it encompasses the problem's core components and introduces variables to craft legal proposals. It takes inspiration from mathematical models but leaves enough flexibility to be molded to legal problems and policy proposals.

[44] Mountford & Tuffnell, *supra* note 1 at 44–46 (citing Katherine A White, comp, A Yankee Trader in the Gold Rush: The Letters of Franklin A Buck [Boston: Houghton Mifflin, 1930], 107, 110; William Tell Parker, journal, July 22, 1850, Henry E Huntington Library, San Marino, California).

As depicted below, the first variable of the methodology—the starting point—is the status-quo Moon, i.e., the Moon as it currently exists. It is important to note that the status quo Moon is not undefiled, as it appears to the naked eye from Earth, but rather the condition of the Moon following almost 70 years of human exploration and use. In that time, space vehicles have landed on the Moon, humans have walked on it, and objects have crashed into the Moon and been left there in various states of disarray. This becomes relevant for the methodology below with the proposition, for example, that humans could depart the Moon in 2043 better than it was in 2023.

To this first variable, the Thesis subtracts the impact and effects of lunar operations, which will be described more fully herein. The focus of such operations in this Thesis is lunar mining operations, comprising lunar landing, infrastructure build-up, extraction and refining, and transportation from the Moon. Thus, the effects of lunar mining operations address land use, resource depletion, and waste products from mining operations.

Next, to blunt the impact of lunar operations, the Thesis adds the protections and safeguards of space law. As will be more fully explained herein, the variable of space law is broad and encompasses treaties, U.N. General Assembly resolutions, customary international law, and related State laws and regulations. In theory, these protections would offset and even reverse the threats posed by lunar mining operations to the status quo Moon.

Lastly, the methodology equation includes the Moon ex post facto, which envisions the condition of the Moon after the impact of lunar mining operations is incorporated and legal protections are observed. Four Environmental Targets ("ETs") from the U.N. Biodiversity Summit of 2022 are also part and parcel of the ex post facto Moon to ensure these environmental considerations are observed. These ETs are addressed further herein and represent the most pressing concerns for lunar preservation. The equation qua methodology posits that legal

protections are sufficiently robust and protective only if the ex post facto Moon with ETs is better than or equal to the status quo Moon. Only in that way can it be said that the legal regime protects or improves lunar environmental interests from the worst effects of lunar mining operations.

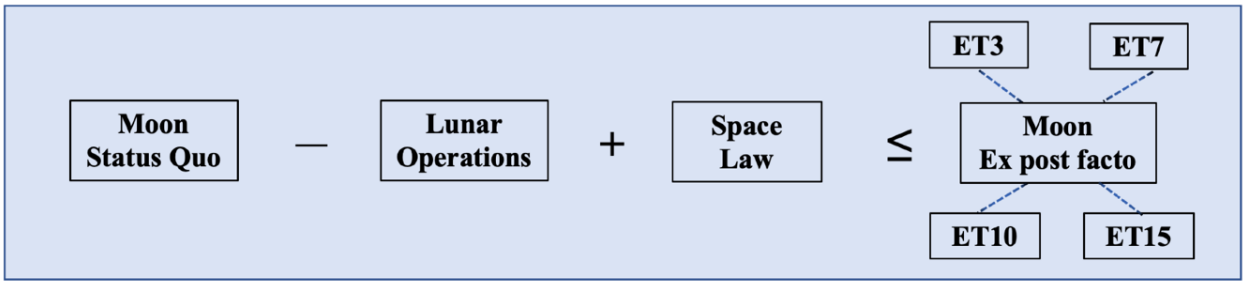

Figure 1. Methodology as Research Formula

Complex legal and regulatory regimes can scarcely be reduced to a handy formula with precision. Indeed, the variables above do not represent exact values as one would find in a classic mathematical formula. Thus, a limitation of the formula is that it can lead to reductionist or oversimplified views on an incredibly complex subject matter. Still, the formulaic methodology provides several benefits for the Thesis.

First, the methodology is a clear roadmap for what the Thesis will discuss and research. As a fundamental question, the Thesis asks whether space law is adequate to protect the lunar environment. Thus, the formula permits a binary determination: either it is "true," and the Moon with ETs is adequately insulated from environmental threats, or the equation is "false," so proposals must shore up the existing legal infrastructure. Even if the equation is "true," future generations must ensure that successive mining operations do not exceed set limits such that ETs are not achievable, later rendering the equation "false." Moreover, if space law is not adequately durable and protective—i.e., if the equation is "false"—what measures may States take to safeguard such environmental interests? How might we propose scaling back lunar mining operations or bolstering space law to meet future ETs? If the formula is "true," it guarantees that

conditions are optimal to proceed with lunar mining operations, knowing that humankind can still leave the Moon in a condition as pristine as it is status quo.

Second, the methodology provides a visual and easily accessible tool to test and modify aspects of the Thesis. To illustrate, if the impact of lunar operations is increased, then the safeguards of space law provisions must proportionately increase to offset the impact of lunar operations or the ETs must be reduced so that the formula remains "true." Alternatively, if space law protections are increased, the formula could absorb even more damaging lunar operations. As a final illustration, if ETs were added to the formula, lunar operations must decrease, or space law protections must increase. In this way, the methodology demonstrates a prevailing tension among the variables in the Thesis. This inherent relationship among components also allows for thought experiments when adjusting the variables of the formula.

Third, the methodology as formula presents a visual reminder of the sequence of topics in this Thesis. The chapters will progress from the status quo Moon (Section IV) to lunar mining operations (Section V), to space law and authorities (Section VI), to the ex post facto Moon (Section VII), and finally to legal analysis and proposals (Sections VIII and IX). In this way, the methodology presents a logical sequence to examine the central legal problem and put forth proposals.

The core of the Thesis will be to overlay proposed commercial lunar mining operations with existing space laws and the stark reality of limited lunar real estate. For example, suppose a company plans to mine 1,000 acres near the lunar south pole. The Thesis will examine whether such a proposal in the abstract would comply with the non-appropriation principle and due regard principle in the OST.

As an additional example, if another company plans to mine for Labradorite near the south pole of the Moon, then based on known deposits of lunar minerals, the Thesis will explore which provisions of the OST can ensure that the company does not fully deplete the Moon of this mineral. And if the company were to substantially mine all of the Labradorite early on, the Thesis will examine other States' recourse under the OST and related legal provisions. Through concrete examples, ecosystem priorities will be aligned with outer space activities to judge whether existing space law provides adequate safeguards for the space environment.

Ultimately, the methodology will reveal that the OST lacks (1) sufficient textual specificity (i.e., is overly aspirational and imprecise), (2) foresight for the types of outer space land and environmental disputes that may arise, and (3) general awareness and concern for environmental protection, which garnered more global attention just as the OST went into force in 1967. For instance, while Article IX of the OST briefly forbids "harmful contamination" of the Moon and other celestial bodies, it says little about preserving lunar historical sites, natural resources, or geographical features.[45]

These shortcomings provide a basis to propose revising treaty law, creating beneficial customary international law, or marshaling non-State actors to voluntarily develop standards for environmental preservation in outer space. In summary, the Cold War-era space law framework is not likely to hold up well against lunar mining operations, keeping in mind the proposed ETs. Still, this realization will likely spur innovative proposals and an ongoing dialogue to foreclose a destructive land rush in outer space.

[45] See *Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 27 January 1967, 610 UNTS 205 (entered into force 10 October 1967), at art IX.

IV. The Status Quo Moon

> "*None of the invaders—Western or Chinese—were arriving into unoccupied territories. The transnational circuits that converged on gold rush borderlands had catastrophic impacts on indigenous communities. While the appearance of goldseekers might present new opportunities for employment and trade, the miners and their followers also brought death and destruction through disease, violence, and environmental cataclysm*."[46]

A. Past and Present Moon

Following the description of the methodology used in this Thesis, this section describes the first variable in the methodology formula in greater depth. The Moon today does not fit the concept that perhaps most people hold as Earth's virtually untouched, pristine satellite. Instead, the Moon has already been trodden by humans since the Apollo 11 landing in 1969.[47] And even when space operations did not involve humans setting foot on the Moon, humans have inevitably landed objects—sometimes quite forcefully—on the surface of the Moon. Thus, the status quo Moon in 2023 is already a ragged canvas for humanity's many excursions, absorbing impacts and harboring obsolete objects and human waste.[48]

Humanity's first object in outer space was the Soviet Union's Sputnik satellite in 1957.[49] This launch was the harbinger of crewed space flight, though humanity soon learned that it is "easier to go for launch" but much more complicated once humans are in orbit.[50] Today, over 70

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[46] Mountford & Tuffnell, *supra* note 1 at 12.

[47] NASA, "Apollo 11 Mission Overview" (5 January 2022) at 1, online: *Apollo 11* <https://www.nasa.gov/mission_pages/apollo/missions/apollo11.html>.

[48] John Wenz, "Here's How Much Poop is on the Moon" (13 January 2015), online: <https://www.popularmechanics.com/space/moon-mars/a13598/is-there-poop-on-the-moon-17630231/> (stating that because of weight limitations, Americans left behind about 96 bags of urine, feces, and throw-up during the Apollo missions).

[49] US Department of State, "Sputnik, 1957" (last visited 20 February 2023), online: *Milestones: 1953-1960* <https://history.state.gov/milestones/1953-1960/sputnik>.

[50] "Space Junk: How do we Solve the Problem of Dead Satellites?" (7 August 2022), online (video): <https://youtu.be/yfQUsqOfYs0>.

"national and regional space agencies" support substantial space programs and capabilities.[51] Yet, unlike the early years of the Space Race, it is not just States with spacefaring capabilities that are active in outer space today. Instead, States must now share outer space with private companies.[52] Without regulations and management of outer space activities, the cislunar space may feel congested and unruly.

This is to say nothing of orbital debris, a topic with substantial attention for many years now.[53] Of approximately 34,000 orbiting objects of ten or more centimeters in size, about 29,000 can be tracked with reliability.[54] With around 6,000 satellites in orbit, fewer than half still function.[55] Non-functioning satellites and objects continue to orbit the Earth, posing a hazard to cislunar and lunar operations.

Since the first human arrival, the Moon has served as a junkyard for explorers unable to bring back human and mechanical waste on the return trip to Earth. With more instances of waste on the lunar surface, risks for landings and future lunar missions invariably increase. Waste can interfere with proper landings or be picked up by forceful takeoffs and landings, becoming airborne debris that can injure humans or damage property. By some estimates, the Moon is covered with

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[51] Simonetta Di Pippo, "Space Technology and the Implementation of the 2030 Agenda" (December 2018), online: *UN Chronicle* <https://www.un.org/en/chronicle/article/space-technology-and-implementation-2030-agenda>.

[52] Ben-Itzhak, *supra* note 13.

[53] "Tracking Space Debris is a Growing Business" (16 September 2021), online: *The Economist* <https://www.economist.com/science-and-technology/tracking-space-debris-is-a-growing-business/21804756?utm_medium=cpc.adword.pd&utm_source=google&ppccampaignID=18798097116&ppcadID=&utm_campaign=a.22brand_pmax&utm_content=conversion.direct-response.anonymous&gclid=CjwKCAjwzuqgBhAcEiwAdj5dRrGpKjTzMsF_PrPgjNQuibFVyT76NlTO8uNFK49w2XY-k3gnu5EqkBoCAvUQAvD_BwE&gclsrc=aw.ds>.

[54] *Ibid*.

[55] *Ibid*.

400,000 pounds (181,436 kilograms) of human trash.[56] This is a sizeable amassing of garbage over humanity's twelve trips to the Moon.[57] This is also an awe-inspiring collection of garbage after only 300 hours that humans have been present on the Moon.[58]

Human trash includes spacecraft, spare parts, insulating blankets, wet wipes, human excrement, cameras, and photos.[59] NASA has even created publicly-accessible compilations of human artifacts left on the Moon, sorted by the U.S., the Soviet Union, and the Apollo Missions.[60] Strange and personal objects have been strewn around the Moon.[61] The reasons for stranded objects are largely practical, but these objects nevertheless present hazards for landing, debris, and obstacles to safe exploration of the lunar surface.[62] Unfortunately, such dangers from human trash are only expected to multiply with future missions to the Moon.[63]

The condition of the status quo Moon is worth emphasizing early in the Thesis because the methodology is premised partly on the notion that in future lunar operations, humans can leave the Moon better than they found it. This would not be possible if the Moon were untouched by humans as it was before the Apollo missions. It is essential to note the substantial impact humans have already had on the Moon, though we do not even reside on it. Leaving human waste on the Moon is one thing, but we have also left approximately 7,000 kilograms of non-biological waste on the

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[56] Nicholson, Sibel, "The Moon is Covered with 400,000 Pounds of Human Trash" (1 February 2018), online: *Interesting Engineering* <https://interestingengineering.com/science/the-moon-is-covered-with-400000-pounds-of-human-trash>.

[57] *Ibid*.

[58] William Park, "The Strangest Objects We've Left on the Moon" (19 February 2016), online: *BBC* <https://www.bbc.com/future/article/20160219-the-strangest-objects-weve-left-on-the-moon>.

[59] Nicholson, Sibel, *supra* note 56.

[60] NASA, "A Compilation of Human Artifacts on the Moon" (last visited 14 March 2023), online: *Human Artifacts on the Moon* <https://history.nasa.gov/humanartifacts.html>.

[61] Park, *supra* note 58.

[62] *Ibid*.

[63] *Ibid*.

surface of the Moon. Considering the state of the Moon today, the methodology is anchored in the possibility of lunar exploration while remedying some of the environmental damage we have already committed against the Moon.[64] Nevertheless, it is important that large swaths of the Moon remain untouched and undefiled. To the greatest extent possible, these areas should remain so.

B. Lunar Resources

In 2010, President Obama signaled that NASA would end its focus on lunar exploration and turn its attention to objects farther in outer space, like Mars and asteroids.[65] President Obama's reasoning was logical: based on a scientific understanding prevailing at the time, the Moon was a dusty satellite with nothing more to offer humanity for scientific research or economic development.[66] However, in a relatively short time, the American stance toward lunar exploration would reverse when President Trump proclaimed that the U.S. would renew its interest in the Moon and its intentions of landing there again.[67] The Moon would again take center stage in NASA's exploration goals.[68]

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[64] Cagri Kilic, "Mars is Littered with 15,694 Pounds of Human Trash from 50 Years of Robotic Exploration" (20 September 2022), online: *Yahoo News* <https://www.yahoo.com/video/mars-littered-15-694-pounds-123719142.html>.

[65] The White House, "President Barack Obama on Space Exploration in the 21st Century" (15 April 2010), online: *NASA News* <https://www.nasa.gov/news/media/trans/obama_ksc_trans.html> (President Obama stated: "Now, I understand that some believe that we should attempt a return to the surface of the Moon first, as previously planned But I just have to say pretty bluntly here: We've been there before Buzz has been there There's a lot more of space to explore, and a lot more to learn when we do So I believe it's more important to ramp up our capabilities to reach -- and operate at -- a series of increasingly demanding targets, while advancing our technological capabilities with each step forward And that's what this strategy does And that's how we will ensure that our leadership in space is even stronger in this new century than it was in the last").

[66] *Ibid*.

[67] Jacqueline Feldscher, "NASA Reassesses Trump's 2024 Moon Goal" (16 February 2021), online: *Politico* <https://www.politico.com/news/2021/02/16/nasa-trump-2024-moon-landing-goal-469135#:~:text=NASA%20is%20reviewing%20the%20Trump,will%20need%20to%20be%20delayed.>.

[68] *Ibid*.

The U.S. Artemis Program, devised by the Trump Administration and embraced by the Biden Administration, lends "momentum and bipartisan political support" for an incredibly ambitious, once-in-a-generation push for new space flight.[69] The earliest steps comprised the successful launch of the uncrewed U.S. Space Launch System moon rocket and Orion spacecraft in November 2022.[70] After the Artemis I mission concludes, other missions will include a crewed orbit of the Moon and an eventual return to the lunar surface.[71]

The reversal in American space policy toward the Moon is partly explained by a political changing of the guard but partly by an advancement in science justifying a new chapter of the limelight on the Moon.[72] The earlier notion that the Moon is bone-dry has been shattered or significantly modified.[73] Therefore, with President Trump's pronouncement and President Biden's adoption, NASA has pivoted to centralize the Moon in its future space missions.[74] The Artemis program has set the objective of learning and practicing "how to live in space sustainably."[75] Secondary considerations will include learning how the Earth was formed and transforming the Moon into a potential stepping stone to Mars and other deep-space destinations.[76]

Of primary importance, U.S. and international scientists have discovered that the Moon harbors vast amounts of frozen water around its North and South Poles.[77] Despite hypotheses about

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[69] *Ibid*.

[70] Christian Davenport, "The Moon Beckons Once Again, and This Time NASA Wants to Stay", *The Washington Post* (9 January 2023), online: <https://www.washingtonpost.com/technology/interactive/2023/nasa-moon-artemis-launch/>.

