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### Cooperation

#### Contention 1: Cooperation

#### Appropriation makes space conflicts inevitable- creates rivalrous competition and congestion

Babcock, 19 -- Professor of Law, Georgetown University Law Center

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III. PROPERTY IN OUTER SPACE

“Space law must take into account private needs and build on private opportunities; to do this, it must embrace the principle of private property.”215

In our legal system, there are three types of property ownership— private, public, and communal.216 Private property usually involves a single owner, either “a legal person like a corporation” or “a natural person.”217 Public property, on the other hand, is owned by the state or its agents, while “common property” usually involves at least two entities who “hold the property in question either as joint tenants or as tenants in common.”218 If neither of these situations is involved, the property may be “characterized as null property, open-to-entry property, or res nullius, and the resources covered by these arrangements are open to use by one and all without restrictions.”219

The debate over the property ownership provisions of the OST and the Moon Treaty is between private and common ownership with commercial interests favoring the first, and those concerned with assuring the sustainability of outer space resources and equitable access to them favoring ownership in common.220 This Part explores these two types of ownership in the context of outer space,221 identifying their benefits and flaws before concluding that considering outer space as common property owned by the citizens of the globe is more closely aligned with overarching international principles of how space should be managed.222

At its heart, the debate about property type is about rights in that property. Property rights, like any other right, are “social artifacts.”223 They are neither fixed nor assumed, and may “vary from one society to another and over time within the same society.”224 They consist of “bundles of rights that can be and often are separated or combined in complex ways.”225 Some forms of property management, like custodial or stewardship management, allow for disaggregating those bundles.226

At a minimum, these bundles include possessory rights or the entitlements of ownership per se, usufructuary rights or rights to make use of property in specified ways, exclusion rights or rights to prevent others from using property without permission, and disposition rights or rights to dispose of property according to the wishes of the owner.227

Some of these rights, such as exclusion rights, the right to prevent access to or use of the property, and disposition or alienation of the property, may be problematic in outer space under international law, as discussed in Part IV.228

Possessory rights, a stick in the property rights bundle, can be “subdivided.”229 Some of the ways this can be done are discussed in Part VI and are worth considering in the context of outer space.230 “[E]ven relatively full bundles of rights are not unlimited or unrestricted.”231 Imagining property regimes of less than full and unimpeded ownership in outer space is conceivable, as is altering the structure of property rights to eliminate or lessen perverse incentives, like competition, from the implementation of those rights.232

For private property rights to emerge out of a common property regime or from null property where there is no ownership, like outer space, “cost-effective technologies for measuring, monitoring, and enclosing private property must emerge” to enable the claiming and transferring of “identifiable units of the resource.”233 If there is no private rights technology or “the distributional cost hurdle is too high, private property rights cannot emerge because the transaction cost wedge is simply too large.”234 Instead, “political or regulatory property rights will emerge.”235 While property rights are continually created and abandoned, depending on economic conditions, the act of defining property “has a high fixed cost element,” such as the cost of establishing and defending boundaries, which can have an effect on the emergence of property rights.236

One of the problems facing the creation of private property rights in outer space is the emergence of technology to define those rights in an area that is without static geographic and political boundaries.237 Another problem is how to grant, let alone enforce, those rights without violating international space law that bans the appropriation of outer space and its resources. So, the presence of potential entrepreneurs eager for the development of that technology, like Bruce Yandle and Andrew Morriss’s cattlemen of yore and the development of barbed wire, may not stimulate its production because its application would conflict with international prohibitions.238

Robert Ellickson suggests that “bottom-up, somewhat ad hoc property systems can [emerge and] reproduce most or all of the benefits of formal property law with a minimum of economic investment, procedure, and social disruption.”239 “Informal governance, like formal regulation, can ‘privatize’ [CPRs]”; Zachery Arnold points to “the ‘lobster gangs’ chronicled by James Acheson” as a “classic example of informal privatization.”240 Elinor Ostrom writes about how communities under the right “sociopolitical conditions” can protect valuable CPRs from over-consumption or damage.241 But, none of these approaches appears appropriate for circumstances in outer space where small groups are unlikely to form around CPRs or where communication among entities will be intermittent at best, making any sharing of informal management approaches unlikely.242 With this as background, the Article describes what space might look like under the two basic property regimes—private ownership and ownership in common.

A. Space Under a Traditional Private Property Regime

Private property is the cornerstone of American ideals and “a foundation of the Constitution as well as its philosophical precepts.”243 Indeed, “private property—and individual ownership specifically—runs throughout the DNA of this Nation.”244 Private property is often considered a driver of our economy because it creates incentives for investments in new technology and resource development, both of which are in play in the development of outer space.245 Property ownership can also encourage people to care about their property, protect adjacent land owners from the external effects of activities undertaken on their property, and assure its sustainability for future generations.246 Selfinterest can motivate a property owner to preserve their property to attract future buyers.247 To Richard Posner, the value of possession lies in its “economic efficiency” because it “tends to allocate resources to those persons best able to use them productively, for they are the people most likely to be willing to incur the costs involved in possession.”248 Possession of property puts the rest of the world on notice of that possession.249 While possession is most commonly understood as physically holding onto an object, a more modern view sees it as a “form of control.”250

But, private property can also “enhance income disparity, exacerbate[] economic tensions among individuals, and consolidate[] power among the one percent.”251 M. Alexander Pearl calls property privatization “a black hole focused solely on centralization of power and economic wealth without regard to the sustainability of an essential resource or the communities that depend upon its continued existence.”252 Hanoch Dagan goes further, quoting Eric Posner and Glen Weyl, by saying,

The key remedy for this predicament is to eradicate the institution of private ownership. Since “private ownership of any asset, except homogenous commodities, may hamper allocative efficiency,” we need to reconstruct markets so they are “competitive by design.” More precisely, we must discard private property and adopt in its stead a regime that partly transfers property’s “two most important ‘sticks’”— the right to use and the right to exclude—”from the possessor to the public at large.”253

When the value of a resource is increasing, it is more likely to be privatized so that the entity responsible for developing it can “fully capture the resulting benefits.”254 Indeed, a movement from common to private property occurs when the efficiency gains from private property are more than the costs of creating and maintaining it, such as “the basic costs of exclusion (fences, guards, and so on) and the extra vigilance needed to deter interlopers from absconding with rising-value resources.”255 This balancing of costs and benefits may be irrelevant in outer space, as the costs of establishing private property in the first place would be huge, and the complexity and cost of technological innovations called for in outer space would be magnitudes greater than what is required on Earth.256

1. The Positive and Negative Features of Private Property

Many believe that transporting the concept of private property to space should cause no concern; in fact, they view it positively.257 “By guaranteeing rights in extracted minerals taken from space, private industry could usher all of humanity into a new technological era.”258 Among the advantages of private property ownership in space is the “reduc[tion] of wasteful use” and the right to transfer alienability to others, which “would compensate for positive externalities, thereby creating added incentive to productively develop space.”259 Private property would also enable colonization of celestial bodies like the moon.260

In the absence of private ownership, there is the possibility that “each individual developer will seek to maximize his or her own gain by extracting as much value as quickly as possible without regard to the effect on the communal resource.”261 The President’s Commission on Implementation of U.S. Space Exploration Policy found that although the idea of private property in space is complicated because of national and international legal issues, it was imperative that they be addressed early in the process, “otherwise there will be little significant private sector activity associated with the development of space resources, one of our key goals.”262

For those who seek development of space resources, “a reliable property rights regime will remove impediments to business activities on these bodies and inspire the commercial confidence necessary to attract the enormous investments needed for tourism, settlement, construction, and business development, and for the extraction and utilization of resources.”263 The resources supporting private space mining companies are essentially worthless if the companies have no legal right to the resources they have mined.264 “Without the legal right to use water and hydrogen mined from celestial bodies, and to alienate platinum group elements, the potential profitability of private space expeditions collapses along with the goals of deeper space exploration and settlement.”265 The lack of a stable private property regime in outer space also means that space settlements will not be able “to claim sufficient land to yield enough of the only ‘product’ the settlement can sell profitably enough to guarantee its survival.”266 The strong belief is that unless private property rights in outer space and its resources are recognized, commercial enterprises will be unable to sustain any type of successful commercial activities in outer space.267

The absence of “‘security derived from ownership and sovereign control, [means that] entities that might be interested in the development of space resources will be reluctant to undertake [the] expensive and risky path’ implicit in all space travel”268 without some return on their investment.269 In all likelihood, such a return would be “in the form of the right to exploit limited areas of space and in proceeds from the sale of space resources.”270 This uncertainty arguably leaves a large “legal void, a wasteland of indeterminacy and instability.”271 According to Reinstein, “Unless people and nations are encouraged to exploit the riches of space, humanity will never know their benefit. And the more we are able to exploit, the more humanity stands to benefit. If commercialization is to be successful, space law must encourage investment in outer space development.”272

But, recognition of private property claims by the United States or by any other country could violate Article II of the OST’s prohibition against the national appropriation of space resources, including the surface of celestial objects.273 “[E]ven well-crafted domestic legislation that carefully addresses international law issues would create a significant risk of frustrating the explicit terms of the Outer Space Treaty, the intent and purpose of the treaty, or both.”274 No nation, including the United States, can independently alter the current international legal framework governing activities in outer space.275 And amending the OST to strike the language is unlikely, since the ban against appropriation of property in outer space is a “fundamental tenet of the treaty.”276

Coffey believes that

full ownership rights further [violate] the OST by disregarding the concerns of developing nations. If lunar real estate were put on the market, only the wealthy, developed nations and their citizens would be able to purchase it. If developing nations tried to purchase land later when they could afford it, they would be at a disadvantage because the prime locations are likely to be taken and the land’s current owners could demand whatever price they wanted. This could perpetuate current disparities of wealth and resources on Earth to the [m]oon and outer space.277

This would be in violation of the Treaty’s intent as expressed in Article I that outer space and its resources shall be the “province of all mankind.”278 Ownership of space real estate could also lead to speculative purchases, the goal being not to develop the property, but to hold it until market conditions are more favorable, and then sell it for a large profit— again, leading to the exclusion of poorer nations from the market.279 In all likelihood, the international community would react unfavorably to “a private property regime in outer space” because it would be perceived as benefiting large space-faring nations, like the United States and Russia, “at the expense of nations that do not have such capabilities.”280 But restricting ownership to anything less than fee simple absolute, like a lease or a license,281 means that the rights-holder could not alienate their property in any way, which decreases any significant incentive to acquire the right in the first place.282

2. The Rule of First Possession

The “most extreme proposal” with respect to implementing a property regime in outer space is to apply “first possession rules.”283 Under these rules, a country could claim territory it discovered, and then decide whether “to open up settlement in its new territory to its own citizens or to the international community as a whole.”284 Within its own territory, the discovering nation’s sovereignty “would extend to its outer space territory, where it could govern as it pleased.”285 Such an approach would directly conflict with international space law forbidding countries from appropriating outer space or its resources.286 MacWhorter also worries that a first possession rule in space could devolve into “a space race and colonialism in a situation that requires limitation and prudence,” and would be difficult to sell to other nations, especially non-space faring ones.287 If the rules were applied to commercial enterprises, without a “centralized mechanism for demarcating the property”288—such as a sovereign289—the inevitable result would be disputes among putative property owners, like what happened in the West during the homesteading era.290 Reinstein agrees: “If the rule of ownership was no more than ‘first come, first served,’ with ownership going to the first person to grab a celestial body, an unmitigated land-rush would ensue.”291 But MacWhorter also believes that limited property rights under a first possession rule might be an “appropriate first step,” if, for example, the property claim extended no further than to the claimed materials brought back to Earth.292

Those who are concerned that less technically adept nations would be severely disadvantaged by a property rights regime that is premised “on the ‘right of [first] grab,’ the first-come, first-served theory of property acquisition,” oppose such an approach.293 “By the time space capable nations develop the technological prowess and capital reserves to fund meaningful development of outer space, the earlier space-faring nations [and their citizens], left unchecked, might already have locked up the most accessible and valuable resources.”294 This would carry forward current disparities in global wealth distribution into the “Space Age.”295

The argument against a right of first possession gains salience from the fact that prior wrongs inflicted on less developed countries may be the reason they are not “space-capable.”296 This inequitable situation would persist, as those who profit from private property rules like the right of first possession will have the political ties, money, and understanding of the “rules of the game” to prevent their reform.297 An additional problem with the proposal is its enforceability. The fact that outer space is infinite makes it more difficult to “police” and to enforce the various treaties that apply to it.298 In outer space, “a breaching private party could pursue its interests outside the scope of such an agreement with relative impunity before it was discovered by the relevant international authority.”299

3. Less than Fee Ownership

There are less than fee ownership property regimes that can give the holder of a defeasible fee all the rights of an owner with complete title to the property, except the right to alienate it.300 Thus, “leaseholds, licenses, reversionary interest, easements, and covenants” might work well in outer space without violating international laws.301 There are also three types of defeasible fees that might be useful in outer space.302 “Defeasible fees, unlike fee simple absolute,” might convey property to a company, but are encumbered by an “automatic reversion or right of entry interest.”303 The first of these is a “fee simple subject to condition subsequent.”304 These conditions, “if triggered, would revert the realty back into the control of the multinational community.”305 So to the extent space resources have been appropriated, the withdrawal is not permanent.306

Then there is a “fee simple determinable,” which is like a fee simple subject to condition subsequent, “except that a fee simple determinable creates an automatic reversion to the grantor upon the occurrence of the condition—the grantor need not assert the right of reverter in order to reestablish possession of the property.”307 A third type of defeasible fee is a “fee simple subject to executory limitation[, which] reverts ownership upon the occurrence of a specified event or condition not back to the grantor, but to an heir or third party.”308 In each of these situations, a fee simple is less than absolute because it can revert back to the grantor or a third party if some later condition occurs.309 In the case of development of outer space resources, examples of later changes in circumstances that could revert title to the grantor might be those that damage the resource or make its continued development non-sustainable, or the developer’s violation of international law or any terms regulating or otherwise limiting their actions.

