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What Should We Do with Our Moon?: Ethics and Policy for Establishing International Multiuse Lunar Land Reserves

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ABSTRACT

The planned expansion of the human presence on our moon demands that we reconsider our relationships with our planet's partner. Threats to the moon such as those engendered by mining encourage the preservation of various precious areas of our moon's surface through the emplacement of international multiuse land reserves. These reserves, arising from tested environmental science strategies as well as values drawn from the ethnographic field, allow concurrent pursuits of industry, science, environmental preservation, respect for human cultural landscapes, as well as future recreation. By protecting the near side patterns in the moon, the Hertzsprung and Von Kármán Craters on the far side, and polar regions at Malapert, Peary, and Florey, we leave room for industry while also avoiding pointless losses of the moon's own majesty or damage to ourselves in our interactions with the moon. In creating these reserves in line with the Outer Space Treaty, we move closer to the desirable environmental justice outcome in which each human theoretically has a say in the fate of our moon, which is the cultural heritage of every one of us.

1. Introduction

What should we do with our moon? Many people in space industries and studies ardently debate this hot button question. For various reasons, numerous national and private entities plan a near-future return of humans to our moon, this time to stay. What form this human presence should take remains unclear amid a cacophony of competing voices. Some industrialists understand our moon as a territory that is free, perhaps even predestined, to be exploited for resources. Technology firms may wish to utilize our moon as a lab for developing equipment for Mars and beyond. Scientific researchers may desire to maintain the moon as unsullied so that natural science investigations can avoid complicating contaminations. Finally, environmentalists request that the unique and majestic features of our moon be preserved for their own sake. The space policy expert Christopher J. Newman, for instance, recently stated, "The moon is planet Earth's unique companion, and a policy of sustainability could be an enduring legacy of this new era of lunar exploration" [1]. How do we move forward in ways that potentially satisfy these divergent voices?

In this article, I offer a proposal which conforms to the Outer Space Treaty and which slices through competing opinions by establishing international multiuse land reserves in five strategic locations on our moon. My argument emerges from ethnographic field data collected among citizens of the United States that support environmental ethics for properly returning humans physically to our moon. These quantitative and qualitative environmental ethical data then orient materials drawn specifically from secular space policy studies. The result is a values-grounded proposal for initiating international multiuse land reserves in the region of the Malapert Massif near our moon's south pole, Peary and Florey craters near the north pole, Hertzsprung Crater and von Kármán Crater on the far side, and the feature known to various cultures as the Woman, Man, Toad, or Rabbit in the Moon. The International Union for Conservation of Nature (IUCN), an influential advisory body to the United Nations, recommends creating land reserves to preserve abiotic geologies that "have significant value for intrinsic, scientific, educational, cultural, spiritual, aesthetic, ecological, or ecosystem reasons" [2], and the places on our moon I have listed fit this description. The multiuse dimension of these reserves means that they can respond positively at once to commercial, scientific, ecological, and future recreational outcomes.

As well, the international character of the reserves moves us closer to the desirable environmental outcome in which we all theoretically have a say in our moon's future, given that every human being can claim the moon as a part of a cultural heritage even if none of us actually owns the moon. The reserves proposed here hence are in line with a goal of the UN's Committee on the Peaceful Uses of Outer Space (COPUOUS) that, "Preserving the use of outer space for current and future generations is consistent with upholding the long-standing principle

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contained in Article I of the Outer Space Treaty that the exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all humankind" [3].

Many of the competing voices regarding our moon's future will, therefore, find something that they like within the diverse facets of this proposal, which also coheres with methods and goals pertaining to the establishment of land reserves on Mars [4–6]. Let us commence our discussion of the relevant issues by turning to lunar mining scenarios.

2. Outlines of moon mining

Mining various resources remains a central draw of diverse national and commercial efforts not just to return a human presence to our moon but also to expand humanity's lunar footprint. Along with initiatives like the European Space Agency's Moon Village quest, the United States National Aeronautics and Space Administration's Project Artemis represents one example of such efforts. In conjunction with private entities, Project Artemis seeks the development of the moon for lunar and Earth purposes, as well as to provide a stepping stone on the way to Mars. Our moon is attractive for this activity since space liftoffs and landings are eased by our moon's lack of an atmosphere in conjunction with a gravity of just 1/6 that of Earth, and a proposed Gateway space station that anchors near our moon could make transport to and from the moon even easier. Implementing these plans appears to demand considerable use of lunar raw resources as well as a substantial long-term human presence on our moon's surface, even if only by robots at times.

With potential riches to be made on our moon, numerous companies are investing in the plans and hardware necessary to mine assorted materials from the moon's regolith. Moon miners may covet rare metals for use on Earth or in space like those from the platinum group, thorium, or titanium. However, thoughtful metals recycling on Earth may be more practical in the long term than mining and transporting metals from the moon, as Julie Michelle Klinger effectively argues [7]. Therefore, in this essay, I focus on another resource desired by lunar miners, the energy source helium-3.

The isotope of helium known as helium-3 may spark an environmentally disruptive technology on Earth, given that, in theory, fusing helium-3 with itself produces electricity without radioactive waste, thus resulting in ecologically clean nuclear power. Since helium-3 power may not produce atmospheric carbon emissions or significant nuclear byproducts, it could potentially change how humans fight climate change. A problem with helium-3, however, consists of a lack of access. The particles of helium-3, arriving in the solar wind, are deflected by the Earth's magnetic field so that there is very little helium-3 on our planet. Although our moon lacks a magnetic field, helium-3 from the sun can land on and bind with the lunar regolith. With a significant investment in infrastructure and energy, in the future, helium-3 could be separated from crushed lunar regolith, shipped to Earth, and used to fuel fusion power reactors. Entrepreneurs could reap massive profits from such large investments.