[71] *Ibid*.

[72] Feldscher, *supra* note 67.

[73] *Ibid*.

[74] *Ibid*.

[75] *Ibid*.

[76] Davenport, *supra* note 70.

[77] NASA, "NASA's SOFIA Discovers Water on Sunlit Surface of Moon" (26 October 2020), online: *NASA News* <https://www.nasa.gov/press-release/nasa-s-sofia-discovers-water-on-sunlit-surface-of-moon>.

water on the Moon, researchers could not confirm this partly because the frozen water is contained mainly in deep craters, the depths of which had rarely or never seen daylight.[78] Therefore, the frozen water is mainly invisible and was not discovered with any certainty until after President Obama's 2010 speech. This development had economic, political, and scientific ramifications for the U.S. and other leading space powers.[79]

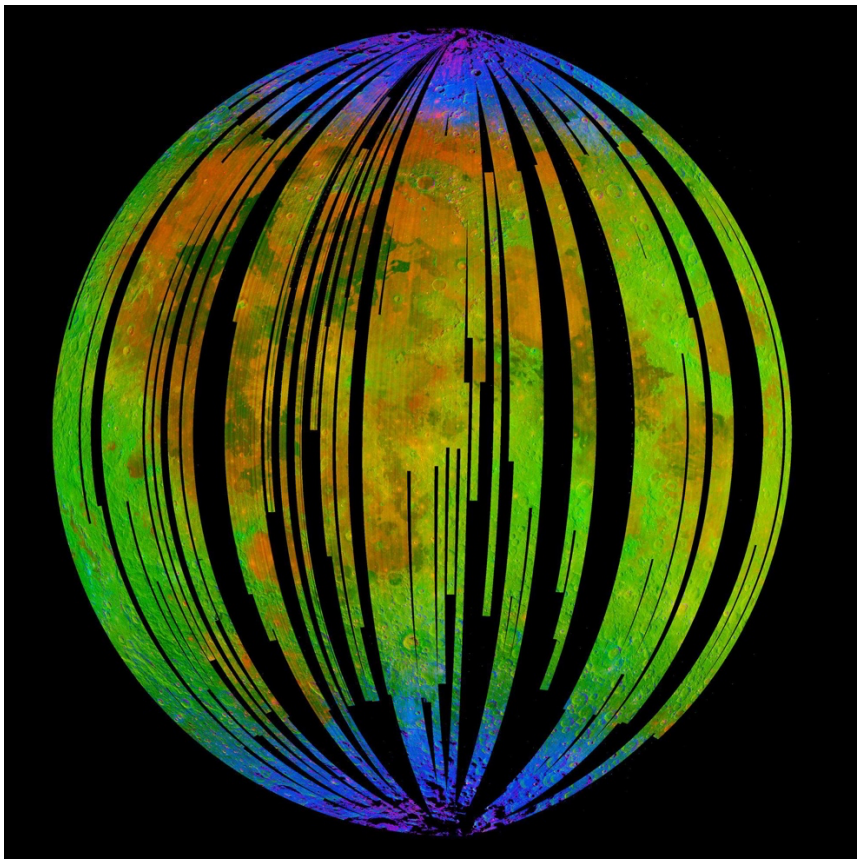

Figure 2. Composite Image Using Data from NASA's Moon Mineralogy Mapper[80]

The discovery of vast reserves of frozen water on the Moon, depicted in Figure 2, changed exploration priorities because water is fundamental to survival and deeper exploration of outer

[78] *Ibid*.

[79] NASA, "Water on the Moon" (last visited 20 February 2023), online: *NASA Science* <https://moon.nasa.gov/inside-and-out/water-on-the-moon/>.

[80] ISRO/NASA/JPL-Caltech/Brown University/USGS (A composite image using data from NASA's Moon Mineralogy Mapper Blue reflects areas of confirmed water ice on the lunar surface).

space. The obvious uses of water include human consumption, the creation of fuel, means of plant cultivation, and waste management. However, other benefits of water are equally valuable, such as breaking apart H_2O to form oxygen molecules and hydrogen atoms. Such molecular deconstruction can generate energy or create fuel for propulsion and exploration. In essence, billions of kilograms of frozen water signal that life on the Moon is sustainable and that the Moon itself may be transformed into a launching pad or refueling station for destinations further in the solar system.

Besides frozen water, the Moon also contains reserves of rare earth elements ("REEs").[81] Like water, these resources offer a means to power electronic devices and create wealth on Earth. Such resources take on enhanced value as humans deplete these substances through terrestrial mining and refining. Indeed, States covet REEs and guard them zealously within their borders.[82] With lunar reserves of unknown capacity, the Moon presents a lifeline for materials soon to be exhausted on Earth.

The unique geography of the Moon is worth noting. Many of the resources discussed already are clustered around the South Pole of the Moon, bringing concentrated interest to a relatively small area of the Moon.[83] Therefore, competition and jockeying for limited terrain and resources may cause enhanced conflict between States. Although our notion of where the Moon's most valuable resources may further develop, our current understanding is clear that most

[81] NASA, "Is Mining Rare Minerals on the Moon Vital to National Security?" (last visited 20 February 2023), online: *Solar System Exploration Research* <https://sservi.nasa.gov/articles/is-mining-rare-minerals-on-the-moon-vital-to-national-security/>.

[82] *Ibid*.

[83] NASA, "Moon's South Pole in NASA's Landing Sites" (15 April 2019), online: *NASA News* <https://www.nasa.gov/feature/moon-s-south-pole-in-nasa-s-landing-sites>.

resources are concentrated in a relatively small area, increasing the odds that States will rush to arrive, exploit as quickly as possible, and disagree on access when competing parties later arrive.

Lastly, historic landing sites on the Moon represent another consideration for preserving lunar terrain.[84] The original bootprints near the Apollo 11 landing site embody a sociohistorical relic worthy of preservation for future generations.[85] Even untrodden areas of the Moon deserve some degree of protection to maintain the untouched beauty of our satellite, as explained further herein. Whether this interest is protected depends on the strength of legal protections and the will of the parties concerned.

C. The Moon's Future: Clear Intentions to Explore and Exploit

Like the California free-for-all mining boom following the news of the 1848 discovery of gold, the lunar frontier beckons as a destination for any State or company with the resources and determination to journey to the Moon. As will be more fully described in Section VI of the Thesis, Article 1 of the Outer Space Treaty—a cornerstone of outer space law—states that the "exploration and use of outer space" is "the province of all mankind."[86] This central tenet forms the basis for viewing the vastness of outer space as a commons that is explorable by all and owned by none.[87]

If Article I of the OST opens the door for the "exploration and use" of outer space "by all States," Article II of the OST immediately limits the greatest ambitions of ownership, stating that outer space and celestial bodies are "not subject to national appropriation by claim of sovereignty, using use or occupation, or by any other means."[88] This limitation—the so-called non-

[84] NASA, "NASA Sets Guidelines for Apollo Moon Landing Sites" (last visited 20 February 2023), online: *Solar System Exploration Research* <https://sservi.nasa.gov/articles/nasa-sets-guidelines-apollo-moon-landing-sites/>.
[85] *Ibid*.
[86] *OST*, *supra* note 18.
[87] *Ibid*, art II.
[88] *Ibid*, art I, II.

appropriation principle—forbids States from appropriating or owning celestial bodies in any way. Some scholars argue that extracting minerals and other natural resources from public space terrain, especially for in situ usage, is not tantamount to "appropriation" under Article II of the OST.[89] This legal distinction sees a difference between claiming part of a celestial body, including the terrain below the surface, and merely using surface materials without overt claims of ownership that would exclude other States.

This goes to an important definitional distinction. Under international law, the exploration of the Moon is conceptually different from the *exploitation* of the Moon.[90] Whereas exploration connotes scientific development (including collection and removal of samples from space bodies) and new knowledge of the unknown, exploitation involves the "permanent appropriation of materials *in situ*."[91] While the preamble and Article I of the OST encourage exploration of the Moon and other celestial bodies, the argument for exploitation is less cogent.[92]

Further muddying the waters, some States have enacted national legislation expressly permitting legal ownership over what its nationals mine from asteroids.[93] The U.S., Luxembourg, the United Arab Emirates, and Japan have aggressively passed provisions to empower their citizens.[94] These legal provisions, and the notable absence of provisions on specific points, set the

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[89] Wrench, *supra* note 21 at 439.

[90] Lyall & Larsen, *supra* note 12 at 172.

[91] *Ibid*.

[92] *Ibid*.

[93] Brian Fung, "The House just passed a bill about space mining The future is here", *Washington Post* (22 May 2015), online: <www.washingtonpost.com> [https://www.washingtonpost.com/news/the-switch/wp/2015/05/22/the-house-just-passed-a-bill-about-space-mining-the-future-is-here/]. (stating "Any asteroid resources obtained in outer space are the property of the entity that obtained such resources, which shall be entitled to all property rights to it, consistent with applicable provisions of Federal law); Sarah Scoles, "Luxembourg's New Law Lets Space Miners Keep Their Plunder", Wired (2017), online: <www.wired.com> [https://www.wired.com/story/luxembourgs-new-law-lets-space-miners-keep-their-plunder/].

[94] Atkins, Scott, "The Commercialisation of Outer Space" (2022) 19:3 Norton Rose Fulbright.

stage for aggressive space exploitation, akin to prospectors' arrival in California, eager to make their fortune.

D. The California Gold Rush as Cautionary Tale

On January 24, 1848, James Marshall fatefully discovered the first golden nuggets, sparking a massive influx of miners and investment, later known to the world as the California Gold Rush.[95] Marshall could not have immediately comprehended his discovery, which would set off a deluge of events with "far-ranging importance for California, the United States, and the world."[96] California would never be the same as news of the discovery of gold spread worldwide.[97] Over the next decade, hundreds of thousands of Argonauts—referring to "Jason's followers in search of the Golden Fleece of classical mythology"—flooded California seeking wealth and opportunity.[98]

A first come, first served mentality characterized the early mining regime in California.[99] Marshall's discovery harkened innumerable settlers, investors, and prospectors to a "wild territory with no regulatory state to guide prospecting operations or tax fruits of the land."[100] Supposedly, the U.S. Government was the overseer of California's gold country for the use of all citizens of the young republic.[101] However, in practice, the government played virtually no role. It permitted the Argonauts to seize land, enrich themselves, and control land use "through a self-administered

[95] James Rawls, Richard Orsi & Marlene Smith-Baranzini, eds, *A Golden State: Mining and Economic Development in Gold Rush California* (University of California Press, 1999).
[96] *Ibid* at 276.
[97] *Ibid* at 1.
[98] *Ibid* at 1.
[99] *Ibid*.
[100] *Ibid* at 140.
[101] *Ibid* at 140.

system of mining codes that prevailed far in advance of any constitutionally authorized body of laws."[102]

Thus, the U.S. Government took little or no action to regulate the California Gold Rush, perhaps because Congress was drawn to the more pressing national division over slavery or because it wished to encourage "untamed economic development in the territory."[103] Indeed, the national policy can be drawn from government regulation and intentional lack of regulation. In any case, the trickle of Argonauts—also known as forty-niners because of the boom in 1849—soon increased exponentially, flooding the region as prospectors from near and far dug up their part of the public domain that belonged to all and none simultaneously.

On arriving in California, Argonauts banded together in makeshift towns and mining camps that lacked basic governance via elected officials, laws, and regulations.[104] In this basic state of nature, forty-niners needed more laws to guarantee the priority of mining rights or reliable property ownership. Still, they benefited from the lack of "the corruption of flawed institutions, the power of established elites, and the iniquities of laws designed to protect vested interests rather than to ensure equal opportunity."[105] Forty-niners relied on self-governance, feeding into the common notion of the American Wild West.[106] For the meanest and strongest among the forty-niners, anarchy was welcome; for all others, mining camps were "brutal and lawless."[107] Miners fought for themselves but also for their unbridled potential to become unthinkably rich.[108]

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[102] *Ibid* at 124.
[103] *Ibid* at 140.
[104] *Ibid*.
[105] *Ibid* at 140.
[106] *Ibid* at 140.
[107] *Ibid*.
[108] *Ibid*.

Mining operations fostered a peripatetic existence in which Argonauts searched, surveyed, reached for their pickaxe, and moved on quickly.[109] For this reason, mining towns did not grow into cities as they did in other parts of the U.S. but were existentially frozen in time as "temporary encampments."[110] Mobile mining and weak laws also encouraged a mentality of miners that the environment served humankind's will. Land and living resources were used up and left bereft with no thought for the next generation. Years after the initial boom, an observer noted in 1881:

> "*hydraulic, or even sluice mining is not an aesthetic pursuit; the regions where it is practiced may be, before the miner's advent, like the garden of the Lord for beauty; but after his work is completed, they bear no resemblance to anything, except the chaos which greeted the eye of the seer at the dawn of the Mosaic record of the rehabilitation of the earth for the use of man. . . . It is impossible to conceive of anything more desolate, more utterly forbidding, than a region which has been subjected to this hydraulic mining treatment*."[111]

Historians and sociologists noted the unspeakable toll on the environment: mountains flattened; water sources polluted and diverted; trees cut down; hazards to animals created from underground shafts, pollution and waste strewn; and settlements left as ghost towns.[112] Most Argonauts did not turn a profit, fewer still became rich, and overall, the environment bore the highest price tag.[113]

The California Gold Rush is similar yet different from today's space race. Certainly, the environmental havoc may be no different two centuries later. Mining takes an inherently destructive and irreversible toll on terrain and all nearby lifeforms. If Californians still feel the impact of the Gold Rush today, how long will we mourn the scars of lunar mining on the face of the Moon?

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[109] *Ibid* at 141.

[110] Rawls, Orsi, & Smith-Baranzini, *supra* note 47.

[111] *Ibid* at 144.

[112] *Ibid* at 145.

[113] *Ibid* at 145.

Yet, the modern space race is different from the California Gold Rush in some respects. To our knowledge, there are no lifeforms on the Moon, so there are no trees to cut down or animals to harm. However, there are unquestionably mountains and unspoiled expanses on the Moon that would be regrettable to see in any state except untouched. Another beneficial difference is the existence of some space laws, regrettably vague though they may be, whereas at the start of the California Gold Rush, there was virtually no law and order to govern miners' conduct.

Ultimately, the forty-niners of the twenty-first century are coming. All the themes of 1848 may be applicable in 2048: acts of lawlessness, the mantra of "might makes right," unbridled nomadic exploration, temporary encampments, and extreme wealth for the very few most powerful. In 2048, States and private operators must be able to rely on the rule of law, not the rule of violence. Lawmakers and lawyers can create a legal and regulatory environment vastly different from the unpredictability and violence of prior rushes for natural resources. The OST was mainly drafted by the two superpowers of the Cold War. However, today approximately 53 States are spacefaring.[114] Substantial lunar mining is on the horizon, and asteroid mining may soon follow. Observers should expect a land grab when mining in outer space becomes feasible. At all costs, we must avoid the same mistakes and shortcomings of the California Gold Rush.

[114] Goguichvili, Linenberger & Gillette*The Global Legal Landscape of Space*, *supra* note 19.

V. Lunar Mining Operations

Figure 3. Image Depicting Hydraulic Mining at the California Gulch in Colorado (1878)[115]

A. Statements of Intention

Section V of the Thesis transitions from the status quo Moon (the first variable in the methodology formula) to the vast array of lunar mining operations that may become a reality in the coming years. The methodology is feasible and helpful only if it offers a reliable framework to evaluate the problem. Therefore, this section will analyze States' intentions and capabilities concerning lunar mining.

We are now in an era dubbed by some as the New Space Race or "NewSpace," denoting a modern period marked by reduced technological costs, increased market investment,

[115] Photograph depicting hydraulic mining at the California Gulch in Colorado, ca. 1878. W.G. Chamberlain, photographer. Library of U.S. Congress, Prints and Photographs Division. LC-USZ62-110833. http://hdl.loc.gov/loc.pnp/cph.3c10833.

entrepreneurial spirit, and social innovation.[116] Pundits have quickly noted that the U.S. and much of the West are again in a space race.[117] Yet, the New Space Race is not about which State will launch a space vehicle or land on the Moon first, but which State or private company will first set up a resource extraction operation on the Moon. Were the People's Republic of China ("PRC") to arrive on the Moon before the U.S., the PRC could try to exhaust lunar resources and even exclude the U.S. from some regions of the Moon.[118] Yet, one should not assume that the U.S. would not seize on similar tactics to ensure its continued access to lunar resources and ability to reap such resources.

