## 1AC

### Underview

#### 1] Aff gets 1AR theory to prevent infinite abuse it’s DTD since the 1AR needs it to make the time investment worth, no RVIs because you can dump on a 30 sec shell for 6 minutes, and competing interps since the 2n can’t dump on a reasonability bright-line that excludes only what they did wrong – 1AR theory comes first the 1AR is too short to be able to rectify abuse and adequately cover substance.

#### 2] Procedural fairness first a) probability – one round cant alter subjectivity, but it can rectify fairness skews, b) link turns their role of the ballot since it proves we couldn’t engage in it and it is exclusionary, c) answers are self-defeating since they presuppose the judge evals them fairly.

### Solvency

#### Plan: The appropriation of outer space by private entities is unjust.

#### Enforcement through banning constellations in the LEO by claiming they violate Article II of the OST, Johnson 20

[Christopher D. Johnson, 2020, "The Legal Status of MegaLEO Constellations and Concerns About Appropriation of Large Swaths of Earth Orbit", Secure World Foundation, https://swfound.org/media/206951/johnson2020\_referenceworkentry\_thelegalstatusofmegaleoconstel.pdf, date accessed 1-23-2022] //Lex AT

Are Constellations Appropriation? The astronomy community has already voiced concerns about the impact that constellations will have on astronomy (AstronomyNow 2019). Constellations also bring potential risks from space debris and radiofrequency interference, both of which will have an effect on space sustainability. Starlink’s 1584 satellites in the 550 km region would effectively triple the number of satellites in the 400–600 km region, for example. Leaving these important concerns aside, constellations should also be considered in the context of their general legal status – and specifically whether large swaths of Low Earth Orbit are being impermissibly claimed and possessed by individual actors (whether the commercial actor itself, or by the authorizing national government). For example, and as mentioned above, the OneWeb constellation will be in 12 orbital planes at 1200 km. Phase 1 of the SpaceX Starlink constellations will fly 66 satellites in 24 orbital planes, for a total of 1584 satellites in its initial constellation. Do these megaconstellations constitute an impermissible appropriation (or ownership) of particular regions of outer space? Without offering a definitive conclusion, the following sections first argue why, and then why not, these large constellations in LEO constitute impermissible appropriations of sections of outer space. The reader can consider for themselves which of the following opposing arguments they find more convincing. Yes, This Is Impermissible Appropriation Article II of the Outer Space Treaty, discussed above, is clear on the point that the appropriation of outer space, including the appropriation of either void space or of celestial bodies, is an impermissible and prohibited action under international law. No means or methods of possession of outer space will legitimize the appropriation or ownership of outer space, or subsections thereof. Excludes Others The constellations above, because they seem to so overwhelmingly possess particular orbits through the use of multiple satellites to occupy orbital planes, and in a manner that precludes other actors from using those exact planes, constitute an appropriation of those orbits. While the access to outer space is nonrivalrous – in the sense that anyone with the technological capacity to launch space objects can therefore explore space – it is also true that orbits closer to Earth are unique, and when any actor utilizes that orbit to such an extent to these proposed constellations will, it means that other actors simply cannot go there. The Legal Status of MegaLEO Constellations and Concerns About Appropriation... 15 To allow SpaceX, for example, to so overwhelmingly occupy a number of altitudes with so many of their spacecraft, essentially means that SpaceX will henceforth be the sole owner and user of that orbit (at least until their satellites are removed). No other actors can realistically expect to operate there until that time. No other operator would dare run the risk of possible collision with so many other spacecraft in that orbit. Consequently, the sole occupant will be SpaceX, and if “possession is 9/10th of the law,” then SpaceX appears to be the owner of that orbit. Done Without Coordination Additionally, SpaceX and other operators of megaconstellations are doing so without any real international conversation or agreement, which is especially egregious and transgressive of the norms of outer space. Compared to the regime for GSO, as administered by the ITU and national frequency administrators, Low Earth Orbit is essentially ungoverned, and SpaceX and others are attempting to seize this lack of authority to claim entire portions of LEO for itself; and before any international agreement, consensus, or even discussion is had. They are operating on a purely “first come, first served” basis that smacks of unilateralism, if not colonialism. Governments Are Ultimately Implicated As we know, under international space law, what a nongovernmental entity does, a State is responsible for. Article VI of the Outer Space Treaty requires that at least one State authorize and supervise its nongovernmental entities and assure their continuing compliance with international law. As such, the prohibition on nonappropriation imposed upon States under Article II of the Outer Space Treaty applies equally to nongovernmental private entities such as SpaceX. Nevertheless, through the launching and bringing into use of the Starlink constellation, SpaceX will be the sole occupant, and thereby, possessor, both fact and in law, of 550 km, 1100 km, 1130 km, 1275 km, and 1325 km above our planet (or whatever orbits they finally come to occupy). The same is true for the other operators of these large constellations which will be solely occupying entire orbits.

#### Exemptions destroy the coercive power of legal regimes – causes circumvention across the board.

Hickman and Dolman 2 – John and Everett, 2002, Associate professor in the Department of Government and International Studies at Berry College in Mt. Berry, [“Resurrecting the Space Age: A State–Centered Commentary on the Outer Space Regime,” Volume 21 Number 1, <https://doi.org/10.1080/014959302317350855>] Elmer Recut Justin

Thus a state party need merely announce its intention to withdraw and then wait one year. Withdrawal of a single state party to the treaty, however, would not necessarily terminate the treaty between the other state parties. Yet, the decision of an important state not to be bound by a regime–creating treaty obviously endangers the entire treaty. The decision of the United States or China to withdraw from the OST would have far greater implications for the survival of the international space regime than the same decision by Bangladesh, Burkina Faso, or Papua New Guinea—the equality of states under international law remains nothing more than a useful  ction. For the OST to remain good international law, it must be accepted as such by the major space faring states of the 21st Century: the United States, Russia, the European Union, Japan, and China. One defection from the regime by a member of this group would no doubt lead to its effective collapse, as the remaining space faring states are unlikely to use the kind of coercion necessary to enforce the regime. A more likely response to such a defection is a scramble to make similar claims to sovereignty, based on historical precedent and effective occupation. Similar rushes to stake claims for territory sovereignty in other celestial bodies might follow.

#### Private entities are non-governmental.

Dunk 11 – Frans G. von der Dunk, 2011, [“The Origins of Authorisation: Article VI of the Outer Space Treaty and International Space Law,” University of Nebraska] Justin

4. Interpreting Article VI of the Outer Space Treaty One main novel feature of Article VI stood out with reference to the role of private enterprise in this context. Contrary to the version of the concept applicable under general international law, where “direct state responsibility” only pertained to acts somehow directly attributable to a state and states could only be addressed for acts by private actors under “indirect,” “due care”/“due diligence” responsibility,18 Article VI made no difference as to whether the activities at issue were the state’s own (“whether such activities are carried on by governmental agencies” . . .) or those of private actors (. . . “or by non-governmental entities”). The interests of the Soviet Union in ensuring that, whomever would actually conduct a certain space activity, some state or other could be held responsible for its compliance with applicable rules of space law to that extent had prevailed. However, the general acceptance of Article VI as cornerstone of the Outer Space Treaty unfortunately was far from the end of the story. Partly, this was the consequence of key principles being left undefined.

#### Outer space is, Betz 21

[Eric Betz, 3-5-2021, "The Kármán Line: Where does space begin?", Astronomy, https://astronomy.com/news/2021/03/the-krmn-line-where-does-space-begin, date accessed 1-22-2022] //Lex AT

These days, spacecraft are venturing into the final frontier at a record pace. And a deluge of [paying space tourists](https://astronomy.com/news/2020/08/six-ways-to-buy-a-ticket-to-space-in-2021) should soon follow. But to earn their astronaut wings, high-flying civilians will have to make it past the so-called Kármán line. This boundary sits some 62 miles (100 kilometers) above Earth's surface, and it's generally accepted as the place where Earth ends and outer space begins. From a cosmic perspective, 100 km is a stone's throw; it's only one-sixth the driving distance between San Francisco and Los Angelas. It’s also well within the clutches of Earth's overpowering gravitational pull and expansive atmosphere. So, how did humans come to accept this relatively nearby location as the defining line between Earth and space? The answer is partly based on physical reality and partly based on an arbitrary human construct. That's why the exact altitude where space begins is something scientists have been debating since before we even sent the first spacecraft into orbit. What is the Kármán Line? [Experts have suggested](https://books.google.com/books/about/The_Never_Ending_Dispute.html?id=fG4_AQAAIAAJ) the actual boundary between Earth and space lies anywhere from a mere 18.5 miles (30km) above the surface to more than a million miles (1.6 million km) away. However, for well over half a century, most — including regulatory bodies — have accepted something close to our current definition of the Kármán Line. The Kármán line is based on physical reality in the sense that it roughly marks the altitude where traditional aircraft can no longer effectively fly. Anything traveling above the Kármán line needs a propulsion system that doesn’t rely on lift generated by Earth’s atmosphere — the air is simply too thin that high up. In other words, the Kármán line is where the physical laws governing a craft's ability to fly shift. However, the Kármán line is also where the human laws governing aircraft and spacecraft diverge. There are no national borders that extend to outer space; it’s governed more like international waters. So, settling on a boundary for space is about much more than the semantics of who gets to be called an astronaut. The United Nations has historically accepted the Kármán line as the boundary of space. And while the U.S. government has been reticent to agree to a specific height, people who fly above an altitude of 60 miles (100 km) typically earn astronaut wings from the Federal Aviation Administration. Even the Ansari X-prize chose the Kármán line as the benchmark height required to win its $10 million prize, which was claimed when Burt Rutan’s SpaceShipOne became the first privately-built spacecraft to carry a crew back in 2004.