Beyond difficulties that arise from location, however, another drawback to helium-3 energy involves the mining itself. There is no perfectly sustainable way to mine anywhere, after all. In the case of helium-3, rather than appearing in easily collected clumps, particles are scattered quite thinly amid the lunar regolith. According to the lunar geographer Ian A. Crawford, "By any objective standard, the ^{3}He isotope is actually very rare in lunar soils," having only parts per billion concentrations [8]. This means helium-3 mining cannot be pursued without substantial destruction of the lunar surface.

The former astronaut and helium-3 mining enthusiast Harrison Schmitt offers a sense of just how devastating this mining can be, whether he intends to or not. Schmitt tells us that his example city of Adelaide can be supplied with one year's worth of 1000 MW power with "two square kilometers of large portions of the lunar surface, to a depth of 3 m, [which] contains 100 kg of helium-3" [9]. Highlighting the ecological inefficiency of the process of destroying mineral formations to sift out helium-3, Schmitt relates that only 100 kg of useable helium-3 results from processing "10 million tonnes of regolith" [9].

Placing Schmitt's numbers into a larger, practical context, as I write, there already are 385 cities worldwide with energy needs at least as those of Schmitt's example of Adelaide. With two square kilometers per year processed for each of these cities, at least 770 square kilometers will need to be destroyed at least for Adelaide-sized cities and for just one year. For making things worse, there are innumerable energy-hungry municipalities that are smaller than Adelaide, and their needs will require the devastation of even more lunar real estate. Further, the destruction that I describe here is for just one year, whereas the successful implementation of helium-3 power means that such regolith wrecking will continue for decades.

In terms of an environmental calamity, such demolition of the lunar surface likely will not be purely temporary, either. Our moon lacks plate tectonics, meaning that the moon's surface cannot heal itself from the changes wrought by mining. Intentional remediation of the lunar surface in the wake of mining will be needed to provide restoration. This fact can militate against the economic efficiency of moon mining. Unfortunately, lunar surface remediation also can be neglected, leaving mining scars in the lunar landscape perhaps for billions of years.

Mining helium-3 from our moon thus could incite an ecological debacle. Perhaps, though, helium-3 mining on our moon will not occur quite as I have described so far. The lunar specialist Ian Crawford, for one, indicates that lunar helium-3 mining may prove a minor commercial activity at best. Besides highlighting the great energy and hardware demands of helium-3 mining, Crawford stresses the economic inefficiencies introduced by shipping helium-3 to our home planet. Crawford feels that if we will receive energy at all from our moon, solar collectors on our moon that beam power back to Earth will be a more efficient and realistic outcome than is helium-3 mining [8].

Such solar power collectors, however, also threaten the ecology of the moon's surface through their construction, if made from lunar silicon, as well as their placement. Further, a power beam that stretches 400,000 km represents a potential ecological hazard. But my point here is not to problematize Crawford's well-considered critiques. Instead, I argue that we do not know what future scenario will occur on the moon, but we have reason to be concerned by prospective environmental impacts. An expanding human presence on our moon means that we still must protect lunar ecologies even if Schmitt's, Crawford's, or my divinations of the future are mistaken.

Preserving lunar landscapes, as it turns out, involves cherishing aspects of our current mundane lives, since each day supplies the opportunity for us to observe the moon's surface. Our moon differs from other cultural objects of our sky because it features patterns that are discernible to the naked eye. Unlike Jupiter, which may have influenced ancient Chinese ethnoastronomy [10] but is just a dot of light in our sky, our moon is more than a dot of light. It is a concatenation of visual patterns through which lunar features can be recognized and cherished, as they have been across human histories.

Unfortunately, these treasured lunar patterns can be threatened by mining or other commercial activities on our moon since humans on Earth can see severe lunar damage with their own eyes. Therefore, the space scholar Mark Williamson highlights potential negative outcomes from moon mining in saying, "The impact from such a [helium-3] mine from an aesthetic and cultural point of view would be considerable, because the moon is visible from the Earth" [11]. On Earth, mining has eliminated entire mountains in some places; if the Apennine Mountains on our moon were leveled, the image of the 'man in the moon' known to Westerners would lose his nose, and each of us could observe this loss constantly forever after.

The prospective eternal loss of the nose of the man in the moon represents just one great human and ecological tragedy that may arise from the expanding human presence on our moon. Sadly, though, more losses may accrue for humans, as well as for our moon. One aspect of the expanding human presence on our moon consists of nurturing future tourism, and a lunar landscape that is demolished by mining will please few people who seek moon recreation. Further, regolith that has been crushed and processed to a depth of 3 m makes for poor scientific study, so that intensifying humanity's footprint through helium-3 mining actually can hamper science. On this note, the space ethicist James S. J. Schwartz cogently has argued that our first moral duty in space is scientific study, not commercial gain [12], and non-strategically mining lunar regolith out of an unguided thirst for resources jeopardizes scientific data and thereby violates this ethical duty.

The commercialization of our moon should, therefore, concern us in terms of potential ecological, recreational, and scientific problems. Making things worse, these troubles impact all of humanity. The moon exists as the historical and cultural heritage of all human beings, not just wealthy lunar mining company owners. From the standpoint of environmental justice, we all should have a say in what happens in a place that is a part of all of our lives. Stated differently, eroding our cultural identities and social processes due to the whims of lunar mining company executives creates acute unfairness, as the space anthropologist Alice Gorman argues [13]. Our moon needs to be respected in its own right for the bountiful roles that it plays and has always played in human histories and cultures, and the heritage outcomes for diverse humans should be respected, too. I can make this last point more strongly by explicating some of the bountiful ways in which our moon has transformed human societies.