With more lunar landers anticipated soon, the world is enjoying an era of "cheap rockets and new technology."[119] This signifies a faster tempo of development and a sooner-than-anticipated deadline for questions about lunar occupation and quasi-ownership.[120] Such landers—with and without humans and with public or private money—may be only the first of a flood of lunar vehicles constituting a rush to the Moon.[121] While this is an exciting time to monitor space launches and developments for lunar research, the main concern remains humankind's capacity for reckless exploitation of outer space.[122]

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[116] Roy Balleste, "The Ethics of Space Exploration: Harrowing Stories of Death, Survival, and the Unknown" (2022) 37:2 Connecticut Journal of Int'l Law 141 at 146 (citing Ruvimbo Samanga, "NewSpace: Developing Property Rights in Outer Space: Legal Provisions for Investment-driven Innovation" (July 2021), online: *Knowledge Constellation* <https://constellation.iislweb.space/ruvimbo-samanga-newspace>).

[117] "Starlink's Performance in Ukraine has Ignited a New Space Race", *The Economist* (5 January 2023) [*Economist*], online: <https://www.economist.com/leaders/2023/01/05/starlinks-performance-in-ukraine-has-ignited-a-new-space-race> (quoting Bill Nelson, the head administrator of NASA, on January 1, 2023).

[118] *Ibid*.

[119] "Which Firm will Win the New Moon Race?", *The Economist* (18 January 2023), online: <https://www.economist.com/science-and-technology/2023/01/18/which-firm-will-win-the-new-moon-race>.

[120] *Ibid*.

[121] *Ibid*.

[122] *Ibid*.

Statements of intention from the most significant space powers are only part of the equation. More and more, private enterprises spearhead space operations and planning, relegating States to observant bystanders. Private companies leverage their agility over lumbering government bureaucracies to launch more quickly and inexpensively than the States that kicked off the original Space Race. Notably, of 178 successful missions in 2022, 90 were completed by companies (often subcontracted by governments), and 61 were by one firm, the Space Exploration Technologies Company ("SpaceX").[123] Private companies show no signs of slowing in 2023 and 2024.

Elon Musk's SpaceX, a company devoted to rockets and satellites, hopes to complete up to 100 orbital flights in 2023.[124] Mr. Musk regularly trumpets the aspirations and accomplishments of SpaceX on Twitter, a social media platform he acquired in October 2022.[125] SpaceX's anticipated plus-up of launches and assets would mark a 64% increase over the 61 missions SpaceX oversaw in 2022. The company's 2022 numbers were the most impressive and accomplished numbers any private or State rocket launcher could boast in 2022.[126]

Even putting aside the statements from States and private companies, the energy and accomplishments in the launch industry speak volumes. The number and volume of orbital flights are consistently growing year over year. Every launching party sets new ambitions for the next

[123] *Ibid*.

[124] Micah Maidenberg, "SpaceX Aims to Increase Launches as Rivals Prep New Rockets", *The Wall Street Journal* (8 January 2023), online: <https://www.wsj.com/articles/spacex-aims-to-increase-launches-as-rivals-prep-new-rockets-11673132510>.

[125] *Ibid*.

[126] *Ibid*.

year and the next chapter in development.[127] In 2017, 86 launches reached orbit; five years later, the number increased to 180.[128]

Lastly, smaller space programs have announced statements of intention to join the New Space Race. Among these parties, one can expect "at least one lunar landing attempt in 2023."[129] iSpace Inc., a leading launch company from Japan, successfully launched its M1 mission with the help of SpaceX in December 2022.[130] The iSpace rocket will take a longer route to the Moon, expected to arrive in the spring of 2023, when it will drop off a United Arab Emirates lunar rover, a rover for the Japanese space agency, and various other payloads.[131] Experts expect as many as five additional lunar landing attempts in 2023 alone.[132] For its part, NASA has hired companies to deliver government payloads to the Moon.[133] These companies—Intuitive Machines and Astrobotic Technology—look forward to more work with the U.S. Government.[134]

Smaller State space programs attempt to keep pace with private companies. In 2023, there could be three lunar missions from smaller State programs. India says its Chandrayaan-3 mission was delayed in 2022 but could be ready in 2023.[135] Japan's project, the Smart Lander for Investigating the Moon, or SLIM, could allow Japan to test its lunar landing technologies.[136]

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[127] *Ibid*.

[128] *Ibid*.

[129] Michael Roston, "Space and Astronomy: What to Expect in 2023", *New York Times* (3 January 2023), online: <https://www.nytimes.com/2023/01/03/science/space-and-astronomy-what-to-expect-in-2023.html?nl=todaysheadlines&emc=edit_th_20230103>.

[130] *Ibid*.

[131] *Ibid*.

[132] *Ibid*.

[133] *Ibid*.

[134] *Ibid*.

[135] *Ibid*.

[136] *Ibid*.

Lastly, Russia scrubbed its Luna-25 mission in 2022, but Roscosmos, the Russian space agency, intends to try again in 2023.[137]

Why is this important? These details are vital because when one speaks about humanity's potential impact on the lunar surface and the Moon's resources, part of what one needs to quantify is how many States, companies, and individuals are interested in lunar development. And of that subset, how many have the means and motivation to achieve their goals? Early indications are that potential lunar mining operators are numerous, thus increasing the threat to environmental preservation on the Moon. Ultimately, carefully considering the most significant space powers, more minor space powers, and companies is vital to understanding the scope of interest and intentions in lunar development. This builds into the methodology and helps understand the legal problem's scope.

B. In Search of Ice Water and Elements

After understanding the rising demand for lunar exploration and exploitation, one must consider the planned operations and extent of exploitation contemplated by actors. A helpful starting point for understanding space exploitation and the potential limits thereto is the work of the Committee on Space Research ("COSPAR"). COSPAR's mission—to avoid biological contamination of planetary bodies—is empowered by Article IX of the OST, which mandates protection from harmful contamination in outer space.[138] Therefore, the core activities of COSPAR include developing and promoting a Policy on Planetary Protection, embodying "the only international reference standard for spacefaring nations and guiding compliance with Article IX"

[137] *Ibid*.

[138] Jean-Claude Worms, Athena Coustenis & Gerhard Kminek, "Planetary Protection Policy" (last visited 14 March 2023), online: *Earth & Environment* <https://cosparhq.cnes.fr/assets/uploads/2021/01/Research_Outreach_PPP_2020.pdf>.

of the OST.[139] Humans must avoid biological contamination of the Moon (known as forward contamination) and the introduction of extraterrestrial matter during return trips to Earth (known as backward contamination).[140]

In 2021, COSPAR updated its Planetary Protection Policy by including Category II sub-designations to cover lunar missions and exploration to various lunar regions.[141] By creating new subcategories—II(a) and II(b)—under Category II, COSPAR is lending new recognition to how vital permanently shadowed regions ("PSRs") will be for scientific development, exploration, and exploitation in the age of the Artemis program.[142] COSPAR's Planetary Protection Policy, while ultimately normative and non-binding, is nevertheless significant for low-risk and high-risk missions in outer space.

The Moon will keep its overall Category II status, but COSPAR gives Category II(b) status to a small number of missions to PSRs near the Moon's poles. In contrast, most of the Moon retains Category II(a) status.[143] This shift in COSPAR categories is a recognition of the treasure-trove of resources in PSRs. Since PSRs are now Category II(b), parties traveling to the lunar poles must record their "full organic inventory." In contrast, most other lunar missions must report only volatiles produced during propulsion.[144] Therefore, the implications are that COSPAR values

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[139] *Ibid*.

[140] *Ibid*.

[141] National Aeronautics and Space Administration Office of Safety & Mission Assurance, "COSPAR Updates Planetary Protection Policy for Lunar Missions" (31 August 2021), online: *Planetary Protection, Policies, and Requirements* <https://sma.nasa.gov/news/articles/newsitem/2021/08/31/cospar-updates-planetary-protection-policy-for-lunar-missions>.

[142] *Ibid*.

[143] *Ibid*.

[144] *Ibid*.

certain regions of the Moon more highly than others based on notions of preservation and resource management.[145]

This represents only the latest shift in humankind's understanding of the Moon and its vast resources. Indeed, the Moon was historically viewed as a barren wasteland with little comfort to offer humanity.[146] Researchers could detect traces of water in rock samples brought back from the Moon by Apollo 14.[147] Still, without traces of biological material or life, the Moon was dismissed as a potentially life-sustaining satellite.[148] COSPAR deemed the Moon a Category I body at that time, meaning that no planetary protection safeguards were warranted.[149] In hindsight, scientists could not have comprehended just how much water the Moon possesses: the lunar poles store "at least 600 billion kilograms of water ice – or enough to fill 240,000 Olympic-size pools, according to the Planetary Society."[150] Still more ice water may be discovered via on-the-ground exploration.

Additionally, attitudes shifted in the 1990s after several lunar missions found more substantial water deposits on the Moon than previously believed.[151] While the Moon may have had indigenous water deposits than once believed, it is likely that impacts from comets, asteroids, and other celestial bodies left water ice on the Moon throughout its lifecycle.[152] While estimates state that the Moon is "on average 100 times drier than the Sahara Desert," the Moon's poles harbor substantial amounts of ice water.[153] Such areas retain water because it is protected from the direct heat and light of the sun, which would otherwise break down water molecules or cause

[145] Worms, Coustenis & Kminek, *supra* note 138.
[146] Office of Safety & Mission Assurance, *supra* note 141.
[147] *Ibid*.
[148] *Ibid*.
[149] *Ibid*.
[150] Davenport, *supra* note 70.
[151] Office of Safety & Mission Assurance, *supra* note 141.
[152] *Ibid*.
[153] *Ibid*.

evaporation.[154] Thanks to the Moon's tilted axis, PSRs in craters at high latitudes receive no sunlight or sunlight only at a steep angle so that the low points of craters never see daylight.[155] These regions at the Moon's pole also remain as cold as -250 degrees Celsius, so the ice water never has an opportunity to vaporize or evaporate.[156]

One of NASA's earliest recognitions of substantial ice water deposits near the lunar poles was in 2009 as the Lunar Crater Observation and Sensing Satellite ("LCROSS") dispatched a 2,200-kilogram object to crash at the south pole near the Cabeus crater.[157] The satellite detected water from the material that flew into space due to the collision.[158] LCROSS's findings and subsequent surveys from a reconnaissance orbiter led COSPAR to "reassess the importance of the Moon from a Planetary Protection perspective."[159] This prompted COSPAR to classify the Moon as Category II in 2008, signifying "significant interest relative to the chemical and biological evolution of the solar system."[160]

As discussed in Section III of the Thesis, large quantities of ice water at the lunar poles could be a game-changer for lunar and interstellar exploration. This untapped resource provides water for drinking, growing plants, and cleaning, as well as a source of oxygen for breathing and hydrogen for fuel.[161] For geologists and historians, PSRs also present an unspoiled record of comet and asteroid impacts that could shed light on our current scientific understandings of biology and chemistry.[162]

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[154] *Ibid*.
[155] *Ibid*.
[156] *Ibid*.
[157] *Ibid*.
[158] *Ibid*.
[159] *Ibid*.
[160] *Ibid*.
[161] *Ibid*.
[162] *Ibid*.

While we have a much less developed understanding of the locations and extent of elemental deposits on the Moon, satellites and orbiters have contributed to a basic understanding of the Moon's elements and where various deposits can be found.[163] The U.S. Geological Society and NASA are developing increasingly reliable maps depicting elemental deposits below the Moon's surface.[164] Still, the Moon possesses "platinum group and rare earth metals," along with Helium-3, which could potentially fuel nuclear fusion.[165] This combination of resources could sustain life on the Moon and facilitate a lunar economy for a long-term presence.[166]

This section of the Thesis is fascinating in its own right from a scientific perspective. Still, the primary relevance of the Thesis is to portray the lure that ice water and REEs present to spacefaring States. Indeed, the more we learn about the treasures and bodies of elements quickly depleted on Earth, the more the impetus for lunar exploration may grow. When that happens, the urge for a lunar "gold rush" may grow exponentially.[167] Thus, when NASA or private companies next send humans to the Moon, the mission "will look very different from the Apollo missions."[168]

The purpose of missions will pivot to resource reconnaissance and extraction, and those arriving on the Moon will focus primarily on "one of 13 potential locations at the lunar south

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[163] Williams, Matt, "Want to Mine the Moon? Here's a Detailed Map of all its Minerals" (4 May 2020), online: *Universe Today* <https://www.universetoday.com/145887/want-to-mine-the-moon-heres-a-detailed-map-of-all-its-minerals>.

[164] *Ibid*.

[165] Davenport, *supra* note 70.

[166] Williams, Matt, *supra* note 163.

[167] Mineral Resources Program, "Do We Take Minerals For Granted?" (2023) at 4, online: *United States Geological Survey* <https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/mineralsprdoc-508.pdf> (noting that "As large emerging economies, such as China and India, increase their participation in the global economy, demand for critical mineral resources is increasing at a rapid rate That means that we are depleting our known mineral deposits at an increasing rate, requiring that new deposits be found and put into production").

[168] Davenport, *supra* note 70.

pole."[169] Failure to be laser-focused on ice water would undermine the greater purpose of NASA's Artemis program, which is to one day "create a permanent human presence on the moon."[170] This is why NASA is considering building a nuclear reactor on the Moon to sustain extended power requirements, transportation, and mining operations.[171]

C. Prime Real Estate and Land Scarcity

Land scarcity is the leading factor driving States and companies to rush to the Moon and begin mining operations. This unforgiving part of the equation means that if a party is not first, they are effectively last. There is too little room on the Moon's surface to accommodate all parties wishing to create small encampments and begin exploration and mining. Section V.D. below will describe in further detail what is entailed with settlement and mining but suffice it to say that the Moon's surface is not limitless, and predominantly the tiny spaces around the lunar poles and PSRs present the prime real estate that all actors will likely target. These limited locations are optimal for maximum sunlight, renewable energy, and all-important resource placement.

The U.S. and PRC have already identified potential landing and settlement locations at the Moon's south pole.[172] States desire locations with high elevation (and thus more sunlight) and nearness to craters where scientists believe astronauts will find ice water.[173] With only limited options for optimal sunlight and proximity to water and mineral resources, it is unsurprising that the American and Chinese space agencies have chosen overlapping landing coordinates on the

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[169] *Ibid*.

[170] *Ibid*.

[171] *Ibid*.

[172] Jak Connor, "NASA and China encounter never-before-seen problem with Moon landing" (9 May 2022), online: *TweakTown* <https://www.tweaktown.com/news/88291/nasa-and-china-encounter-never-before-seen-problem-with-moon-landing/index.html>.

[173] *Ibid*.

Moon.[174] By some estimates, only one percent of the lunar surface would be ideal as a settlement location.[175] Thus, the Moon offers shockingly little land for efficient mining operations. With significant variability of lunar features, the most optimal lunar real estate becomes more scarce and thus more contested among spacefarers.

Of course, the separate issue of the financial viability of lunar mining operations is pressing and not to be ignored; nevertheless, it is outside the scope of this Thesis and deserves discussion in a separate publication. Potential operators and States must evaluate and maneuver the potentially vast costs of operations and risks of space exploration.[176] While a lack of financial viability may stop some potential mining operations in their tracks, this Thesis proceeds on the sound assumption that many mining operators will find the financial resolve to carry mining plans to fruition.

D. Expected Environmental Impact of Lunar Mining

There is not yet a definitive account of what a lunar mining operation will consist of and what degree of environmental harm will be inflicted by such operations. Still, several scientific and engineering authorities have detailed models, some endorsed by NASA and other leading space agencies. Despite the early state of the science, and the possible desire by engineers and policymakers to keep aspects of their progress secret, many mining operators anticipate it will be most straightforward and cost-efficient to bring as little as possible to the Moon and produce as much as possible on the Moon. This would be possible through metalwork but also 3D printing, thus reducing the payload from Earth to the Moon.[177]

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[174] Martin Elvis, Tony Milligan & Alanna Krolikowski, "The peaks of eternal light: A near-term property issue on the moon" (2016) 38 Space Policy 30 [*The peaks of eternal light*].

[175] *Ibid*.

[176] Andrea Sommariva et al, "The Economics of Moon Mining" (2020) 170 Acta Astronautica 712.

[177] NASA, "The Lunar Gold Rush: How Moon Mining Could Work" (last visited 20 February 2023), online: <https://www.jpl.nasa.gov/infographics/the-lunar-gold-rush-how-moon-mining-could-work>.

The most significant impact relating to infrastructure and lunar placement is anticipated to be mining equipment, infrastructure, and housing. While some resource extraction may be possible on the Moon's surface or just below it, much extraction may only be possible with heavy machinery going well below the Moon's surface. The machinery and the support equipment to power the machinery and handle the Moon dust, which will no doubt be a hazard and impede operations, will represent a significant investment and a disturbance to the lunar surface.[178] Regarding REEs, operators must consider whether to refine all or part of their resources in situ or whether it is feasible or advisable to transport resources back to the Earth for refining and processing. Operators may transport resources back to Earth since refining infrastructure exists here. Any added machinery on the Moon will use up valuable and limited terrain near the poles.