### Advantage

#### Privatization of space will increase space debris collisions, Muelhaupt 19

[Theodore J. Muelhaupt, June 2019, "Space traffic management in the new space era", [Journal of Space Safety Engineering](https://www.sciencedirect.com/science/journal/24688967), https://www.sciencedirect.com/science/article/pii/S246889671930045X?via%3Dihub, date accessed 1-23-2022] //Lex AT

The last decade has seen rapid growth and change in the space industry, and an explosion of commercial and private activity. Terms like NewSpace or democratized space are often used to describe this global trend to develop faster and cheaper access to space, distinct from more traditional government-driven activities focused on security, political, or scientific activities. The easier access to space has opened participation to many more participants than was historically possible. This new activity could profoundly worsen the space debris environment, particularly in low Earth orbit (LEO), but there are also signs of progress and the outlook is encouraging. Many NewSpace operators are actively working to mitigate their impact. Nevertheless, NewSpace represents a significant break with past experience and business as usual will not work in this changed environment. New standards, space policy, and licensing approaches are powerful levers that can shape the future of operations and the debris environment. 2. Characterizing NewSpace: a step change in the space environment In just the last few years, commercial companies have proposed, funded, and in a few cases begun deployment of very large constellations of small to medium-sized satellites. These constellations will add much more complexity to space operations. Table 1 shows some of the constellations that have been announced for launch in the next decade. Two dozen companies, when taken together, have proposed placing well over 20,000 satellites in orbit in the next 10 years. For perspective, fewer than 8100 payloads have been placed in Earth orbit in the entire history of the space age, only 4800 [1] remain in orbit and approximately 1950 [2] of those are still active. And it isn't simply numbers – the mass in orbit will increase substantially, and long-term debris generation is strongly correlated with mass. This table is in constant flux. It is based largely on U.S. filings with the Federal Communications Commission (FCC) and various press releases, but many of the companies here have already altered or abandoned their original plans, and new systems are no doubt in work. Although many of these large constellations may never be launched as listed, the traffic created if just half are successful would be more than double the number of payloads launched in the last 60 years and more than 6 times the number of currently active satellites. Current space safety, space surveillance, collision avoidance (COLA) and debris mitigation processes have been designed for and have evolved with the current population profile, launch rates and density of LEO space. By almost any metric used to measure activity in space, whether it is payloads in orbit, the size of constellations, the rate of launches, the economic stakes, the potential for debris creation, the number of conjunctions, NewSpace represents a fundamental change. 3. Compounding effects of better SSA, more satellites, and new operational concepts The changes in the space environment can be seen on this figurative map of low Earth orbit. Fig. 1 shows the LEO environment as a function of altitude. The number of objects found in each 10 km “bin” is plotted on the horizontal axis, while the altitude is plotted vertically. Objects in elliptical orbits are distributed between bins as partial objects proportional to the time spent in each bin. Some notable resident systems are indicated in blue text on the right to provide an altitude reference. The (dotted) red line shows the number of objects in the current catalog tracked by the U.S. Space Surveillance Network (SSN). All the COLA alerts and actions that must be taken by the residents are due to their neighbors in the nearby bins, so the currently visible risk is proportional to the red line. Fig 1 Download : Download full-size image Fig. 1. Objects in LEO orbit by altitude per 10 km altitude bin. Elliptical orbit objects distributed by portion spent in each bin. Some notable existing resident systems are listed on the right. New residents, including some replacement systems, are on the left. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.) The red line of the current catalog does not represent the complete risk; it indicates the risk we can track and perhaps avoid. A rule of thumb is that the current SSN LEO catalog contains objects about 10 cm or larger. It is generally accepted that an impact in LEO with an object 1 cm or larger will cause damage likely to be fatal to a satellite's mission. Therefore, there is a large latent risk from unobserved debris. While we cannot currently track and catalog much smaller than 10 cm, experiments have been performed to detect and sample much smaller objects and statistically model the population at this size [3]. The (solid) blue line represents the model of the 1 cm and larger debris that is likely mission-ending, usually called lethal but not trackable. If LEO operators avoid collisions with all the objects in the red line, they are nonetheless inherently accepting the risk from the blue line. This risk is already present. The (dashed) orange line is an estimate of the population at 5 cm and larger and is thus an estimate of what the catalog might conservatively be a few years after the Space Fence, a new radar system being built by the Air Force, comes on line (currently planned for 2019) [4]. Commercial companies offering space surveillance services, such as LeoLabs, ExoAnalytics, Analytic Graphics Inc., Lockheed, and Boeing, might also add to the number of objects currently tracked. Space Policy Directive 3 (SPD-3) [13] specifically seeks to expand the use of commercial SSA services. Existing operators can expect a sharp increase in the number of warnings and alerts they will receive because of the increase in the cataloged population. Almost all the increase will come from newly detected debris [5]. The pace of safety operations for each satellite on orbit will significantly change because of the increase in the catalog from the Space Fence. This effect is compounded because the NewSpace constellations described in Table 1 will drastically change the profile of satellites in LEO. The green bars in Fig. 1 represent the number of objects that will be added to the catalog (red or orange lines) from only the NewSpace large LEO constellations at their operational altitudes. This does not include the rocket stages that launch them, or satellites in the process of being phased into or removed from the operational orbits. Neighbors of one of these new constellations may face a radically different operations environment than their current practices were designed to address. Satellites in these large LEO constellations typically have planned operational lifetimes of 5–10 years. Some companies have proposed to dispose of their satellites using low thrust electric propulsion systems, which would spiral satellites down over a period of months or years from operating altitudes as high as 1500 km through lower orbits where the Hubble Space Telescope, the International Space Station, and other critical LEO satellites operate [6]. Similar propulsive techniques would raise replacement satellites from lower launch injection orbits to higher operational orbits. These disposal and replenishment activities will add thousands of satellites each year transiting through lower altitudes and posing a risk to all resident satellites in those lower orbits. More importantly, failures will occur both among transiting satellites and operational constellations, potentially leaving hundreds more stranded along the transit path. Aerospace studies [7–9] have shown that failed satellites, whether they fail during operations or fail during disposal, can pose as great or even greater risk than the many thousands of operational satellites (Fig. 2). Given the rapid flux in the proposed large LEO constellations (LLC), we created a Future Constellations Model (FCM) with elements that represented the characteristics of the different systems being proposed. In our models, almost all the collisions and the resulting debris from those collisions occur because of failed systems. Most large constellation operators intend to perform active collision avoidance for active systems, whether operational or in some stage of check-out or disposal, but failed satellites are assumed to be incapable of maneuver. Fig. 2 also shows that satellites in the disposal phase can contribute to collisions similarly to satellites in the operational phase. Fig 2 Download : Download full-size image Fig. 2. Collisions during operations and disposal over 10 years for various NewSpace Future Constellation Models (FCMs). 4. A notional illustration of workload The highest risk to operational satellites comes from the lethal but non-trackable debris that is depicted in the blue line in Fig. 2. However, operators perform collision avoidance only on the objects that can be tracked and cataloged. Advances in tracking and NewSpace launches will both act to increase this workload. A key element of the problem is that an increase in the LEO population will lead to an increase in close approaches to existing satellites [5], and the potential for accidental collisions. Conjunction prediction, collision probability (Pc), and maneuver planning for most existing satellite operators is a time- and personnel-intensive operation. Orbit analysts, and propulsion, navigation, and communications systems personnel are involved in evaluating and planning maneuvers over several days and must do so even if the ultimate decision is to “fly through” a close approach. Since most existing systems have small numbers of vehicles and the number of conjunctions any given operator experiences is relatively small, COLA remains a manual process. For systems not designed with automated maneuver planning, a COLA assessment that progresses all the way to a maneuver plan can consume considerable effort, whether or not the maneuver is executed. If a large constellation is deployed next to an existing resident system, the existing system may experience many conjunctions and alerts due to its close proximity of the dense new constellation. A sufficiently large constellation will, in effect, form a “shell” where frequent opportunities for conjunctions will be created. For example, Fig. 3 depicts a fictional scenario where 1225 “New” satellites are distributed in 35 planes in circular orbits at 1000 km altitude, at 98° inclination. These are placed near a hypothetical “Old” six-satellite constellation operating in a nearly circular orbit at the same altitude and 63° inclination. Following a common operations practice, we assume that the Old satellite operators flag a conjunction at Pc> 10−7, start COLA assessment with additional tracking at Pc> 10−6, and plan a COLA maneuver when the Pc> 10−5. A conjunction with Pc > 10−4 would typically be considered a significant risk leading most operators to maneuver. Fig 3 Download : Download full-size image Fig. 3. “New” large LEO constellation at same average altitude as “Old” existing constellation. Currently, the Old system in this example would typically see a warning (Pc > 10−6) a few times a month at this altitude, and of those, a few per year might cross the maneuver threshold. For the operations center, this would be multiplied by the number of satellites in the constellation. When the New system parks nearby, the number of COLA alerts jumps substantially. But the number of alerts depends entirely on the error bubble, (covariance) used. If the typical errors of the public external tracking data and the orbit propagation methods that are widely available (General Perturbations, or GP) are used for both constellations, over a 30-day period we see 129 conjunctions that cross the threshold for COLA assessment (Pc> 10−6), and 53 that cross the maneuver planning threshold (Pc> 10−5) (Fig. 4). This is nearly 2 per day. This could be an enormous workload for a manual process. If a high accuracy catalog (Special Perturbations, or “SP”) and a high-fidelity propagator with its typical covariances is used, the number of conjunctions goes from 129 to a more manageable 10. SP data is maintained by the Air Force, but it is not widely available. It is interesting to note that nine of those 10 crossed the maneuver-planning threshold, and of those, four crossed the Pc> 10−4 where many operators would choose to execute a maneuver. Compared to GP, the SP-quality data resulted in far fewer warnings and flagged four very close conjunctions. The operations center would have been able to concentrate on fewer “false alarms”. We also computed the case where GPS-quality owner-operator data was used for both systems, in which we assumed near-real-time owner-operator position data of very high quality was provided by both operators and used in the collision analysis. In this case, NONE of the conjunctions resulted in a warning and no COLA alerts were generated. The closest approach was 99 m, with a Pc of 3.7 × 10−7 using SP. But because of the quality of the GPS-based position data, this conjunction did not raise an alert because the fully-informed operators could be confident that a collision would not occur. Fig 4 Download : Download full-size image Fig. 4. Number of COLA alerts in 30 days for various qualities of position knowledge when a fictional new system is deployed near an existing one. In the example, an operations center for the Old constellation of six satellites could go from about one COLA assessment a week to nearly one per day per satellite, if only the published satellite catalog is available. If a new constellation operates too close to an existing system, the operator workload may become unreasonable using existing processes. But high accuracy data makes this manageable, and GPS-quality owner-operator data for both systems makes the problem vanish. Since these constellations are likely to be operated by different companies or governments, sharing high-quality position data would likely require an active space traffic management organization. Existing operators will not necessarily have large constellations parked nearby, but they will nonetheless be affected by the new activity. The new large constellations’ satellites typically will have relatively short lifetimes and will need frequent replenishment. The traffic transiting up and down will be substantial, and failures could leave stranded objects at intermediate altitudes, permanently increasing the collision risk. 5. Conjunction warning overload NewSpace operators will face a different challenge due to the vast increase in numbers of satellites. While there are likely as many operational plans as there are operators, a large constellation must consider close approaches with itself. Even if there are no neighboring systems, self-conjunctions can occur between two members of the same constellation. Depending on the configuration, a given operator could see hundreds to thousands of self-conjunctions that cross typical warning thresholds each day using current practices. This could be an issue for a space traffic management (STM) agency, even if it is not an issue for the operator. Aerospace models show that for one possible NewSpace constellation, more than 500,000 self-conjunctions each year could result that cross the typical Pc > 10−6 warning threshold. If no action were taken, we would expect 2–3 collisions per year. This is clearly unacceptable. Thus, current tracking accuracy and processes might produce millions of warnings per year for NewSpace operators to prevent half a dozen actual collisions. Under current practices operators would need to sort through an enormous haystack to find the needles, and because a handful of actual collisions will occur, the warnings cannot be ignored. Note that predictions such as the ones above are based on the current process of using non-cooperative external tracking and observation (i.e., skin tracking), and the resulting covariances. The number of warnings could be drastically reduced by using more accurate owner-operator information, but that is not currently universally done. The Space Data Association provides such a service, but only uses owner-operator data from members. In any case, current practices will need to change to avoid an unreasonable number of warnings. Recognizing this, many NewSpace operators are planning extensive automation to operate their constellations and mitigate the workload of manual COLA assessments, particularly for self-conjunctions. Most are also taking steps to obtain much higher quality position data than external observation permits. While automation may mitigate the COLA assessment workload for new operators, current operators may have to continue their labor-intensive assessments. The interaction between a NewSpace constellation and a nearby existing or a second large NewSpace constellation will create new challenges for operators. 6. The problem with maneuvers Recent years have seen a steady growth in the use of low-thrust propulsion via ion thrusters. These highly efficient systems have the feature of long, even continuous thrusting. A feature of the automation planned by some of the NewSpace operators is to make extensive use of low-thrust systems for both transit and station-keeping. One approach is to launch into low LEO orbit, transition to the higher LEO operational altitude via low-thrust, and at end-of-life, deorbit the same way. During automated operations, the individual vehicles may autonomously maneuver as needed. Orbit insertion at low LEO altitudes for functional check-out testing has the advantage of allowing early satellite failures to more safely occur in very low, “self-cleaning” orbits. But the slow spirals up to the operational altitude and down for disposal create numerous opportunities for conjunctions with all the resident satellites between the injection altitude and the operational altitude. Existing catalog and COLA processes have no effective way of dealing with frequent or continuous maneuvers, since they are based on predictions generated days in advance, with no assumption of maneuvers. If an existing constellation is operating in proximity to one of these automated constellations, its current COLA process breaks down. The automated maneuvers may move one vehicle in the constellation out of a conjunction, or it could create a new problematic conjunction. The existing practices have an inherent lag and data latency, and a small maneuver will at the very least add to the covariance error. The timelines of the current catalog process and automated maneuvers for a large constellation are fundamentally incompatible.