3. Potential enormous cultural loss

The scholar of religion Mircea Eliade informs us that in the Paleolithic cultures that preceded agriculture, the moon was so culturally respected that it was depicted prominently in several Ice Age cave paintings such as at Lascaux [14]. Throughout numerous eras since then, the moon has appeared in countless religious symbols in relation to themes like fertility, vegetation, regeneration, water, and fate [14]. Across cultures and times, the moon manifests as an object of awe, veneration, or admiration, including, for instance, among some Buddhists. Authoritative ancient Buddhist books repeatedly praise our moon for being 'stainless' like an ideal person, embodying goodness itself, or manifesting 'splendor' [15–17]. In fact, in a Buddhist scriptural text, the Buddha himself notably displayed his personal esteem for the moon by protecting the lunar deity Candima from the eclipsing depredations of the sky spirit Rahu [18].

The moon also was perhaps the first object of quasi-scientific astronomical interest. Astronomy is difficult without a grid for locating things in the sky, and the monthly traverse of the celestial ecliptic plane by our moon creates a useful type of grid that can be used without precision instruments, as early astronomers in places like India and China recognized [10,19]. As such, for thousands of years, the moon has played important roles in calendar-making, the timing of rituals, wedding dates, and other social events. Indeed, people in ancient Mesopotamia and Babylonia were so tightly attuned to the moon that they developed astronomical location techniques, such as the use of angular geometry, that still see employment today [20]. Because of the moon's "centrality in the human imagination," according to the historian Bernd Brunner, when we examine the moon, "We are also studying an aspect of ourselves" [21]. Or, as the British writer C. S. Lewis averred, historically, our moon remains laden with "a huge mass of our emotional wealth" [22].

Because the patterns of the moon's face play roles in all of our lives, as I mentioned, cultures have discerned meanings behind those patterns in their own ways. In contradistinction to the 'man in the moon' recognized by Westerners today, for instance, the Roman writer Plutarch asserted the feminine image of a woman in the moon [23]. Alternatively, some cultures have perceived not a human being but a toad in the moon instead [24].

The historical Aztecs and Maya of Central America provided a fascinating template, although, by understanding the moon to contain the image of a rabbit or hare [25]. Of interest to comparative folklore, cultures across Asia also portray our moon as possessing a rabbit image. Mainline and popular South Asian texts like the *Bhagavad Gītā* and the *Pañcatantra* depict the moon as *śaśi*, "that which contains the rabbit," or *śaśāṅka*, "rabbit marked" [26,27]. Moreover, the *jātaka* tales of the Indian Buddhist scriptures contain a famous story in which a self-sacrificing rabbit becomes rewarded for his virtue by having his likeness painted onto the moon [28].

As Buddhism spread from its birthplace in South Asia into China, the image of this Indian Buddhist scriptural rabbit then merged with an important hare in Chinese culture, Yutu or the Jade Hare [24]. As described in the Chinese classic *Songs of the South*, the moon's Jade Hare prepares the herbs that make gods immortal while also providing company for the moon goddess Chang'e [29]. Because the Indian concept of a rabbit in the moon converged with this Chinese figure, among huge numbers of humans who live in Asia or related cultural zones, the image of the rabbit in the moon has enjoyed reverence for millennia.

Whether one calls the moon's near side patterns a rabbit, man, woman, toad, or something else, however, it remains obvious that lunar patterns play crucial historical roles in shaping human lives. Our destinies also are tied to this area scientifically, as we see in space-age culture. In 1959, the Soviet probe Luna 2 smashed into the lunar surface, thus marking humanity's first direct encounter with another world. Luna 9 made the first soft landing and returned the first photos of the moon's surface in 1966. In addition, the years between 1969 and 1972 marked the in-person arrival of humans in the form of six Apollo missions. All of these missions have left human-fabricated materials that evidence human achievement in space and which lay within the rabbit in the moon feature. At least some of these materials should be memorialized in ways similar to the memorialization of significant events on Earth. In fact, because of no atmospheric weathering, we may expect that Armstrong and Aldrin's footprints are just as the astronauts left them. We should protect these footprints and other artifacts rather than watch them get erased by, for instance, an errant mining vehicle.

Because all of the important space-age sites that I just listed exist within the pattern known as the rabbit in the moon, by ecologically protecting this pattern, we also can preserve our space-age history. Such protection is precisely what I propose here, as the method for establishing nature reserves that I describe in a moment can maintain precious astronaut footprints. It is not difficult to design a land reserve in the region of the rabbit in the moon whose recreational areas are placed intentionally near historical landmarks so that future lunar tourists can readily engage in historical sightseeing.

Reflecting this maintenance, if we wish to create the interesting Apollo Archaeological Reserves suggested by the space archaeologist P. J. Capelotti [30], a land reserve that enshrines the rabbit in the moon eases our path. Likewise, preserving the rabbit in the moon with a land reserve facilitates the adoption of the far-sighted Apollo archaeological preservation campaign of Drs. Lisa Westwood, Beth O'Leary, and Milford Wayne Donaldson [31]. Such a land reserve can exist in concert, as well with the "Declaration of the Rights of the Moon" of the Australian Earth Laws Alliance in terms of its request to be "mindful of the immeasurable value the Moon holds as a repository of deep time and connection among all beings who have ever lived on Earth" [32].

The collection of patterns on the near side of our moon, therefore, meets the standard for environmental protection of the space ethicist Tony Milligan in terms of its "uniqueness as a source of special standing, a standing, which would make it worth conserving, and not simply for the purposes of scientific enquiry" [33]. But how do we appropriately safeguard such a lunar ecological and cultural gem? The answer on which I focus here involves implementing land reserves, which segregate valued nonhumans from the human business-as-usual world through multipurpose environmental planning. Now let us examine this model more fully.

4. Environmental response: Land reserves

Arguing for the establishment of land reserves involves both policy and values. Hence, before proceeding on to policy issues, I highlight the origins of the ethics that shape my discourse. Ethics, even secular ones, must be built on some kind of solid and enduring cultural tradition. Moreover, as a scholar of environmental ethics and in an effort like this essay, I must focus upon only one traditional source of ethics. Appealing to multiple traditions in an essay like this produces uncontextualized, pointless mush. In light of these factors, the one and only enduring cultural tradition which sources values for this essay is Buddhism, particularly in its incarnation in the United States.