Housing for mining operators will take up substantial space on the Moon. It may need to be built so that it is temporary and mobile to make a plausible argument that such structures do not violate the non-appropriation principle under Article II of the OST, as discussed above. Finally, storage facilities may also occupy substantial space on the lunar surface, crowding already crowded areas near the lunar poles. Secure facilities for helium-3, oxygen, and hydrogen, among other materials, will be required to ensure easy access for longer-term settlements on the Moon.[179]

Each of these measures would disturb the aesthetic of the Moon and its resource deposits.[180] Smaller settlements may not be visible to the naked eye from Earth, but more extensive mining operations may be visible. Indeed, because the Moon's dusty surface, the regolith, is easily disturbed by movements and impacts, even minor operations may impact nearby terrain. The

[178] *Ibid*.

[179] *Ibid*.

[180] University of Arizona, "Skimming the Lunar Surface" (April 2021), online: *Lowell Institute for Mineral Resources* <https://minerals.arizona.edu/innovation/lunarmining>.

extent of upending terrain is unclear and hinges partly on whether refining operations will be co-located with mining operations or if resources will be transported back to Earth for refining and processing.

Launching areas will require an extensive berth from mining and residential areas since, on liftoff and landing, the regolith will be easily disturbed and hazardous to personnel and buildings once airborne. Thus, a road network will be necessary for transport to and from launch areas, which may be visible from Earth. In sum, the environmental impact on the Moon is already substantial, even in theory only. As is often the case, the real-world execution of lunar mining will likely entail more than we can presently envision and thus take an even more significant toll on the environment.

In sum, the environmental impact of lunar mining operations is expected to be vast and severe. This is because several parties are interested in lunar mining and are able to pursue it (Section V.A.), the Moon contains extremely valuable ice water and REEs (Section V.B.), the distribution of ice water and REEs is uneven, resulting in an extreme scarcity of the most valuable geographic locations on the Moon (Section V.C.), and the expected necessary build-up of mining settlements (Section V.D.). Each of these considerations alone would mean considerable impact on the Moon, but taken together, they represent a considerable threat.

Finally, the historic toll of human exploration on the Moon has already been described in Section IV.A. The scale of human waste after Soviet missions, six Apollo missions, and approximately 300 hours of human presence on the Moon is vast and hard to comprehend.[181] While these bits of human and mechanical waste may be viewed as historical remnants, they also present

[181] Park, *supra* note 58.

hazards to future lunar missions if they complicate landing sites or threaten human life during launches from the lunar surface.[182]

VI. Space Law and Authorities

> "*The quest to exert technological mastery over water and geology exacted huge, long-term environmental costs. Gold's impact on the natural world was devastating. Mining made moonscapes of the gold regions, leaving behind denuded forestlands, open pits, polluted water courses, and toxic tailings ponds. […] 'Little more than a year ago,' the radical English writer William Howitt observed during a visit in 1853, the White Hills at Bendigo had been wooded, but now the area was 'perfectly bare of trees, and the whole of it riddled with holes of from ten to eighty feet deep—all one huge chaos of clay, gravel, stones and pipe—clay, thrown up out of the bowels of the earth!'* "[183]

This section presents the next part of the methodology formula guiding this Thesis. At its heart, this section reflects that space law is fundamentally composed of international law with elements of environmental law. Therefore, a reliable grasp of space law's many sources will accurately lead to understanding the environmental principles constraining lunar mining operations. Treaty provisions, customary international law, U.N. resolutions, domestic laws, and aspirational soft law present a multi-layered environment where States and private actors find source material for permission and prohibition. Notably, this Thesis's subtitle is inspired by the law's ability to sanction or condemn human behavior under a theory of lawfulness or lawlessness. Indeed, past abuses of environmental interests could be deemed lawless, while the reasonable restriction on human activities to protect the environment should be lawful.

Within the relevant body of law, treaties form the earliest and most prominent binding source material, yet the relevant treaties lack relevancy and specificity in some aspects. In contrast,

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[182] *Ibid*.

[183] Mountford & Tuffnell, *supra* note 1 at 24 & 25 (citing Edwin Lithgow to his mother, February 20, 1853, NLS MS 2543, 41–42, Lithgow Papers; James Harvey Hoey to Jane Brown, November 13, 1852, NLS Acc 12100, 17, Brown Family Papers, National Library of Scotland; William Howitt, Land, Labor and Gold: or, Two Years in Victoria Volume II [London: Longman, Brown, Gren, and Longmans, 1855], 47–48).

customary international law may offer some helpful and persuasive guidance, though such norms are not fully applicable or binding on parties in the outer space context. Next, U.N. resolutions attempt to remain abreast of pertinent space issues as they develop. Domestic laws may quickly address issues in space, but they only bind parties from the applicable State. Finally, soft law such as the non-binding Artemis Accords or U.S. Cislunar Policy is entirely aspirational, arguably political, and ultimately unilateral. Still, such undertakings seek to build a broad coalition through subjective but widely held views of the law.

A. Treaty Law

The most logical starting place to discuss outer space law is the treaty law that underpins legal obligations in outer space. Beginning almost 60 years ago, the U.N. shepherded five foundational space treaties for consideration by States.[184] These core treaties comprise the legal framework for outer space activities.[185] It is impossible not to read these treaties as products of their time: the Cold War. This explains, as an initial matter, why the treaties emphasize averting escalation, militarization, and colonization of outer space.[186] In an age in which the U.S. and the Soviet Union were in a constant and anxious stand-off, these international relations concerns prevailed over more prospective future concerns, like environmental harm or the future desirability of settlements on celestial bodies.

As space technological development advanced rapidly in the 1990s and 2000s, space laws and governance must also keep pace to address new challenges to the core principles of the early outer space treaty law. Rather than drafting new treaties or amending the existing treaties, this will likely require a delicate approach to reinterpreting critical provisions of the treaties, such as those

[184] Goguichvili, Linenberger & Gillette, *The Global Legal Landscape of Space*, *supra* note 12.
[185] *Ibid*.
[186] *Ibid*.

relating to greater commercialization, while continuing to constrain militarization.[187] Current U.S. Vice President Kamala Harris is not the first person to point out that space laws were "written for a space industry of the last century."[188]

1. Outer Space Treaty

The OST comprises the core legal principles underlying virtually all activities concerning outer space. This foundational U.N. text entered into force in 1967, after the Sputnik launch but before the Apollo 11 mission. After substantial debate within the U.N., States gave the OST a broad consensus and mandate. Today it remains the critical legal text for legal parameters in outer space.

This Thesis questions whether the OST, as the vital space law legislation, can adequately protect environmental interests. For that reason, extra attention will be focused on the OST. Primarily, this Thesis considers whether the time is ripe for a broader environmental mandate (it almost certainly is) and whether Article IX of the OST adequately lays the groundwork for an "international environmental law" for outer space" (it almost certainly does not).[189]

The context of the treaty's negotiation and ratification is critical. At that time, only State actors explored space; moreover, only *two* States had space programs to speak of: the U.S. and the Soviet Union.[190] As already discussed in this Thesis, formative principles of space law—outer space as a commons, the non-appropriation principle, the incorporation of international law, and

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[187] *Ibid*.

[188] The White House, "Remarks by Vice President Harris On Supporting the Commercial Space Sector" (12 August 2022), online: *Briefing Room* <https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/08/12/remarks-by-vice-president-harris-on-supporting-the-commercial-space-sector/>.

[189] Thomas Cheney, "Beyond Planetary Protection? Article IX of the Outer Space Treaty as a Foundation for an International Environmental Law for Outer Space" (January 2021), online: *Harvard Adsabs* <https://ui.adsabs.harvard.edu/abs/2021cosp...43E2218C/abstract>.

[190] The White House, *supra* note 188.

no nuclear weapons in space—are contained in the first four articles of the OST. Related to the treaty's ratification context, its historical background is also significant. Notably, the OST predated the environmental movement of the late 1960s and early 1970s.[191] Perhaps as a result, the OST omits environmental protection provisions that would be included in later international instruments, such as the Moon Agreement.[192]

Yet, the OST may be starting to show its age.[193] Notably, the OST's seventeen articles are brief and lack desirable specifics. While intentional ambiguity can sometimes benefit parties by allowing them to read provisions flexibly, ambiguous terms and silence may also lead to stalemate or indefensible legal interpretations. Thus, for example, the OST scarcely speaks in terms of environmental law, except to say in Article IX that States must act with "due regard" for the interests of all other States and that States must conduct exploration while avoiding the "harmful contamination" of the Moon and other celestial bodies.[194] It is concerning that the OST barely addresses environmental concerns, even as companies now prepare for space transport and lunar mining.[195]

Based on this scarcity of detail and others, past State efforts to establish rules relating to resource extraction "have run into the lunar regolith."[196] Absent any appetite to amend the OST, States have turned to other legal agreements in hard and soft law. However, efforts at alternative measures illuminating valuable aspects of the law have regrettably stalled. For example, the U.S.

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[191] Cheney, *supra* note 189.

[192] *Ibid*.

[193] The White House, *supra* note 188.

[194] *OST*, *supra* note 18 at Art IX.

[195] United States National Science & Technology Council, "National Cislunar Science & Technology Strategy" (2022), online (pdf): <https://www.whitehouse.gov/wp-content/uploads/2022/11/11-2022-NSTC-National-Cislunar-ST-Strategy.pdf> (speaking in terms of "economic development" of the Moon for the first time in American policy).

[196] *supra* note 119.

has refused to sign the Moon Agreement (1984), discussed further herein, and Russia and the PRC have rejected the latest proposal from the U.S.: the Artemis Accords of 2020.[197]

The sometimes vague and aspirational nature of the OST's provisions likely contributes to the OST's broad appeal and ratification. The OST embodies a trade-off between broad appeal for agreeable but sometimes vague provisions and more precise, exacting provisions that no coalition of states would likely support. In any case, academics and commentators have fairly criticized the OST as myopic, aspirational, imprecise, and with only 17 articles, perhaps too succinct and general to be helpful in critical situations.

This Thesis does not require a discussion of every article of the OST; what follows is a description of only those articles most relevant to this Thesis. Perhaps the drafters of the OST wished to give the highest importance to the general sentiments of Article I, stating that all States are entitled to the exploration and use of outer space, regardless of their economic or scientific development.[198] As a great commons, the States agreed to "free access to all areas of celestial bodies."[199] Article II of the OST adds that outer space is "not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[200] Therefore, no State Party to the OST may appropriate or own any part of outer space, much like the high seas on Earth or the airspace above them and seabed below them. Historically, one can view the OST as a conciliatory document between the U.S. and the Soviet Union intended to de-escalate the space

[197] *Ibid*.
[198] *OST*, *supra* note 18.
[199] *Ibid*.
[200] *Ibid*.

race and reassure the two superpowers that a space war and mutual annihilation were not imminent.[201]

Notably, the OST is arguably now part of customary international law, such that the provisions of the OST bind even non-signatory States due to its widespread endorsement and what is viewed as the obligatory nature of the treaty provisions.[202] Thus, absent persistent objections, even non-signatory States would be bound by Article IX, stating that spacefaring States must be respectful and cooperative with other States, demonstrating "due regard to the corresponding interests of all other States Parties to the Treaty."[203] Such safeguards extend to the Moon and other celestial bodies. For example, States must avoid "harmful contamination" of them and "adverse changes" to the Earth's environment.[204]

If any signatory to the OST believes that its actions or those of its citizens would cause "potentially harmful interference with activities of other State Parties in the peaceful exploration and use of outer space," States must "undertake appropriate international consultations" before going any further.[205] However, Article IX has mainly been confined to interpreting biological contamination since its ratification.[206] Still, this article of the OST has found expression in the non-binding COSPAR Planetary Protection guidelines.[207]

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[201] Andrew Brehm, "Private Property in Outer Space: Establishing a Foundation for Future Exploration" (2015) 33 Wis Int'l L J 353 at 357 (noting that "[m]odern international space law can be traced back to the Cold War and the intensive space race between the United States and the Soviet Union").

[202] Lyall & Larsen, *supra* note 12 at 71.

[203] *OST*, *supra* note 18.

[204] *Ibid*.

[205] *Ibid*.

[206] Cheney, *supra* note 189.

[207] *Ibid*.

Article IX resonates with other international law norms incorporated into space under Article III of the OST.[208] Article IX's prohibition against harmful contamination corresponds to the "no harm" rule of international environmental law.[209] This rule shields the environment in areas beyond national jurisdiction, such that one State cannot emit pollution that crosses the border into a neighboring State.[210] By correlation and via OST Article III's incorporation of international law into space law, these same international norms would apply equally to lunar mining. On the Moon, however, where jurisdictions and borders do not exist, every State owes a duty to every other State not to pollute or otherwise defile the Moon. Thus, the due regard responsibility with the no-harm rule forms a powerful deterrent for reckless mining and may even pave a path to State responsibility if environmental harms rise to the level of internationally wrongful acts.

Of interest, the OST forbids State appropriation of any part of outer space. However, by the treaty's terms, States are permitted to maintain "stations, installations, equipment, and space vehicles on the moon and other celestial bodies."[211] This is evident because Article XII of the OST states that all such possessions are "open to representatives of other States Parties to the Treaty based on reciprocity."[212] Thus, this introduces an apparent paradox between non-appropriation and the permission to build and maintain structures on the Moon.

Despite its brevity, the OST sometimes uses imprecise language and raises questions about what was envisioned when drafting the treaty. For instance, the OST states that no State party may appropriate any part of the Moon, yet lunar stations, temporary installations, equipment, and

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[208] *OST*, *supra* note 18 at Art III.

[209] Peter Stubbe, "Legal Consequences of the Pollution of Outer Space with Space Debris" (July 2017), online: *Harvard Adsabs* <https://ui.adsabs.harvard.edu/abs/2017oeps.book...68S/abstract>.

[210] *Ibid*.

[211] *OST*, *supra* note 18.

[212] *Ibid*.

vehicles are permissible.[213] Additionally, the treaty delicately balances State interests in maintaining privacy and safety from other States. Yet, the treaty also authorizes prior announced visits from other States, thus seemingly dispelling some notion of privacy or secrecy.

While the OST deems outer space a global commons, national leaders of State parties to the OST have sometimes departed from this foundational premise. The Trump Administration, for instance, claimed that "the United States does not view [space] as a global commons," a sharp departure from the Obama Administration's legal interpretation.[214] So far, the Biden Administration appears to follow the Obama Administration's policy, highlighting how prone treaty interpretation can be within State practice with the transition of presidential power. Notably, the Trump Administration's refusal to recognize the foundational premise that outer space is a global commons signals a shift in at least one powerful spacefaring State's approach to space law. States wishing to exert dominion over celestial bodies and their resources may begin with the simple but controversial supposition that space is not, in fact, a global commons.

The OST is suitable for viewing through the "evolutionary approach" to treaty interpretation.[215] Under this perspective of treaty interpretation, later developments in space law, through subsequent treaties, guidelines, and legal developments, provide a basis for interpreting the legal framework.[216] Accordingly, this Thesis next explores the subsequent Moon Agreement and forms of international and national laws and soft law to help interpret the meaning of Article

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[213] *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, (entered into force 5 December 1979) [*Moon Agreement*] (Article 11 of the Moon Agreement, though it was not widely adopted, also assumes as permissible "[t]he placement of personnel, space vehicles, equipment, facilities, stations, and installations on or below the surface of the moon").

[214] Benjamin Silverstein & Ankit Panda, "Space Is a Great Commons It's Time to Treat It as Such" (9 March 2021), online: *Carnegie Endowment for International Peace* <https://carnegieendowment.org/2021/03/09/space-is-great-commons.-it-s-time-to-treat-it-as-such-pub-84018>.

[215] Cheney, *supra* note 189.

[216] *Ibid*.

IX of the OST.[217] The Thesis will synthesize these sources of law to determine if there is a reliable basis to read space law as protective of the lunar environment. Ultimately, though the OST was drafted and ratified some years before the environmental movement gathered steam in the U.S., this poor timing should not be a bar to implying environmental safeguards.

2. Moon Agreement

Following the adoption of the OST, four space-related U.N. General Assembly resolutions became treaty law focusing on unique aspects of outer space exploration. The Rescue Agreement (1967) addresses States' obligations to rescue spacefarers in distress.[218] The Liability Convention provides a framework for attaching liability to States for the objects they launch into space.[219] The Registration Convention mandates that States provide details to the U.N. about the orbits and specifications of launched space objects.[220]

Lastly, the U.N. drafted the Moon Agreement, which never gained widespread support from States, but particularly from spacefaring States.[221] Several States objected to the Moon Agreement partly because it calls for a cessation of resource appropriation until adequate international oversight can be guaranteed.[222] The relevant provision of the Moon Agreement, Article 11, reiterates in paragraph 1 that "the moon and its natural resources are the common

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[217] *Ibid*.

[218] *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space*, (entered into force 19 December 1967) [*Rescue Agreement*] [hereinafter Rescue Agreement].

[219] *Convention on Registration of Objects Launched into Outer Space*, (entered into force 29 November 1971) [*Liability Convention*] [hereinafter Liability Convention].

[220]*Convention on Registration of Objects Launched into Outer Space*, (entered into force 12 November 1974) [*Registration Convention*] [hereinafter Registration Convention].