#### Climate change leaves dead satellites stuck in space magnifying debris from megaconstellations, O’Callaghan 21

[Jonathan O’Callaghan, 5-19-2021, "What if space junk and climate change become the same problem?", WION, https://www.wionews.com/science/what-if-space-junk-and-climate-change-become-the-same-problem-386124, date accessed 1-23-2022] //Lex AT

Our atmosphere is a useful ally in clearing up space junk. Collisions with its molecules cause drag, pulling objects back into the atmosphere. Below 300 miles above the Earth's surface, most objects will naturally decay into the thicker lower atmosphere and burn up in less than 10 years. In the lower atmosphere, carbon dioxide molecules can rerelease infrared radiation after absorbing it from the sun, which is then trapped by the thick atmosphere as heat. But above 60 miles where the atmosphere is thinner, the opposite is true. “There’s nothing to recapture that energy,” said Matthew Brown, also from the University of Southampton and the paper’s lead author. “So it gets lost into space.” The escape of heat causes the volume of the atmosphere, and thus its density, to decrease. Since 2000, Brown and his team say the atmosphere at 250 miles has lost 21% of its density because of rising carbon dioxide levels. By 2100, if carbon dioxide levels double their current levels — in line with the worst-case scenario assessment by the Intergovernmental Panel on Climate Change — that number could rise to 80%. For space junk, the implications are stark. More than 2,500 objects larger than 4 inches in size currently orbit at or below an altitude of 250 miles. In the worst-case scenario, increased orbital lifetimes of up to 40 years would mean fewer items are dragged into the lower atmosphere. Objects at this altitude would proliferate by 50 times to about 125,000. Even in a best-case scenario, where carbon dioxide levels stabilize or even reverse, the amount of space junk would still be expected to double. Brown thinks a more probable outcome is somewhere in between, perhaps a 10 times or 20 times increase. The research is “very important work,” said John Emmert, an atmospheric scientist at the US Naval Research Laboratory in Washington, D.C., who has studied atmospheric density loss. However, Emmert says more research is needed to understand the severity of the problem — with the impact of the sun’s solar cycle also known to be a major factor in atmospheric density changes. The findings may also pose challenges for regulators and satellite operators, especially SpaceX, Amazon and other companies seeking to build megaconstellations of thousands of satellites to beam internet service down to the ground from low Earth orbit.

#### Private debris cleanup will fail due to government uncertainty, Erwin 21

[Sandra Erwin, 10-21-2021, "Analysis: Space Force endorsement not enough to incentivize debris removal industry", SpaceNews, https://spacenews.com/analysis-space-force-endorsement-not-enough-to-incentivize-debris-removal-industry/, date accessed 1-23-2022] //Lex AT

WASHINGTON — U.S. Space Force generals [made headlines](https://spacenews.com/u-s-space-force-would-support-commercial-services-to-remove-orbital-debris/) recently calling for the development of commercial services to clean up orbital debris. These statements convey a sense of urgency about the risk of collisions in space but the government’s indecision about how to manage this problem is delaying private investments and efforts to develop space cleanup businesses, says an industry analyst. In a [white paper](https://www.avascent.com/news-insights/avascent-apogee/building-the-business-case-for-space-debris-removal/) published Oct. 21 by the consulting firm Avascent, analyst Nick Bolger points to comments made last month by [Maj. Gen. DeAnna Burt](https://spacenews.com/space-force-backs-development-of-commercial-orbital-debris-removal-systems/), the vice commander of the Space Force’s Space Operations Command, who said “there is a use case for industry to go after” space debris removal as a business opportunity. From an industry perspective, however, the business case is not quite so clear, Bolger said. “Significant developments need to settle across industry in order to prove out this claim,” he said of Burt’s comments. With 16,000 satellites expected to be launched from 2021 to 2025, there is wide consensus that space sustainability and safe spaceflight operations are at risk. But actions to address the problem are being “challenged by shifting priorities of domestic and international governing agencies,” Bolger argues. “Varying opinions of regulatory stakeholders on how to approach debris removal prevents the U.S. government from taking action per se,” he said. A major obstacle is uncertainty about what agencies should take the lead in specific areas. A case in point is the transition of space traffic management responsibilities from the Defense Department to the Commerce Department which has for years been bogged down in studies and analysis. The Space Force says it wants to buy debris removal services, but if space traffic management moves to another agency it’s not clear who would make those buying decisions. “As far as a business case goes, I believe that investors may be wary of backing some of these nascent companies without a guarantee of future procurements by the government,” Bolger said. Another concern is the lack of standard metrics about collision hazards, he said. Agencies “self-regulate their space operations, often leveraging varying data sources and risk criteria to determine their need for collision avoidance maneuvers.” There’s been a number of close calls and near-miss collisions in recent years, and yet “governing bodies have shown little indication of taking the lead on deploying space debris removal and remediating technologies in the near future,” Bolger noted.

#### Kessler Syndrome destroys all satellites and traps us on earth, Ratner 18

[Paul Ratner, 8-29-2018, "How the Kessler Syndrome can end all space exploration and destroy modern life", Big Think, https://bigthink.com/surprising-science/how-the-kessler-syndrome-can-end-all-space-exploration-and-destroy-modern-life/, date accessed 1-23-2022] //Lex AT

What makes that situation possible is the fact that there are millions of micrometeoroids as well as man-made debris that is already orbiting Earth. The danger posed by even a small fragment that’s traveling at high speeds is easy to see. As [calculated by NASA](https://www.businessinsider.com/space-junk-kessler-syndrome-chain-reaction-prevention-2018-3), a 1-centimeter “paint fleck” traveling at 10km/s (22,000 mph) can cause the same damage as a 550-pound object traveling 60 miles per hour on Earth. If the size of the shard was increased to 10 centimeters, such a projectile would have the force of 7 kilograms of TNT. Now imagine thousands of such objects flying around at breakneck speeds and crashing into each other. If a chain reaction of exploding space junk did occur, filling the orbital area with such dangerous debris, the space program would indeed be in jeopardy. Travel that goes beyond the LEO, like the planned mission to Mars, would be made more challenging but still conceivably possible. What would, of course, be affected if the Kessler Syndrome’s worst predictions came to pass, are all the services that rely on satellites. Core aspects of our modern life—GPS, television, military and scientific research—all of that would be under threat. NASA experienced a small-scale Kessler Syndrome incident in the 1970s when Delta rockets that were left in orbit started to explode into shrapnel clouds. This inspired Kessler, an astrophysicist, to show that there is a point when the amount of debris in an orbit gets to critical mass. At that point, the collision cascading would start even if no more things are launched into space. And once the chain of explosions begins, it can keep going until the orbital space can no longer be used. In Kessler’s estimate, it would take 30 to 40 years to get to such a threshold. [NASA says](https://www.nasa.gov/centers/wstf/site_tour/remote_hypervelocity_test_laboratory/micrometeoroid_and_orbital_debris.html) that its experts caution that we are already at critical mass in the low-Earth orbit, which is about 560-620 miles (900 to 1,000 kilometers) out. According to NASA estimates, the Earth’s orbit currently has [500,000 pieces of space debris](http://orbitaldebris.jsc.nasa.gov/faqs.html#3) up to 10cm long, over 21,000 pieces of debris longer than 10cm, and more than 100 million pieces of space debris smaller than 1cm. A 2009 incident dubbed the [Cosmos-Iridium collision](http://www.spacesafetymagazine.com/space-debris/kessler-syndrome/iridium-33-cosmos-2251-years-later-learned-then/)featured a space collision between Russian and American communication satellites that provided a preview of potential attractions in the massive debris field it created. The accident resulted in more than 2,000 pieces of relatively large space junk.