Leases and licenses are additional examples of impermanent types of property transfers.310 While a lease transfers exclusive possession of property from a grantor to a grantee, the transfer is only for a limited period of time; a license does not transfer any property and merely allows one party to use property that is managed and controlled by another party.311 Then there are easements, which “are rights, conveyed with the property.”312 Easements generally allow the property owner who owns the transferred property to continue to make some specified use of it.313 A negative easement, on the other hand, allows the entity that transferred property to prohibit the person who received it from using it in a specified way.314 Covenants are found in property conveyances and may prevent the grantee from using the property in some specific way.315

In each situation, not only is less than a full fee interest in property conveyed, but that interest can be restricted in a multitude of ways.316 In some situations, when the restrictive conditions are not complied with, the property can revert back to its original holder; in other cases, the reversion is automatic if conditions contained in the grant occur.317 But, each situation is predicated on some entity owning or holding the property in question, which would violate the terms of international space law unless the entity was some international authority.318 An international organization could establish specific rules governing activities in outer space, oversee their implementation, and enforce them.319 The International Seabed Authority (ISA), established by UNCLOS, could serve as a model for such an authority.320 The ISA was established in 1994 and since then it has issued new regulations governing exploring and prospecting for marine mineral resources and has contracted with seven nations granting them exclusive fifteen-year prospecting rights.321

However, “[t]here are drawbacks to forming a new international body to oversee the exploitation of space resources.”322 They can be expensive to establish and support.323 Non-spacefaring nations might not want to invest money in a venture which might “freeze them out of the decision-making process and put them at a disadvantage if they someday are able to participate in lunar missions.”324 There are the inevitable questions that arise whenever a new international governing organization is created, such as whether it should be under the authority of the United Nations or be completely independent, and how power should be allocated between spacefaring nations and developing countries without the expertise of money to venture into space.325 Further, there is an underlying equity question about spending money to create a new administrative authority.326 That authority will spend money that might otherwise have helped poorer countries develop the capacity to participate in outer space directly.327

An alternative to creating a new entity and new laws to administer a private property system in outer space is to extend terrestrial property law to outer space.328 Coffey proposes dividing the ISS between participating nations and then allowing each participant nation to apply its law to its assigned portion.329 But, this alternative suffers from some of the same flaws that establishing a centralized authority suffers—namely, it allows the powerful countries to control activities in outer space, specifically access.330 It allows those countries to collectively “set precedent for property rights in space instead of establishing formal international laws that the international community agrees upon.”331 The proposal “disregards the ‘common heritage’ provision of the OST,” because it completely excludes developing nations, who likely are not participants in the ISS, and provides them with no benefits from resources derived from space unless they eventually become technically proficient.332 Allowing countries to dictate any agreement that governs behavior in outer space also presents a risk that a country may be excluded from participation for unrelated reasons, like “diplomatic problems between the nations, unwillingness to share equipment and resources, or pressure from other members.”333

Thus, while establishing a private property regime in outer space might encourage development of celestial resources, it is hard to design a way around the ban against appropriating property and to establish a system that is both workable and protects the interests of less developed countries.

B. Space Under a Commons Property Regime

This Section discusses what about space makes it more like a commons than private property. Indeed, early space treaties treated space as though it was a commons.334 But, like private property, commons also have negative features that may be problematic in space, and simply declaring something a commons does not dictate the rules under which it should be managed. When various commons management approaches are tried, like the law of first possession under a private property regime, they are also found wanting.335

1. Early Treaties and Analogous Areas of the Globe

Early treaties, such as the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, which “requires space-faring nations to rescue stranded astronauts and wayward objects and return them to the appropriate country,” “envisions space as a commons beyond the possession and control of any one nation or people.”336 So too, the 1972 Convention on International Liability for Damage Caused by Space Objects, which “was established to resolve concerns over financial liability in the event that a spacecraft or other space machine causes damage to other space-based or [e]arth-bound assets,” and the 1975 Convention on Registration of Objects Launched into Outer Space, which “imposes a requirement that states maintain and submit to the [United Nations] thorough records of all objects launched into outer space.”337

Indeed, the 1967 OST “allocates the use of orbital space as if it were a common property resource”338 by declaring outer space an open access resource and banning appropriation by any country.339 Jared Taylor notes that “during the Treaty’s preliminary negotiations, one drafter analogized the absence of property rights in space to the absence of property rights in the ocean.”340 According to Taylor, later treaties, as well as the practices engaged in by spacefaring nations and private companies, “have confirmed the spirit of the Outer Space Treaty: space is a resource from which no nation or private entity can be excluded”341—a true open access commons.342

The 1959 Antarctic Treaty343 established “the foundation for international space law.”344 Like outer space, Antarctica and the oceans “presented a dilemma regarding habitation and defense. No nation occupied these territories and no nation desired a ‘race to own’ without a guarantee of who would emerge victorious.”345 Both the Antarctic Treaty and the Deep Seabed Hard Mineral Resources Act (the “Deep Seabed Act”)346 eschewed the concept of private property as well as the rights of first possession, in part, because the riches of those areas might allow developing nations to share in those riches as opposed to remaining economically marginalized.347 The Deep Seabed Act provides a model for how to regulate activities in a commons, like outer space, which it manages to do without privatizing the marine resource.348 As a result, it is “customary and accepted legal reasoning” to analogize between private ownership rights outside of national sovereignty, like those the Deep Seabed Act granted, and a “land claims recognition law for celestial bodies.”349

“The oceans and Antarctica . . . have much in common with the moon. They can be harsh environments that are difficult to reach to extract minerals [and are resource rich]. They are also designated international areas in which no nation has a sovereign claim.”350 The history of the earth’s oceans is a progression from “the domain of conquering armadas and privateers, when good legal title required as little as arbitrary lines drawn on a map,” to the concept of a “free sea” open to all countries, where no single country could “obstruct the use of that privilege.”351 International space law built on that history of open passage and “free sea.”352 The roots of the idea of granting non-space faring nations right of access can also be found in the 1958 Geneva Convention on the High Seas, which granted “landlocked states the right to sail the oceans by requiring their coastal neighbors to grant free passage over land and through territorial waters.”353 The legal framework of UNCLOS united “a broad spectrum of national and private interests into a shared agreement on the possession and usage of a seemingly borderless area of the global commons,” setting another useful precedent for outer space.354 However, UNCLOS, as a model, is impractical in “the vast reaches of outer space”—space is simply too vast and unlimited.355’

2. Common Property

Common property is property, the rights to which belong to more than one entity.356 Like private property, common property is endemic to life in the United States and always has been, even though many Americans view it ambivalently.357 There is considerable overlap between property held in common and that which is privately owned. Carol Rose suggests that collective, but privately owned property, like a tenancy in common, “has all the hallmarks of individual private property,” and, therefore, should not be seen as “fundamentally problematic or prone to inefficient use.”358 Additionally, the plasticity of the commons, demonstrated by the appearance of new commons, like the “knowledge commons, cultural commons, infrastructure commons, and neighborhood commons,” indicates that the concept might fit in outer space.359

A commons, or CPR, is frequently asserted to resist “privatization and/or commodification of those resources,” making it oppositional to a claim that something is private property.360 Sheila Foster and Christian Iaione’s suggestion that the “language of the ‘commons’” is often used to prevent the enclosure of public urban space “by economic elites,” resonates with the situation in outer space where wealthy countries or private companies want to claim or enclose space that the public owns.361 A claim that something is a commons acknowledges that “it is a shared resource that belongs to all of its inhabitants,”362 like outer space, which is the “province of all mankind.”363

But there are problems with the idea of declaring anything a commons, just like there are problems with declaring something private property. One problem with the commons approach is the inability to exclude members of the commons from using the resource.364 Lacking the right to exclude, a user of CPRs has no incentive to do anything other than fully exploit the commons because if she refrains, her co-users will.365 The result is an “open access resource vulnerable to the tragic conditions of rivalry, overexploitation, and degradation.”366 Another problem is that since under a commons property regime the rights and interests of the present generation dominate those of future generations, there is no assurance that the claims of an unidentified future generation will have any effect on how the commons is managed.367 There are also management difficulties.368 “Under a communal system, one member wishing to preserve the CPR for future generations’ use faces significant—and perhaps insurmountable—transaction costs of negotiating with all members of the community and paying them to use the resource suboptimally.”369 And, exiting a commons when group action causes individual harm, without destroying “social gains from cooperation,” can be difficult.370

There is no one-size-fits-all solution to these problems, and there may be multiple approaches to the development of solutions.371 In the search for solutions, various legal scholars have promoted variations on the concept of a commons, highlighting different features.372 Pearl proposes something he labels the “vital commons,” which includes CPRs that are “essential to human existence,” like air or water, and which may require a different approach to their management.373 Pearl’s vital commons has five key traits:

(1) the benefits of the CPR are internalized by nearly all members of a given massive population; (2) the costs of the CPR’s depletion are externalized among nearly all members of that same massive population; (3) augmentation or depletion of the CPR by one party affects the ability to use the CPR by another party within the same massive population; (4) the CPR itself is necessary for sustenance; and 5) damage or depletion of the CPR is non-remediable or extremely difficult to correct.374

Outer space has most of these traits—the potentially affected population is the entire globe; its resources, as far as is known, are not renewable; and the benefits and costs of development of outer space resources could be widely internalized or externalized.375 Additionally, restoration of any depleted resources in outer space may be difficult, and the impact on any of those resources may be so dire that its overuse and depletion could be “the epitome of apocalypse.”376 Finally, the vastness of outer space makes it difficult to subject it to “local” regulation—i.e., regulation by individual nations, which might opt not to regulate certain activities or to regulate lightly.377

Similar to Garrett Hardin’s open pasture, a major problem with a commons is that, “absent a system that allocates use rights, it is difficult, if not impossible, to restrain the impulse of users to pursue their individual self-interests, even when pursuit of those interests result in the degradation or exhaustion of the resource.”378 This is why, he argued, “‘freedom in the commons’—i.e., the lack of controls on individual behavior and self-interest—ultimately leads to its ruin and hence to the ‘tragedy.’”379 If the amount of use of a CPR or the intensity of that use is too much, then the result can be “congestion” that decreases the values of those resources.380 “Similarly, certain types of uses can create incompatibilities with many ordinary uses and conservation of such spaces, creating the conditions for rivalry or subtractability.”381

The unbounded nature of space and the variety and wealth of its resources is already attracting potential users with competing or conflicting ideas about how space should be used.382 Even if space was regulated, this “magnetic pull” to occupy and develop space may create rivalry among different users, especially if those users are drawn to the same areas of outer space.383 Unless the development of outer space resources is regulated, too many entities vying for the same resource could lead not only to congestion and rivalous behavior,384 but also to accidents and serious conflict—the conditions the space treaties are intended to avoid.385

The way to prevent a tragedy on land held in common is not necessarily its transformation to private property, which is one solution Hardin called for.386 Oran Young says “[i]nstitutional innovation,” like individual transferable quotas, “can create a form of private property and, in the process, alleviate the perverse incentives arising from the condition of non-excludability.”387 Creating public property or, in the alternative, using regulatory controls can also avoid the tragedy to the commons.388 The owners of a commons can also self-regulate to control the adverse effects of non-excludability.389

But as Young notes, while each approach has its plus side, each approach, like privatization, can also have negative effects.390 “Privatization can lead to outcomes that are grossly unfair[, and] [g]overnments [may] lack both the capacity and the will to manage public property well.”391 And common property approaches can lead to nonsustainable use of the property, and “work best in situations where the sense of community is strong and social pressure is capable of controlling behavior effectively”—characteristics uncommon in outer space.392

So, we have learned thus far that (1) the race is on to extract valuable resources from outer space and celestial bodies;393 (2) the international legal framework governing those activities is far from complete, inviting behavior that may be in the economic best interests of the actor, but not necessarily of the globe;394 (3) the international legal principles governing this behavior may be counter-productive when it comes to incentivizing economic behavior, but beneficial non-spacefaring countries;395 and (4) the push to privatize space, which is clearly a global commons, may lead to rivalrous behavior, which could dissolve into military activity and squeeze out poorer countries from the benefits of space, in direct contradiction of the goals of international space law.396

We have also learned that while privatizing open access areas, like outer space, is not necessarily good or necessary to avoid the tragedy of the commons (the over-utilization of common or shared pool resources), the features of a commons make it difficult to avoid that tragedy and to provide for future generations.397 So the solution may lie in crafting new property regimes, perhaps combining the best features of both approaches. It is to that task this Article now turns—the circumstances in which new forms of property might emerge and what they might be.