That said, it remains crucial to stress that the outcome of this essay, a plan to create lunar land reserves, remains secular and thoroughly sculpted by secular space policy studies. Thus, my reliance upon Buddhist cultural values arises for the sake of scholarly precision, not the advancement of any religion. Besides the secularized outcome I ultimately offer here, I recognize that there exist myriad potential cultural perspectives on the issues that I address, and I enthusiastically invite alternative voices to contribute to a conversation that helps us wholesomely to answer the question, ‘What should we do with our moon?’

While later in this article, Buddhists from the field will assert the principles of interconnection and nonharm in support of land reserves on our moon, at this point, I highlight Buddhist moral support for reserves through history. Managing ecologies by setting aside precious lands like this essay proposes is as old as is the Buddhist tradition itself. The semi-scriptural *Commentary on the Majjhima Nikāya* tells us that even in the time of the Buddha around 500 BCE, a follower of the tradition named Vassakāra initiated a reserve to care for monkeys with park rangers [34]. Across ancient Buddhist realms, pious monarchs further created geographic reserves, both large and small, or designated special calendar times in order to defend nonhumans. Such activities have not disappeared with time, since in today’s world, the Bhutanese government has sponsored environmental reserves in order to reach a constitutionally mandated 60% of forest cover, specifically as an expression of perceived Buddhist best policy [35]. Adding to these parcels, for Buddhist motivations, some Tibetans like the Wild Yak Brigade’s Sönam Dargyé and Trashi Dorjé have risked political peril and even their lives in campaigns to forge and maintain ecological reserves [36]. Similar stories arise in many Buddhist locations. Hence, one way of pursuing environmental responsibility on a place like our moon involves setting aside lands for special treatment, and throughout the history of the tradition, Buddhists have followed such approaches.

Of course, along with Buddhism, contemporary environmental science substantially embraces the establishment of strategic land reserves while it teaches us cutting-edge methods for doing so. We can gain a lot, therefore, by allying Buddhist value inspiration for land reserves with some environmental science concepts, and that is what I will do now by following the multiuse environmental science strategy of a giant of an ecologist, Aldo Leopold.

5. Scientific grounding

A professor at the University of Wisconsin from 1933 to 1948, Leopold sought to overcome a limitation of environmental science in which a profusion of uncontrolled variables sometimes makes it difficult to establish a scientifically valuable control data set. His method for responding to this situation, the ‘base-datum of normality’” which supplies ‘a picture of how healthy land maintains itself’, consists of restricting an area from all human interference starting from a known inception date [37]. Ideally, this method provides a scientifically accessible time capsule of ecology, a ‘most perfect norm’ freely developing control sample for comparison with other ecologies, which may see greater human interference [37]. For example, protecting an area today to develop without interference for a century can provide enormously useful longitudinal scientific data. In this essay, I exclude some of the land-as-organism presumptions that Leopold included in his presentation, so instead of a ‘base-datum of normality’, here I speak of a ‘baseline ecology’, which, as a solely scientific method, consists of discouraging nonscientific human incursions in areas that supply ongoing ecological control samples.

Leopold stated that “all wilderness areas, no matter how small or imperfect, have a large value to land science” [37], so that the baseline ecology method as applied to our moon restricts access to (relatively) pristine places and thereby transforms regions into scientific control samples with known inception dates. In this method, no effort is placed into maintaining an area as it is or as we want it to be, for this strategy will forestall the scientific understanding of ecological succession that we seek. Instead, reserves remain unmolested to develop as they will while humans precisely chart temporal changes. This approach relies on tested ecological principles of environmental scientists beyond Leopold, such as those of Andrew Balmford, who insists that “nature and not people will determine … changes over time” [38].

On our moon baseline ecology reserves can purvey tremendously valuable information regarding the impacts of an expanded human presence as well as the dynamics of lunar ecological systems in themselves. If we keep baseline ecology reserves separate from transportation launch areas, we can even reduce the predicted negative scientific blows wrought by lunar rocketry [39]. As a plus, by preserving ecologies without undue interference, these baseline ecology reserves further aid the protection of important space-age historical spots as much as possible like they were at the time that they made history. In this way, this essay’s proposal helps to counteract the prospective scientific trouble emerging from the greater human presence that previously I mentioned.

But, beyond possessing these scientific and cultural virtues, the baseline ecology reserve approach of this essay additionally yields terrific ecological, recreational, and commercial value. Such value accrues because these reserves are designed to serve multiple purposes at once, thus satisfying otherwise conflicting voices, as well as compliance with existing space law. Let us now look at some United Nations policies that guide the implementation of lunar reserves that retain diverse dimensions.

6. Multizoned for many uses

This article’s method for establishing lunar reserves creates significant benefits by providing positive outcomes beyond purely scientific or commercial ones by supporting uses by zones. Simply creating reserves in the first place engenders zones that include free industry on one side and multipurpose sustainable areas on the other. But, looking merely within reserves, we also can establish multiple zones based upon the extensive ecological experience of the United Nations Man and the Biosphere (MAB) program. UNESCO’s MAB program has overseen the implementation of over 669 biosphere reserves in over 120 countries since 1976 [40]. In initiating such reserves, the MAB meets divergent needs by dividing land reserves into separate regions of preservation, recreation, and sustainable industry and commerce. If the multiuse MAB approach is applied to lunar ecosphere reserves (‘biosphere’ may not be the right word for the moon), we simultaneously can meet the needs of science, culture, historical preservation, recreation, and responsible commerce.