#### Public satellite data is key to biodiversity, Pennisi 21

[Elizabeth Pennisi, 18 NOV 2021, "Satellites offer new ways to study ecosystems—and maybe even save them", No Publication, https://www.science.org/content/article/satellites-offer-new-ways-study-ecosystems-maybe-even-save-them, date accessed 1-23-2022] //Lex AT

But such studies could only provide a snapshot of one forest at a time. To get the big picture of forests around the world, Cavender-Bares has sought a higher vantage. Now a plant ecologist at the University of Minnesota, Twin Cities, Cavender-Bares has devised ways to translate light measured by spectrometers flown over forests into insights about their health and resilience. She and others have [found this light](https://doi.org/10.1007/978-3-030-33157-3_1), captured from an airplane or satellite, holds clues to intimate details such as photosynthesis levels, the genetic diversity of the trees, and even the microbial inhabitants of the soil they grow in. Such remote sensing methods are not only revolutionizing how scientists such as Cavender-Bares study ecosystems, they’re also poised to become powerful new tools in the fight to protect them. Over the past year scientists have gathered to revise the most important international treaty aimed at conservation, the Convention on Biological Diversity (CBD). With the loss of plant and animal species accelerating, some researchers say conservation efforts should turn to remote sensing to monitor biodiversity in near–real time across wide swaths of the globe—and help policymakers prioritize the most critical areas. Historically, researchers had to venture out to jungles, deserts, and mountaintops to document the flora and fauna. But species distributions and abundances are changing faster than ground-based surveys can track, because of climate change, human activities, and other factors. Remote sensing offers the possibility of faster, more standardized monitoring across the entire globe. “In the past decade, there’s been a revolution in the technology available to characterize ecosystems from space,” says David Schimel, a research scientist at NASA’s Jet Propulsion Laboratory. Researchers are just beginning to figure out what remote sensing can and can’t do and how to incorporate it into global conservation efforts. But Schimel and others see great promise for supplementing ground-based measurements with a fuller picture of ecosystems’ health gleaned from aloft. “We want to transform the way biological research is done,” he says. CAVENDER-BARES FIRST learned that reflected or emitted light could help signal forest health during a graduate school visit to the Laboratory for the Use of ­Electromagnetic Radiation (LURE) at Paris-Sud University. In lab studies there almost 40 years ago, plant physiologist Jean-Marie Briantais and colleagues had shown they could measure photosynthetic activity by comparing how leaves fluoresce, or emit certain wavelengths of light, before and after being exposed to flashes of extremely bright white light. As the light displaces electrons inside chlorophyll, the intensity of red and infrared (IR) light emitted from the leaves varies, depending on how healthy the plant is. Later, Ismael Moya, a biophysicist at LURE, developed a sensor that required no extra light source, relying on sunlight instead. Moya went on to demonstrate that fluorescence could be detected from an airplane flying over crops, opening the way to surveying fields’ productivity remotely. “I just became fascinated with what we could learn from the interaction of plants with light and have been for 28 years,” Cavender-Bares says. In that time, researchers have mostly used methods based on reflected light, but fluorescence remains a valuable tool. By now, airplanes, drones, and towers all provide spectroscopic data on vegetation. So does NASA and the U.S. Geological Survey’s series of Landsat satellites, the first of which were launched in the 1970s. Initially, the agencies expected the satellites’ cameras to primarily capture images in visible light, but an experimental spectral sensor on board proved the value of recording more of the electromagnetic spectrum, such as near-IR light, and by 2013 the satellites were monitoring 11 portions of the spectrum. With these “multispectral” data, researchers can monitor how “green” or productive a vegetated landscape is. Spectroscopically detected dips in chlorophyll can also signal a forest that is suffering because of drought or insect invasion—or has been cleared for development.

#### Biodiversity loss causes extinction, Gallagher 21

[[Katherine Gallagher](https://inhabitat.com/author/katherinegallagher/), Apr 5, 2021, "“Extinction – The Facts” explores the global extinction crisis", Inhabitat - Green Design, Innovation, Architecture, Green Building | Green design &amp; innovation for a better world, https://inhabitat.com/extinction-the-facts-explores-the-global-extinction-crisis-and-its-consequences/, date accessed 1-19-2022] //Lex AT

Biodiversity loss [Biodiversity](https://inhabitat.com/tag/biodiversity/) refers to the variety of life found on Earth, including plants, animals and micro-organisms. Each of these species and organisms form unique communities and habitats, working together in various ecosystems to maintain balance. The United Nations brought 500 international scientists together in 2019 to investigate the current state of our natural world, only to find that the planet was losing biodiversity at a rate never seen before in the history of humanity. The results were unexpected and unprecedented; there were at least 1 million plant, animal and insect species threatened with extinction at a rate 100 times faster than their natural evolutionary rate. The numbers are nearly split, between about 500,000 insects and 500,000 plants and animals, with populations growing smaller by the day. “Extinction is a natural process,” explained professor Kathy Willis, a plant scientist at the University of Oxford. “Things come, they grow, their populations get huge and then they decline. But it’s the rate of extinction; that’s the problem.” When scientists look at previous groups in fossil records, extinction happens over millions of years. Today, we’re looking at tens of years. Since 1970, vertebrate animals — such as birds and reptiles — have declined by a total of 60%, while large animals have disappeared from three-quarters of their historic ranges. Professor Elizabeth Hadly, a biologist at Stanford University, said one of the most concerning aspects of this decline is that it’s happening simultaneously around the world. “In the Amazon, in Africa, in the [Arctic](https://inhabitat.com/tag/arctic); it’s happening not at one place and not with one group of organisms, but with all biodiversity, everywhere on the planet.” James Mwenda, a conservationist at Ol Pejeta Conservancy in Kenya, is the caretaker for the world’s last two living northern white rhinos, a [species](https://inhabitat.com/tag/species) that once numbered in the thousands throughout Central Africa. “Many people think of extinction being this imaginary tale told by conservationists, but I have lived it. I know what it is,” he said in the documentary. As a caretaker, Mwenda watched the northern white rhino population go from seven in 1990 to just two today, a mother and daughter named Najin and Fatu. A subspecies of the white rhinoceros, the northern white rhino was pushed to the critically endangered list due to hunting and habitat loss. “They’re here because we betrayed them,” he said sorrowfully. “And I think they feel it, this threatening tide of extinction that is pushing on them.” Losing entire portions of the planet’s individual species is tragic enough in itself, but the crisis encompasses much more than that. All of biodiversity is interlocked on a global scale, and the planet needs all parts of it to function properly. Humans are not outside of those ecological systems by any means. For example, a loss in insect species can put [pollination](https://inhabitat.com/tag/pollination/) at risk, which in turn puts food production at risk, affecting both humans and animals alike. Human influence The documentary also examines the ways that humans are driving biodiversity loss. Things like overfishing, deforestation and the illegal wildlife trade are the biggest contributors, but there are also less obvious threats like consumer-driven demand for products like clothes, which can cause pollution in their production. The [illegal wildlife trade](https://inhabitat.com/tag/illegal-wildlife-trade/) has become a multibillion dollar global industry over the last 20 years. Increased income in certain countries like China and Vietnam, where endangered animal parts may be seen as a status symbol or used for medicinal purposes, is one of the largest drivers. Pangolins, for instance, represent the most trafficked animals in the world, and the demand for their scales is directly responsible for their declining numbers. The scale of global [overfishing](https://inhabitat.com/tag/overfishing/) has dramatically increased as well. In some parts of the world, limits on ocean catch aren’t regulated. Scientists have seen declines in larger predator fish as their food supply dwindles due to overfishing, so the impact on marine ecosystems is widespread.

#### Debris triggers nuclear miscalculation—uniquely likely in space, Blatt 20

[[Talia M. Blatt](https://hir.harvard.edu/author/talia/), May 26th, 2020, "Anti-Satellite Weapons and the Emerging Space Arms Race", Harvard International Review, https://hir.harvard.edu/anti-satellite-weapons-and-the-emerging-space-arms-race/, date accessed 1-23-2022] //Lex AT

Despite their deterrent functions, ASATs are more likely to provoke or exacerbate conflicts than dampen them, especially given the risk they [pose](https://thebulletin.org/2019/06/arms-control-in-outer-space-the-russian-angle-and-a-possible-way-forward/) to early warning satellites. These satellites are a crucial element of US ballistic missile defense, capable of [detecting missiles](https://www.globalsecurity.org/space/world/japan/warning.htm) immediately after launch and tracking their paths. Suppose a US early warning satellite goes dark, or is shut down. Going dark could signal a glitch, but in a world in which other countries have ASATs, it could also signal the beginning of an attack. Without early warning satellites, the United States is much more susceptible to nuclear missiles. Given the strategy of counterforcing—[targeting](https://www.belfercenter.org/sites/default/files/files/publication/isec_a_00273_LieberPress.pdf) nuclear silos rather than populous cities to prevent a nuclear counterattack—the Americans might believe their nuclear weapons are imminently at risk. It could be [twelve hours](https://books.google.com/books?id=ET8lDwAAQBAJ&pg=PA1&lpg=PA1&dq=%22Protecting+Space+Assets%22+johnson-freese&source=bl&ots=6Oq0IdeBjw&sig=ACfU3U1G6Hj8QdP4JlCRNxA6i5XplZwHyg&hl=en&sa=X&ved=2ahUKEwj1n-jT2YzpAhUugnIEHUuMCu4Q6AEwA3oECAkQAQ#v=onepage&q=%22Protecting%20Space%20Assets%22%20johnson-freese&f=false) before the United States regains satellite function, which is too long to wait to put together a nuclear counterattack. The United States, therefore, might move to mobilize a nuclear attack against Russia or China over what might just be a piece of debris shutting off a satellite. Additionally, accidental warfare, or strategic miscalculation, is uniquely likely in space. It is [much easier](https://books.google.com/books?id=VyXTDwAAQBAJ&pg=PA339&lpg=PA339&dq=space+offense+dominant&source=bl&ots=Mw0bgJ51qf&sig=ACfU3U3DeZiEHpr9nfszlCbJZIoyyssIpg&hl=en&sa=X&ved=2ahUKEwjrs-WD3IzpAhVulHIEHbL0AE4Q6AEwCXoECAoQAQ#v=onepage&q=space%20offense%20dominant&f=false) to hold an adversary’s space systems in jeopardy with destructive ASATs than it is to [sustainably defend](https://www.cnas.org/publications/commentary/the-us-military-should-not-be-doubling-down-on-space) a system, which is expensive and in some cases not technologically feasible because of limitations on satellite movement. Space is therefore [considered](https://books.google.com/books?id=VyXTDwAAQBAJ&pg=PA339&lpg=PA339&dq=space+offense+dominant&source=bl&ots=Mw0bgJ51qf&sig=ACfU3U3DeZiEHpr9nfszlCbJZIoyyssIpg&hl=en&sa=X&ved=2ahUKEwjrs-WD3IzpAhVulHIEHbL0AE4Q6AEwCXoECAoQAQ#v=onepage&q=space%20offense%20dominant&f=false) offense-dominant; offensive tactics like weapons development are prioritized over defensive measures, such as [improving GPS](https://www.politico.com/story/2018/04/06/outer-space-war-defense-russia-china-463067) or making satellites more resistant to jamming. As a result, countries are left with poorly defended space systems and rely on offensive posturing, which increases the risk that their actions are perceived as aggressive and incentivizes rapid, risky counterattacks because militaries cannot rely on their spaced-based systems after first strikes.