#### Competition and congestion make space war inevitable- only cooperative space governance solves

Chen, 21 -- Executive Director, Centre for Research in Air and Space Law, McGill University

[Kuan-Wei Chen; Ram S. Jakhu Acting Director, Institute of Air and Space Law, McGill University; Steven Freeland Emeritus Professor of International Law, Western Sydney University, "Space exploration should aim for peace, collaboration and co-operation, not war and competition," Conversation, 10-11-21, https://theconversation.com/space-exploration-should-aim-for-peace-collaboration-and-co-operation-not-war-and-competition-169317, accessed 1-14-22]

When the Soviet Union launched Sputnik 1 in 1957, it represented humanity’s first significant foray into the cosmos. Our imagination was opened to the wonder and lure of space for human endeavour as science fiction suddenly became science fact. A space arms race? At the time, the prevailing Cold War mentality contributed to suspicion and fear about what it meant to be in space, and resulted in the military roots of space technology and applications. John F. Kennedy famously stated that “if the Soviets control space they can control the earth, as in past centuries the nation that controlled the seas dominated the continents.” The Space Race, as it would become known, was characterized by fierce competition between the Soviet Union and the United States to achieve space superiority. Space technology and applications have evolved rapidly since Sputnik 1. Seven decades of space exploration and use have revolutionized the way the world communicates and greatly enhanced navigation on air, ground and sea. Space science has enabled us to monitor weather patterns, enhance land use and greatly advance our understanding of our own planet and our place in the universe. The desire to counter the space ambitions of others and to achieve superiority in space seems to have re-emerged. Despite the proliferation and commercialization of space activities, and the recognition of space as an essential part of every country’s economic, social and scientific progress, there is an alarming build-up of counter-space capabilities worldwide. Crowded space Even as private citizens can now crew space missions, military strategists are warning the competitive and congested nature of space will lead to an outbreak of conflict in outer space. Simmering tensions on Earth increase the risk that humanity may somehow lurch into an unimaginable space war, destroying economies and critical civilian and military infrastructure that have become so heavily space-dependent. In April, the International Committee of the Red Cross warned the international community that “the human cost of using weapons in outer space that could disrupt, damage, destroy or disable civilian or dual-use space objects is likely to be significant.” If a war in space takes place, the devastation might have long-lasting effects. Preventing colonialism However, despite assertions to the contrary, a space war is not inevitable. A notion that space is the new “warfighting domain” contradicts the six-decade-long understanding that space is a shared area governed by international law, where global interests converge to ensure its exploration and use for the benefit of all countries, irrespective of the degree of their economic or scientific development. The first space-focused UN General Assembly resolution recognized the desire “to avoid the extension of present national rivalries into this new field.” In 1967, a decade after Sputnik 1, diplomats came together during the height of Cold War brinksmanship to conclude the Outer Space Treaty. Today, 111 countries are parties to this phenomenal feat of international diplomacy, which underlines the common interest of all humanity to explore and use outer space “for peaceful purposes.” The treaty also affirms that space, including the moon and celestial bodies, are free to be explored and used by all states “on a basis of equality and in accordance with international law.” Departing from the traditionally reactive nature of international law, the Outer Space Treaty initiated the most significant principle of law for enhancing the common interest of all in space in order to thwart potential colonization ambitions in space. By declaring that outer space “is not subject to national appropriation” by any means, the Treaty established a foundational governance system based on mutual understanding and friendly relations. The race towards peace Since the 1980s, the UN General Assembly has every year passed a resolution on the prevention of an arms race in outer space (PAROS), the latest of which reminds the international community of “the importance and urgency of preventing an arms race” and calling on states to “refrain from actions contrary to that objective.” The prevention of an arms race in outer space is vital yet contemplates and may even legitimize increased military uses of space. A proper emphasis of the humanity of space and the preservation of its safety, stability and sustainability drives the need for peace in outer space. The Outer Space Treaty, and multilateral dialogue at the UN, have for decades provided the anchor to keep space free from conflict. There is no reason why this overarching legal and institutional framework for peace cannot continue to shelter us from irresponsible behaviour in space. The diplomatic language is shifting in this direction, as are initiatives to clarify international law as it applies to the military uses of outer space. Governments, industry stakeholders, civil society and the younger generations all have a role to play in promoting the benefits and common interests of humanity in space, drawing inspiration from the words of the first human in space, Soviet cosmonaut Yuri Gagarin: “There is room in space for everybody.” In an era when humanity is faced with climate change, a global pandemic and the rapid exhaustion of resources, there is no room for assertions of dominance and superiority. Rather, the common interests in peace that we all share are even more important, both on Earth and in outer space.

#### Congestion causes debris

Fabian 19 (Christopher; January 2019; B.S. from the United States Air Force Academy, thesis submitted in partial fulfillment of the requirements for a M.S. from the University of North Dakota, approved by the Faculty Advisory Committee and in coordination with Dr. Michael Dodge, David Kugler, and Brian Urlacher; University of North Dakota Scholarly Commons, “A Neoclassical Realist’s Analysis Of Sino-U.S. Space Policy,” <https://commons.und.edu/theses/2455/>)

b. Defect/Defect The ubiquity of space technology has also yielded the negative externality of overcrowding the space domain. Despite its seemingly unlimited size, there are a limited number of useful earth-centric orbits to optimize terrestrial coverage. It is projected that there are over 300,000 medium sized objects capable of causing catastrophic failure of a satellite upon collision currently in earth’s orbit.159 Of these objects, 20,000 are actively tracked by the comparatively robust space surveillance network (SSN) of the United States Air Force, only 1,000 are active payloads, and even fewer have maneuver capability.160 Recent trends indicate that the problem of orbital congestion will only worsen in the coming decades as the barriers to entry are reduced. Launch service cost is rapidly decreasing due to an increased number of service providers and technology revolutions such as reusable rockets. Also, the miniaturization and simplification of satellite payloads further reduces the cost and infrastructure needed to be a spacefairing nation.161 This is evidenced by the near doubling of state operated satellites from 27 in 2000 to over 50 in 2012, coupled with a near doubling in total space objects from 1997 to 2007.162 The accumulation of space debris is a vital concern to the sustainable development of the space environment due to the increased probability of conjunction between active payloads and all other objects that results from crowded orbits. This increase in collision probability occurs proportionally to the number of objects in a given orbital domain. The tripling of orbital debris projected to occur in the next century, due to routine use and accumulation alone, would cause a tenfold increase in the probability of collision. In the event of a catastrophic collision between two objects, the resulting debris cloud could cause a cascading effect. Each successive collision increases the probability of another occurrence in a given orbit until an instability threshold is reached. At this threshold, debris removal due to decay would be negligible compared to debris created by subsequent collisions. As the propagation of debris continues, the cost of launching a satellite would eventually outweigh the benefits received due to the probability of that asset being destroyed by errant debris, effectively rendering the given orbit unusable. This debris propagation model and the dangers associated with it are colloquially referred to as the Kessler Syndrome. Kessler asserts unstable regions of low earth orbit (LEO) currently exist and that, barring the addition of more debris, a major collision would occur once every 10-20 years. If debris doubles, as it has in the last decade, the collision rate would increase to 2.5 years. Although most models’ time scales are on the order of centuries, it is widely accepted that the current rate of debris accumulation will render critical orbits unusable unless immediate measures are taken to return stability.163 There is near universal acceptance of the danger space debris presents, yet little substantive action has been taken to solve the problem. Current debris accumulation and propagation models show that earth orbiting domains are finite resources. Continued unsustainable development moving forward may preclude future usage, making earth orbits rivalrous goods.164 Furthermore, orbital domains are made a non-excludable good by the OST which states, “Outer space… shall be free for exploration and use by all States without discrimination of any kind.”165 As a non-excludable public good, space succumbs to the tragedy of the commons where the privately beneficial strategy of space utilization differs significantly from the socially optimal strategy promoting orbital stability.166 Understandably, most analysis has focused on solving the problem of orbital instability by addressing the market failure responsible for debris creation. The current reasoning suggests that if actors creating space debris internalize the cost of their actions, a solution can arise. Proposed solutions run the gamut of ideologies from free market tax incentives, to command and control legislation, to restructuring orbital property rights. Scientific solutions have also been proposed, but technological feasibility and cost remain major problems. Furthermore, analogous environments susceptible to the tragedy of the commons have been examined in hopes that they may prove applicable to the problem of orbit instability.167 This analysis is ultimately useful if the problem is to be solved under nominal conditions, but there is an underlying problem that needs to be addressed before any of these proposed solutions can realistically be enacted.

#### That cascades into global nuke war

Les Johnson 13, Deputy Manager for NASA's Advanced Concepts Office at the Marshall Space Flight Center, Co-Investigator for the JAXA T-Rex Space Tether Experiment and PI of NASA's ProSEDS Experiment, Master's Degree in Physics from Vanderbilt University, Popular Science Writer, and NASA Technologist, Frequent Contributor to the Journal of the British Interplanetary Sodety and Member of the American Institute of Aeronautics and Astronautics, National Space Society, the World Future Society, and MENSA, Sky Alert!: When Satellites Fail, p. 9-12 [language modified]

Whatever the initial cause, the result may be the same. A satellite destroyed in orbit will break apart into thousands of pieces, each traveling at over 8 km/sec. This virtual shotgun blast, with pellets traveling 20 times faster than a bullet, will quickly spread out, with each pellet now following its own orbit around the Earth. With over 300,000 other pieces of junk already there, the tipping point is crossed and a runaway series of collisions begins. A few orbits later, two of the new debris pieces strike other satellites, causing them to explode into thousands more pieces of debris. The rate of collisions increases, now with more spacecraft being destroyed. Called the "Kessler Effect", after the NASA scientist who first warned of its dangers, these debris objects, now numbering in the millions, cascade around the Earth, destroying every satellite in low Earth orbit. Without an atmosphere to slow them down, thus allowing debris pieces to bum up, most debris (perhaps numbering in the millions) will remain in space for hundreds or thousands of years. Any new satellite will be threatened by destruction as soon as it enters space, effectively rendering many Earth orbits unusable. But what about us on the ground? How will this affect us? Imagine a world that suddenly loses all of its space technology. If you are like most people, then you would probably have a few fleeting thoughts about the Apollo-era missions to the Moon, perhaps a vision of the Space Shuttle launching astronauts into space for a visit to the International Space Station (ISS), or you might fondly recall the "wow" images taken by the orbiting Hubble Space Telescope. In short, you would know that things important to science would be lost, but you would likely not assume that their loss would have any impact on your daily life. Now imagine a world that suddenly loses network and cable television, accurate weather forecasts, Global Positioning System (GPS) navigation, some cellular phone networks, on-time delivery of food and medical supplies via truck and train to stores and hospitals in virtually every community in America, as well as science useful in monitoring such things as climate change and agricultural sustainability. Add to this the [weakening] ~~crippling~~ of the US military who now depend upon spy satellites, space-based communications systems, and GPS to know where their troops and supplies are located at all times and anywhere in the world. The result is a nightmarish world, one step away from nuclear war, economic disaster, and potential mass starvation. This is the world in which we are now perilously close to living. Space satellites now touch our lives in many ways. And, unfortunately, these satellites are extremely vulnerable to risks arising from a half-century of carelessness regarding protecting the space environment around the Earth as well as from potential adversaries such as China, North Korea, and Iran. No government policy has put us at risk. It has not been the result of a conspiracy. No, we are dependent upon them simply because they offer capabilities that are simply unavailable any other way. Individuals, corporations, and governments found ways to use the unique environment of space to provide services, make money, and better defend the country. In fact, only a few space visionaries and futurists could have foreseen where the advent of rocketry and space technology would take us a mere 50 years since those first satellites orbited the Earth. It was the slow progression of capability followed by dependence that puts us at risk. The exploration and use of space began in 1957 with the launch of Sputnik 1 by the Soviet Union. The United States soon followed with Explorer 1. Since then, the nations of the world have launched over 8,000 spacecraft. Of these, several hundred are still providing information and services to the global economy and the world's governments. Over time, nations, corporations, and individuals have grown accustomed to the services these spacecraft provide and many are dependent upon them. Commercial aviation, shipping, emergency services, vehicle fleet tracking, financial transactions, and agriculture are areas of the economy that are increasingly reliant on space. Telestar 1, launched into space in the year of my birth, 1962, relayed the world's first live transatlantic news feed and showed that space satellites can be used to relay television signals, telephone calls, and data. The modern telecommunications age was born. We've come a long way since Telstar; most television networks now distribute most, if not ali, of their programming via satellite. Cable television signals are received by local providers from satellite relays before being sent to our homes and businesses using cables. With 65% of US households relying on cable television and a growing percentage using satellite dishes to receive signals from direct-to-home satellite television providers, a large number of people would be cut off from vital information in an emergency should these satellites be destroyed. And communications satellites relay more than television signals. They serve as hosts to corporate video conferences and convey business, banking, and other commercial information to and from all areas of the planet. The first successful weather satellite was TIROS. Launched in 1960, TIROS operated for only 78 days but it served as the precursor for today's much more long-lived weather satellites, which provide continuous monitoring of weather conditions around the world. Without them, providing accurate weather forecasts for virtually any place on the globe more than a day in advance would be nearly impossible. Figure !.1 shows a satellite image of Hurricane Ivan approaching the Alabama Gulf coast in 2004. Without this type of information, evacuation warnings would have to be given more generally, resulting in needless evacuations and lost economic activity (from areas that avoid landfall) and potentially increasing loss of life in areas that may be unexpectedly hit. The formerly top-secret Corona spy satellites began operation in 1959 and provided critical information about the Soviet Union's military and industrial capabilities to a nervous West in a time of unprecedented paranoia and nuclear risk. With these satellites, US military planners were able to understand and assess the real military threat posed by the Soviet Union. They used information provided by spy satellites to help avert potential military confrontations on numerous occasions. Conversely, the Soviet Union's spy satellites were able to observe the United States and its allies, with similar results. It is nearly impossible to move an army and hide it from multiple eyes in the sky. Satellite information is critical to all aspects of US intelligence and military planning. Spy satellites are used to monitor compliance with international arms treaties and to assess the military activities of countries such as China, Russia, Iran, and North Korea. Figure 1.2 shows the capability of modem unclassified space-based imaging. The capability of the classified systems is presumed to be significantly better, providing much more detail. Losing these satellites would place global militaries on high alert and have them operating, literally, in the blind. Our military would suddenly become vulnerable in other areas as well. GPS, a network of 24-32 satellites in medium-Earth orbit, was developed to provide precise position information to the military, and it is now in common use by individuals and industry. The network, which became fully operational in 1993, allows our armed forces to know their exact locations anywhere in the world. It is used to guide bombs to their targets with unprecedented accuracy, requiring that only one bomb be used to destroy a target that would have previously required perhaps hundreds of bombs to destroy in the pre-GPS world (which, incidentally, has resulted in us reducing our stockpile of non-GPS-guided munitions dramatically). It allows soldiers to navigate in the dark or in adverse weather or sandstorms. Without GPS, our military advantage over potential adversaries would be dramatically reduced or eliminated.