One area of lunar ecosphere reserves, the core Preserve, will remain a strict Leopoldian baseline ecology that admits no entrance other than for no-footprint science. This region of each reserve will forever supply potent, date-stamped scientific data. Another area, the Sustainable Reserve, will allow commerce and industry while resembling a true baseline ecology. Environmental impact statements, such as those that the space ethicist William R. Kramer insists be a part of all lunar activities [41–43], can help to determine places with the Sustainable Reserve areas.

Each reserve also will contain a third zone designed for human recreation. On Earth, areas that are set aside primarily for human recreation are called 'parks' [44], so that each ecosphere reserve will contain a park area. Although the idea of lunar recreation may seem remote to my reader, SpaceX and Blue Origin, among other entities, are working hard as I write to provide and profit from lunar recreational activities. Perhaps some of these companies will create a vibrant lunar tourism sector. And, if we project growth in the lunar recreation sector, we realize the importance of creating lunar reserves so that future moon vacationers may enjoy higher quality getaways with opportunities for primeval camping as well as historical sightseeing. Therefore, the recreational gains for future lunar tourists in this essay usefully augment boons pertaining to better science, human environmental justice, ecological preservation, and organized industry.

In spotlighting the figure of the woman/man/rabbit in the moon as I have so far, I have emphasized protecting the patterns of the moon that are found on its near side. But we should create multipurpose reserves on our moon's far side, too, as I now delineate.

7. Far side reserves

Although the display of only one lunar side toward Earth means that the patterns on the moon's near side get all of our historical attention, there are scientific, ecological, recreational, and even cultural reasons to place multipurpose reserves on the far side of our moon as well. The far side, for instance, houses the Chinese probe Chang'e–4, named for the moon goddess that I mentioned previously, in its Von Kármán crater. Chang'e–4 made the difficult first soft landing on the far side of our moon, and therefore, deserves historical recognition alongside that pertaining to the human hardware on the moon's near side. The far side's Von Kármán crater thus should be protected with a reserve.

Moreover, reflecting the criteria for protection that I mentioned previously of 'uniqueness as a source of special standing', another area, the Hertzsprung Crater region, should be managed with a far side multipurpose reserve. The region surrounding this crater remains geologically primitive on lunar scales, embodying an early era of our moon's history, and therefore, should contain scientific riches. As well, the Hertzsprung Crater can provide far side equatorial recreational experiences that are quite alternative to those at the other locations of this proposal.

The Von Kármán and Hertzsprung Craters focus our attention on the moon's cultural dichotomy, in which the lunar near side enjoys numerous layers of human cultural meaning that the generally hidden far side does not. This difference appears in this proposal as an essential environmental principle: If our moon absolutely must receive damage that can threaten human culture or lunar ecology, then that damage should be moved first, and worst, to the far side of our moon. While we should avoid hurting our lunar cultural icon at all, it is worse to harm the near side than the far side. This proposal, therefore, calls for the protection of much, or best all, of the near side of our moon while leaving most of the far side open for free industry and commerce.

In this way, the cultural dichotomy of our moon determines some provisions of this land reserve proposal. But so does another intriguing quality of our moon, its nearly vertical axis relative to the sun, which, in turn, produces peerless polar environments. Having inspected the front and back sides of the moon, now let us examine realities at its poles.

8. Polar reserves

An interesting feature of our moon is its less than two degrees of obliquity, or axial tilt relative to our sun, which creates different outcomes than Earth's season-bringing tilt of 23.5° [45]. At our moon's poles, for instance, one can find high places that almost never witness darkness. Amid these sunny high-altitude places are deep craters whose bottoms have never seen the sunlight that streams horizontally across the pole. Among the beauties of these dark and frozen craters is the freedom from almost all kinds of astronomical interference, and so, whether using one's naked eye or a telescope, the views of the starry cosmos from these craters should be so astounding that atmosphere-clad Earthlings cannot imagine the luminous multicolor spectacle. As the Apollo astronaut Jim Irwin described the sky view from the moon even from the outside of a dark crater, unlike on Earth, our sun is seen 'in all its power and glory', and the 'vast array of stars', 'far more than can be seen from Earth', shine with a 'dazzling brilliance' [46]. Therefore, the combination of sunny peaks and eternally dark craters make the poles of our moon distinctive and grand not just on our moon but also in the context of the whole solar system. Embodying Milligan's "uniqueness as a source of special standing" [33], these places need protection for scientific, ecological, and recreational reasons while they also make room for possible commercial uses.

Such commercial uses of our moon are already multiplying in terms of human effort. One can mine helium-3 at the poles, so some firms look at this, but one also can use the dark polar craters as energy sources. A number of these craters, being among the coldest places in our solar system, contain significant amounts of water ice. In theory, this water ice can be mined, thereby providing water for human miners to drink, as well as, once the water molecules are split, supplies of oxygen for breathing or for combining with liquid hydrogen as rocket fuel. Firms such as Moon Express and the Shackleton Energy Company already cultivate the infrastructure necessary to mine and then profit from selling this polar crater water ice to future humans and their moon rockets.

The matchless environments of the poles attract other industries as well. For instance, some people have proposed placing communication towers on the south pole's Malapert Massif, a collection of mountains, which rises to an altitude of 8000 m above the depressed crater floor in front of it [47]. When communicating from Earth to the far side of the moon, a network of line-of-sight communication emplacements would be useful, and Malapert is close enough to the pole to provide one crucial node in the network. Further, communication towers, in theory, may be powered by the solar power collectors that some wish to place on Malapert, given that its high altitude polar slopes may see sunlight 85% of the time [47]. Moreover, for reasons that I mentioned, some astronomers wish to place telescopes like the proposed Ultimately Large Telescope into the interference-free dark craters that dot the Malapert region [48]. Without an atmosphere, light pollution, radio interference, or infrared obstacles, telescopes in these craters can render fantastic images of our solar system, the center of our galaxy, and beyond, in a veritable bonanza for space science.