[221] *Moon Agreement*, *supra* note 213 [hereinafter Moon Agreement].

[222] Rosanna Sattler, "Transporting a Legal System for Property Rights from the Earth to the Stars" (2005) 6 Chi J Int'l L 23 at 30 (stating that the Moon Agreement curtails ownership rights and forbids property rights "until an international body is created").

heritage of mankind," mirroring language from the OST.[223] Paragraph 2 of Article 11 reflects the language of non-appropriation contained in the OST.[224] Finally, paragraph 3 of Article 11 states that "neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become the property of any State, [organization, or person]."[225]

While enlightening, again, the Moon Agreement gained little momentum, no large spacefaring nation has ratified it, and it is not overly influential in the space law regime.[226] Regrettably, the Moon Agreement has received the least support of all the space treaties partly for its reaffirmation and elaboration of OST provisions in the context of appropriating and exploring the Moon and exploiting its resources.[227] This treaty holds that the Moon shall be used by all states "exclusively for peaceful purposes" and that "any threat or use of force or any other hostile act or threat of hostile act on the moon is prohibited." Additionally, it prohibits the placement or use of weapons of mass destruction on the Moon, as well as the "establishment of military bases, installations, and fortifications, the testing of any type of weapons and the conduct of military maneuvers."[228] Ultimately, this treaty has too few signatories to be impactful except as a persuasive tool for developing treaty law.[229]

In terms of the development of treaty law, however, the Moon Agreement could conceivably be reliable evidence of "subsequent developments" in State understandings of the OST, especially Article 7 of the Moon Treaty. Article 7 states in part: "In exploring and using the

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[223] *Moon Agreement*, *supra* note 213.

[224] *Ibid*.

[225] *Ibid*.

[226] Andrew Tingkang, "These Aren't the Asteroids You Are Looking For: Classifying Asteroids in Space as Chattels, Not Land" (2012) 35 Seattle U L Rev 559 at 572.

[227] Goguichvili, Linenberger & Gillette*The Global Legal Landscape of Space*, *supra* note 19.

[228] *Ibid*.

[229] [JurisM cite: "writes rules"]

Moon, the States Parties shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise."[230] This new language—incorporated in a space law treaty more than a decade after the ratification of the OST, following the environmental awareness movement, and describing environmental harm in much more graphic terms—is evidence of a shift in interpretations among the OST States Parties, even if very few States ultimately ratified the Moon Agreement.[231]

In much more recent times, the Moon Agreement has suffered another setback. The Kingdom of Saudi Arabia officially notified the Secretary General of the U.S. in January 2023 that it will withdraw from the Moon Agreement, effective 5 January 2024.[232] Many were surprised by this development, though presumably, Saudi Arabia wished to clarify that it no longer wanted to be bound by the restrictive terms of the Moon Agreement. Nevertheless, it signals one fewer signatory to that convention, thus further reducing the total number of States that agree to be bound by the terms of the Moon Agreement.

B. Customary International Law

Beyond treaty law, customary international law comprises international norms of conduct that are widespread, uniform, and backed by a sense of State obligation.[233] Like conventions, customary international law can address environmental law, and it forms a key source of international law, incorporated under Article III of the OST.[234] A prominent example of this is the

[230] *Moon Agreement*, *supra* note 213 at Art 7.

[231] Cheney, *supra* note 189.

[232] John Sheldon, "Saudi Arabia's Moon Ambitions" (11 January 2023), online: *Middle East Space Monitor* <https://mideastspace.substack.com/p/saudi-arabias-moon-ambitions>.

[233] Lyall & Larsen, *supra* note 12 at 71.

[234] *OST*, *supra* note 18 at Art III.

Stockholm Declaration of 1972, which addresses environmental preservation to benefit the world's population.[235] In particular, Principle 21 of this declaration requires States to ensure that "activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction."[236] Even putting aside the number of signatories to the Stockholm Declaration, the treaty's provisions are viewed as customary international law based on the widespread State approval of this text to date.

Additionally, the Rio Declaration on Environment and Development (1992) constitutes a U.N. Declaration that has arguably become customary international law today. Of particular interest, Principle 15 of the Rio Declaration states, "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[237]

While these provisions arguably form a basis to limit harmful lunar mining operations, claims of legal obligations from customary international law are always subject to attack. At issue is the notion that international practice is sufficiently widespread and that activities or beliefs in question rise to the level of *opinio juris*. There is likely a stronger argument that the Stockholm Declaration and Rio Declaration embody customary international law, and thus provide legal justification for delaying lunar mining until environmentally friendly and cost-effective measures can be imposed to prevent environmental degradation. On the other hand, opponents have a colorable argument that these declarations are not sufficiently widespread, uniform, and longstanding. They may also argue that States do not view the declarations as legally binding and instead agree to the declarations out of convenience and friendly support. In short, customary

[235] *Stockholm Declaration on the Human Environment*, UN Doc A/CONF 48/14 (1972).
[236] *Ibid*.
[237] *Rio Declaration on Environment and Development*, A/CONF151/26 (Vol I) (1992) Principle 15.

international law may be used in favor of limits on lunar mining, but it is also subject to fair criticism as to its strength and applicability.

C. General Principles of Law

This Thesis has discussed the necessary treaty provisions in space law. Additionally, many of the provisions of the OST are now widely accepted as tenets of customary international law, as described above. From the widely accepted sources of international law, at least one other source is worth mentioning: general principles of law.[238] In the environmental law context, at least one such tenet applies. In the *Corfu Channel* case, the International Court of Justice held that Albania violated "every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States."[239] As discussed above, this general principle of law has led to the "no harm" principle in environmental law.[240] This provision could be used to confine lunar mining, but similar to customary international law, it lacks specificity and may be overcome by arguments that treaty law, for example, permits lunar mining.

D. U.N. Resolutions

Resolutions that the U.S. General Assembly adopts, while non-binding, help drive space law development and cooperation of Member States in outer space.[241] Additionally, documents drafted and disseminated by the Committee on the Peaceful Uses of Outer Space ("COPUOS") help push the development of space law.[242] Several resolutions and COPUOS documents are relevant to this Thesis.

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[238] *Statute of the International Court of Justice*, 33 UNTS 993 Art 38.

[239] ICJ, ICJ Rep 4, *Corfu Channel (UK v Albania)*, 22.

[240] *Trail Smelter (US v Canada)*, 1941.

[241] United Nations, "Space Law: Resolutions" (last visited 20 February 2023), online: *COPUOS* <https://www.unoosa.org/oosa/en/ourwork/spacelaw/resolutions.html>.

[242] *Ibid*.

The U.N. Office for Outer Space Affairs ("OOSA") has developed a non-binding set of principles called the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space.[243] While directly applicable to orbital debris mitigation and not necessarily the environmental preservation of the Moon, the Guidelines provide a valuable measuring stick for determining how much OOSA concerns itself with space environmental concerns. Various General Assembly resolutions reflect the importance of environmental safeguards in outer space. For example, Resolution 72/78 constitutes an important resolution adopted on the fiftieth anniversary of the OST.[244] This resolution emphasizes the importance of "environmental monitoring" in the space law context.[245] Another resolution entitled International Cooperation in the Peaceful Uses of Outer Space emphasizes in paragraph 34 that: "more attention be paid to all matters relating to the protection and the preservation of the outer space environment […]."[246]

The COPUOS Long-Term Sustainability Guidelines of 2019 resulted from a working group from UNCOPUOS. Upon UNOOSA charging the working group with specific questions, the group investigated "sustainable space utilization supporting sustainable development on Earth, space debris, space operations, and regulatory regimes and guidance for actors in the space arena."[247] In June 2019, the U.N. COPUOS adopted the final Guidelines for the Long-term

[243] United Nations, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space" (2010), online: <https://www.unoosa.org/res/oosadoc/data/documents/2010/stspace/stspace49_0_html/st_space_49E.pdf>.

[244] UN General Assembly, *Declaration on the fiftieth anniversary of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (2017).

[245] *Ibid* at 2.

[246] UN General Assembly, *International Cooperation in the Peaceful Uses of Outer Space* (2001) at 7.

[247] United Nations, "Long-term Sustainability of Outer Space Activities" (last visited 22 February 2023), online: *UNOOSA* <https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html>.

Sustainability of Outer Space Activities, providing helpful but non-binding guidance for all Member States to review and use for further development of best practices.[248]

E. U.S. Laws, Regulations, and Unilateral Statements

While domestic State laws do not carry the weight of sources of international law under Article 38 of the Statute of the International Court of Justice, such laws are vital in the space law context.[249] Besides regulating the licensing requirements for launches and space operations under Article VI of the OST, States also spur citizens to action through laws meant to incentivize certain actions. Indeed, if States sense a conspicuous absence of international legal provisions on lunar resource extraction, States may actively seek to fill the void.[250]

For example, the U.S. Congress passed the Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act of 2015, which states that U.S. citizens are "entitled to any asteroid resource or space resource obtained […] by applicable law, including the international obligations of the United States."[251] Additionally, the "American Space Renaissance Act" was an ambitious attempt to remake the American space framework.[252] Such pieces of national legislation and public statements from senior officials fill out the legal and regulatory environment for space law. These efforts are all the more critical as states lack any appetite today for new treaty law negotiations.[253]

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[248] *Ibid*.

[249] *Statute of the International Court of Justice*, , United Nations (1946).

[250] See generally Ram Jakhu & Joseph Pelton, *Global Space Governance: An International Study* (2017) (noting various state efforts to bolster space governance).

[251] *Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act of 2015*, HR 2262 (2015–2016) Section 51303.

[252] *American Space Renaissance Act*, –HR 4945.

[253] Baker, *supra* note 37 (suggesting that treaties today are more likely to be broken than brokered).

Beyond U.S. laws, the American regulatory framework provides procedures with limited efficacy for assessing the environmental impact of missions to the Moon. In this context, the National Environmental Policy Act ("NEPA")—a core piece of American environmental legislation—mandates that the Office of Commercial Space "integrate environmental values" into its licensing process.[254] This ensures that applicants for space launch licenses must comply with relevant environmental statutes, regulations, and Executive Orders.[255]

Yet, there are shortcomings in the environmental impact review process. For example, NEPA was signed into law in 1970 and has received only sporadic updates and amendments, with very few relating specifically to outer space.[256] Additionally, the NEPA and environmental review process do too little to evaluate *post-launch* lunar activities, instead focusing largely on Earth-based activities without the nomenclature to address extensive lunar-based operations.[257] This constitutes a significant oversight in the regulatory scheme.

U.S. regulations outline procedures for environmental reviews of proposed space operations.[258] While some proposals may qualify for categorical exclusions (indicating that no meaningful environmental review is necessary), the majority of proposals require either an Environmental Assessment ("EA") or the still more comprehensive Environmental Impact Statement ("EIS").[259] The EA and EIS require a statement of the anticipated environmental impact of operations, an agency review, and a period for public comment before the project execution.[260]

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[254] FAA, "Environmental Regulations" (last visited 14 March 2023), online: *US Department of Transportation* <https://www.faa.gov/space/environmental>.
[255] *Ibid*.
[256] *Ibid*.
[257] *Ibid*.
[258] *Ibid*.
[259] *Ibid*.
[260] *Ibid*.

The regulations are mainly effective for proposals that will be limited to operations on Earth, but they are ill-suited for space operations proposals. This is because lunar operations are more unpredictable and unprecedented in contrast to Earth-based projects. Therefore, an applicant-driven proposal may well misstate or misrepresent the true extent of environmental harm. If this were the case, the environmental review process could be fundamentally miscalibrated.

As for unilateral statements on behalf of the U.S., one instance bears discussion. In 2020, President Trump declared in an executive order that "the United States does not view space as a global commons."[261] This declaration, a part of a larger American push to encourage Americans toward "commercial exploration, recovery, and use of resources in outer space," was somewhat unexpected and unprecedented.[262] As for the declaration's implications for this Thesis, the executive order seems to shake the foundation of a pillar of space law: that the use and exploration of outer space is the province of all humanity, i.e., a commons that is available to all States and non-State actors equally.[263] If the U.S., as the largest State engaged in outer space activity, introduces unpredictability through novel legal interpretations, then all other space actors may question the rule of law and long-standing legal interpretations of the OST. Fundamental understandings about the contours of space law among allies will be reexamined.

Additionally, environmental concerns and safeguards are historically predicated in part on the notion of the commons. Accordingly, land and water are worth preserving and maintaining as clean and usable because it is to be enjoyed by all. However, following President Trump's

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[261] The White House, "President Donald J Trump is Encouraging International Support for the Recovery and Use of Space Resources" (April 2020), online: *Executive Order* <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/04/Fact-Sheet-on-EO-Encouraging-International-Support-for-the-Recovery-and-Use-of-Space-Resources.pdf>.

[262] *Ibid*.

[263] *OST*, *supra* note 18 at Art I.

declaration, if the U.S. does not view outer space as a commons, traditional environmental protection rationales may be undermined or discarded entirely. Such a sea shift in rationales for environmental protection could be catastrophic and ultimately undermine many of the conclusions and proposals in this Thesis. Notably, President Biden has not echoed President Trump's declaration, indicating that the 2020 U.S. position was unique to the administration then in power.

F. Soft Law

Finally, several soft law, non-binding, quasi-legal initiatives round out this section of the Thesis. Most notably, the Artemis Accords, an initiative begun in 2020, seek to lay out new "rules of the road" for space exploration.[264] With 23 signatories to the Accords, the U.S. Government hopes to marshal its allies in conjunction with the goals of NASA's future Artemis missions. The Accords are partly a legal interpretation of some of the authorities described above but also partly a political rallying cry to gain State support for an American plan for space operations. Of note for this Thesis, Section 10(2) of the Accords states that signatories "emphasize that the extraction and utilization of space resources, including any recovery from the surface or subsurface of the Moon […], should be executed in a manner that complies with the Outer Space Treaty and in support of safe and sustainable space activities. The Signatories affirm that the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty […]."[265] Thus, while reaffirming the principles of safety and sustainability, the U.S. signals that it reads the non-appropriation principle through a lens of broad permissibility.

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[264] United States of America, "The Artemis Accords" (13 October 2020), online: <https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf>.

[265] *Ibid* at 4.

In addition to the Artemis Accords, the U.S. released its Cislunar Strategy, a non-binding document to guide U.S. actions and telegraph U.S. priorities to other States.[266] This strategy, like the Artemis Accords, is an internal policy document of the U.S. Thus, it has no binding legal effect under international law per se. Nevertheless, such documents can nudge global legal interpretations and influence States, primarily if such documents are delivered by large spacefaring States or garner broad State support. In this strategy, the U.S. uses the language of "economic development" for U.S. activities in the cislunar space, perhaps the first time such a term has been used so prominently.[267] This may indicate a more significant trend in U.S. space policy, which could, in turn, steer international legal policy.

G. Legal Shortcomings

The legal authorities noted in this section are numerous and varied. Nevertheless, are they adequate to preserve the environmental interests of humankind on the Moon? Section VII will discuss the hoped-for condition of the Moon should lunar mining operations go forward. Then, Section VIII will provide a critical analysis using the methodology formula. Still, it is worth reflecting on whether the hard and soft law provisions appear sufficient to rein in potentially aggressive lunar mining operations.

As a general matter, the binding legal provisions discussed above are impressive. The "due regard" requirement under Article IX of the OST is far-reaching. Similarly, the "harmful contamination" prohibition under the same article is compelling. Against this, the OST's brevity and lack of detail mean that mining operators have leeway to make colorable arguments that their

[266] Cislunar Technology Strategy Interagency Working Group, "National Cislunar Science & Technology Strategy" (November 2022), online: <https://www.whitehouse.gov/wp-content/uploads/2022/11/11-2022-NSTC-National-Cislunar-ST-Strategy.pdf>.

[267] *Ibid* at ii.

operations do not violate their obligations under Article IX of the OST. A broader argument for environmental protection could include the fact that many of the provisions of the OST are now customary international law and thus may be read more broadly than just the text of the OST. General principles of law, such as the "no harm" principle in international environmental law, may prove to have more teeth than Article IX. Though international law unquestionably applies under Article III of the OST, the no harm principle does not cleanly apply in a situation without clear borders, which existed in the *Corfu Channel* case.

The Moon Agreement contains the most compelling provisions, though this agreement is regrettably non-binding for all States (including the large spacefaring States), except signatories. This is lamentable since Article 7 of the Moon Agreement has the most teeth and reveals that State interpretation of environmental safeguards likely evolved in the decade after the OST was ratified. U.N. resolutions and documents from COPUOS may also be non-binding, but they help clarify the intentions and interpretations of States as they gather before the U.N.