#### Space conflicts go nuclear- both fast and probable

Grego, 15 -- a physicist in the Global Security program at UCS

[Laura Grego, an expert in space weapons and security; ballistic missile proliferation, and ballistic missile defense, "Preventing Space War", Union of Concerned Scientists, 07-05-2015 <https://allthingsnuclear.org/lgrego/preventing-space-war>]

So says a very good New York Times editorial “Preventing a Space War” this week. Sounds right, if X-Wing fighters come to mind when you think space conflict. But in reality conflict in space is both more likely than one would think and less likely to be so photogenic. Space as a locus of conflict The Pentagon has known that space could be a flash point at least since the late 1990s when it began including satellites and space weapons in earnest as part of its wargames. The early games revealed some surprises. For example, attacking an adversary’s ground-based anti-satellite weapons before they were used could be the “trip wire” that starts a war: in the one of the first war games, an attack on an enemy’s ground-based lasers was meant to defuse a potential conflict and protect space assets, but instead was interpreted as an act of war and initiated hostilities. The games also revealed that disrupting space-based communication and information flow or “~~blinding~~” could rapidly escalate a war, eventually leading to nuclear weapon exchange. The war games have continued over the years with increased sophistication, but continue to find that conflicts can rapidly escalate and become global when space weapons are involved, and that even minor opponents can create big problems. The report back from the 2012 game, which included NATO partners, said these insights have become “virtually axiomatic.” Participants in the most recent Schriever war games found that when space weapons were introduced in a regional crisis, it escalated quickly and was difficult to stop from spreading. The compressed timelines, the global as well as dual-use nature of space assets, the difficulty of attribution and seeing what is happening, and the inherent vulnerability of satellites all contribute to this problem. Satellite vulnerability & solutions Satellites are valuable but, at least on an individual basis, physically vulnerable. Vulnerable in that they are relatively fragile, as launch mass is at a premium and so protective armor is too expensive, and a large number of low-earth-orbiting satellites are no farther from the earth’s surface than the distance from Boston to Washington, DC.

#### Nuke war causes extinction – won’t stay limited

Edwards 17 [Paul N. Edwards, CISAC’s William J. Perry Fellow in International Security at Stanford’s Freeman Spogli Institute for International Studies. Being interviewed by EarthSky. How nuclear war would affect Earth’s climate. September 8, 2017. earthsky.org/human-world/how-nuclear-war-would-affect-earths-climate] Note, we are only reading parts of the interview that are directly from Paul Edwards – MMG

In the nuclear conversation, what are we not talking about that we should be?

We are not talking enough about the climatic effects of nuclear war. The “nuclear winter” theory of the mid-1980s played a significant role in the arms reductions of that period. But with the collapse of the Soviet Union and the reduction of U.S. and Russian nuclear arsenals, this aspect of nuclear war has faded from view. That’s not good. In the mid-2000s, climate scientists such as Alan Robock (Rutgers) took another look at nuclear winter theory. This time around, they used much-improved and much more detailed climate models than those available 20 years earlier. They also tested the potential effects of smaller nuclear exchanges. The result: an exchange involving just 50 nuclear weapons — the kind of thing we might see in an India-Pakistan war, for example — could loft 5 billion kilograms of smoke, soot and dust high into the stratosphere. That’s enough to cool the entire planet by about 2 degrees Fahrenheit (1.25 degrees Celsius) — about where we were during the Little Ice Age of the 17th century. Growing seasons could be shortened enough to create really significant food shortages. So the climatic effects of even a relatively small nuclear war would be planet-wide. What about a larger-scale conflict? A U.S.-Russia war currently seems unlikely, but if it were to occur, hundreds or even thousands of nuclear weapons might be launched. The climatic consequences would be catastrophic: global average temperatures would drop as much as 12 degrees Fahrenheit (7 degrees Celsius) for up to several years — temperatures last seen during the great ice ages. Meanwhile, smoke and dust circulating in the stratosphere would darken the atmosphere enough to inhibit photosynthesis, causing disastrous crop failures, widespread famine and massive ecological disruption. The effect would be similar to that of the giant meteor believed to be responsible for the extinction of the dinosaurs. This time, we would be the dinosaurs. Many people are concerned about North Korea’s advancing missile capabilities. Is nuclear war likely in your opinion? At this writing, I think we are closer to a nuclear war than we have been since the early 1960s. In the North Korea case, both Kim Jong-un and President Trump are bullies inclined to escalate confrontations. President Trump lacks impulse control, and there are precious few checks on his ability to initiate a nuclear strike. We have to hope that our generals, both inside and outside the White House, can rein him in. North Korea would most certainly “lose” a nuclear war with the United States. But many millions would die, including hundreds of thousands of Americans currently living in South Korea and Japan (probable North Korean targets). Such vast damage would be wrought in Korea, Japan and Pacific island territories (such as Guam) that any “victory” wouldn’t deserve the name. Not only would that region be left with horrible suffering amongst the survivors; it would also immediately face famine and rampant disease. Radioactive fallout from such a war would spread around the world, including to the U.S. It has been more than 70 years since the last time a nuclear bomb was used in warfare. What would be the effects on the environment and on human health today? To my knowledge, most of the changes in nuclear weapons technology since the 1950s have focused on making them smaller and lighter, and making delivery systems more accurate, rather than on changing their effects on the environment or on human health. So-called “battlefield” weapons with lower explosive yields are part of some arsenals now — but it’s quite unlikely that any exchange between two nuclear powers would stay limited to these smaller, less destructive bombs.

#### Appropriation undercuts cooperation- reinforces space as a competitive environment

Manning, 21 -- senior fellow with the Scowcroft Center for Strategy and Security

[Robert A. Manning, opinion contributor, “The dangers of anarchy in space,” The Hill, 11-29-21, <https://thehill.com/opinion/583317-rethinking-space-the-dangers-of-anarchy-in-the-cosmos>]

I can’t think of a more dramatic illustration of how reckless actions in space put all at grave risk than [Russia’s recent anti-satellite (ASAT)](https://www.washingtonpost.com/politics/2021/11/23/russia-proved-it-can-shoot-down-satellite-does-this-make-space-less-secure/) test blowing up one of its own defunct satellites and creating a cloud of more than 1,500 pieces of space debris. All this reflects a troubling anarchy in the cosmos, a militarization of space, one ill-conceived aspect of unrestrained arms racing, the pathology of this era of great power competition. Space junk is inadvertent, but satellites that can kill or disable satellites and cyber jamming highlight the military risks. The anti-space antics also reveal the mutual vulnerabilities that should spark a rethink of current policies in the interest of self-preservation. The private sector has entered the space business with new technologies enabling the miniaturization of satellites, called Cubesats, some no bigger than a shoebox. [Google, Amazon and Elon Musk’s SpaceX](https://www.cnbc.com/2019/12/14/spacex-oneweb-and-amazon-to-launch-thousands-more-satellites-in-2020s.html) plan to launch some 50,000 such satellites in this decade. These are all at risk from [27,000 pieces of space debris](https://www.nasa.gov/mission_pages/station/news/orbital_debris.html), tracked by the Department of Defense’s impressive Space Surveillance Network (SSN), as well as by some half a million smaller pieces, the size of marbles. With both satellites and debris traveling at roughly 17,000 miles an hour, collisions could be catastrophic. Yet there is a paucity of rules governing behavior in space, which, like sea, air and cyber, are global commons. The 1967 Outer Space Treaty (OST) is the one accord signed by all major space-faring nations, 197 nations in all. They agreed to the principles in the OST, which says: “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 not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. and shall be the province of all mankind.” In the real world, the treaty is sadly outdated by both technology (as ASAT tests demonstrate) and geopolitics, as the U.S., Russia and China plan Moon bases and private sector firms plan to exploit minerals on asteroids, for starters. In this era of populist nationalism and major powers competing for dominance, fashioning new regimes or codes of conduct for space appears highly problematic. But there are arenas of strategic competition and arenas for cooperation. Some would argue for cooperating only with democracies or like-minded actors. There are some areas – like technology sharing – where this makes sense. But nations cooperate, pooling risks and burdens when they perceive that their interests intersect. The threat of space debris to all nations’ vital economic and national security assets in space would seem one such instance. DOD's space surveillance network is the premier mechanism for monitoring space junk. Russia has some orbital monitoring capacity, but few other states do. Moreover, the U.S. already has [space sharing agreements](https://www.stratcom.mil/Media/News/News-Article-View/Article/1825882/100th-space-sharing-agreement-signed-romania-space-agency-joins/) with over 100 nations to provide data and notifications to avoid collisions. The U.S. gave a heads-up to China about such risks during the Obama administration, according to well-placed sources. In addition, private sector firms and start-ups in Japan and Europe are exploring ways of getting rid of space junk. There is money to be made, and I’d hazard a guess that the engineers at [Jeff Bezos](https://thehill.com/people/jeffrey-jeff-bezos)’s Blue Origin and [Elon Musk](https://thehill.com/people/elon-musk)’s Space X might be interested in a public-private partnership6. It would be faster and cheaper if the space-faring states, pooling resources, invited private sector bids for contracts to help rid the lower Earth orbit of dangerous space junk. Share the burden and the benefits.

#### That shreds the potential for sustainable space development

Islam 18

[Mohammad Saiful Islam – Institute for Advanced Judicial Studies, Beijing Institute of Technology; International, “The Sustainable Use of Outer Space: Complications and Legal Challenges to the Peaceful Uses and Benefit of Humankind,” Beijing Law Review, 06-2018, <https://www.scirp.org/journal/paperinformation.aspx?paperid=85201>]

The current situation of use of outer space is so **competitive** to the public and private sectors as well to attain potential benefits in the economic and political field. This aspect indicates that the importance and complexity of space use are increasing to national security and in social, economic and environmental development. From the one side, the increasing of space faring nations, use of outer space by public and private sectors, from the other side, the use of outer space through effective means, environmentally sound as well as use for commercial purposes is a new great challenge to the international community today. Moreover, space law’s simplicity is challenged by the growing, each and every day, different technology as like as newfangled aspect to use of outer space. Another important undertaking is an upholding sustainable use of space for economic, social and environmental development, basically for developing countries. This stressed by general assembly resolution indicated that “The general assembly of UN stresses the importance of promoting effective means of using space technology to assist in the solution of problems of regional or global significance and of strengthening the capabilities of Member States, in particular developing countries, to use the applications of space research for economic, social and cultural development” [(United Nations, 2000)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref49). The objectives of this research are to make fertile events of present complications of outer space law; to identify the national and international challenges to sustainable uses of outer space; and to attempt to accumulate urgently required development of outer space for peacefully gaining the potential benefits for humankind.