While many of these lunar mining and development goals remain understandable, they often do not take environmental planning fully into account, nor do they always genuinely respect the amazing preciousness of some lunar spots at the poles. The entire Malapert Massif system, for instance, emerges as a geographically diverse set of summits and craters that stretch from Cabeus Crater to Scott Crater about 100 km from the moon's south pole. The primal geology of the highlands, which rise in altitude to rival the Andes Mountains, represents a rare, fascinating, and glorious mix of often- and never-lit spots that remain incomparable in manifestation and should therefore be treasured appropriately.

To this geographic and geologic magnificence and rarity, the Malapert Massif adds the crucial dimension of the terrific naked eye and telescopic astronomy that I mentioned, which alone may make Malapert into a recreational hotspot. When one considers the scientific, cultural, and recreational value of these starry sky perspectives, one realizes that the Malapert Massif possesses value to humans if it is preserved as it is rather than given over to mining robots with a lesser appreciation of the beauties of the lunar sky. The Malapert Massif is a lunar gem but also a human one and needs protection on this basis. Much as we protect places like Victoria Falls both for the sake of the site as well as our own sakes, so the Malapert Massif deserves a protective ecological reserve for its sake as well as for the sake of human culture, science, and recreation into the far future. In 100 years, humans likely will not be able to preserve the Malapert region in a pristine form, so future moon campers and astronomers need us to protect the site for them starting today.

Like at Malapert but with alternative local geological and astronomical spice, lunar experiences of wonder and awe also may be found at the Peary and Florey Crater systems at our moon's north pole. While we may wish to leave northern Peary Crater open for industrial development, for reasons similar to those of the south pole, the southern Peary Crater and Florey Crater region should be protected with the Peary and Flory Ecosphere Reserve. Along with peerless scientific opportunities, this spot will offer camping under a sky so majestic that even gods will swoon.

The intentionally multipurpose nature of the reserves proposed here regarding the proper disposition of lunar polar lands provides solutions that are superior to some previous plans for human activities on our moon's surface. For instance, a line-of-sight communications network makes sense, but this can be accomplished by placing towers on crater rims near the south pole or in northern Peary rather than on the one-of-a-kind slopes of Malapert. Likewise, instead of on Malapert, solar power installations fruitfully can appear on crater rims near Shackleton in the south or on Peary's northern rim. Both of these alternative placements can take advantage of nearby water ice craters rather than tapping Malapert's craters. Because of the discretionary features of the poles that provide alternatives to marring Malapert, turning Malapert or the southern Peary/Florey region into reserved zones does not necessarily inhibit desired industrialization or settlement initiatives like that of the Moon Village Association. This is especially true of the south pole region since industrializing activities can unfold outside of protected zones. Of course, because of the multiuse nature of these land reserves, things like telescopes can appear even within the ecosphere reserves as long as activities are pursued with ecological sustainability.

As you can see, our moon requires our attention in terms of placing multipurpose reserves, which encompass the patterns on the near side, the Von Kármán and Hertzsprung Craters on the far side, and the Malapert, Peary, and Florey regions of the poles. Aldo Leopold and the UN's MAB program teach us how to envision and manage these extraterrestrial reserves. But do human values such as those of Buddhists approve of the strategy of creating nature reserves on our moon? As it turns out, American Buddhists in the field assert the values that are necessary for establishing lunar reserves, as I now explain.

9. Ethnographic voices of approval

Like people from Japan, India, Russia, China, Australia, the European Space Agency countries, and some other places, residents of the United States live in a spacefaring culture, which generally promotes space exploration and therefore provides its citizenry with educational experiences to inspire support for space travel. This makes the United States among the best of locations for discovering informed grassroots ethical reactions to space travel, including among American Buddhists, who can offer us capable contemporary ethical perspectives regarding lunar nature reserves.

In order to understand Buddhist attitudes toward our moon, with the approval of my university's Institutional Review Board, I visited seven important Buddhist centers in the southeastern United States. I surveyed practitioners at centers across all three Buddhist great sects of Theravāda (N = 44), Mahāyāna (N = 40), and Vajrayāna (N = 37), gaining representative samples from each type, as well as a balanced overall sample of N = 121. Moreover, in order to highlight the distinctiveness of Buddhist voices from among those of the general American public, I collected a control data set from 78 randomly selected university undergraduate students. For the sake of economy in this piece, I refer my reader to another work of mine [49] for understanding more of the demographic details of the ethnographic data that I present here.

Since American Buddhists tend to be informed citizens yet typically are not experts in space policy, in the field, I avoided asking direct space policy questions and instead focused my interactions with Buddhists in terms of their extensions of ethical values. All informants took the same sixteen prompt survey about the application of Buddhist ethics to extraterrestrial environments. I also gathered qualitative comments both through my survey as well as through discussions with Buddhists. The quantitative prompts that are relevant for this essay include:

1. Our moon and other extraterrestrial places should be valued and protected from undue harm, even if no living beings exist there. (responses on a five-point scale from strongly agree to strongly disagree)
2. I think that Buddhist principles should be utilized to guide the possible mining and settlement of the moon. (responses on a five-point scale)
3. If we do use Buddhist principles regarding the possible mining and settlement of the moon, those principles should be? (choices offered but alternative responses welcomed)

Establishing nature reserves on our moon requires protecting the moon's surface from troublesome harm even if the moon lacks life. This is a significant barrier, since some people regard the lunar lifelessness that astronaut Buzz Aldrin described as "magnificent desolation" [50] in a negative light. In the eyes of these people, we have little reason to care about injury to a place without biotic entities. Despite this commonly found obstacle, though, Buddhists in this study responded by overwhelmingly asserting ecological protection even for a lifeless moon. A large 88% of Buddhists agreed or strongly agreed that an abiotic moon should be protected from harm. Only 3% of Buddhists disagreed or strongly disagreed with this ethical ideal. A Fisher's Exact statistical test indicated that Buddhists stood out from the general American public in this choice, although, interestingly, many nonBuddhists also chose to protect an abiotic moon, as Table 1 shows:

American Buddhists here, therefore, follow an intriguing grassroots ethic which supports ecologically caring even for a moon without life. It is important to note that this nonharm toward the moon, arising in this case from a matrix of Buddhist values, is an ethical attitude that may be adopted within any (non)religious context. Field subject responses to the next two prompts within my ethnographic survey additionally give us a sense of the shape of this emergent moral code. When reminded by

Table 1
Our moon and other extraterrestrial places should be valued and protected from undue harm, even if no living beings exist there.