Finally, soft law and State law indicate the mood within individual States. The large spacefaring States' policy documents illustrate possible future directions for space law development. The U.S. will remain vocal and engaged in chartering a path forward, though States are sure to form blocs that support preferences from democratic or autocratic States. The number of signatories to the Artemis Accords is a positive start but a far cry from general State practice. Additionally, the U.S. Cislunar Strategy does not seek signatories, but it signals a shift in U.S. policy, consistent with the Artemis Accords, toward economic development and monetization of space assets. Noted space law expert Michel Bourély stated that rapid advancement in space will "require rapid development of law."[268] Bourély seemed to understand that further conversation

[268] Michel Bourély, "Space Commercialization and the Law" (1988) 4:2 Space Pol'y 131 at 131.

and State interpretations would guide the development of law and space activities.[269] Ultimately, the act of space exploration will, by its nature, lead to legal developments.[270]

VII. Moon Ex Post Facto and Environmental Targets

> *"Miners used hydraulic mining technology to extract most of the gold produced in California, British Columbia, Australia, and New Zealand after the first flush of prospectors had scraped away the most easily accessible gold. The process left enormous craters in the goldfields and clogged rivers with toxic debris. The environmental changes were widely commented upon in the nineteenth century and remain visible scars upon the landscape."*[271]

A. Moon Ex Post Facto

The final section before the analysis and proposals addresses the Moon ex post facto and possible environmental targets that embody environmental values—the last variable in the methodology formula. The core premise of the methodology is that the legal regime is adequate only if laws protect the status-quo Moon from mining operations, leaving an ex post facto Moon in at least a comparable, if not better, condition than the status-quo Moon. If this equation proves "false," the legal regime must be revisited and strengthened, or the impact of mining operations must be lessened.

This notion, in its simplest form, targets sustainable development. This concept is indispensable "to satisfy the needs of current space missions while ensuring the viability of future ventures."[272] Thus, protection of the Moon's environment is worthwhile *per se*, but today's explorers and exploiters must also preserve the enjoyment of the Moon for future generations. This

[269] Bourély, *supra* note 268.

[270] See generally Annie Brett & Kenneth Broad, "The Litigation of Exploration" (2018) 63 Vill L Rev 241.

[271] Mountford & Tuffnell, *supra* note 1 at 210.

[272] Christopher Newman & Mark Williamson, "Space Sustainability: Reframing the Debate" (2018) 46 Space Policy 30.

fundamental idea is ever-present in terrestrial ecological and environmental efforts and must be carried over to lunar initiatives.

While non-legal sources provide a foothold for environmental areas of interest, the OST is also helpful. For example, land preservation and conservation are justified under Article IX, requiring some protection of the outer space environment.[273] Debris removal and rules for remediation can be derived from the due regard principle under the OST.[274] Regarding rules for orderly land use, Article III of the OST requires that space activities be conducted under incorporated international law principles, which would include some environmental law.[275]

While international treaty obligations on environmental law are somewhat scarce, the Stockholm Declaration of 1972 addresses environmental preservation to benefit the world's population.[276] In particular, Principle 21 of this declaration requires States to ensure that "activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction."[277] The Rio Declaration, discussed already, also provides justification to potentially limit mining operations in outer space.

Yet, outside of pre-existing legal norms, States have sought to add to the space treaties in the past with little luck or appetite for revisions.[278] States have celebrated no new multilateral agreements since the 1970s.[279] For that reason, States have looked to non-binding norms to supplement the treaty framework.[280] Frustratingly, States have looked to COPUOS and OOSA to

[273] *OST*, *supra* note 18 at Art IX.
[274] *Ibid*.
[275] *Ibid* at Art III.
[276] *Supra* note 235.
[277] *Ibid*.
[278] Goguichvili, Linenberger & Gillette*The Global Legal Landscape of Space*, *supra* note 19.
[279] *Ibid*.
[280] *Ibid*.

advance new legal norms for lunar mining, for example, but with limited success. Such bodies of the U.N. have been accused of being "slow to action, limited in authority, and bogged down by political deadlock."[281] Yet, these bodies were formed to further global space governance, not necessarily to legislate or negotiate new legal norms.

With this as background, the Thesis proposes norms and values that must be incorporated into a concept of the ex post facto Moon so mining operators and other parties understand the highest environmental priorities. Environmental justice and natural legal principles may be found in equity, an often-cited concept to fill "gaps in the law." Without such patches in the law, humanity risks another California Gold Rush but this time on the Moon, where operators will move forward without sufficient input from others.

These principles aim to keep the peace on the Moon once more actors arrive on the lunar surface. This is justified under the Preamble to the OST: "Desiring to contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes…."[282] Thus, cooperation and peace are primary concerns while targeting key aspects of the lunar environment.

B. Environmental Targets

1. U.N. COP15 Biodiversity Conference of 2022

Environmental targets ("ETs") are fungible components that can be overlaid with the formula methodology to emphasize environmental priorities as benchmarks. The Thesis takes inspiration from the U.N. COP15 Biodiversity Conference held in Montreal, Canada, in December 2022. The Biodiversity Conference united approximately 190 States for discussion and decision-

[281] *Ibid*.

[282] *OST*, *supra* note 18 at Preamble.

making regarding protecting biodiversity through environmental safeguards.[283] At the end of the conference, the States "approved a sweeping United Nations agreement to protect 30 percent of the planet's land and oceans by 2030 and to take a slew of other measures against biodiversity loss."[284] Experts call this concern a crisis that is not well-known and poses risks to food supplies and worldwide species.[285] The agreement struck at the COP15 Biodiversity Conference contains monitoring mechanisms and reflects broad consensus and focus on environmental priorities.[286]

Remarkably, the U.N. agreement sets forth 23 ETs, the most prominent of which is the "30x30" ET, which reserves 30 percent of land and sea worldwide under special protection.[287] Currently, only about 17 percent of land and 8 percent of oceans worldwide enjoy fishing, farming, and mining restrictions.[288] This deal features benchmarks for measuring targets and charting the progress of States.[289] States will even receive a so-called report card to show their progress toward biodiversity ETs.[290]

This landmark environmental deal brokered by the U.N. is unrivaled in modern times for its scope and participation by virtually every State in the world. With its broad consensus and aggressive environmental goals, the COP15 Biodiversity Conference offers inspiration for environmental conservation in other areas, like outer space. Indeed, if 190 States can gather and agree on certain ETs on Earth, they would presumably agree that many of the same ETs should

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[283] Catrin Einhorn, "Nearly Every Country Signs On to a Sweeping Deal to Protect Nature", *New York Times* (19 December 2022), online: <https://www.nytimes.com/2022/12/19/climate/biodiversity-cop15-montreal-30x30.html>.
[284] *Ibid*.
[285] *Ibid*.
[286] *Ibid*.
[287] *Ibid*.
[288] *Ibid*.
[289] *Ibid*.
[290] *Ibid*.

also apply in outer space as well. In that spirit, this Thesis embraces four ETs most applicable to lunar mining and most likely to translate to outer space law.

ET 3 ("Protected Areas") is the central ET among the 23 put forth by the U.N. This enshrines the "30-by-30" target whereby States agree to protect a minimum of 30% of their land and sea territories by 2030.[291] This ambitious goal sets a floor commitment that States may exceed if possible. The ET would translate fluidly to lunar terrain preservation as well. While on Earth, each State commits to protect at least 30% of its sovereign territory. On the Moon, where no State owns any territory, a universal commitment to set aside 30% of the Moon's land would be a starting point. States would remain free to preserve even more than 30% of the Moon, especially if States are primarily interested in development near only the lunar poles.

ET 7 ("Pollution") is the next important ET, which focuses on the broad reduction of pollution from all sources: materials and harmful pollution from light and noise.[292] In the context of lunar mining, this ET offers a necessary means to combat the introduction of any harmful materials or by-products of mining operations. Mining will introduce chemical products due to drilling and digging, generate substantial noise, and create noise and light pollution. While light and noise may not be such a nuisance with no known animal life on the Moon, as more humans inhabit the Moon, their ideas of peace and tranquility will be more critical. Furthermore, light pollution will certainly impact the aesthetic of the Moon as viewed from Earth. Additionally, the mere presence of humans on the Moon will produce waste products by using materials and

[291] Gloria Dickie, "Factbox: Conservation Targets Proposed for Halting Nature Loss", *Reuters* (7 December 2022), online: <https://www.reuters.com/business/environment/conservation-targets-proposed-halting-nature-loss-2022-12-07/>.
[292] *Ibid*.

producing human waste. This, too, must be controlled and mitigated (or removed to Earth for processing) as much as possible.

Relatedly, COSPAR's primary concern is the many forms of harmful contamination under Article IX of the OST.[293] Scientific discovery must guide humanity's understanding of the microbes and elements humans bring to the Moon and, conversely, the biological and elemental environment on the Moon that could impact human existence on Earth.[294] ET 7's concept of "pollution" must be broad enough to include the concept of harmful contamination within COSPAR's core mission.

ET 10 ("Sustainable Management") refers to the need to "sustainably manage areas used for extractive industries."[295] This directly applies to lunar mining, where large swaths of the Moon's surface and subsurface will be used to extract ice water and REEs. States and private operators must view mining operations as more than a one-time extraction operation. Sustainable management will serve as a vehicle to further interests in minimal land disturbance, posturing for future uses, immediate clean-up after operations, and remediation efforts. In this way, actors will understand that their operations are not a one-time undertaking but one part of a continuum of human activity that relies on sustainable practices for the long-term occupation of the Moon.

Finally, ET 15 ("Corporate Disclosure") addresses perhaps the most critical actors in the lunar mining industry: private companies. Under ET 15, "businesses and financial institutions must regularly monitor and assess their impacts on nature throughout their operations, supply chains, and value chains. They would need to disclose these impacts publicly."[296] This ET uses the tools

[293] Worms, Coustenis & Kminek, *supra* note 138.
[294] *Ibid*.
[295] Dickie, *supra* note 291.
[296] *Ibid*.

of transparency and public accountability to incentivize corporations to comport with ETs 3, 7, and 10. It is a compliance mechanism to shape corporate behavior in ways that benefit the environment. After all, shareholders chart the direction of a company with notions of profit but also with sentiment (and sometimes backlash) from the public. Without such disclosures, corporations may be motivated to act in ways that help their bottom line but are not in the best interests of the lunar environment.

These are by no means the only ETs that could apply to the Moon. While many of the ETs from the COP 15 Biodiversity Conference apply to plants and animals—not presently known to exist on the Moon—many of the ETs are more broadly about preserving the environment for humankind. Therefore, more ETs would apply to the Moon, and ETs 3, 7, 10, and 15 offer only a starting point with the targets that are most applicable and translatable to lunar concerns.

It is worth noting that these ETs could apply to the Moon and Mars, for example, and cislunar space. This space, like the geostationary orbit, is a finite resource. Without limits on human usage of cislunar space and lunar terrain, humans are likely to use up as much as they can in a brief period before others can enjoy the undisturbed sanctity of the space.

2. High Seas Treaty of 2023

A final point of influence and inspiration is the "Draft agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction," a draft international agreement known as the U.N. High Seas Treaty.[297] This treaty follows over a decade of negotiations, marking an important chapter in protecting marine areas outside national boundaries and jurisdiction.[298] There are

[297] Esme Stallard, "What is the UN High Seas Treaty and why is it needed?" (9 March 2023), online: *BBC News* <https://www.bbc.com/news/science-environment-64839763>.
[298] *Ibid*.

obvious parallels with the protection of the Moon and outer space more generally: "two-thirds of the world's oceans are currently considered international waters," meaning that these areas are akin to the lunar surface where all countries have a right to use and exploration.[299] Yet, only approximately one percent of these international waters have formal safeguards against climate change, overfishing, and extensive shipping lanes.[300]

The High Seas Treaty complements the ETs of the 2022 Biodiversity Conference, particularly ET 3's "30-by-30" target whereby States agree to protect a minimum of 30% of their land and sea territories by 2030.[301] This goal is furthered by a key mechanism of the High Seas Treaty to create Marine Protected Areas ("MPAs") where human activity can occur "provided it is consistent with the conservation objectives."[302] This is a significant recognition from the U.N. that natural spaces that comprise a "commons" outside the jurisdiction of any State deserve a concerted effort for conservation and protection from unscrupulous human activities. MPAs provide a baseline of protection and untouchable spaces unless there are adequate assurances that human activity will not harm the environment. While the High Sea Treaty will not enter into force until it enjoys 60 signatories, finalizing the treaty text is nevertheless momentous and should be influential on the development of space law.

VIII. Analysis and Research Findings

> *"Years of legal challenges culminated in 1884 when the absentee owner of an agricultural estate sued one of the largest miners in California for inundating his lands with debris. Judge Lorenzo Sawyer of the Ninth U.S. Circuit Court declared mining debris a nuisance and perpetually enjoined miners from discharging it into rivers. Sawyer's decision hardly marked a return to California's preindustrial landscape. He had ruled against one part of California's industrial economy, the*

[299] *Ibid*.

[300] *Ibid*.

[301] Dickie, *supra* note 291.

[302] *Draft agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*, (2023) Art I.

> *hydraulic miners, because their mining debris harmed the economic interests of another, and increasingly important, part of the industrial economy, the heavily mechanized farmers of the Central Valley."*[303]

At its core, this Thesis examines and weighs the sufficiency of offsetting measures. Applying the methodology, the Thesis asks whether environmental threats and legal safeguards achieve equilibrium. If they do, then humanity has an approximate guarantee that future mining operations, at least as currently envisioned, will not leave the Moon in an even worse condition than it enjoys today. However, if an equilibrium is not achievable, then to preserve the ex post facto Moon with ETs, either future harm must be minimized, or additional legal safeguards must be devised if environmental priorities are to be protected.

The finest details of mining operations' specifications are well beyond the scope of this Thesis. Indeed, technical and engineering journals are much better equipped to describe the minutiae of mineral byproducts, for example, resulting from lunar mining techniques. While legal safeguards are naturally within the scope of the Thesis, this only begs the question of whether the methodology formula is expected to prove valuable in a true-or-false examination. That question is the central inquiry of this section.

A. Treaty Law

1. Article II of the Outer Space Treaty

The core environmental protections of the Moon are contained in the OST. Of particular note, Article II contains the non-appropriation principle, precluding any State or person from appropriating the Moon (or other celestial body) "by claim of sovereignty, by means of use or occupation, or by any other means."[304] Yet, the terms of Article II are brief and subject to differing

[303] Mountford & Tuffnell, *supra* note 1 at 220 (citing Robert L Kelley, Gold vs Grain: The Hydraulic Mining Controversy in California's Sacramento Valley [Glendale, CA: Arthur H Clark, 1959], 229–40).
[304] *OST*, *supra* note 18 at Art II.

interpretations. As discussed, several States, led by the U.S., have taken more expansive positions about the non-appropriation principle through national legislation and unilateral statements. This means that States with varying interpretations of Article II may make colorable but divergent legal interpretations without a clear and definitive meaning for Article II.

Article II does not offer adequate protection from the mining development of the Moon because proponents of lunar mining can take a good-faith position that resource extraction does not equal "national appropriation" under Article II. That is, the U.S. is not claiming ownership and sovereignty over the Moon merely because it would extract relatively small parts of the Moon through mining operations. This position, it is argued, is tantamount to fishing on the high seas of Earth, where every State and individual may own what they collect, yet they do not claim ownership of the high seas per se. In the same way, lunar mining does not constitute an ownership interest in the Moon per se, only in what a party may mine from the Moon.

Thus, treaty interpretation will be more important in the lunar mining debate. In this context, it is vital to remember that space law comprises a part of the larger body of international law.[305] But to properly understand the terms and provisions of treaties, parties must refer to Article 31(1) of the Vienna Convention on the Law of Treaties, the so-called treaty on treaties.[306] This provision states that "A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose."[307] Unfortunately, neither proponents nor opponents have a clear and winning argument, even using the provisions of the Vienna Convention.

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[305] Jakhu, Pelton & Nyampong, *supra* note 23 at 115.

[306] *Vienna Convention on the Law of Treaties*, 23 May 1969, 1155 UNTS 331 (entered into force 23 May 1969) [*VCLT*].

[307] *Ibid* at para 31(1).

Relating to "appropriation" under Article II of the OST, proponents of lunar mining would argue that appropriation means the creation of ownership over real property. In contrast, opponents of lunar mining may note that the exploitation of lunar minerals is, by definition, appropriation because it requires a substantial territorial presence and the usurpation of part of the Moon. This Thesis does not aim to resolve this ongoing debate; rather, by highlighting that key terms are challenging to define, even with the assistance of settled treaty tools, the Thesis demonstrates how key space law provisions can be read ambiguously. And ambiguity in legal provisions inevitably leads to disagreements and conflict.

Also of concern, Article II of the OST has not been tested in a major conflict or legal disagreement among States. Thus, the legal interpretation of the most powerful or earliest State to mine the Moon may prevail. While environmentalists may cite the non-appropriation principle to inhibit the creation of large mining settlements on the Moon (claiming national appropriation by "occupation"), mining operators may reply that their settlements do not constitute occupation if they are open to other parties and thus are non-exclusionary in practice. And even if they did constitute "occupation" under Article II of the OST, if miners' operations are also partly for exploration, then Article IV of the OST would conceivably condone a "facility necessary for peaceful exploration of the Moon."[308] Thus, operators may seek to frame their mining operations from the earliest phase as part exploratory and part mining operations. At the very least, the paradoxical nature of Articles II and IV of the OST is challenging to reconcile in this context.