Sustainable development is the **establishing** principle for achieving present human needs without damaging the demands of future generations maintaining integrity and constancy of the natural systems. The modern idea of sustainable development is derived from the Brundtland Report in 1987. Generally considered in modern application and exploration of outer space, fundamental elements are the area must be dedicated to peaceful purposes; and the area must be preserved for future generations [(Heim, 1990)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref17). It is an **indispensable** and inordinate challenge to confirm uphold the healthy environment and make sure development without destroying the rights of future generations in space. Article IX of The Outer Space Treaty provided, in the exploration and use of outer space, States should pursue studies and conduct exploration of outer space so as to avoid harmful contamination and also adverse changes in the environment of the Earth [(Outer Space Treaty, 1967)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref35). The issues of what constitutes harmful contamination in Earth’s environment have yet to be interpreted. The legal definition of “adverse” and “harmful” will also modification as Earth, indigenous sciences progress, separately or in concert, with the planetary exploration space sciences [(Robinson, 2005)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref38). As a result of multifaceted political, economic, scientific, technological, educational, and other global problems, there has been practicing exclusively only international cooperation for sustainable space development among the developed countries [(Noichim, 2005)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref34). The space faring nations should promote a supportive environment for peaceful and sustainable use of space, decrease environmental effects on Earth and protect the terrestrial environment. We should escape a regime that will ultimately reflect the over-exploitation of resources and environmental havoc [(Fountain, 2002)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref9).

Adoption of space law treaties and principles at the international level is a foremost landmark in the development of the first era of international space law. Space law treaties and principles arrange a set of rules to ensure the peaceful and sustainable uses of outer space. In the matter of raising space faring nations, implementation of the existing space law is also an abundant challenge. Moreover, some major space faring countries did not ratify some of the treaty and more or less other countries raise the question of the effectiveness of present laws. About the advance notification of space activities, Article XI of the Outer Space Treaty provides, appropriately notify conducting space activities by the space faring State to the United Nations as well as the public together with nature, locations, conduct, general function of the space object and results of such activities [(Outer Space Treaty, 1967)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref35). The world is now perceiving multiplayer space power, control the use of nuclear weapons and other kinds of weapons in space is excessive undertaking. Article IV delivers, “States Parties to the Treaty undertake not to place in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner” [(Outer Space Treaty, 1967)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref35). This article is one of the most significant provisions on arms control is accompanied by other treaties of arms control. Commercialization of space is widely spread issue in outer space activities and major space faring nations like the U.S. highly promoted commercialization by private and non-governmental sectors. Appropriate administration, supervision and control are a vigorous **concern** for absent of international and national appropriate law. Article VI of the Outer Space Treaty provides that, the activities of non-governmental entities in outer space shall require authorization and provide continuing supervision by way of national legislation or any other means in order to ensure that national activities were carried out in conformity with the provisions of the outer space treaty [(Outer Space Treaty, 1967)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref35). Preserve environmental balance by decrease adversarial environmental changes. Harmful contamination through the extra environmental matter of the celestial bodies could introduce adverse environmental changes. Article 7.1 of the Moon Agreement states that “States’ Parties shall take measures to prevent the disruption of the existing environmental balance” [(“Moon Agreement”, 1979)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref31). Article IX of the Outer Space Treaty is required in the exploration and use of outer space “to avoid [its] harmful contamination”. Regarding “the environment of the Earth” treaty required to “avoid adverse changes... resulting from the introduction of extraterrestrial matter and, where necessary shall adopt appropriate measures for this purpose” [(Outer Space Treaty, 1967)](https://www.scirp.org/journal/paperinformation.aspx?paperid=85201#ref35).

#### Sustainable development solves climate change

Santos 13

[Filipe Durate Santos—Center for Astrophysics and Gravitation, “Space System for Sustainable Development,” Apogeo Spatial, 03-01-2013, <https://apogeospatial.com/space-system-for-sustainable-development/>]

The space environment is being used by more and more State and private sector entities for an increasingly diverse range of outer space activities. The long-term sustainability of these activities is currently in dangerdue to the proliferation of space debris, the growing probability of collisions, and the congestion of orbital positions and radio frequency spectra, particularly in the low-Earth orbit and geostationary orbit environments. However, space activities contribute decisively to the well-being of humanity and to sustainable development. Sustainability is a relatively recent concept introduced in the 1980s and defined by the United Nations World Commission on the Environment and Development in 1987 as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs.” This definition did not satisfy everyone, and other definitions arose. Gradually, it became clear that sustainable development is not a concept of a strictly scientific nature that can be defined without ambiguities; opinions differ on what precisely should count among the human needs for the application of the principle of intergenerational equity. These needs can be categorized into the social, economic, and environmental realms, but the relative importance of the different components is a matter of opinion. Sustainable development is these days a meeting point for the debate about the state of the world and how to respond to the social, economic, environmental, and institutional challenges we are facing. We are still very far from achieving it but we can identify the main drivers of unsustainability, which can be organized into four leading groups. Space systems play a crucial role in addressing the problems raised by these four groups of drivers, which constitute the “square of unsustainability.” See FIGURE 1. Finally, the fourth driver is anthropogenic climate change, mainly due to CO2 emissions from fossil fuel burning and to land use changes, especially deforestation. All four groups of drivers are strongly interconnected and interdependent. To reach some form of sustainable development, these issues must be addressed in ways that are both simultaneous and integrated. The magnitude and difficulty of this task reveal the perilous state the world is in. **Climate change** is one of the **majo**r environmental risks facing humanity in the 21st century. The scientific community has reached a strong consensus that anthropogenic emissions of greenhouse gases are intensifying the natural greenhouse effect in the atmosphere. These emissions are causing a climate change that will very likely intensify during the 21st century. The signs that this climate change is happening are becoming ever more obvious and unequivocal. According to the Intergovernmental Panel on Climate Change (IPCC), the global average surface temperature (land and ocean) has increased by 0.8° C since preindustrial times and by 1.0° C over land alone. In the Arctic, the average surface temperature increase has been higher, about twice the global value. Earth observation from space over the past 50 years has **fundamentally** changed our understanding and knowledge of the Earth system. See FIGURE 5. With increasingly sophisticated space systems, it is now possible to obtain quantitative measurements of temperatures in the atmosphere, concentrations of atmospheric gases, precipitation and wind speed, elevations of land and water, water movement, types of soils, and vegetation cover. In addition, satellite observations yield continually updated knowledge of the state of the atmosphere, helping meteorologists to devise models that project the weather into the future with much improved accuracy compared to pre-satellite forecasts. Seven-day forecasts have more than doubled in accuracy over the past three decades, particularly in the Southern Hemisphere. Satellites have been used to monitor the stratospheric ozone layer, which blocks damaging ultra-violet light from reaching the Earth’s surface, and to monitor atmospheric aerosol loading. Furthermore, they have contributed decisively to improvements in our understanding of the climate system and of climate change, through monitoring of the atmosphere, sea and land surface temperatures, ice sheet floes, Arctic sea ice extension, the El Niño-Southern Oscillation, and Earth’s carbon cycle. Recently, an ensemble of satellite altimetry, interferometry, and gravimetry datasets has been used to conclude that, since 1992, melting of the polar ice sheets has contributed, on average, 0.59 mm to the annual rate of global sea level rise. Extreme precipitation and floods are very likely to become more frequent because of climate change. Floods are just one example of various types of disasters where satellites are very useful for humanitarian relief, rapidly mapping and assessing local emergency situations and reconstruction activities. Space systems are extensively used these days in the management of disasters related to geophysical, meteorological, hydrological and climatic events. The uses of satellites in disaster management are becoming more integral to reducing reaction time and to providing accurate information for rescue and disaster control operations. Satellites are very useful in disasters for communications, remote sensing and mapping. Meteorological and storm warning satellite technology can also help in predicting water-related disasters and in setting up precautionary activities.

#### That causes extinction- resilience fails

Beard et al. 21 [S.J. Beard, Lauren Holt, Asaf Tzachor, Luke Kemp, Shahar Avin, Phil Torres, and Haydn Belfield, \* Centre for the Study of Existential Risk, “Assessing climate change’s contribution to global catastrophic risk,” 2021, *Futures*, Vol. 127, https://doi.org/10.1016/j.futures.2020.102673, Table 1 & Fig. 2 Omitted]

3.1. Climate change and planetary boundaries

While most of the impacts of climate change so far have fallen within the range of what was experienced during the Holocene, the rate of change is faster than in the Holocene and we are now beginning to see climate change push beyond these boundaries. In the latest edition of the planetary boundaries’ framework, climate change is placed in the zone of increasing risk, implying that while this boundary has been breached, there remains some potential for normal functioning and recovery (Steffen et al., 2015). It thus lies between what the authors identify as the ‘safe zone’ and other ‘high risk’ transgressions, such as disruption to the biochemical flows of nitrogen and phosphorus and loss of biosphere integrity.

As part of their discussion of BRIHN Baum and Handoh (2014) note that climate change is the planetary boundary for which the risk to humanity has received most meaningful consideration and they suggest that this attention is deserved. Yet little research attention has been paid to climate change’s extreme or catastrophic effects. Kareiva and Carranza (2018) argue that, despite currently falling outside of the area of high risk, climate change has the clear potential to push humanity across a threshold of irreversible loss by “changing major ocean circulation patterns, causing massive sea-level rise, and increasing the frequency and severity of extreme events… that displace people, and ruin economies.” Even if humanity was resilient to each of these individual impacts, a global catastrophe could occur if these impacts were to occur rapidly and simultaneously.

One scenario that has received comparatively more attention is that of the global climate crossing a tipping point that would trigger environmental feedback loops (such as declining albedo from melting ice or the release of methane from clathrates) and cascading effects (such a shifting rainfall patterns that trigger desertification and soil erosion). After this point, anthropogenic activity may cease to be the main driver of climate change, making it accelerate and become harder to stop (King et al., 2015).

Other scenarios can be discerned from the numerous historical cases in which the modest, usually regional, climatic changes experienced during the Holocene have been implicated in the collapse of previous societies, including the Anasazi, the Tiwanaku, the Akkadians, the Western Roman Empire, the lowland Maya, and dozens of others (Diamond, 2005, Fagan, 2008). These provide a precedent for how a changing climate can trigger or contribute to societal breakdown. At present, our understanding of this phenomena is limited, and the IPCC has labelled its findings as “low confidence” due to a lack of understanding of cause and effect and restrictions in historical data (Klein et al., 2014). Further study and cooperation between archaeologists, historians, climate scientists and global catastrophic risk scholars could overcome some of these limitations by identifying how the impacts of climate change translate into social transformation and collapse, and hence what the impacts of more rapid and extreme climatic changes might be. There is also the potential for larger studies into how global climate variations have coincided with collapse and violence at the regional level (Zhang, Chiyung, Chusheng, Yuanqing, & Fung, 2005; Zhang et al., 2006). However, these need to be interpreted and generalized with care given the differences between pre-industrial and modern societies.

Societies also have a long history of adapting to, and recovering from, climate change induced collapses (McAnany and Yoffee, 2009). However, there are two reasons to be sceptical that such resilience can be easily extrapolated into the future. First, the relatively stable context of the Holocene, with well-functioning, resilient ecosystems, has greatly assisted recovery, while anthropogenic climate change is more rapid, pervasive, global, and severe. Large-scale states did not emerge until the onset of the Holocene (Richerson, Boyd, & Bettinger, 2001), and societies have since remained in a surprisingly narrow climatic niche of roughly 15 mean annual average temperature (Xu, Kohler, Lenton, Svenning, & Scheffer, 2020). A return to agrarian or hunter-gatherer lifestyles could thus have more devastating and long-lasting effects in a world of rapid climate change and ecological disruption (Gowdy, 2020).7 Second, modern human societies may have developed hidden fragilities that amplify the shocks posed by climate change (Mannheim 2020) and the complex, tightly-coupled and interdependent nature of our socio-economic systems makes it more likely that the failure of a few key states or industries due to climate change could cascade into a global collapse (Kemp, 2019).

A third set of plausible scenarios stem from climate change’s broader environmental impacts. Apart from being a planetary boundary of its own, Steffen et al. (2015) point out that climate change is intimately connected with other planetary boundaries (see Table 1). Climate change is thus identified by the authors as one of two ‘core’ boundaries with the potential “to drive the Earth system into a new state should they be substantially and persistently transgressed.” This transformative potential was elaborated on in subsequent work exploring how the world could be pushed towards a ‘Hothouse Earth’ state, even with anthropogenic temperature rises as low as 2 °C (Steffen et al., 2018).