#### Nuke war leads to extinction and is the most probable impact scenario – scientific consensus agrees

Tegmark 17 Max Tegmark, 5-26-2017, "Why 3,000 Scientists Think Nuclear Arsenals Make Us Less Safe," Scientific American Blog Network, https://blogs.scientificamerican.com/observations/why-3-000-scientists-think-nuclear-arsenals-make-us-less-safe/, SJBE Max Erik Tegmark is a Swedish-American physicist and cosmologist. He is a professor at the Massachusetts Institute of Technology and the scientific director of the Foundational Questions Institute.

Delegates from most United Nations member states are gathering in New York next month to negotiate a nuclear weapons ban, and 30 Nobel Laureates, a former U.S. Secretary of Defense and over 3,000 other scientists from 84 countries have signed an [open letter](https://futureoflife.org/nuclear-open-letter/) in support. Why? We scientists like to geek out about probabilities, megatons and impact calculations, so we see the nuclear situation differently than many politicians and pundits. From the public debate, one might think that the cold war threat is over and that the most likely way to be killed by a nuke is by being attacked by Iran, North Korea or terrorists, but that’s not what nerdy number crunching reveals. Those media-dominating scenarios could potentially kill millions of people—except that Iran has no nukes and North Korea lacks missiles capable of reliably delivering their dozen or so Hiroshima-scale bombs. But scientific research has shown that a nuclear war between the superpowers might kill hundreds or potentially even thousands of times more people, and since it’s not a hundred times less likely to occur, the laws of statistics tell us that it’s the nuke scenario most likely to kill you. Why is superpower nuclear war so risky? First of all, massive firepower: there are more than [14,000 nuclear weapons](https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/) today, some of which are hundreds of times more powerful than North Korea’s and those dropped on Japan. Over 90 percent of these belong to Russia and the US, who keep thousands on hair-trigger alert, ready launch on minutes notice. A [1979 report by the US Government](https://www.princeton.edu/~ota/disk3/1979/7906/7906.PDF) estimated that all-out war would kill 28-88 percent of Americans and 22-50 percent of Soviets (150-450 million people with today’s populations). But this was before the risk of nuclear winter was discovered in the 1980’s.Researchers realized that regardless of whose cities burned, massive amounts of smoke could spread around the globe, blocking sunlight and transforming summers into winters, much like when asteroids or supervolcanoes caused mass extinctions in the past. A peer-reviewed analysis published by Robock et al (2007) showed cooling by about 20°C (36°F) in much of the core farming regions of the US, Europe, Russia and China (by 35°C in parts of Russia) for the first two summers, and about half that even a full decade later. Years of near-freezing summer temperatures would eliminate most of our food production. It is hard to predict exactly what would happen if thousands of Earth’s largest cities were reduced to rubble and global infrastructure collapsed, but whatever small fraction of all humans didn’t succumb to starvation, hypothermia or epidemics would probably need to cope with roving, armed gangs desperate for food. There are large uncertainties in Nuclear Winter predictions. For example, how much smoke is produced and how high up it rises would determine its severity and longevity. Given this uncertainty, there is no guarantee that most people would survive. It has therefore been argued that the traditional nuclear doctrine of Mutual Assured Destruction (MAD) be replaced by Self-Assured Destruction (SAD): even if one of the two superpowers were able to launch its full nuclear arsenal against the other without any retaliation whatsoever, nuclear winter might still assure the attacking country’s self-destruction. Recent research has suggested that even a limited nuclear exchange between India and Pakistan could cause enough cooling and agricultural disruption to endanger up to [2 billion people](https://hinwcampaignkit.org/section-4/section-4/), mostly outside the warring countries. The fact that nuclear powers are taking the liberty to endanger everyone else without asking their permission has led to growing consternation in the world’s non-nuclear nations. This has been exacerbated by a seemingly endless [series of near-misses](https://futureoflife.org/background/nuclear-close-calls-a-timeline/) in which nuclear war has come close to starting by accident, and leaders of many non-nuclear nations feel less than thrilled by the idea of being destroyed by something as banal as a malfunctioning early warning-system in a nation that they are not threatening. Such concerns prompted 185 non-nuclear nations to sign the 1970 Non-Proliferation-Treaty (NPT), promising to remain nuke-free in return for the nuclear nations phasing out theirs in accordance with NPT Article VI, whereby each party "undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict and effective international control”. Nearly 50 years later, many of these "have-nots” have concluded that they were tricked, and that the "haves” have no intention of ever keeping their end of the bargain. Rather than disarming, the U.S. and Russia have recently announced massive investments in novel nuclear weapons. Russia has recently touted a cobalt-encased doomsday bomb reminiscent of the dark comedy "Dr. Strangelove,” and the U.S. plans to spend a trillion dollars replacing most of its nuclear weapons with new ones that are more effective for a first strike. Adding insult to injury, India, Pakistan and Israel have been allowed to join the nuclear club without major repercussions. "The probability of a nuclear calamity is higher today, I believe, that it was during the cold war," said former U.S. Secretary of Defense William J. Perry, who signed the open letter. This disillusionment from the “have-nots” prompted 123 of them to launch an initiative in the United Nations General Assembly, where the nuclear nations lack veto power. In late 2016, they voted to launch the aforementioned UN negotiations that may produce a nuclear weapons ban treaty this summer. But a ban obviously wouldn’t persuade the nuclear ``haves” to eliminate their nukes the next morning, so what’s the point of it? The way I see it, most governments are frustrated that a small group of countries with a minority of the world's population insist on retaining the right to ruin life on Earth for everyone else with nuclear weapons. Such “might makes right” policy has precedent. In South Africa, for example, the minority in control of the unethical Apartheid system didn't give it up spontaneously, but because they were pressured into doing so by the majority. Similarly, the minority in control of unethical nuclear weapons won't give them up spontaneously on their own initiative, but only if they're pressured into doing so by the majority of the world's nations and citizens. The key point of the ban is to provide such pressure by stigmatizing nuclear weapons. Nuclear ban supporters draw inspiration from the 1997 Ottawa treaty banning landmines. Although the superpowers still refuse to sign it, it created enough stigma that many people now associate mines not with national security, but with images of children who have had limbs blown off while playing in peace-time. This stigma caused leading arms manufactures to half production in response to investor pressure and dwindling demand. In 2014, the Pentagon announced that it was halting landmine use outside of the Korean peninsula. Today, the global landmine market has nearly collapsed, with merely a single manufacturer (South Korean Hanwa) remaining. The "have-not” negotiators hope that a nuclear ban treaty will similarly stigmatize nuclear weapons, persuading us all that we’re less safe with more nukes—even if they are our own. If this happens, it will increase the likelihood that the ``haves” trim their nuclear arsenals down to the minimum size needed for effective deterrence, reverting from SAD back to MAD and making us all safer. Here is the text of the letter. A list of some of the notable signatories follows. AN OPEN LETTER FROM SCIENTISTS IN SUPPORT OF THE UN NUCLEAR WEAPONS NEGOTIATIONS Nuclear arms are the only weapons of mass destruction not yet prohibited by an international convention, even though they are the most destructive and indiscriminate weapons ever created. We scientists bear a special responsibility for nuclear weapons, since it was scientists who invented them and discovered that their effects are even more horrific than first thought. Individual explosions can obliterate cities, radioactive fallout can contaminate regions, and a high-altitude electromagnetic pulse may cause mayhem by frying electrical grids and electronics across a continent. The most horrible hazard is a nuclear-induced winter, in which the fires and smoke from as few as a thousand detonations might darken the atmosphere enough to trigger a global mini ice age with year-round winter-like conditions. This could cause a complete collapse of the global food system and apocalyptic unrest, **potentially killing most people on Earth** – even if the nuclear war involved only a small fraction of the roughly 14,000 nuclear weapons that today’s nine nuclear powers control. As Ronald Reagan said: “A nuclear war cannot be won and must never be fought.” Unfortunately, such a war is more likely than one may hope, because it can start by mistake, miscalculation or terrorist provocation. There is a steady stream of accidents and false alarms that could trigger all-out war, and relying on never-ending luck is not a sustainable strategy. Many nuclear powers have larger nuclear arsenals than needed for deterrence, yet prioritize making them more lethal over reducing them and the risk that they get used. But there is also cause for optimism. On March 27 2017, an unprecedented process begins at the United Nations: most of the world’s nations convene to negotiate a ban on nuclear arms, to stigmatize them like biological and chemical weapons, with the ultimate goal of a world free of these weapons of mass destruction. We support this, and urge our national governments to do the same, because nuclear weapons threaten not merely those who have them, but all people on Earth.