Alternatively, mining operators may seek to design their lunar structures as moveable, semi-permanent buildings that are available to other States and companies to use (under an exchange agreement or fee schedule). In this way, such facilities would not be exclusionary or

[308] *OST*, *supra* note 18 at Art IV.

affixed to the lunar surface and thus less likely to constitute "appropriation." Because Article II of the OST can be turned on its head so easily with colorable legal arguments for opponents and proponents, this signals a critical weakness in Article II as it pertains to environmental safeguards. With ambiguous terms, a paradoxical reading vis-à-vis Article IV, and questionable enforceability, the contours of Article II ultimately do not offer strong or reliable legal safeguards against the excesses of lunar mining.

2. Article IX of the Outer Space Treaty

Next, Article IX of the OST presents the due regard obligation and the prohibition of harmful contamination.[309] Like Article II, Article IX is notably brief and unclear on critical points. States will be guided in the exploration and use of outer space by "the principle of cooperation and mutual assistance and shall conduct all their activities in outer space […] with due regard to the corresponding interests of all other States Parties to the Treaty."[310] However, in the lunar mining context, what use would a State have for "cooperation and mutual assistance," much less "due regard" if a State is the first (and only) State to land on the Moon for mining operations?

Indeed, these principles and considerations would strongly encourage a free-for-all or first-come-first-served mentality for States rushing to explore the Moon. This is because the first States to arrive would not need to coordinate with any other States and are free to operate with relative impunity. However, as more States arrive, the notions of cooperation, mutual assistance, and due regard become more relevant but also more restrictive in the field of competing States. Therefore, in the "galactic gold rush" scenario, the strictures of Article IX of the OST do little or nothing to

[309] *Ibid* at Art IX.
[310] *Ibid*.

prevent an environmental calamity in lunar mining and, in fact, may actually encourage speedy and reckless development to arrive first for lunar mining operations.

Even after a few mining operators arrive in the same lunar area, how shall the parties deconflict competing mining interests in a safe and orderly manner? The due regard principle lacks the necessary specificity and clarity to protect the environment from unscrupulous actors.[311] Mining operators require clear boundaries and rights rather than platitudes about cooperation, partnership, and due regard for other operators' rights and interests.[312] Without clear left and right boundaries, mining operators may resort to priority rights based on the earliest arrival, the richest State, or intimidation tactics.

Additionally, Article IX of the OST provides little or no explanation of what "harmful contamination" of the Moon and other celestial bodies would look like.[313] Presumably, this could be one of the most vital provisions of the OST, used to fully enjoin mining operators from projects that would result in harmful contamination on the Moon. Yet, without clarity about what qualifies as contamination and at what point it becomes "harmful," again, both proponents and opponents of lunar mining can make colorable arguments that mining operations do or do not run afoul of the "harmful contamination" provision of Art. IX. Some have argued that under such uncertain guidance, the Precautionary Principle should apply, and "any error should be on the side of the undue rigour and prevention rather than of risk."[314] This would represent one of many approaches, though it sadly carries no binding force.

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[311] *Lunar Policy Handbook*, by Moon Dialogs, No LPH-P/1-2, (Handbook) (2023) at 11, online: <Handbook> [https://static1.squarespace.com/static/5d36544d1438f10001b32ebd/t/641b37f94066625409321c81/1679505406530/Lunar_Policy_Handbook_Jan_16_23_Single_Pages_LR+%281%29.pdf].

[312] *Ibid*.

[313] Lyall & Larsen, *supra* note 12 at 174.

[314] *Ibid*.

The analysis reveals that States are in a paradoxical position. On the one hand, they wish to spur their citizens to develop space technologies, lest the State fall behind rival States and lose prestige. Yet, on the other hand, States fill a paternalistic role, granting licenses and supervising space activities for responsible, sustainable, and lawful compliance with laws and regulations. Thus, States are tugged in one direction "to be rigorous in their requirements as to the avoidance of disruption and contamination" while also desiring to give their constituent citizens and companies ample room to maneuver and outpace citizens of rival States in space technology and development.[315] In this dichotomy, many of the leading space-active States have clearly opted for the latter approach, risking neglect of their duties under the OST to the detriment of the space environment.

Sadly, the shortcomings of the OST are on full display in the context of environmental protection. This is partly a reflection of the bipolar climate in which the OST was negotiated and signed. It is also a reflection of the fact that environmental well-being was not a core concern in international law until the late 1960s and 1970s. It was only during the later ecological movement that the Moon Agreement was discussed and drafted. Yet, the OST is the most binding and relevant legal authority, so if it is inadequate to offer a shield against mining operations, then humanity must turn to other legal safeguards for additional support.

3. The Moon Agreement

While the Moon Agreement sets forth in Article 7(1) that States shall not violate the sanctity of the "existing balance of [the Moon's] environment" through adverse environmental changes and the contamination through the introduction of extra-environmental matter "or

[315] *Ibid* at 178.

otherwise," the Moon Agreement suffers from a noticeable lack of State support.[316] Indeed, even with its underwhelming State support at present, the Moon Agreement will lose one of its vital signatories in 2024.[317] Until Saudi Arabia's notification that it would withdraw from the Moon Agreement, no State "had ever withdrawn from any of the five United Nations treaties on space-related activities."[318] This expected withdrawal is momentous and further weakens State support for the Moon Agreement, which legally binds very few States.

Article 11 of the Moon Agreement does a great deal to explain and clarify earlier provisions of the OST. In particular, paragraph 3 of Article 11 says that "neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become the property of any State, [organization, or person]."[319] Thus, the Moon Agreement goes further than the text of the OST to explicate some of the undefined provisions of the OST. It addresses the notion of non-appropriation in greater detail and specificity.

Yet, Article 11 of the Moon Agreement also does much to obscure the meaningfulness of the Moon Agreement's other provisions. Of particular concern, Article 11.1 says that the "moon and its natural resources are the common heritage of mankind…"[320] The Moon Agreement regrettably provides no definition of the "common heritage of mankind" or its legal significance. Article 11 of the Moon Agreement goes on to mandate the stand-up of an "international regime to govern the activities when exploitation of the natural resources of the Moon is about to become

[316] *Moon Agreement*, *supra* note 213 at Art 7.

[317] Stefan-Michael Wedenig & Jack Wright Nelson, "The Moon Agreement: Hanging by a Thread?" (26 January 2023), online: *McGill University Institute of Air & Space Law* <https://www.mcgill.ca/iasl/article/moon-agreement-hanging-thread#:~:text=Per%20Article%2020%20of%20the,France%2C%20Mexico%2C%20and%20Australia.>.

[318] *Ibid*.

[319] *Moon Agreement*, *supra* note 213.

[320] *Ibid* at para 11.1.

feasible."[321] The practicalities of establishing such a regime are undoubtedly vast and complicated. Yet, the timing of this obligation only further complicates matters, requiring that the regime come into existence when lunar exploitation is "about to become feasible," rather than when it is feasible.[322]

The Moon Agreement is guided by the "orderly and safe development of the natural resources of the Moon."[323] Yet, the balance that the Moon Agreement seeks to strike is based upon "equitable sharing" by States in the benefits stemming from lunar resources. This presupposes that space-active States must be willing to give an *equitable* (and not necessarily *equal*) share of benefits (i.e., profits) to developing countries. The ambiguities of this scheme are perhaps too numerous to even detail in this Thesis. Operative terms within Article 11 of the Moon Agreement are undefined, leaving States to grapple with what the convention even strives to accomplish (and perhaps reflecting the meager ratification of the treaty). What would be equitable? Which body would be responsible for establishing and maintaining a distribution scheme? What recourse would aggrieved developing States have against the richer States? Absent clarification of key concepts and terms, the Moon Agreement's Article 11 premise is inherently flawed; worse, it actually disincentivizes space-active States from even entertaining such a framework, even as well-intentioned as it may be.

Ultimately, proponents of the Moon Agreement cite the treaty as potential evidence of evolving State practice, noting that the Moon Agreement was passed years after the OST and supplements much of the language of the OST. Proponents note that the Moon Agreement adds rich color and detail to the OST, which was adopted before the global environmental movement

[321] Lyall & Larsen, *supra* note 12 at 181.

[322] *Ibid*.

[323] *Moon Agreement*, *supra* note 213 at para 11.7.a.

truly began. Even if the Moon Agreement is not a binding legal authority, proponents argue that it is nevertheless persuasive as an interpretive aid.[324]

Yet, opponents emphasize that the Moon Treaty is binding only on its few signatory States and that the small number of signatories is itself evidence that States have largely *rejected* the supplementary terms of the Moon Agreement—otherwise, more States would sign on to the Moon Agreement. This is very likely the greatest weakness of the Moon Agreement: it enjoys only 18 signatories at present and, indeed, is losing one signatory in the next year.

Moreover, if States took contention with only a few of the provisions of the Moon Agreement, they could ratify the treaty with certain reservations. However, if States have largely foregone the treaty as a whole, as they have done, that is perhaps more indicative of a wholesale rebuke of the treaty. Ultimately, regarding environmental safeguards, the Moon Agreement is little more than persuasive guidance and would provide a sturdy legal basis on which to rest environmental safeguards, but only if significantly more States embraced the agreement.

B. Customary International Law

Regrettably, customary international law is not able to fill in the gaps where treaty law falls short. Many of the same weaknesses and shortcomings in treaty law, doom customary international law measures for environmental safeguarding. Additionally, opponents of the Stockholm Declaration and Rio Declaration may argue that these declarations do not constitute customary international law, which is notoriously difficult to establish and prove.[325] In part, reaching critical mass for State practice and proving the *opinio juris* component of customary international law is inherently a subjective effort that is rarely clear-cut or definitive.

[324] Wedenig & Nelson, *supra* note 317.

[325] Lyall & Larsen, *supra* note 12 at 71.

Turning first to the Stockholm Declaration, this declaration requires States to ensure that "activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction."[326] Yet, even putting aside whether this obligation is truly an international custom, several definitional terms within this provision are open to interpretation. In the lunar mining context, would the mining area fall under a State's or company's "jurisdiction or control"? Arguably, if a party is merely mining an area without excluding other parties, the mining operator does not enjoy genuine jurisdiction or control of the area. Indeed, the party may take affirmative steps to avoid this very perception. Further, even if a party with jurisdiction or control impacted the nearby lunar region (which is beyond national jurisdiction), what would constitute "damage" to this area? Proponents of lunar mining would maintain that merely changing the terrain and removing resources does not constitute "damage" but rather an alteration to the terrain; damage would require a higher level of harm.

The Rio Declaration is equally susceptible to arguments about loopholes based on the language of the declaration. Principle 15 is particularly susceptible: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[327] Proponents of lunar mining have numerous methods of legal attacks, claiming that a mining operation would not cause "serious or irreversible damage," that the term "cost-effective measures" is inherently vague and subjective, and that "environmental degradation" necessarily requires a judgment call.

Ultimately, customary international law through U.N. Declarations provides no real teeth to protect environmental interests from lunar mining operations. This is because the declarations

[326] *Supra* note 235.

[327] *Rio Declaration*, *supra* note 237 at Principle 15.

themselves are aspirational and moral in nature rather than legally binding. Next, proponents of environmental safeguards may claim that these declarations restate or form customary international law, but proving this is another matter. It may be an uphill battle demonstrating sufficiently widespread and consistent State practice combined with *opinio juris*. Finally, both the Stockholm and Rio Declarations present numerous definitional problems. Similar to the treaty provisions, when the text of a treaty or declaration is somewhat vague or open to interpretation, then both sides of a debate can make equal use of the text in support of their argument.

C. Other Sources of Law and Authorities

Rather than potentially constraining States and companies, sources of soft law incentivize a "go-forth-and-conquer" mentality. U.S. policies and national laws serve as unambiguous messages to U.S. citizens and as diplomatic communications to other States that the U.S. aims to be the first to meaningfully return to the Moon. While internal laws and regulations governing licensing and launching certainly provide a litany of restrictions, the American approach—like those in Luxembourg, India, the United Arab Emirates, and Japan—generally appears to be focused on rapid development while asking questions later.

President Trump's Executive Order, declaring that outer space is not a commons, underscored a time of shifting American space policy. In considering whether space law meaningfully restricts the most destructive practices of lunar mining, it is most remarkable to note that the U.S., arguably the leading spacefaring State, has used its full diplomatic, informational, and economic might to incentivize companies to proceed at a breakneck speed toward lunar arrival. The term "global commons" is a political one rather than a legal one, but it nevertheless places a finger on the scale of legal considerations.[328]

[328] Jakhu, Pelton & Nyampong, *supra* note 23 at 126.

Key U.S. environmental statutes and regulations fair no better. They are wholly inadequate to address the full scope of planned lunar operations.[329] This is partly because environmental damage in outer space is extremely difficult to anticipate. Also, operating proposals are drafted by applicants, with help from well-paid lobbyists, experts, and attorneys, and with every incentive to downplay potential environmental harm. The NEPA, while well-intentioned, is not well suited to regulate a completely new source of environmental activity and harm. As a final consideration, U.S. regulations are overly vague in the outer space context and completely untested.[330] This introduces a level of ambiguity and uncertainty that undermines guarantees of environmental protection in outer space.

A key challenge in this context is the lack of directly-applicable precedent construing the OST and Moon Agreement in the lunar mining context. Lawyers recognize the value of precedent to render legal provisions predictable based on past judicial or regulatory interpretations. This permits lawyers to advise their clients with some degree of certainty established in the past course of conduct. In uncharted territory, however, lawyers and clients must rely only on their subjective interpretations of the law and best guesses as to the outcome.

This can lead to shocking results if parties embrace aggressive but defensible legal arguments. It may also create some hesitancy and reticence for mining operators if they have no stomach for significant investments and undertakings with unclear legal guidance as support. Ultimately, from the environmentalist's perspective, the murkiness of the law cuts both ways: impacting operators and questioning whether any legal provisions genuinely protect the environment.

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[329] FAA, *supra* note 254.

[330] *Ibid*.

Finally, soft law authorities, such as the U.S.-led Artemis Accords and the U.S. Cislunar Strategy, reaffirm the position that the Moon may be mined and that such mining operations are not tantamount to an act of national appropriation under Article II of the OST. All of this represents a monumental change in how the U.S. (and thus presumably other States) view resource extraction. U.S. accords and policies have sought to bring mining into mainstream space policy by normalizing mining practices. In the several decades since the OST was ratified, States have been less concerned with nuclear war and land appropriation in outer space and more interested in economic development and commercial interests, perhaps as a vehicle to further State research and development in space.

With States serving as the gatekeepers and monitors of space exploration under Article VI of the OST, and with many of them also pushing for more aggressive development of lunar resources, the writing is on the wall for environmentalists.[331] The inescapable conclusion is that the OST and other legal and quasi-legal authorities cannot guarantee that the Moon and any combination of relevant ETs will be safeguarded from unscrupulous mining operators. Instead, the legal regime results in guesswork on many vital aspects: land occupation and use, compulsory remediation, and enforcement mechanisms. Without certainty as to legal provisions, the haste of mining operations threatens to trample and overwhelm notions of environmental preservation before the law can catch up.

This conclusion has limitations. States and companies still need to put forth concrete plans for lunar mining. While early press releases provide some insight, no definitive mining plans in detail have been forthcoming just yet. Thus, one limitation is that the impact of lunar mining is not yet known to a high degree of certainty. Additionally, while lunar mining could be a reality as

[331] Lyall & Larsen, *supra* note 12 at 172.

early as 2024 if past space operations are a reliable indicator, the timeline may be pushed back considerably based on technological development and fundraising. If deadlines are delayed, the U.N. and its Member States will enjoy more time to assess the problem and devise solutions.

As for future directions, the U.N. must further assess the condition of space law provisions to determine if new articles are timely. Indeed, the U.N. is making gradual progress on this issue. In 2022, COPUOS' Legal Subcommittee created a Working Group on the Legal Aspects of Space Resource Activity. The Working Group received a five-year mandate to collect data, study the legal framework, and "assess the benefits of further development of a framework for such activities, including by way of additional international governance instruments."[332] Commentators call the establishment of the Working Group a significant acknowledgment that the OST "does not adequately address space resource activity and how the benefits of outer space are to be shared."[333] It also represents the first time since the 1970s that COPUOS Member States have announced any willingness for a new "international governance instrument" beyond standard non-binding guidelines.[334] While the Working Group's mandate is ongoing, States eagerly await its results.