The connection between climate change and biosphere integrity (the survival of complex adaptive ecosystems supporting diverse forms of life) is particularly strong. The IPCC is highly confident that climate change is adversely impacting terrestrial ecosystems, contributing to desertification and land degradation in many areas and changing the range, abundance and seasonality of many plant and animal species (Arneth et al., 2019). Similarly, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has reported that climate change is restricting the range of nearly half the world’s threatened mammal species and a quarter of threatened birds, with marine, coastal, and arctic ecosystems worst affected (Diaz et al., 2019). According to one estimate, climate change could cause 15–37 % of all species to become ‘committed to extinction’ by mid-century (Thomas et al., 2004).

Disruption to biosphere integrity can have profound economic and social repercussions, ranging from loss of ecosystem services and natural resources to the destruction of traditional knowledge and livelihoods. For instance, desertification, which threatens a quarter of Earth’s land area and a fifth of the population, is already estimated to cost developing nations 4–8 % of their GDP (United Nations, 2011). Many other rapid regime shifts involving loss of biosphere integrity have been observed, including shifts in arid vegetation, freshwater eutrophication, and the collapse of fish populations (Amano et al. 2020). There is a theoretical possibility of still more profound regime shifts at the global level (Rocha, Peterson, Bodin, & Levin, 2018). However, the contribution of loss of biosphere integrity to GCR is yet to be assessed. Kareiva and Carranza (2018) argue that it is unlikely to threaten human civilization, due both to a lack of plausible mechanisms for this threat and the fact that “local and regional biodiversity is often staying the same because species from elsewhere replace local losses.” However, in their classification of GCRs, Avin et al. (2018) suggest the potential for ecological collapse to threaten the safety boundaries of multiple critical systems with diverse spread mechanisms at a range of scales, from the biogeochemical and anatomical to the ecological and sociotechnological. Note that both these studies were conducted for largely conceptual purposes and should not be taken as rigorous analyses of this risk, this topic warrants further investigation.

3.2. Classifying climate change’s contributions to global catastrophic risk

Climate change’s contribution to GCR goes well beyond its impact on the earth system. Taking Avin et al.’s list of critical systems, we note that previous studies have mostly focused on the effects of climate change on physical and biogeochemical systems (e.g. global temperature and sea-level rise) or the lower-level critical systems that are most directly related to human health and survival (e.g. Heath Stress). However, these represent a very limited assessment of risk as it only accounts for climate change as a direct hazard/ threat and our "ontological" vulnerabilities to it. A more comprehensive risk assessment must consider the higher-order critical systems threatened by climate change passively (through a lack of alternatives) and actively (through intentional design).

The probability of a global catastrophe is higher when sociotechnological and environmental systems are tightly coupled, creating a potential for reinforcing feedback loops. If environmental change produces social changes that perpetuate further environmental change, then this could actively work against our efforts at adaptation. When this change has the potential to produce significant harm, via human vulnerabilities and exposure, we describe such loops as ‘global systems death spirals.’ These spirals could produce self-perpetuating catastrophes, whereby the energy and resources required to reverse or adapt to collapse are beyond the means of dwindling human societies. Feedback loops like this could thus create tipping points beyond which returning to anything like present conditions would become extremely difficult. Global systems would shift to very different states in which the prospects for humanity would likely be bleaker.

In the rest of this section, we explore just one potential spiral, between an ecological system (the biosphere) and two sociotechnological systems (the human food and global political systems). We explore each system and its interactions. Fig. 2 illustrates our model of this spiral.

3.2.1. The human food system

Climate change’s impact on biosphere integrity (discussed in the previous section) could harm the human food system due to loss of ecosystem services, disruption of the cycles of water, nitrogen and phosphates, and changes in the dynamics of plant and animal health (B´elanger & Pilling, 2019). Crossing this planetary boundary is already having severe implications for global food security, including loss of soil fertility and insect-mediated pollination (Diaz et al., 2019).

Systems for the production and allocation of food are already enduring significant stress. The sources of stress include climate change, soil erosion, water scarcity, and phosphorus depletion. The natural resource base, arable land and freshwater upon which food production rely are being degraded. While global food productivity and production has increased dramatically over the past century to meet rising demand from an expanding global population and rising standard of living, these constraints and risks are increasing the vulnerability of our global food supply to rapid and global disruptions that could constitute global catastrophes (Baum, Denkenberger, Pearce, Robock, & Winkler, 2015).

Climate change will further reduce food security in at least three interconnected ways. First, it will affect growing conditions, including direct threats to agricultural yields from heat, humidity, and precipitation in many regions; although initially improving conditions in some (Lott, Christidis, & Stott, 2013). Second, it will increase the range of agricultural pests and diseases (Harvell et al., 2002). Third, it will increase the occurrence of extreme weather events that impair the integrity of food production and distribution networks, from production to harvest, post-harvest, transport, storage, and distribution, thereby increasing our vulnerability and exposure to supply shocks (Bailey et al., 2015). The IPCC estimates, with medium confidence, that at around 2 °C of global warming the risk from permafrost degradation and food supply instabilities will be ‘very high’, while at around 3 °C of global warming the risk from vegetation loss, wildfire damage, and dryland water scarcity will also be very high (Arneth et al., 2019). Very few studies have considered the impacts of 4 °C of global warming or more; however, the IPCC highlighted one study finding that any potential agricultural gains from climate change will be lost by this point and there could be a decrease of 19 % in maize yields and 68 % in bean yields in Africa, an 8 % reduction in yields in South Asia, and a substantial negative impact on fisheries by 2050 (Porter et al., 2014). Furthermore, multiple extreme weather events could disrupt food distribution networks (Bailey and Wellesley, 2017).

While there are opportunities to adapt, disruption to the entire global food system cannot be resolved via food aid alone. Indeed, there is the potential for isolationist or heavy-handed responses that would do more harm than good. Given the high degree of interconnectivity and feedback within the global food system, our initial research suggests that any one of these climate change effects could trigger scenarios that would critically undermine the global food system’s ability to meet the minimum nutrition for well-being; making food security for all an unachievable goal, let alone rise to the challenge of continuing to grow (A. Tzachor, 2019, 2020); this would constitute what Kuhlemann (2019) terms a ‘threshold of significance.’

3.2.2. The global political system

Disrupting the global food system can create and exacerbate conflict and state failure (Brinkman & Hendrix, 2011). However, once again, this needs to be seen against the backdrop of a global political system under stress, with climate change as a significant contributing factor. Climate change influences political systems in many ways, from being a locus of activism and a stimulus for reform to driving rising inequality and population displacement (Arneth et al., 2019; Diffenbaugh & Burke, 2019). This is not a new phenomenon, changes in the climate are believed to have contributed to conflict between people and states throughout human history, driven by resource scarcity, population displacement, and inequality (Lee, 2009; Mach et al., 2019). As part of a comprehensive risk assessment of climate change, King et al. (2015) conducted an extensive literature review on climate change and conflict and used this to inform a series of international wargaming exercises. These found that climate change is expected to increase international conflict while highlighting the role that population displacement, state failure, and water and food insecurity would play in this (see also Mach et al., 2019; Natalini, Jones, & Bravo, 2015).

Quantitative studies of the impact of climate change on violence and conflict have provided more mixed results. A survey of empirical studies by Detges (2017) found that there may be multiple differing trends: extreme weather events appear to have more significant effects on violence than do long-term climate trends, while levels of small-scale conflict and interpersonal violence appear to be more affected than large-scale conflicts and international war. Empirical studies also highlight how climate change’s impact on conflict is predominantly as a risk multiplier and intensifier. Thus, climate change may contribute more by increasing our vulnerability to other conflict-inducing factors, such as loss of livelihood, forced migration, environmental change, and food insecurity, than by acting as a direct cause of conflict (Abel, Brottrager, Cuaresma, & Muttarak, 2019; Hsiang, Burke, & Miguel, 2013; Schubert et al., 2008).8

Of particular relevance to GCR is the effect of climate change on the risk of nuclear war (Parthemore, Femia, & Werrell, 2018). However, to our knowledge, this has never been rigorously assessed, although the potential is certainly there. One recent model of the risk of nuclear war highlighted how varied, and common, incidents with the potential to trigger a nuclear exchange are (Baum, de Neufville, & Barrett, 2018). It outlined 14 different causal pathways to an exchange, including the escalation of conventional wars and international crises, human error, and the emergence of new non-state actors. For all but two of these, they identify historical examples of potentially precipitating incidents, with 60 incidents in total (i.e. a little less than one a year). This suggests that the absence of nuclear war was less due to a lack of potential causes, tan the global political system’s ability to defuse them. Thus, the real significance of climate change may be its capacity to undermine this system: the combination of social, political, and environmental disruption, a lingering sense of global injustice, and rising food, water, and energy insecurity could increase the probability that crises escalate or that false alarms are mistaken for genuine emergencies. This topic needs further research.

3.3. The emergence of a global systems death spiral

Yet, we should not conclude that a nuclear exchange is the only, or even most likely, scenario in which political instability might produce a global catastrophe. Conflict and political instability, even of moderate severity, are themselves two of the most significant drivers of biodiversity loss due to breakdowns in monitoring, governance, and (public and private) property rights (Baynham-Herd, Amano, Sutherland, & Donald, 2018). This closes a potentially reinforcing feedback loop between loss of biosphere integrity, food insecurity and political breakdown.

The mechanisms by which these cascading failures might spread include many of the natural, anthropogenic, and replicator effects identified by Avin et al. (2018), making them harder to contain. At the natural level, climate change involves changes to the global atmospheric and biogeochemical systems and poses other naturally spreading harms, like global ecological collapse. At the anthropogenic level, the global interconnectedness of sociotechnological systems means that while small shocks are easier to recover from, larger shocks can be harder to contain and control. Finally, biological and informational replication can also spread the negative impacts of climate change, from vector-borne diseases and invasive species to climate fatalism and dangerous geoengineering technologies.

Given these numerous spread mechanisms, critical system failures could precipitate global catastrophes. Furthermore, the spiral we have explored is unlikely to be the only set of interlinked systemic disruptions that climate change could initiate (other death spirals could involve bio-insecurity and disease), nor are these the only causal connections between these three systems. Until we understand the nature of such death spirals better, we must act cautiously. We now turn to consider what this would mean.

### Solvency

#### Contention 2: Solvency

#### The appropriation of outer space by private entities is unjust. I advocate that the Public Trust Doctrine is the appropriate principle of justice for outer space.

#### PTD is durable, flexible, and solves- deflates the propensity for conflict and encourages sustainable development

Babcock, 19 -- Professor of Law, Georgetown University Law Center

[Hope M., B.A., Smith College; L.L.B., Yale, "The Public Trust Doctrine, Outer Space, and the Global Commons: The to Call Home ET", Syracuse Law Review, Vol. 69, No. 2, 2019, p. 191-262, <https://scholarship.law.georgetown.edu/facpub/2201>, accessed 1-14-22]

V. HOW TO MANAGE PROPERTY IN OUTER SPACE

[W]e must accord the highest priority to efforts to solve or avoid the tragedy of the commons, the free rider problem, and the harmful impacts of side effects as they arise in connection with human/environment relations. For the most part, success in this endeavor will depend on our ability both to understand the sources of perverse incentives and to devise systems of rights and rules or, in other words, governance systems capable of altering incentives sufficiently to alleviate problems of this sort.425

The lack of property lines or boundaries in outer space make it difficult to delineate an individual claim to ownership, which could lead to overlapping and conflicting claims of development rights. Assertion of ownership rights over space and its resources conflicts with the ban on appropriation of outer space in the governing treaties and could lead to rivalrous conditions, perhaps even to war. Without a management system that assures equitable access to and sharing of celestial resources, any form of property regime runs the risk of violating the equitable principles that animate the OST and Moon Treaty—that space should be developed for the benefit of all mankind.426

The Article, to this point, has established that outer space is closer to a global commons than it is to private property. Yet, treating space as a global commons, as noted previously, poses a unique management problem: how to design a management approach that protects open access commons resources from overconsumption or damage while still incentivizing the development of those resources. Hardin believed that privatization of property was the best way to achieve efficiency and sustainability, Ellickson argued that informal norms were the best way to achieve “sustainable equilibrium,” and Ostrom promoted “a range of management techniques specific to that community in order to redirect the march towards total exhaustion.”427 While these ideas do not work in isolation for space, they each contribute in some way to a solution.