#### Megaconstellations destroy the ozone, Pultarova 21

[Tereza Pultarova, June 07, 2021, "Air pollution from reentering megaconstellation satellites could cause ozone hole 2.0", Space, https://www.space.com/starlink-satellite-reentry-ozone-depletion-atmosphere, date accessed 1-23-2022] //Lex AT

Chemicals released as defunct satellites burn in the atmosphere could damage Earth’s protective ozone layer if plans to build megaconstellations of tens of thousands of satellites, such as SpaceX's [Starlink](https://www.space.com/spacex-starlink-satellites.html), go ahead as foreseen, scientists warn. Researchers also caution that the poorly understood atmospheric processes triggered by those chemicals could lead to an uncontrolled [geoengineering](https://www.space.com/global-warming-aerosol-reflector-block-sunlight) experiment, the consequences of which are unknown. For years, the space community was content with the fact that the amount of material that burns in the atmosphere as a result of Earth's encounters with [meteoroids](https://www.space.com/topics/meteors) far exceeds the mass of defunct satellites meeting the same fate. Even the rise of megaconstellations won't change that. The problem, however, is in the different chemical composition of natural meteoroids compared to artificial satellites, according to Aaron Boley, an associate professor of astronomy and astrophysics at the University of British Columbia, Canada. "We have 54 tonnes (60 tons) of meteoroid material coming in every day," Boley, one of the authors of a [paper published May 20 in the journal Scientific Reports](https://go.redirectingat.com/?id=92X1588396&xcust=space_us_5124491294381495000&xs=1&url=https%3A%2F%2Fwww.nature.com%2Farticles%2Fs41598-021-89909-7&sref=https%3A%2F%2Fwww.space.com%2Fstarlink-satellite-reentry-ozone-depletion-atmosphere), told Space.com. "With the first generation of Starlink, we can expect about 2 tonnes (2.2 tons) of dead satellites reentering Earth's atmosphere daily. But meteoroids are mostly rock, which is made of oxygen, magnesium and silicon. These satellites are mostly aluminum, which the meteoroids contain only in a very small amount, about 1%." Uncontrolled geoengineering The scientists realised that megaconstellations have a significant potential to change the chemistry of the upper atmosphere compared to its natural state. But not only that. The burning of aluminum is known to produce aluminum oxide, also known as alumina, which can trigger further unexplored side effects. "Alumina reflects light at certain wavelengths and if you dump enough alumina into the atmosphere, you are going to create scattering and eventually change the albedo of the planet," Boley said. Albedo is the measure of the amount of light that is reflected by a material. In fact, [increasing Earth's albedo](https://www.space.com/36431-harvard-researchers-geoengineer-earth-atmosphere.html) by pumping certain types of chemicals into the higher layers of the atmosphere has been proposed as a possible geoengineering solution that could slow down global warming. However, Boley said, the scientific community has rejected such experiments because not enough is known about their possible side effects. "Now it looks like we are going to run this experiment without any oversight or regulation," Boley said. "We don't know what the thresholds are, and how that will change the upper atmosphere." The Cygnus re-supply vehicle, which delivers cargo to the International Space Station, burning up in the atmosphere during its reentry. (Image credit: ESA/Alexander Gerst) Ozone hole 2.0 The aluminum from re-entering satellites also has a potential to [damage the ozone layer](https://www.space.com/arctic-ozone-hole-closes.html), a problem well known to humanity, which has been successfully solved by widespread bans on the use of chlorofluorocarbons, chemicals used in the past in aerosol sprays and refrigerators. In their paper, Boley and his colleague Michael Byers cite research by their counterparts from the Aerospace Corporation, a U.S. non-profit research organization, which identified local damage to the planet's ozone layer triggered by the passage of polluting rockets through the atmosphere. "We know that alumina does deplete ozone just from rocket launches themselves because a lot of solid-fuel rockets use, or have, alumina as a byproduct," Boley said. "That creates these little temporary holes in the stratospheric ozone layer. That's one of the biggest concerns about compositional changes to the atmosphere that spaceflight can cause." Advertisement The ozone layer protects life on Earth from harmful UV radiation. The depletion of ozone in the stratosphere, the second lowest layer of the atmosphere extending between altitudes of approximately 7 to 40 miles (10 to 60 kilometers), led to an increased risk of cancer and eye damage for humans on Earth. Gerhard Drolshagen, of the University of Oldenburg, Germany, who has published papers about the effects of meteoroid material on Earth, told Space.com that reentering satellites usually evaporate at altitudes between 55 and 30 miles (90 and 50 km), just above the ozone-rich stratosphere. However, he added, the particles created as a result of the satellites' burning will eventually sink to the lower layers. Boley said that as the alumina sinks into the stratosphere, it will cause chemical reactions, which, based on existing knowledge, will likely trigger ozone destruction. Drolshagen, who wasn't involved in the recent study, agreed that because "satellites are mostly made of aluminum, the amount of aluminum deposited in the atmosphere will certainly increase."

#### Ozone collapse---extinction,

Susan **Hunt 19**. Biology M.A., “What Will Happen to Life on Earth if Ozone Depletion Continues?“, <http://www.ozonedepletion.co.uk/what-will-happen-life-earth-if-ozone-depletion-continues.html>. Rez

Most scientists are agreed that without the earth’s ozone layer, we would all cease to exist. That’s one of the main reasons that global ozone levels are now constantly monitored and worldwide research is taking place into ozone depletion. Land and Water Life Would Suffer Without the ozone layer’s protection from the sun, people, animals and plant life would be destroyed. Even underwater life would not be safe since UV rays can penetrate clear water to a certain depth before being absorbed. Of course, the actual effect on mankind of less ozone depends on the extent to which it is depleted. Experts believe that for every 1% drop in ozone protection, there is an increase of around 2% in UV-B rays which get through to the planet’s surface. Good News However, research carried out for the United Nations Environmental Programme showed that ozone levels had not fallen further between 2002 and 2005, thanks to initiatives such as the Montreal Protocol. One of the greatest problems with ozone is that we need the “right” amount to maintain life as we know it today. **Too little and life on earth could be wiped out** – but too much and we won’t receive the amount of sunlight that we need. (Some scientists are now concerned that global warming will lead to much higher levels of ozone which could block out too much sun). It is widely known that rates of **skin cancer** are linked to UV-B exposure – which is one of the reasons that it’s so important to use suncream and to make sure that children are protected from the sun. (Latest research suggests that you are more at risk from just two or three instances of extreme sunburn than from prolonged but limited exposure such as sunbathing.) Increase in Disease However, increased exposure to the sun’s radiation can also cause blindness and cataracts and, alarmingly, some experts now believe that the amount of protection we receive from vaccinations (for diseases such as measles) could be reduced in people exposed to higher levels of UV-B rays. Depending on the level of exposure to the sun, effects can range from premature ageing to certain kinds of skin cancer. Over the past decade there has been a large increase in the number of people developing skin cancer but this could be attributed to the rise in the popularity of sunbathing over the past quarter-of-a-century rather than simply to reduced ozone levels. Our Food Chain Many biological systems are damaged by exposure to UV-B and research has shown that its effects are proportional to the time and intensity of exposure and of course, small and delicate organisms are much more vulnerable to damage than larger species, such as humans. Exposure to higher levels of UV-B can stunt the **growth** and **photosynthesis** of a variety of crops such as maize, rye and sunflowers and can also affect the **reproductive capacity of aquatic life**. Many are already under UV-B stress, and if their exposure is further increased then we could see disruption of some food chains.