Fisher's exact $p < 0.0001$		Frequency	Percent	Cumulative Percent
Buddhist	Strongly agree	81	66.9	66.9
	Agree	26	21.5	88.4
	Neutral	10	8.3	96.7
	Disagree	1	0.8	97.5
	Strongly disagree	3	2.5	100.0
	Total	121	100.0	
Control	Strongly agree	21	26.9	26.9
	Agree	35	44.9	71.8
	Neutral	10	12.8	84.6
	Disagree	10	12.8	97.4
	Strongly disagree	2	2.6	100.0
	Total	78	100.0	

the survey itself about the lifeless nature of the moon and then queried whether Buddhist values applied to such an abiotic place, Buddhists with zeal extended their values intentionally to include abiotic extraterrestrial realities. As Table 2 below shows, about 90% of Buddhists agreed or strongly agreed that moon mining rests within the jurisdiction of Buddhist values and only about 4% felt conversely. Table 2 thereby offers rare and exciting data regarding how environmental, ethical values can reach from Earth into space:

When asked what values should be applied off-Earth, these American Buddhists together delineated an ethic of nonharm combined with a concept of our universe as interconnected. As Table 3 below exhibits, more than 87% of these Buddhists grounded their moral perspectives on the Buddhist notion that the universe is interconnected on every level across time and space. Called dependent arising in English or *paṭicca-samuppāda* in the scriptural language of Pāli, for these Buddhists, this notion of vast interconnection serves as a basis for values for use on the moon as an alternative to the commonly found living/nonliving binary that I mentioned. As such, these Buddhists appear to embody a sense of the space ethicist Mark Lupisella's "cosmocentric ethic," in which human beings possess a "duty to their larger universe and its evolution" whether living beings are involved or not [51].

Besides this sense of connectedness, in addition, Buddhists based their moral perspectives primarily on the value of nonharm. Nonharm, or ahimsa, consists in Buddhism as the wish to shield others from suffering or injury. Usually applied in Buddhist worlds only to living entities, here 83% of Buddhists creatively apply nonharm to abiotic lunar phenomena in terms of respect for their integrities. These field subjects thereby innovatively weave together sentiments of nonharm with perceptions of interconnection in producing an environmental ethic made specifically for the realities of our moon, as we see in Table 3 above.

These data represent just a small number of Americans, not the totality of humanity that can claim our moon as a cultural heritage. Nonetheless, when combined with the millennia-long Buddhist example of initiating reserves to protect places of special ecological value, these data suggest moral support for establishing multiuse nature reserves on our moon, as I previously delineated. Moreover, elements of this support, like the value of nonharm, are principles that anyone, Buddhist or not, can hold. Now we need to examine how these values can become manifest in discreet space policies.

Table 2
I think that Buddhist principles should be utilized to guide the possible mining and settlement of the moon.

Fisher's exact $p < 0.0001$		Frequency	Percent	Cumulative Percent
Buddhist	Strongly agree	72	59.5	59.5
	Agree	37	30.6	90.1
	Neutral	7	5.8	95.9
	Disagree	1	.8	96.7
	Strongly disagree	4	3.3	100.0
	Total	121	100.0	
Control	Strongly agree	9	11.5	11.5
	Agree	19	24.4	35.9
	Neutral	31	39.7	75.6
	Disagree	16	20.5	96.2
	Strongly disagree	3	3.8	100.0
	Total	78	100.0	

Table 3
If we do use Buddhist principles regarding the possible mining and settlement of the moon, those principles should be.

N = 121	Frequency	Percent
Interconnected universe	105	86.8
Nonharm	100	82.6
Compassion	80	66.1
Loving kindness	72	59.5
Other	11	9.0

10. Space policy results

What do these American Buddhist moral views mean for campaigns to mine our moon? As it turns out, on the whole, proponents of lunar mining get much of what they want from these data. There exists little here within Buddhist viewpoints that specifically forbids the mining of the moon outright if doing so benefits humanity. Nonetheless, the Buddhist perspectives here counsel that mining and other efforts on the moon should be guided by a sense of ethical responsibility, an awareness of human moral interconnection with the moon, and a sensibility defined by the value of nonharm. While not stopping mining, these Buddhists assert that ecological care and respect for a given extraterrestrial locality, rather than just attention to the process of resource extraction, must always be on the agenda if humans are to be responsible spacefaring merchants and industrialists.

This moral perspective, of course, also remains the guiding vision behind the proposal to establish multipurpose reserves: to avoid harming what is most important while also facilitating desirable human activities and justice. Hence, at least in terms of values expressed, Buddhists in this study provide moral support for initiating lunar multiuse land reserves that respond positively to the moon's charged environmental interactions with human beings.

Complicating these ecological strategies, though, multipurpose reserves like those proposed here must respond to a stumbling block on the way to industrializing the moon at present: the issue of property rights. Commercial firms often prefer to own their assets, yet space law does not possess a set of clear rules for extraterrestrial real estate ownership. The Outer Space Treaty and the Moon Treaty forbid ownership of land beyond Earth, but few countries have ratified the Moon Treaty, and the Outer Space Treaty has come under attack for its property ban, such as by the Trump administration [52].