This Part identifies some management approaches designed to achieve those goals from the right of first possession rule to the application of norms, and evaluates each one for its suitability and ability to meet the dual goals of equitably and sustainably allowing the profitable development of outer space resources, as well as for its efficiency, fairness, cost effectiveness, and ease of implementation and enforcement. One conundrum is that

not only does one size not fit all, but also there are apt to be multiple approaches to the development of solutions. To take a single example, any effort to avoid or alleviate the tragedy of the commons must include the creation of some sort of exclusion mechanism or system for rationing available supplies of the relevant good(s) or service(s) among prospective users. But it turns out that there are distinctive ways to meet this condition under structures of private property, common property, or public property.428

This Part also shows that there are a number of solutions whose effects are comparable in terms of conservation, but are significantly different when criteria like “efficiency, equity, or robustness” are examined.429

A. Hybrid Governance Hybrid forms of governance are a way of managing property.430 An example of a hybrid governance regime is a “nested governance system,” in which one form of governance, self- or local governance, is nested in a larger, “centralized governance regime.”431 In this management scenario, the public authority, which acts as a designer and mediator of these co-designed systems, becomes a “collaborative institutional ecosystem [of] manager[s]” enabling “the networks, actions and reactions of others in the ecosystem [to be] independent and free [while] nested within the local government, consistent with a polycentric system.”432 Elected officials “assist, collaborate, and provide technical guidance (data, legal advice, communication strategy, design strategies, sustainability models, etc.) to enable themselves to manage, mediate, and coordinate the ecosystem.”433 The public official becomes a manager who enables and supports “parts of the ecosystem to allow it to ‘nest’ within the larger policy of the city.”434 Arnold calls this nested system of governance a “spatially hybrid property regime.”435 Given the different levels of government that might be involved in outer space— international, national, and even local—nested hybridity might become a reality. Another hybrid form of governing property, particularly commons, which contains separate, yet overlapping power centers is called “subsidiarity.”436 “Subsidiarity is the idea that power should be shared with ‘the lowest practicable tier of social organization, public or private.’”437 It is based on the impression that “governments look for allies at different hierarchical levels to facilitate the initiatives of proactive citizens who, individually or in groups, are willing to take direct care of the commons.”438 Space-faring nations could involve subunits of government in the actual management of space, like states, provinces, and towns, as well as special interest groups that might benefit from the development of space, like universities or space development enterprises.439 Foster and Iaione use horizontal subsidiarity as a means of engaging an active urban citizenry in maintaining the city for the collective welfare of its citizens.440 However, there is no reason to limit the principle’s application to the urban environment. Indeed, the goal of reorienting “public authorities away from the central state to an active citizenry willing to cooperatively govern common resources” seems equally useful in outer space where there are similar sub-governing units.441 Indeed, to the extent this approach breaks the tie between the space development industry and government and the industry’s push to realize the principle of first possession, subsidiarity as a management principle may hold some merit, if adjusted to meet the physical circumstances of outer space.442 And a nested system of governance or subsidiarity could involve interested parties in governance providing for more local resolution of conflicts, if and when there are regulations to apply. B. Application of the Right of First Possession Property Rule As noted previously, the space industry favors allowing ownership of property in outer space because it enables them to profit from their investment in the development of space resources and counter balances the risks of each venture they undertake.443 They argue that “[o]wnership rights would also provide incentives for expeditions to make the initial treks to the moon”444 and “would allow a free market to develop in property rights” on celestial bodies like asteroids or the moon.445 Critical to protecting those investments is the right of first possession.446 But, as also discussed earlier, “full ownership” of property in outer space, like the surface of an asteroid or the moon, violates Article II of the Outer Space Treaty, making any implementing rule a nullity.447 One approach around the ban, allowing application of the principle, might be to create “a real property rights system based on jurisdictional sovereignty” distinguishing “between absolute territorial sovereignty and functional or jurisdictional sovereignty.”448 An essential part of this proposal is to permit “private entities to occupy locations on a first-come, first-served basis so long as the occupation does not interfere with the activities of other entities.”449 The proposal “would permit private property rights in outer space once a private entity made effective use of the property for a period of one year, and continued to use the property in a peaceful way that allowed for free and open use of outer space.”450 The genesis of this proposal, according to Andrew Brehm, are the Homestead Acts, “which similarly encouraged private exploration and settlement in new frontiers.”451 The key elements of this proposal are the non-interference requirement and the diligence requirement.452 But, eventually, the land transferred to the homesteader, which was the incentive for undertaking the hard work in the first place.453 Other scholars have advocated using the General Mining Law of 1872 (GML).454 The GML not only gave the first discoverer of a valuable mineral the exclusive right to develop it, but also to the land around the discovery.455 Ownership of the land remained in the United States until the discovering entity perfected its claim, at which point the land transferred to the miner.456 At that point, the proposal runs afoul of the OST ban, just like using the Homestead Act as a model.457 Another reason the models will not work in outer space is that the United States originally owned the land before it was transferred to a private entity.458 As no sovereign owns land in outer space, there is no sovereign to transfer anything to anybody.459 Therefore, the right of first possession rule under any approach cannot get over the non-appropriation hurdle of the international space treaties, regardless of any other attributes they may have, and is unworkable. C. Establish Exclusive Economic Zones (EEZ) Like Those Under UNCLOS One approach that has captured the attention of some space law scholars is the idea of establishing development or enterprise zones on celestial bodies.460 Under this approach, existing organizations could allocate areas on celestial bodies for the construction of installations by different countries “with the understanding that a certain exclusive economic zone would radiate from that location.”461 Nations could then allow activities to occur in those zones and regulate them.462 “Alternatively, an international organization could divide celestial bodies into shares for each country to presently or eventually exploit, as opposed to a system of arising economic zones.”463 The EEZ proposal is not that different from traditional Euclidian zoning to the extent it “separates incompatible land uses and excludes harmful ones to avoid negative spillovers” from the co-location of conflicting uses.464 Zoning can also be used to “control the kind of users allowed to consume the commons by excluding those who are likely to take out more than what might be considered their fair share of the commons and leave everyone worse off, at least fiscally.”465 Separating incompatible land uses and excluding those who might over-consume the commons might be a useful approach in outer space, if the obstacles to creating it can be overcome, which they cannot. The fact that the proposal assures development rights for countries creates several problems. First, creating an exclusive zone from which some entities are excluded in all likelihood would “directly interfere with the free exploration and use principles in Article I of the Outer Space Treaty.”466 Second, the proposal’s administration requires the presence of an international organization, with its attendant problems.467 Third, given the difficulty tracking asteroids, monitoring and enforcing what happens within these zones may be very difficult.468 Fourth, depending on the perceived fairness of the zones and the allocation process, the proposal could lead to “discord” among various countries causing the possible dissolution of whatever civility norms had been established among spacefaring nations.469 The zoning proposals to date have focused on single uses, principally mining.470 It is possible, however, that as conditions on the moon, for example, become more useful for other uses, such as a place from which to launch ventures into deeper outer space or for extracting water for use in situ or elsewhere, there may be more than one activity occurring in a single zone. One way to avoid one activity interfering with the use by another is the use of “performance zoning,” an idea Lee Anne Fennell proposed to allow for the agglomeration of beneficial uses to produce positive impacts within the zone as well as beneficial spillover impacts.471 Another is to adopt the idea of “poolism,” the “co-production of goods” and adoption of “sharing practices” in a single space, like in a city.472 For such an idea to work, there would have to be a system of assembling uses in a single area of a celestial body, perhaps through performance zoning, and then occupants of that zone would have to be willing and able to collaborate.473 Assuming those obstacles can be surmounted, it is not clear how either of these approaches will overcome the exclusion problems associated with any proposal that excludes some users. D. Lotteries or Tradable Credits Having a lottery or an auction of “ownership rights,” or establishing a system of tradable credits like under the Clean Air Act’s acid rain provision, 474 or under the prior appropriation doctrine for allocating use rights to a quantity of water, might be ways to lessen the equitable problems with the prior proposals, none of which is sensitive to the interests of non-developed countries.475 While an auction theoretically would open up the market in development rights to others than the large spacefaring nations, in practice one would expect that only they would be able to effectively bid on and then secure those rights.476 However, the idea of tradable credits might work.477 Under an outer space trading system, participant nations, “regardless of [their] space-faring capacity, would be allocated a certain number of lunar mining credits. The credits would allow the holder to mine a certain tonnage of natural resources on the moon during a given period.”478 The credits could apply to the amount of the resource a participant was allowed to mine, regardless of location, or could be tied to a particular plot of land on a celestial body.479 Participants could buy and sell their credits to other participants.480 The openness of the process would create an incentive for all countries, regardless of their “spacefaring capacities.”481 Two additional features make this an appealing approach. The first of these, “tonnage limits,” will encourage countries to “make careful choices in where and what to mine,” assuring that valuable resources will still be there for countries that begin mining later, like developing nations.482 The other, a sunset provision, should prevent hoarding and speculative purchases.483 The approach “would allow developing nations to benefit from space exploration and exploitation fairly, without giving them control over an international regime.”484 Another advantage, other than determining the amount of allocable credits, is that there would be no need for an international central authority, because participants will run the market.485 Coffey proposes linking the concept of tradable permits to an exclusive economic zone so that “[w]hen a nation exercises its credits on land, that land will become the exclusive economic zone of that nation,” but would allow others to pass through the zone “as long as they do not disturb it or take resources from it.”486 However, her approach comes close to conflicting with the prohibition against appropriating celestial resources. Yet, there are potential problems even with this promising approach. For example, there is still a need for some international organization to allocate mining credits and to determine the methodology for any allocation, especially how to assure that non-spacefaring nations benefit in some way.487 Some form of international oversight will be needed to “ensure that nations adhere to the rules and do not exceed their allotted tonnage.”488 There is an unresolved question whether commercial mining enterprises would be able to buy credits not only from their own country, but from other countries.489 Then, there is the question of whether space resources may legally be considered personal property, requiring a new international agreement to clarify that “celestial resources may legally belong to those who extract them.”490 Tradable credits would also need to be anchored by a permit, again raising the need for an administering agency.491 To prevent over-consumption of permitted resources, a “timelimited” permit based on something like the prior appropriation doctrine giving the first appropriator superior rights over any later appropriator might be a way to curb over-consumption, but might disadvantage nonspacefaring countries who would come later to the market.492 Therefore, tradable development credits—absent Coffey’s modification—is largely consistent with international law, and could assure equitable distribution of the benefits of space development as well as provide sufficient incentives for development of these resources. However, the approach may be too administratively encumbered and difficult to enforce to be worth adopting. E. Norms as a Management Approach493 Norms are social rules that are promulgated and enforced by the community to which they apply.494 They come from communities and not from an outside organization or governmental entity.495 They provide “social meaning” for individuals in specific communities and thus provide the framework or understandings that guide personal behavior.496 They function as nonlegal rules or obligations that certain individuals feel compelled to follow despite the lack of formal legal sanctions, whether because defiance would subject them to sanctions from others (typically in the form of disapproval, lowered esteem, or even ostracism) or because they would feel guilty for failing to conform to the norm (a so-called internalized norm).497 Concern about esteem is especially important in close-knit groups, which makes norms unlikely to have any effect on the disparate entities that might engage in developing outer space.498 However, if conditions were appropriate for the activation of norms in outer space, it is conceivable that a norm favoring an equitable distribution of space resources could arise. Ellickson’s study of Shasta County, California, demonstrates how norms that originate within a close-knit community can efficiently manage a CPR.499 His theory revolves around the baseline rule that “property rights—be they communal or individual—should be clear and well-known among community members.”500 Besides the absence of any close-knit community in outer space, the fact that property rules in outer space are neither clear nor well known would seem to undercut the application of norms as a management tool in that environment.501 Thus, norms work as a means of controlling individual behavior when individuals see themselves as part of a particular group.502 When this happens, individuals identify with and assimilate the group norm, replacing individual behavior with “group-guided behavior.”503 To the extent that “[i]nformal norms and private ordering seek to identify circumstances that combine the benefits of the unmanaged commons— freedom—with the benefits of privatization—efficiency,” they offer “an appealing degree of autonomy, efficiency, and freedom.”504 But, as in the case of the users of Pearl’s “Ogallala Aquifer,” there is no “close-knit group” of actors in outer space, “no shared workday affairs[,] . . . and the population of users is too large to enable each to sanction the other.”505 Hence, norms as a management approach in outer space, while consistent with international law, inexpensive to administer, implement, and enforce, and capable of responding to inequitable situations, seem unlikely to take hold in that environment.