### Framing

#### The standard is maximizing expected well being or saving lives.

#### 1] Pleasure and pain are intrinsic value and disvalue – everything else regresses – robust neuroscience.

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**Pleasure** is not only one of the three primary reward functions but it also **defines reward.** As homeostasis explains the functions of only a limited number of rewards, the principal reason why particular stimuli, objects, events, situations, and activities are rewarding may be due to pleasure. This applies first of all to sex and to the primary homeostatic rewards of food and liquid and extends to money, taste, beauty, social encounters and nonmaterial, internally set, and intrinsic rewards. Pleasure, as the primary effect of rewards, drives the prime reward functions of learning, approach behavior, and decision making and provides the **basis for hedonic theories** of reward function. We are attracted by most rewards and exert intense efforts to obtain them, just because they are enjoyable [10]. Pleasure is a passive reaction that derives from the experience or prediction of reward and may lead to a long-lasting state of happiness. The word happiness is difficult to define. In fact, just obtaining physical pleasure may not be enough. One key to happiness involves a network of good friends. However, it is not obvious how the higher forms of satisfaction and pleasure are related to an ice cream cone, or to your team winning a sporting event. Recent multidisciplinary research, using both humans and detailed invasive brain analysis of animals has discovered some critical ways that the brain processes pleasure [14]. Pleasure as a hallmark of reward is sufficient for defining a reward, but it may not be necessary. A reward may generate positive learning and approach behavior simply because it contains substances that are essential for body function. When we are hungry, we may eat bad and unpleasant meals. A monkey who receives hundreds of small drops of water every morning in the laboratory is unlikely to feel a rush of pleasure every time it gets the 0.1 ml. Nevertheless, with these precautions in mind, we may define any stimulus, object, event, activity, or situation that has the potential to produce pleasure as a reward. In the context of reward deficiency or for disorders of addiction, homeostasis pursues pharmacological treatments: drugs to treat drug addiction, obesity, and other compulsive behaviors. The theory of allostasis suggests broader approaches - such as re-expanding the range of possible pleasures and providing opportunities to expend effort in their pursuit. [15]. It is noteworthy, the first animal studies eliciting approach behavior by electrical brain stimulation interpreted their findings as a discovery of the brain’s pleasure centers [16] which were later partly associated with midbrain dopamine neurons [17–19] despite the notorious difficulties of identifying emotions in animals. Evolutionary theories of pleasure: The love connection BO:D Charles Darwin and other biological scientists that have examined the biological evolution and its basic principles found various mechanisms that steer behavior and biological development. Besides their theory on natural selection, it was particularly the sexual selection process that gained significance in the latter context over the last century, especially when it comes to the question of what makes us “what we are,” i.e., human. However, the capacity to sexually select and evolve is not at all a human accomplishment alone or a sign of our uniqueness; yet, we humans, as it seems, are ingenious in fooling ourselves and others–when we are in love or desperately search for it. It is well established that modern biological theory conjectures that **organisms are** the **result of evolutionary competition.** In fact, Richard Dawkins stresses gene survival and propagation as the basic mechanism of life [20]. Only genes that lead to the fittest phenotype will make it. It is noteworthy that the phenotype is selected based on behavior that maximizes gene propagation. To do so, the phenotype must survive and generate offspring, and be better at it than its competitors. Thus, the ultimate, distal function of rewards is to increase evolutionary fitness by ensuring the survival of the organism and reproduction. It is agreed that learning, approach, economic decisions, and positive emotions are the proximal functions through which phenotypes obtain other necessary nutrients for survival, mating, and care for offspring. Behavioral reward functions have evolved to help individuals to survive and propagate their genes. Apparently, people need to live well and long enough to reproduce. Most would agree that homo-sapiens do so by ingesting the substances that make their bodies function properly. For this reason, foods and drinks are rewards. Additional rewards, including those used for economic exchanges, ensure sufficient palatable food and drink supply. Mating and gene propagation is supported by powerful sexual attraction. Additional properties, like body form, augment the chance to mate and nourish and defend offspring and are therefore also rewards. Care for offspring until they can reproduce themselves helps gene propagation and is rewarding; otherwise, many believe mating is useless. According to David E Comings, as any small edge will ultimately result in evolutionary advantage [21], additional reward mechanisms like novelty seeking and exploration widen the spectrum of available rewards and thus enhance the chance for survival, reproduction, and ultimate gene propagation. These functions may help us to obtain the benefits of distant rewards that are determined by our own interests and not immediately available in the environment. Thus the distal reward function in gene propagation and evolutionary fitness defines the proximal reward functions that we see in everyday behavior. That is why foods, drinks, mates, and offspring are rewarding. There have been theories linking pleasure as a required component of health benefits salutogenesis, (salugenesis). In essence, under these terms, pleasure is described as a state or feeling of happiness and satisfaction resulting from an experience that one enjoys. Regarding pleasure, it is a double-edged sword, on the one hand, it promotes positive feelings (like mindfulness) and even better cognition, possibly through the release of dopamine [22]. But on the other hand, pleasure simultaneously encourages addiction and other negative behaviors, i.e., motivational toxicity. It is a complex neurobiological phenomenon, relying on reward circuitry or limbic activity. It is important to realize that through the “Brain Reward Cascade” (BRC) endorphin and endogenous morphinergic mechanisms may play a role [23]. While natural rewards are essential for survival and appetitive motivation leading to beneficial biological behaviors like eating, sex, and reproduction, crucial social interactions seem to further facilitate the positive effects exerted by pleasurable experiences. Indeed, experimentation with addictive drugs is capable of directly acting on reward pathways and causing deterioration of these systems promoting hypodopaminergia [24]. Most would agree that pleasurable activities can stimulate personal growth and may help to induce healthy behavioral changes, including stress management [25]. The work of Esch and Stefano [26] concerning the link between compassion and love implicate the brain reward system, and pleasure induction suggests that social contact in general, i.e., love, attachment, and compassion, can be highly effective in stress reduction, survival, and overall health. Understanding the role of neurotransmission and pleasurable states both positive and negative have been adequately studied over many decades [26–37], but comparative anatomical and neurobiological function between animals and homo sapiens appear to be required and seem to be in an infancy stage. Finding happiness is different between apes and humans As stated earlier in this expert opinion one key to happiness involves a network of good friends [38]. However, it is not entirely clear exactly how the higher forms of satisfaction and pleasure are related to a sugar rush, winning a sports event or even sky diving, all of which augment dopamine release at the reward brain site. Recent multidisciplinary research, using both humans and detailed invasive brain analysis of animals has discovered some critical ways that the brain processes pleasure. Remarkably, there are pathways for ordinary liking and pleasure, which are limited in scope as described above in this commentary. However, there are **many brain regions**, often termed hot and cold spots, that significantly **modulate** (increase or decrease) our **pleasure or** even **produce the opposite** of pleasure— that is disgust and fear [39]. One specific region of the nucleus accumbens is organized like a computer keyboard, with particular stimulus triggers in rows— producing an increase and decrease of pleasure and disgust. Moreover, the cortex has unique roles in the cognitive evaluation of our feelings of pleasure [40]. Importantly, the interplay of these multiple triggers and the higher brain centers in the prefrontal cortex are very intricate and are just being uncovered. Desire and reward centers It is surprising that many different sources of pleasure activate the same circuits between the mesocorticolimbic regions (Figure 1). Reward and desire are two aspects pleasure induction and have a very widespread, large circuit. Some part of this circuit distinguishes between desire and dread. The so-called pleasure circuitry called “REWARD” involves a well-known dopamine pathway in the mesolimbic system that can influence both pleasure and motivation. In simplest terms, the well-established mesolimbic system is a dopamine circuit for reward. It starts in the ventral tegmental area (VTA) of the midbrain and travels to the nucleus accumbens (Figure 2). It is the cornerstone target to all addictions. The VTA is encompassed with neurons using glutamate, GABA, and dopamine. The nucleus accumbens (NAc) is located within the ventral striatum and is divided into two sub-regions—the motor and limbic regions associated with its core and shell, respectively. The NAc has spiny neurons that receive dopamine from the VTA and glutamate (a dopamine driver) from the hippocampus, amygdala and medial prefrontal cortex. Subsequently, the NAc projects GABA signals to an area termed the ventral pallidum (VP). The region is a relay station in the limbic loop of the basal ganglia, critical for motivation, behavior, emotions and the “Feel Good” response. This defined system of the brain is involved in all addictions –substance, and non –substance related. In 1995, our laboratory coined the term “Reward Deficiency Syndrome” (RDS) to describe genetic and epigenetic induced hypodopaminergia in the “Brain Reward Cascade” that contribute to addiction and compulsive behaviors [3,6,41]. Furthermore, ordinary “liking” of something, or pure pleasure, is represented by small regions mainly in the limbic system (old reptilian part of the brain). These may be part of larger neural circuits. In Latin, hedus is the term for “sweet”; and in Greek, hodone is the term for “pleasure.” Thus, the word Hedonic is now referring to various subcomponents of pleasure: some associated with purely sensory and others with more complex emotions involving morals, aesthetics, and social interactions. The capacity to have pleasure is part of being healthy and may even extend life, especially if linked to optimism as a dopaminergic response [42]. Psychiatric illness often includes symptoms of an abnormal inability to experience pleasure, referred to as anhedonia. A negative feeling state is called dysphoria, which can consist of many emotions such as pain, depression, anxiety, fear, and disgust. Previously many scientists used animal research to uncover the complex mechanisms of pleasure, liking, motivation and even emotions like panic and fear, as discussed above [43]. However, as a significant amount of related research about the specific brain regions of pleasure/reward circuitry has been derived from invasive studies of animals, these cannot be directly compared with subjective states experienced by humans. In an attempt to resolve the controversy regarding the causal contributions of mesolimbic dopamine systems to reward, we have previously evaluated the three-main competing explanatory categories: “liking,” “learning,” and “wanting” [3]. That is, dopamine may mediate (a) liking: the hedonic impact of reward, (b) learning: learned predictions about rewarding effects, or (c) wanting: the pursuit of rewards by attributing incentive salience to reward-related stimuli [44]. We have evaluated these hypotheses, especially as they relate to the RDS, and we find that the incentive salience or “wanting” hypothesis of dopaminergic functioning is supported by a majority of the scientific evidence. Various neuroimaging studies have shown that anticipated behaviors such as sex and gaming, delicious foods and drugs of abuse all affect brain regions associated with reward networks, and may not be unidirectional. Drugs of abuse enhance dopamine signaling which sensitizes mesolimbic brain mechanisms that apparently evolved explicitly to attribute incentive salience to various rewards [45]. Addictive substances are voluntarily self-administered, and they enhance (directly or indirectly) dopaminergic synaptic function in the NAc. This activation of the brain reward networks (producing the ecstatic “high” that users seek). Although these circuits were initially thought to encode a set point of hedonic tone, it is now being considered to be far more complicated in function, also encoding attention, reward expectancy, disconfirmation of reward expectancy, and incentive motivation [46]. The argument about addiction as a disease may be confused with a predisposition to substance and nonsubstance rewards relative to the extreme effect of drugs of abuse on brain neurochemistry. The former sets up an individual to be at high risk through both genetic polymorphisms in reward genes as well as harmful epigenetic insult. Some Psychologists, even with all the data, still infer that addiction is not a disease [47]. Elevated stress levels, together with polymorphisms (genetic variations) of various dopaminergic genes and the genes related to other neurotransmitters (and their genetic variants), and may have an additive effect on vulnerability to various addictions [48]. In this regard, Vanyukov, et al. [48] suggested based on review that whereas the gateway hypothesis does not specify mechanistic connections between “stages,” and does not extend to the risks for addictions the concept of common liability to addictions may be more parsimonious. The latter theory is grounded in genetic theory and supported by data identifying common sources of variation in the risk for specific addictions (e.g., RDS). This commonality has identifiable neurobiological substrate and plausible evolutionary explanations. Over many years the controversy of dopamine involvement in especially “pleasure” has led to confusion concerning separating motivation from actual pleasure (wanting versus liking) [49]. We take the position that animal studies cannot provide real clinical information as described by self-reports in humans. As mentioned earlier and in the abstract, on November 23rd, 2017, evidence for our concerns was discovered [50] In essence, although nonhuman primate brains are similar to our own, the disparity between other primates and those of human cognitive abilities tells us that surface similarity is not the whole story. Sousa et al. [50] small case found various differentially expressed genes, to associate with pleasure related systems. Furthermore, the dopaminergic interneurons located in the human neocortex were absent from the neocortex of nonhuman African apes. Such differences in neuronal transcriptional programs may underlie a variety of neurodevelopmental disorders. In simpler terms, the system controls the production of dopamine, a chemical messenger that plays a significant role in pleasure and rewards. The senior author, Dr. Nenad Sestan from Yale, stated: “Humans have evolved a dopamine system that is different than the one in chimpanzees.” This may explain why the behavior of humans is so unique from that of non-human primates, even though our brains are so surprisingly similar, Sestan said: “It might also shed light on why people are vulnerable to mental disorders such as autism (possibly even addiction).” Remarkably, this research finding emerged from an extensive, multicenter collaboration to compare the brains across several species. These researchers examined 247 specimens of neural tissue from six humans, five chimpanzees, and five macaque monkeys. Moreover, these investigators analyzed which genes were turned on or off in 16 regions of the brain. While the differences among species were subtle, **there was** a **remarkable contrast in** the **neocortices**, specifically in an area of the brain that is much more developed in humans than in chimpanzees. In fact, these researchers found that a gene called tyrosine hydroxylase (TH) for the enzyme, responsible for the production of dopamine, was expressed in the neocortex of humans, but not chimpanzees. As discussed earlier, dopamine is best known for its essential role within the brain’s reward system; the very system that responds to everything from sex, to gambling, to food, and to addictive drugs. However, dopamine also assists in regulating emotional responses, memory, and movement. Notably, abnormal dopamine levels have been linked to disorders including Parkinson’s, schizophrenia and spectrum disorders such as autism and addiction or RDS. Nora Volkow, the director of NIDA, pointed out that one alluring possibility is that the neurotransmitter dopamine plays a substantial role in humans’ ability to pursue various rewards that are perhaps months or even years away in the future. This same idea has been suggested by Dr. Robert Sapolsky, a professor of biology and neurology at Stanford University. Dr. Sapolsky cited evidence that dopamine levels rise dramatically in humans when we anticipate potential rewards that are uncertain and even far off in our futures, such as retirement or even the possible alterlife. This may explain what often motivates people to work for things that have no apparent short-term benefit [51]. In similar work, Volkow and Bale [52] proposed a model in which dopamine can favor NOW processes through phasic signaling in reward circuits or LATER processes through tonic signaling in control circuits. Specifically, they suggest that through its modulation of the orbitofrontal cortex, which processes salience attribution, dopamine also enables shilting from NOW to LATER, while its modulation of the insula, which processes interoceptive information, influences the probability of selecting NOW versus LATER actions based on an individual’s physiological state. This hypothesis further supports the concept that disruptions along these circuits contribute to diverse pathologies, including obesity and addiction or RDS.