Within this confusing legal context, I offer that the land reserves proposed here avoid sticky property issues in several ways. The reserves themselves will be ownerless international territories, a point to which I will return shortly. But most of the moon's surface is not contained by these reserves, and locations that are outside of protected zones will be governed by whatever space commercial property law that develops.

Even within the reserves, although, there exist places for industry and commerce if pursued sustainably. Perhaps in the sustainable reserve sections of the ecosphere reserves, an open sea fishing model can apply, in which locations cannot be owned by private parties but resources gathered can be owned. The ecologically sustainable business model required in these zones, grounded in environmental impact assessments, may inhibit a lunar industrial version of overfishing. Or, portrayed in another light, surprisingly quickly, lunar commercial sites could experience competitive overcrowding that harms everyone involved [53], and the delimited and zoned reserves of this proposal can help to ameliorate such clashes.

This proposal remains in concert with provisions of the Outer Space Treaty because no nation or small collection of nations will own land in our ecosphere reserves. All nations, whether rich or poor or spacefaring or not, may claim these reserves as their human heritage, thereby realizing a measure of the environmental justice ideal in which all humans have a theoretical voice in the moon's fate. Alternative to property law realms, these reserves will operate on the model of the propertyless Antarctic Treaty System, which has governed research and commerce at the South Pole since the 1940s [54]. More fully, lunar reserves also will operate on the model of the United Nation's 2001 Convention on the Protection of the Underwater Sea Heritage (CPUCH) since no country will own the land, yet the United Nations will be charged with the management of that land [55].

Because of its experience with the vagaries of space property law, UN administration of these reserves should fall to the Committee on the Peaceful Uses of Outer Space, or COPUOS, rather than the MAB, which inspires zones within reserves. The COPUOS already has some experience with environmental protection, too, since it currently administers Special Areas on Mars that are considered to be ecologically sensitive [56].

For space policy clarity, additionally, I spotlight Article VIII provisions of the Outer Space Treaty, which make not real estate, but space hardware, the property of the agent that sent that hardware [57]. The physical Chang'e−4 probe on the moon's far side, for instance, belongs to the government of China. Thus, the zones that I propose are international in character, but legally a spaceship appearing within them is not. Yet it will be in the interests of the nations involved cooperatively to support this proposal regardless of hardware ownership because this proposal protects the historical character of their accomplishments for posterity through the mutual respect that benefits all spacefarers, is a hallmark of space exploration, and in this case provides improved long-term preservation of cherished cultural treasures. Chang'e−4 is best protected historically by all nations working together.

Such mutual respect perhaps is the path to the adoption of this proposal, which cannot be instated simply by COPUOUS fiat. International agreements are needed. Best would be a United Nations treaty that governs the establishment of protective land reserves where needed throughout the solar system. Such a path will instantly improve the cultural, scientific, and ecological values of sites on our moon and elsewhere. However, such international agreements can be difficult to strike. Perhaps, then, as a start COPUOUS can encourage bilateral or other small agreements between countries. It would likely take little time or expense for a couple of space powers to draw reserve boundaries and agree to abide by them, maybe thereby creating follow-the-leader precedents. Reserves fruitfully still can appear through such 'soft-law' international agreements [58] even if big treaties fail in initiating land reserves on our moon. However, the more countries that support these reserves, the better, for broad international management engenders the environmental justice outcome in which all humans theoretically have a voice in the fate of their lunar cultural inheritance.

Whether on the near or the far side of the moon, though, by using reserves to shield important ecological and cultural landmarks, we ensure that our descendants many generations from now not only can enjoy the experiences that we can but also can engage perhaps even a few new, captivating encounters as tourists in primeval Malapert highlands or Hertzsprung Crater settings. In order to enact the values found in this essay, preserve human cultures, as well as gain valuable scientific time-stamped ecological control data, today we should establish lunar multipurpose Ecosphere Reserves at least at the Malapert Peaks and Craters, Peary and Florey Craters, Rabbit/Human in the Moon, Hertzsprung Crater, and von Kármán Crater.

11. Conclusion

The near-term expansion of the human presence on our moon demands that we reconsider our stewardship of the cultural, ecological, scientific, and future recreational dimensions of our planet's lunar partner. Threats to the moon such as those engendered by mining encourage the preservation of various ecologically or historically dynamic areas of our moon's surface through the emplacement of multiuse protective nature reserves. These reserves, arising from tested environmental science strategies, allow concurrent pursuits of commerce, science, environmental preservation, respect for cultures, and future recreation. By protecting the near side patterns in the moon, the Hertzsprung and Von Kármán Craters on the far side, and polar regions at Malapert, Peary, and Florey, we leave room for industry while also avoiding pointless losses of the moon's own majesty or wounds to ourselves in our relationships with the moon. In creating these reserves and empowering COPUOUS to run them, we realize a number of cultural, ecological, scientific, and recreational goods for our solar system, as well as for ourselves. In so doing, we additionally move closer to the environmental justice outcome in which each human theoretically has a say in the fate of our moon, which is the cultural heritage of every one of us without belonging to any one of us.

The benefits that arise from this multiuse planning, though, mean that we should make haste in implementing these reserves. We generate bountiful scientific, cultural, and environmental gains specifically by setting reserve boundaries while environments remain relatively pristine and no human is in the area to cause ecological mayhem, intentional or not. As Elvis et al. state, "Now is an appropriate time to begin developing a governance framework [for the moon] …. Efforts at managing forthcoming disputes are most likely to succeed if they are undertaken before vested interests gain too firm a foothold" [53]. Scientists in the future will want to understand the human impact on the moon, and establishing control samples before humans return to the moon will help to supply them with outstanding historical snapshots of landscape constitution and health. We should not wait until humans return to the moon to implement these reserves because we begin practicing better science and preservation immediately by establishing these reserves today.

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