F. The Public Trust Doctrine (PTD) as a Gap Filling, Place-Holding Management Approach506

The PTD offers both an approach for managing an open access commons and a gap-filling tool until a regulatory regime is adopted.507 The doctrine is based on the idea that the “sovereign holds certain common properties in trust in perpetuity for the free and unimpeded use of the general public.”508 The public’s right to access and use trust resources is never lost, and neither the government nor private individuals can alienate or otherwise adversely affect those resources unless for a comparable public purpose.509 The resources the doctrine protects “have long been part of a ‘taxonomy of property’ [that recognizes] the division of natural wealth into private and public property.”510

“The doctrine places on governments ‘an affirmative, ongoing duty to safeguard the long-term preservation of those resources for the benefit of the general public,’”511 thus limiting the sovereign’s power on behalf of both present and future individuals.512 It directs the government to manage trust resources for public benefit, not private gain.513 It applies to private as well as public resources and is used to preserve the public’s access to CPRs.514 Government agencies have the non-rescindable power to revoke uses of trust resources that are inconsistent with the doctrine.515 This effectively places a permanent easement over trust resources that burdens their ownership with an overriding public interest in the preservation of those resources.516 However, trust resources can be alienated in favor of private ownership, if the alienation will still serve the public’s interest in those resources and not interfere with trust uses of the remaining land.517 The PTD, therefore, protects the “people’s common heritage,”518 just as Article 11 of the Moon Treaty protects outer space as part of the common heritage of mankind.519

The doctrine also appears to be infinitely malleable. Original uses of the doctrine were restricted to only that “aspect of the public domain below the low-water mark on the margin of the sea and the great lakes, the waters over those lands, and the waters within rivers and streams of any consequence,”520 and covered only traditional uses of those lands, like fishing and navigation.521 Over time, the scope and application of the doctrine broadened to protect more public resources and different uses.522 Thus, the doctrine expanded to protect new trust resources, such as dry sand beaches, inland lakes, groundwater, dry riverbeds, and wildlife,523 and passive uses of those resources, like scientific study.524 The original link to navigable water and tidelands disappeared.525 Supporters of the doctrine successfully advocated that it be applied to “wildlife, parks, cemeteries, and even works of fine art,”526 while arguing more recently its application to the atmosphere.527

A doctrine that imposes a perpetual duty on the sovereign to preserve trust resources, prevents their alienation for private benefit, assures public access to them, and can be invoked by anyone seems particularly useful as a management tool in outer space.528 The fact that public access to trust resources is so central to the doctrine makes it reflective, not contradictory, of international space law’s bar against appropriation of outer space and of the principle of space being the “province of all mankind.”529 It avoids the problems of alienation and exclusion associated with any of the management approaches associated with some form of private property and requires neither the creation of a new administrative authority nor the presence of a close-knit group of like-minded people.530 Members of the public, both rich and poor, can invoke and enforce the doctrine as easily as the sovereign.531 It is cost effective to the extent that no separate apparatus is required to implement it, and the doctrine has shown itself to be highly adaptable and innovative as different needs arise.532 It could also fill the gap in international law with respect to managing celestial property. Therefore, of all the management approaches studied here, the PTD seems the most suited to keep order in space until a regulatory regime is imposed.

However, the doctrine provides no incentives for development of trust resources; rather, it might be used to limit or curtail that development, making it an imperfect, perhaps even counter-productive solution by itself to the extent that such development might be beneficial.533 Modifying the doctrine to allow limited use of private property management approaches, like tradable development claims, might buffer that effect—a form of overlapping hybridity between one type of property, a commons, and a management regime from another, private property, enabled by application of the PTD.

CONCLUSION

“Only a legal system that accommodates both the human need for resources and the necessary preservation of mankind’s common heritage can fulfill these criteria.”534

The future is now with regard to the development of outer space and its resources—it is no longer a question of whether humans will engage in these activities, but how soon they will. Technically advanced countries and private commercial enterprises are probing outer space and preparing for landing on an asteroid or the moon to extract their resources.535 Speculators are selling deeds to the moon’s surface and preparing to exploit the tourism potential that space offers.536 But, the legal framework for managing these initiatives is almost nonexistent.537 International treaties came into being before all this activity began in earnest and national laws that might apply are stunted by jurisdictional quandaries like the absence of national boundaries in outer space.538 Thus, there is an urgency to figure out how to control what happens in outer space before its resources are irreparably damaged or permanently monopolized by powerful countries and individuals.

In the absence of regulation, much of the current debate centers on what property regime should be applied in outer space.539 The assumption is that by only allowing private property rights in space, countries and commercial enterprises will undertake the risks and costs of space development.540 However, unless international space law changes, it may prevent this from happening. If it changes, strong management controls will be necessary to prevent destruction or over-consumption of celestial resources, as well as monopolization and competitive behavior by participants, which could lead to hostilities and inequities.

This Article examines various private property regimes, including those of less than full fee ownership, to see if any would avoid the conflict with the international prohibition on appropriation of outer space and its resources. It concludes that none will because each retains the right to exclude and each is insensitive to the treaties’ equity concerns. In contrast, considering outer space to be common is consistent with international space law in both respects.

Hypothesizing that private property in outer space may yet prevail, this Article investigates different private property management approaches, such as the right of first possession, lotteries, and tradable development rights, to see if any would be cost effective, easy to implement and equitable, and would also prevent over-consumption, monopolization or the slide into rivalrous behavior. The Article concludes that each comes up short in some respect. Social norms as a management tool for property held in common, although compliant with international law, are also not up to the task. Instead, although ancient, the PTD, with its malleability, easy and cost-effective implementation and enforcement, non-consumption principle, and consistency with the goals that animate international space treaties, seems best suited to the task of protecting the public’s interests in the global commons that is outer space as it has done for centuries in Earth-bound commons. But, as its principal terrestrial use has been to protect trust resources from development, the doctrine needs some modification to encourage development of celestial resources. Hence, this Article suggests that modifying the PTD to allow the application of private property management tools, like tradable development rights, will not only allow development, but also will assure that when it happens, it will not be just profitable for a few, but will also be sustainable and equitable.

#### Cooperative space development is more efficient

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Grier C. Raclin (Partner, Heron, Burchette, Ruckert & Rothwell, Washington, D.C. B.A. 1975, J.D. 1978, Northwestern University). “From Ice to Ether: The Adoption of a Regime to Govern Resource Exploitation in Outer Space.” Northwestern Journal of International Law & Business, Volume 7 Issue 4. Fall 1986. JDN. https://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1214&context=njilb

It must be recognized that more than half of the countries constituting the United Nations won independence within the last twenty years. These countries reject the traditional method of obtaining sovereignty and benefits through simple occupation of territory. 9 2 They seek to develop industrially quite quickly, hoping to establish a new international economic order in which developed countries are called upon to assist developing countries in a modernization campaign.193 Unless the United States seeks to withdraw from the numerous international organizations governed by one-nation-one-vote systems - a move which would render its terrestrial activities extremely difficult - the United States must now recognize, at least to some extent, developing countries' demands to have a voice in the development and exploitation of Antarctic and outer space resources. 194

From a purely practical standpoint, unilateral action by the United States to explore and exploit lunar and other resources would be extremely inefficient. Such an undertaking would require duplicative research and development, construction, transportation, and management efforts and activities that could be shared more profitably among numerous countries. As the United States has recognized the practicality of shared efforts regarding its plan to share the construction of the space station with Japan, Canada, and the European Space Agency, 195 so will the world's countries undoubtedly find it advantageous to unify in order to explore outer space. The early establishment of a predictable method of sharing the benefits of extraterrestrial resource development also will lessen the likelihood that inefficient "get-it-while-you-can" activities will characterize development efforts.

Finally, adoption of an international accord to regulate commercial activities in outer space and to allocate the benefits of such activities in a predictable manner would appear to be a prerequisite to financing these activities. Banks and investors will be reluctant to lend funds to any mining entrepreneur or consortium that did not have the uncontested, or at least predictable, right to the benefits of the resources it plans to develop or prospect. Similarly, it cannot be expected that an entrepreneur will take on the significant risks associated with extraterrestrial mining activities if its ability to obtain the benefits of those activities is open to question. Indeed, were the United States to fail to adopt a regime governing extraterrestrial resource exploration, it must be anticipated that entrepreneurs might seek the protection of parties to such a convention. Thus, the failure of the United States to secure such an agreement may result in the United States losing its ability to participate in such activities. 196

### Framing

#### The standard is maximizing expected wellbeing. That best recognizes the equal moral weight of all which accords everyone their due.

#### Also, extinction categorically outweighs all other impacts.

Seth D. **Baum &** Anthony M. **Barrett 18**. Global Catastrophic Risk Institute. 2018. “Global Catastrophes: The Most Extreme Risks.” Risk in Extreme Environments: Preparing, Avoiding, Mitigating, and Managing, edited by Vicki Bier, Routledge, pp. 174–184.

2. What Is GCR And Why Is It Important? Taken literally, a global catastrophe can be any event that is in some way catastrophic across the globe. This suggests a rather low threshold for what counts as a global catastrophe. An event causing just one death on each continent (say, from a jet-setting assassin) could rate as a global catastrophe, because surely these deaths would be catastrophic for the deceased and their loved ones. However, in common usage, a global catastrophe would be catastrophic for a significant portion of the globe. Minimum thresholds have variously been set around ten thousand to ten million deaths or $10 billion to $10 trillion in damages (Bostrom and Ćirković 2008), or death of one quarter of the human population (Atkinson 1999; Hempsell 2004). Others have emphasized catastrophes that cause long-term declines in the trajectory of human civilization (Beckstead 2013), that human civilization does not recover from (Maher and Baum 2013), that drastically reduce humanity’s potential for future achievements (Bostrom 2002, using the term “existential risk”), or that result in human extinction (Matheny 2007; Posner 2004). A common theme across all these treatments of GCR is that some catastrophes are vastly more important than others. Carl Sagan was perhaps the first to recognize this, in his commentary on nuclear winter (Sagan 1983). Without nuclear winter, a global nuclear war might kill several hundred million people. This is obviously a major catastrophe, but humanity would presumably carry on. However, with nuclear winter, per Sagan, humanity could go extinct. The loss would be not just an additional four billion or so deaths, but the loss of all future generations. To paraphrase Sagan, the loss would be billions and billions of lives, or even more. Sagan estimated 500 trillion lives, assuming humanity would continue for ten million more years, which he cited as typical for a successful species. Sagan’s 500 trillion number may even be an underestimate. The analysis here takes an adventurous turn, hinging on the evolution of the human species and the long-term fate of the universe. On these long time scales, the descendants of contemporary humans may no longer be recognizably “human”. The issue then is whether the descendants are still worth caring about, whatever they are. If they are, then it begs the question of how many of them there will be. Barring major global catastrophe, Earth will remain habitable for about one billion more years 2 until the Sun gets too warm and large. The rest of the Solar System, Milky Way galaxy, universe, and (if it exists) the multiverse will remain habitable for a lot longer than that (Adams and Laughlin 1997), should our descendants gain the capacity to migrate there. An open question in astronomy is whether it is possible for the descendants of humanity to continue living for an infinite length of time or instead merely an astronomically large but finite length of time (see e.g. Ćirković 2002; Kaku 2005). Either way, the stakes with global catastrophes could be much larger than the loss of 500 trillion lives. Debates about the infinite vs. the merely astronomical are of theoretical interest (Ng 1991; Bossert et al. 2007), but they have limited practical significance. This can be seen when evaluating GCRs from a standard risk-equals-probability-times-magnitude framework. Using Sagan’s 500 trillion lives estimate, it follows that reducing the probability of global catastrophe by a mere one-in-500-trillion chance is of the same significance as saving one human life. Phrased differently, society should try 500 trillion times harder to prevent a global catastrophe than it should to save a person’s life. Or, preventing one million deaths is equivalent to a one-in500-million reduction in the probability of global catastrophe. This suggests society should make extremely large investment in GCR reduction, at the expense of virtually all other objectives. Judge and legal scholar Richard Posner made a similar point in monetary terms (Posner 2004). Posner used $50,000 as the value of a statistical human life (VSL) and 12 billion humans as the total loss of life (double the 2004 world population); he describes both figures as significant underestimates. Multiplying them gives $600 trillion as an underestimate of the value of preventing global catastrophe. For comparison, the United States government typically uses a VSL of around one to ten million dollars (Robinson 2007). Multiplying a $10 million VSL with 500 trillion lives gives $5x1021 as the value of preventing global catastrophe. But even using “just" $600 trillion, society should be willing to spend at least that much to prevent a global catastrophe, which converts to being willing to spend at least $1 million for a one-in-500-million reduction in the probability of global catastrophe. Thus while reasonable disagreement exists on how large of a VSL to use and how much to count future generations, even low-end positions suggest vast resource allocations should be redirected to reducing GCR. This conclusion is only strengthened when considering the astronomical size of the stakes, but the same point holds either way. The bottom line is that, as long as something along the lines of the standard riskequals-probability-times-magnitude framework is being used, then even tiny GCR reductions merit significant effort. This point holds especially strongly for risks of catastrophes that would cause permanent harm to global human civilization. The discussion thus far has assumed that all human lives are valued equally. This assumption is not universally held. People often value some people more than others, favoring themselves, their family and friends, their compatriots, their generation, or others whom they identify with. Great debates rage on across moral philosophy, economics, and other fields about how much people should value others who are distant in space, time, or social relation, as well as the unborn members of future generations. This debate is crucial for all valuations of risk, including GCR. Indeed, if each of us only cares about our immediate selves, then global catastrophes may not be especially important, and we probably have better things to do with our time than worry about them. While everyone has the right to their own views and feelings, we find that the strongest arguments are for the widely held position that all human lives should be valued equally. This position is succinctly stated in the United States Declaration of Independence, updated in the 1848 Declaration of Sentiments: “We hold these truths to be self-evident: that all men and 3 women are created equal”. Philosophers speak of an agent-neutral, objective “view from nowhere” (Nagel 1986) or a “veil of ignorance” (Rawls 1971) in which each person considers what is best for society irrespective of which member of society they happen to be. Such a perspective suggests valuing everyone equally, regardless of who they are or where or when they live. This in turn suggests a very high value for reducing GCR, or a high degree of priority for GCR reduction efforts.