#### 2] Death is bad and outweighs – it destroys the subject itself – kills any ability to achieve value in ethics since life is a prerequisite.

#### 3] Extinction outweighs –

#### 1 – Paternalism – taking everyones lives without their consent is actively violent and takes away people’s autonomy.

#### 2 – Suffering – mass death causes suffering because people can’t get access to resources and basic necessities

#### 3 – Objectivity – body count is the most objective way to calculate impacts because comparing suffering is unethical

#### 4 – Moral uncertainty – if we’re unsure about which interpretation of the world is true – we ought to preserve the world to keep debating about it

#### Apocalyptic images challenge dominant power structures by contesting the implausibility that inequitable structures can produce catastrophe – attempts to describe the world in its totality lock in the squo and close of revolutionary potentiality.

Jessica Hurley 17, Assistant Professor in the Humanities at the University of Chicago, “Impossible Futures: Fictions of Risk in the Longue Durée”, Duke University Press, https://read.dukeupress.edu/american-literature/article/89/4/761/132823/Impossible-Futures-Fictions-of-Risk-in-the-Longue

If contemporary ecocriticism has a shared premise about environmental risk it is that genre is the key to both perceiving and, possibly, correcting ecological crisis. Frederick Buell’s 2003 From Apocalypse to Way of Life: Environmental Crisis in the American Century has established one of the most central oppositions of this paradigm. As his title suggests, Buell tells the story of a discourse that began in the apocalyptic mode in the 1960s and 70s, when discussions of “the immanent end of nature” most commonly took the form of “prophecy, revelation, climax, and extermination” before turning away from apocalypse when the prophesied ends failed to arrive (112, 78). Buell offers his suggestion for the appropriate literary mode for life lived within a crisis that is both unceasing and inescapable: new voices, “if wise enough….will abandon apocalypse for a sadder realism that looks closely at social and environmental changes in process and recognizes crisis as a place where people dwell” (202-3). In a world of threat, Buell demands a realism that might help us see risks more clearly and aid our survival.¶ Buell’s argument has become a broadly held view in contemporary risk theory and ecocriticism, overlapping fields in the social sciences and humanities that address the foundational question of second modernity: “how do you live when you are at such risk?” (Woodward 2009, 205).1 Such an assertion, however, assumes both that realism is a neutral descriptive practice and that apocalypse is not something that is happening now in places that we might not see, or cannot hear. This essay argues for the continuing importance of apocalyptic narrative forms in representations of environmental risk to disrupt conservative realisms that maintain the status quo. Taking the ecological disaster of nuclear waste as my case study, I examine two fictional treatments of nuclear waste dumps that create different temporal structures within which the colonial history of the United States plays out. The first, a set of Department of Energy documents that use statistical modeling and fictional description to predict a set of realistic futures for the site of the Waste Isolation Pilot Plant in New Mexico (1991), creates a present that is fully knowable and a future that is fully predictable. Such an approach, I suggest, perpetuates the state logics of implausibility that have long undergirded settler colonialism in the United States. In contrast, Leslie Marmon Silko’s contemporaneous novel Almanac of the Dead (1991) uses its apocalyptic form to deconstruct the claims to verisimilitude that undergird state realism, transforming nuclear waste into a prophecy of the end of the United States rather than a means for imagining its continuation. In Almanac of the Dead, the presence of nuclear waste introjects a deep-time perspective into contemporary America, transforming the present into a speculative space where environmental catastrophe produces not only unevenly distributed damage but also revolutionary forms of social justice that insist on a truth that probability modeling cannot contain: that the future will be unimaginably different from the present, while the present, too, might yet be utterly different from the real that we think we know.¶ Nuclear waste is rarely treated in ecocriticism or risk theory, for several reasons: it is too manmade to be ecological; its catastrophes are ongoing, intentionally produced situations rather than sudden disasters; and it does not support the narrative that subtends ecocritical accounts of risk perception in which the nuclear threat gives rise to an awareness of other kinds of threat before reaching the end of its relevance at the end of the Cold War.2 In what follows, I argue that the failure of nuclear waste to fit into the critical frames created by ecocriticism and risk theory to date offers an opportunity to expand those frames and overcome some of their limitations, especially the impulse towards a paranoid, totalizing realism that Peter van Wyck (2005) has described as central to ecocriticism in the risk society. Nuclear waste has durational forms that dwarf the human. It therefore dwells less in the economy of risk as it is currently conceptualized and more in the blown-out realm of deep time. Inhabiting the temporal scale that has recently been christened the Anthropocene, the geological era defined by the impact of human activities on the world’s geology and climate, nuclear waste unsettles any attempt at realist description, unveiling the limits of human imagination at every turn.3 By analyzing risk society through a heuristic of nuclear waste, this essay offers a critique of nuclear colonialism and environmental racism. At the same time, it shows how the apocalyptic mode in deep time allows narratives of environmental harm and danger to move beyond the paranoid logic of risk. In the world of deep time, all that might come to pass will come to pass, sooner or later. The endless maybes of risk become certainties. The impossibilities of our own deaths and the deaths of everything else will come. But so too will other impossibilities: talking macaws and alien visitors; the end of the colonial occupation of North America, perhaps, or a sudden human determination to let the world live. The end of capitalism may yet become more thinkable than the end of the world. Just wait long enough. Stranger things will happen.¶ Realism and Risk in the Longue Durée¶ The nature of risk, as Ulrich Beck notes in his foundational Risk Society (1986, 72), is fundamentally anti-realist; in the risk society, “dangerous, hostile substances lie concealed behind the harmless façades. Everything must be viewed with a double gaze, and can only be correctly understood and judged through this doubling. The world of the visible must be investigated, relativized and evaluated with respect to a second reality, only existent in thought and yet concealed in the world.” The traumatic nature of living in a world of risk, exemplified in the canonical toxic-world novels White Noise (Don DeLillo, 1985) and Gain (Richard Powers, 1998), lies in the way that the real world is no longer accessible to perception.4 Risks become perceptible only when they are already no longer threats but events, a condition that makes risk itself appear in a fundamentally literary mode; as Susan Mizruchi (2010, 119) writes, “when improbable risks are actualized in catastrophe, the familiar becomes the uncanny.” What Mizruchi calls the uncanny, Laurence Buell (2001) describes as the gothic; in both cases, Beck’s description of a second, real-er world beneath the phenomenological one finds a strong descriptor and a place in literary history as critics connect risk fiction to more established genres that account for what we cannot perceive and cannot understand. No longer haunted by falling helmets or animate dolls, the risk novel tries instead to theorize the connections between tumors and the factory that closed down two generations ago, between what we know of bioaccumulation and what we feel when we look at a carrot.¶ For many critics, as for F. Buell, the gothic terror of a world of risk produces apocalypticism as a symptom and realism as a solution. 5 Even when apocalypse is recognized as a potentially valuable tool for approaching risk, as in Ursula K. Heise’s insight that in a world of world-threatening danger “apocalyptic narrative….can appropriately be understood as a form of risk perception” (2008, 141), the potential benefit of apocalypse is as the most realistic genre for representing a scenario that is genuinely apocalyptic (as in the exponentially increasing flood of contemporary apocalypse novels depicting climate change, for example).6 As Peter van Wyck has argued, however, the realist commitment to describing the totality of the world’s relations produces its own set of epistemic anxieties in a world defined by risk: contemporary ecological threats can come to make ecological thought itself look like a particularly advanced form of cultural paranoia. I mean this in the sense that once we say that everything is connected in this fashion, we mean that everything is, if not already, then at least potentially integrated into a framework of understanding. And it isn’t. To make everything connected is to see the fissures and cracks rendered by ecological threats—whether the threats posed by wastes or the threats retroactively discovered through accidents— as a kind of recompense for a failure to have properly understood the connections. The real punishing the epistemic for its sins of omission. (ix) Realism, in van Wyck’s account, becomes visible as itself a symptom of the paranoid mindset that the risk society tends to produce, a mindset that insists, as Eve Sedgwick writes concurrently with van Wyck, that “there must be no bad surprises” (2003, 130). In such a mode, comfort comes not from ameliorating the danger that produced the original discomfort, but rather from constructing a model of the world that can give an illusion of totality (ibid. 133-6). A realist approach to representing risk thus has real-world consequences in second modernity, “blotting out any sense of the possibility of alternative ways of understanding or things to understand” (131). Such consequences can be seen nowhere more clearly than in the government experiment with realism that goes by the unglamorous name of the Waste Isolation Pilot Plant (WIPP), where the realism is that of the settler colonial state and the alternative ways of understanding are those of the Native nations who are most vulnerable to the site’s dangers.7