D. Lawfulness and Lawlessness

As a final note, the notions of lawfulness and lawlessness—contained in the subtitle of the Thesis—refer to the presence and absence of applicable, enforceable legal and quasi-legal provisions in the outer space context. The promise of lunar resources has obvious similarities to the California Gold Rush, where early settlers reshaped a frontier largely devoid of legal constraints on mining. Lawlessness invites rash actions with irreversible impacts, while lawfulness

[332] Dennis O'Brien, "Will a five-year mission by COPUOS produce a new international governance instrument for outer space resources?" (20 February 2023), online: *Space Review* <https://www.thespacereview.com/article/4534/1>.
[333] *Ibid*.
[334] *Ibid*.

proclaims orderly, measured, and peaceful limitations. Yet, while the California frontier was later tamed by laws and regulations, the lunar frontier enjoys largely antiquated and aspirational safeguards with meager thrust.

Against miners' remarkable haste, the Moon quietly orbits the Earth, anticipating the next human landing. Assuming that a private company will be the first party to land on the Moon again with the intention and capability to collect ice water and drill for REEs, ETs cannot be adequately safeguarded based on existing space laws. This is because mining operators—whether States or companies—have a reasonable response to virtually every legal provision that would constrain their environmentally-destructive behavior. The scarcity of legal provisions and the provisions' relative lack of clarity provides fodder for mining operators to make colorable arguments in their defense. Armed with legally defensible stances, miners will move forward, and environmental proponents will be powerless to stop them.

If lawlessness will likely dominate the lunar frontier, creative proposals will remain a flashpoint for future discussion about the lunar surface and other extraterrestrial environments.[335] While the primary focus of this Thesis remains the methodology and conclusions discussed in this section, the following section discusses several proposals that may lend themselves to further protection of the lunar environment, even if mining operations begin in 2024.

IX. Proposals

> *"Traveling in Queensland, Australia, in 1873, the British essayist and novelist Anthony Trollope reckoned that it cost £ 5 to extract from the ground an ounce of gold that could be sold for between £3 10s and £4 2s. Trollope factored into his calculations only the labor costs of mining. Had he included the environmental costs—the strip-mining of the goldfields, the rivers clogged with debris, the fisheries ruined, and the towns flooded as a result of that debris, the farmlands despoiled by sludges, the timber consumed for sluices and flumes, and the human*

[335] Lyall & Larsen, *supra* note 12 at 186.

nervous systems poisoned by mercury—the economic costs would have become incalculable."[336]

The preceding section of the Thesis analyzes the adequacy problem of space laws and concludes that more is required of space laws to protect environmental targets on the Moon. Therefore, this Thesis next proposes measures that may mitigate the anticipated harm to the Moon. The preceding sections conclude that even if environmental safeguards are not urgently required, they may be needed in the next few years. Therefore, States should aggressively pursue options for later implementation. The following sections provide creative solutions for consideration.

A. Environmental Impact Assessment

The environmental impact assessment ("EIA") has been used for many years in some form across the world to assess environmental impact.[337] While the U.S. was one of the earliest States to implement EIAs in widespread government use, many States now employ EIAs in some form.[338] The EIA merely contemplates transparency, accountability, and careful evaluation before permitting any action impacting the environment.[339] In the U.S., the national government typically uses EIAs in various tiers, from least to most likely to disturb the environment.[340]

EIAs will likely be quickly approved for government action for small projects with a low expected environmental impact.[341] However, the EIA is more involved in the most significant projects, such as new landing zones or buildings.[342] For projects likely to greatly impact the

[336] Mountford & Tuffnell, *supra* note 1 at 221 (citing Anthony Trollope, Australia and New Zealand, vol 1 [London: Chapman and Hall, 1875], 135–36).
[337] USAID, *Public Participation: Environmental Impact Assessment (EIA) in the United States* (2012).
[338] *Ibid*.
[339] *Ibid*.
[340] *Ibid*.
[341] *Ibid*.
[342] *Ibid*.

environment, a detailed proposal must be drawn up to list all anticipated environmental impacts. Upon review, the government will organize one or more public hearings so that members of the public may attend, ask questions, and demand clarification before a large project is approved. Importantly, revisions to the project may be necessary to reduce the project's environmental footprint. Only once the government and local officials are sufficiently satisfied that the value of the proposed project outweighs the potential harm to the environment can the project move forward.

In the outer space context, as in almost every governmental context, EIAs offer a trusted and time-tested vehicle to evaluate lunar mining operations. In contrast to projects in the U.S., the space context would require a central authority to receive EIA applications and hold hearings for the global public. In practice, the U.N. would fill this role as the major supranational organization. A U.N. body would be well-suited to assessments, hearings, and final determinations with input from the world's States. Of course, a great deal of time and planning would be required to establish a new office of the U.N. to oversee EIAs. However, once the logistics are devised, the review of EIAs could quickly follow.

As a counterargument to EIAs, opponents may note that a lengthy administrative review process may take considerable time and delay or impede the quick pace of development in space.[343] Companies are generally averse to governmental red tape and formalities.[344] They would also be loath to potentially disclose "commercial secrets or market-sensitive information."[345] However, against these concerns are the legitimate interests of State responsibility and environmental preservation of the Moon and other celestial bodies. Additionally, there is virtually no realm of

[343] Lyall & Larsen, *supra* note 12 at 173.
[344] *Ibid*.
[345] *Ibid*.

everyday life where individuals and companies do not sacrifice speed and efficiency in exchange for State regulation, which is necessary to preserve safety, peace, and order. So while EIAs and other forms of State regulation may have drawbacks, the benefits still outweigh the potential shortcomings.

EIAs would provide a well-known method to evaluate mining operators' plans fairly, ask questions about plans for lunar mining operations, and hold operators to account should they deviate from the original plan. A central EIA office at the U.N. would be authorized to ask difficult questions of operators based on public input. Further, the real power of the office would be similar to States allowing space launches: withholding authorization to engage in reckless future conduct. By serving as a gatekeeper to lunar surface activity, the U.N. would guarantee that mining operators do not treat environmental considerations as merely an afterthought to mining operations.

B. Earthly International Law is Space Law

Second, Article III of the OST requires that States Parties to the OST "shall carry on activities in the exploration and use of outer space […] in accordance with international law, including the Charter of the United Nations."[346] While many provisions of environmental law are piecemeal within intrastate laws, States may rely on environmental law treaties, customary international law, and general principles of law on Earth. Thus, these same provisions transfer to conduct in outer space through Article III of the OST.

Among international environmental law treaties, States may lament the scattershot approach to acceptance and ratification of such treaties. Indeed, there is no broad, overarching environmental law treaty like there is for civil aviation or outer space exploration. However, there

[346] *OST*, *supra* note 18 at Art III.

are broadly supported U.N. statements like the Stockholm Declaration, already discussed, resulting from the 1972 U.N. Conference, which meaningfully placed the environment on the agenda as a significant issue for the first time.[347] The Stockholm Declaration began an international dialogue by placing environmental issues atop States' agendas for years to come.[348]

Customary international law and general principles of law further supplement international law transposed from Earth to outer space. As discussed in Section VI.B. above, State sovereignty and the "no harm" principle constrict States from using their territory to harm other States under the *Trail Smelters* arbitration. While that case centered on Canada's use of its territory in ways that hurt a neighboring State's environmental interests, it also applies to outer space. States and their companies will occupy portions of space, orbits, and terrain, such as lunar mining. In doing so, States must refrain from using the space or land they temporarily occupy in ways that would potentially harm other States.

Finally, international developments like the agreement struck at the U.N. COP15 Biodiversity Conference set a precedent for outer space law. If 190 States can agree on environmental objectives and benchmarks for the Earth's protection, this act creates norms and expectations for international law, whether on Earth or in outer space. Article III of the OST is an incredibly powerful and underappreciated conduit to siphon Earth-based international law to the outer space context. It should be acknowledged, and the best parts of terrestrial legal regimes should be leveraged to protect the Moon.

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[347] United Nations, "United Nations Conference on the Human Environment, 5-16 June 1972, Stockholm" (last visited 22 February 2023), online: *UN Conferences* <https://www.un.org/en/conferences/environment/stockholm1972#:~:text=The%20Stockholm%20Declaration%2C%20which%20contained,and%20the%20well%2Dbeing%20of>.

[348] *Ibid*.

C. Lunar Protected Areas

The third proposal takes inspiration from the 2022 U.N. Biodiversity Conference and the 2023 High Seas Treaty. With momentum from U.N. member States that have agreed to preserve 30 percent of their sovereign land and water areas, as well as 30 percent of the high seas through MPAs, States may agree to set aside substantial portions of the lunar surface as well. This is especially enticing in light of the current understanding that only a small portion of the Moon may be of interest to mining operators. If the poles generate the most interest, then other sites—perhaps clustered near a hemispheric band around the Moon—may serve as palatable Lunar Protected Areas ("LPAs") that are relatively devoid of the resources that States and companies desire.

The recency of the U.N. COP15 Biodiversity Conference in 2022 and the High Seas Treaty in 2023 is strong evidence that States presently have an appetite for LPAs. Still, one reason for circumspection may be that our understanding of where the majority of REE deposits are located must be further refined. Only if States and companies can be certain that LPAs will not disqualify what they seek most—vast deposits of REEs—will they presumably agree to limit LPAs that would put these resources out of reach.

In response, 30 percent of the Moon's surface is still a minority portion of the Moon to preserve, leaving the majority of the Moon subject to mining operations so long as their environmental impact is minimized. Moreover, the 30-percent portion of the Moon's surface covered by LPAs could serve a second purpose: to protect lunar areas worthy of landmarking, such as the Apollo 11 landing site. In such a way, environmental concerns will be offered a degree of guarantee that some portions of the Moon's surface will be completely untouched, even if the majority of the Moon is subject to mining operations.

Thankfully, the U.N. Educational, Scientific and Cultural Organization ("UNESCO") now has lengthy experience designating international places and items of interest for heritage purposes.[349] There are pre-existing agreements and ongoing discussions about UNESCO's processes and ever-growing body of protected items.[350] Therefore, a regime to protect heritage locations on the Moon should not represent an unreasonable demand for UNESCO.

D. Permanent Court of Arbitration for Lunar Disputes

As a final proposal, the nature of lunar development and the high stakes for investment and execution virtually guarantee that States and companies will disagree on interpretations of space law. In anticipation of such disputes, the U.N. should investigate the appropriateness of establishing a Permanent Court of Arbitration for Lunar Disputes ("PCALD"). With a central authority for dispute resolution, the parties and their respective governments will be ready when—not if—disputes arise in outer space. Such conflicts could occur based on land claims, rights priorities, nuisance, division of profits, and exclusion of other parties from areas of land. These disputes are virtually guaranteed to arise during the exploration and mining of the Moon.

If the U.N. can first stand up the PCALD or some court or arbitration panel similar to it, the U.N., States, and private parties can rest assured that when disputes arise, the terms of resolution will be predictable and palatable to all parties. Additionally, this will ensure that disputing parties will not resort to unfair dispute resolution or armed conflict if they cannot rely on judicial settlement. The challenge will be justifying such a body when no disputes have yet arisen. The U.N. should take proactive steps to guarantee that when a situation arises in which the PCALD will be called upon, the court can be stood up quickly.

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[349] Lyall & Larsen, *supra* note 12 at 175.

[350] *Ibid*.

The International Court of Justice may also provide a suitable forum for outer space disputes, though the PCALD offers the assurance that the forum is specialized and tailored to the dispute at hand. The knowledge that the rule of law will exist in space, as it does on Earth, will provide peace of mind to the parties venturing to the Moon. It will also potentially prevent the existence of a "lunararchy," i.e., a patriarchy or monarchy of only wealthy, leading spacefaring States that use their power and influence to coerce smaller parties. With the PCALD in reserve, legal principles will prevail so that the forty-niners of 2048 do not feel abandoned by the rule of law and authoritative judicial settlement like the forty-niners of 1848.

X. Conclusion

A. Research Objectives

The objectives of this Thesis are (i) to analyze the adequacy of space laws with respect to environmental protection of the Moon from lunar mining operations, (ii) to conclude whether space laws adequately protect the Moon from such operations using the stated methodology, and (iii) to propose potential solutions for policymakers and space agencies to consider. In all these inquiries, the methodology formula in Figure 1 has been the proverbial North Star. The methodology identifies the critical components in this inquiry and provides a tool to vary inputs and pose "what-if" scenarios.

The Thesis juxtaposes the threats posed by lunar mining operations with the various relevant sources of space law. The conclusion is that space law suffers many regrettable shortcomings based on ambiguous terms, questionable enforceability, and lack of attention to environmental concerns. While none of these shortcomings may be fatal by itself, taken together, they raise many questions about the sufficiency of space laws if a party were to begin unscrupulous mining operations today.

B. Implications of Findings

What should one make of the findings? First, the topic of this Thesis was chosen in part because the threat posed by lunar mining operations is forthcoming, to be sure, but not so distant that this Thesis will become irrelevant due to the passage of time and changed circumstances. Thus, this Thesis hopefully finds resonance in a time period in which it may be of service to later jurists and policymakers.

Second, the ultimate conclusion is, of course, concerning, but rather than lead to stagnation, it should spur States and private actors to reinvigorate efforts to conclude strengthened legal provisions or rein in mining proposals. In a sense, this Thesis is "wargaming" how future threats to the lunar environment will (or will not) be blunted by countervailing environmental safeguards. This is no different than what State governments, militaries, and large corporations do to protect their future interests in the case of ambiguities and unknowns.

Third, the proposals that are discussed are merely the tip of the proverbial iceberg. Space law is sufficiently flexible and sprawling that countless more proposals may abound that complement or improve upon the current proposals. Even if only one out of every ten proposals is ultimately implemented, the outer space environment will be immeasurably improved. The hope is that the methodology formula may produce more ideas about the model for environmental protection, allowing parties "zoom in" and focus on the weaker points of the model to generate the most appropriate proposals.

Fourth, ambiguous and antiquated legal provisions are the enemies of steadfast environmental protection in outer space. The Thesis has demonstrated numerous instances of space law written in unclear or indefinite terms. It has also shown that while international treaties must often be read as living documents that change with time, sometimes the era in which a document

was drafted and ratified confines the object and purpose of the treaty to an overly restrictive degree. The ambiguity and outdated nature of space laws render them less effective than desired. With this, space laws are either ineffective on their own, or they present themselves for equal usage by proponents and opponents of aggressive lunar mining operations. Either way, their efficacy is undercut and the existing outer space legal regime is undermined.

Lastly, States should heed the Thesis findings and adjust their laws and regulations accordingly. This is primarily because States remain the effective gatekeepers to outer space activities for private enterprises under Article VI of the OST.[351] This article says that States "shall bear international responsibility for national activities in outer space."[352] Because national activities are broadly construed to include the actions of non-State private actors, States have an ongoing responsibility to authorize and supervise the space activities of their citizens and companies.[353] A State is thus fully responsible for the acts of its non-State companies as if the State had executed the same acts.[354]

Therefore, States hold enormous power to craft space policies that will permit or constrain private parties' activities in outer space. And while many States have heretofore encouraged aggressive exploration and exploitation of outer space by their citizens, the findings of this Thesis—and other voices in the greater dialogue—may cause more States to proactively restrain activities that will irrevocably change the outer space environment.

Productive measures under Article VI of the OST would include greater scrutiny of company proposals for space activities, more exacting standards for license issuances, and ongoing

[351] *Ibid* at 172.
[352] *OST*, *supra* note 18 at para VI.
[353] *Ibid*.
[354] Lyall & Larsen, *supra* note 12 at 179.

supervision of the activities of all nationals, which effectively act for their States.[355] Because the international regime charges States with the authorization and continuing supervision of its nationals, States are the gatekeepers and regulators of outer space activities. They must uphold this heavy responsibility at all times, lest they face potential international responsibility for the wrongs of their nationals on the Moon.

C. Concluding Remarks

The title of this Thesis is "Galactic gold rush," though the immediate focus of the Thesis is not galactic in scope but limited to the Moon. Still, the title intentionally features a scope that includes our entire galaxy. That is because there is nothing inherently unique about the Moon in relation to environmental concerns; the Moon is merely the nearest ever-present celestial body and thus deserving of the most immediate attention. Nevertheless, the lessons learned from lunar exploration, exploitation, and protection transfer to virtually any celestial body on which humankind may settle and sustain life.

From the age of media to the era of social media, from the age of gazing at the stars to the period of living among them, humankind's laws must adapt and follow us faithfully wherever we go. It is often jokingly said that lawyers look forward to calamity, but that is not so. Instead, we appreciate looking forward to accidents to avert them, or at least to preserve rights and plan for remedies. The presence of laws in outer space is as important as the presence of food, water, and air. Without any of these, the fate of our existence is sealed.

This Thesis is a proactive reflection on the state of space law with an eye to future disagreement. Hopefully, no party will ever need to resort to any of its ideas. However, as stated earlier in the Thesis, what humans do on Earth, so they will do in outer space as well. Therefore,

[355] *Ibid* at 172.

a failure to adequately plan for legal discord in space may result in armed conflict in space. Now is the time to move quickly toward solutions that will oversee and regulate potentially harmful resource extraction activities on the Moon before it is too late.

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