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The Contribution and Significance of Professor Noriyoshi Takemura's Theoretical Work on Astro-Green Criminology

Jack A. Lampkin, York St John University (j.lampkin@yorks.ac.uk)

Abstract

In 2019, Professor Noriyoshi Takemura published a seminal research article in the *Toin University of Yokohama Research Bulletin* entitled "Astro-Green Criminology: A New Perspective Against Space Capitalism." In this paper, Takemura explains the importance of developing an astro-green criminology which would bring outer space environmental issues within the domains of both criminology broadly, and green criminology specifically. Creating the astro-green criminological perspective has since led to the development of the area by both Takemura, and other interested scholars. While astro-green criminology is still at a nascent stage, researchers publishing in this area have achieved notable early successes. Without Takemura's radical and ground-breaking publications on astro-green criminology, it is unlikely that these areas of research would have developed so quickly. This article aims to celebrate the early achievements of astro-green criminology and to afford credit to the thought-leading work of Professor Noriyoshi Takemura. While Takemura's work on astro-green criminology is often cited in literature on space-based environmental harms, his work has not yet received proper exposition and recognition. The present article seeks to fill that void and finishes by exploring how astro-green criminology has traversed into the fuller discipline of space criminology.

Keywords: Astro-green criminology, space criminology, radical criminology, critical criminology, space mining, space debris

1. Introduction

The term *green criminology* was coined by American Professor Michael Lynch over three decades ago (Lynch, 1990). Originally, Lynch called for a *green* version of criminology to focus on environmental harms and crimes, societal issues that had previously been overlooked by criminologists. While some have criticised green criminology for lacking political neutrality (Halsey, 2004; Potter, 2013), most respect the need for a zemiological approach to environmental problems, due mainly to the historical lack of focus on ecological harms from mainstream criminologists (Lampkin, 2020). Consequently, green criminology has been described as a *critical* strand of criminology (Sollund, 2021), one that is keen to expose the failings of the criminal law in achieving environmental protection and addressing ecological crime and harm. Some have even aligned green criminology with *radical* criminology due to certain green criminologists advocating for political and economic change and reform of the capitalist system (Lynch, 2020; Lynch & Stretesky, 2014).

The term astro-green criminology (AGC) has thus far followed very similar conceptual development. AGC has been described as a form of critical or radical criminology that is keen to focus on the failings of domestic and international law which has, up until now, failed to prevent space-related harms like space junk accumulation (Lampkin & South, 2025), rocket emissions pollutions (Lampkin & Carpio-Domínguez, 2024) and the development of space mining initiatives (Lampkin & McClanahan, 2024). As Lampkin & Wyatt (2023: 1282 and 1291) discuss,

It is green and critical criminologists who are best placed to study [issues such as] space junk. This is because critical criminologists take a zemiological approach to the study of criminology, where both crime and social harm are considered useful to the study of socially injurious behaviour'... 'only a critical or radical criminological perspective could adequately address the harms associated with space debris because they are legal activities.

Legal harms are viewed by some criminologists as 'beyond the purview of the discipline' (Stretesky et al., 2013: 1) if the narrow definition of criminology is accepted, that being, that criminology is merely 'the study of crime, criminals and criminal behaviours' (Carrabine et al., 2020: 3). The study of green criminology can be seen to have emerged as a platform to fill the gap between crime and legal harms, arguing that harm is just as worthy of focus (for criminologists) as crime (Canning & Tombs, 2021). The same ideas apply to astro-green criminology. Until Takemura's (2012; 2015; 2019) pioneering work, criminologists - and even green, critical and radical criminologists - had failed to address issues of space-related environmental harms. Situating such issues within green criminology enabled Takemura (2019) to argue for a harm-based approach to the study of space-based environmental damage, recognising at the outset the failure of current legal systems to fully protect terrestrial, extra-terrestrial and atmospheric environments from anthropogenic harm resulting from space expansionism.

Takemura did not, however, delve into any positive aspects of space law and attempts to protect the space environment. Nor did he touch upon some of the ways that domestic (and international) laws attempt to protect outer space, often successfully. For instance, in the UK, 'The Space Industry Act [2018] rightly recognises the need to protect the environments of earth and space' and 'more directly, section 11(2)... makes the grant of all spaceport and launch operator licences contingent upon the submission of an "assessment of environmental effects"' (Simmonds, 2025: 230). Therefore, although such legal frameworks may not completely prevent environmental harm, they will certainly aide in mitigating some of the negative impacts of aerospace development. This realisation has not been considered in Takemura's work on AGC.

Despite this Takemura's (2019) conjuring of the term *astro-green criminology* has undoubtedly inspired other scholars to study space-based environmental harms thereafter (Eski & Lampkin, 2024). However, most research papers only allude to Takemura's foundational article in passing (for instance, see Tourangeau, 2022: 989). In some ways, this is similar to Lynch's original paper calling for a *green* criminology, which is very well cited (574 times on Google Scholar at the time of writing in January 2026), but rarely critiqued in any meaningful detail. Some exceptions to this include Lampkin's (2021: 238) article 'mapping the terrain of an astro-green criminology' which builds on Takemura's (2019) foundational article, after first examining its significance.

Additionally, Cvetkovič (2024: 269) recognises the value of the existential nature of Takemura's work on astro-green criminology, and the 'blind spot in space exploration planning and regulation' which fails to ask deeper and more meaningful questions about space expansionism, such as, 'what are the legitimate purposes of human space exploration?; Does outer space... have any intrinsic value in and of itself?; Are humans justified in expanding their habitat outside of our initial planet?' (Cvetkovič, 2024: 269). Rothe & Collins (2023) also summarise Takemura's (2019) original contribution, focussing on the problems with space capitalism and expansionism which threaten the sanctuary of unspoiled space environments.

As a result, the primary aim of the present work is to address this issue by first exploring, and then providing recognition for, Takemura's pioneering early work in astro-green criminology, celebrating his novel contribution. A secondary aim is to subsequently highlight the significance of this work to the discipline of criminology, and especially, green criminology and astro-green criminology. Even further, this article will finish by discussing how astro-green criminology has traversed into *space criminology*, due largely to its zemiological, as well as criminological, agenda.

2. The birth of astro-green criminology

The most well-cited of Takemura's works on outer space topics is his 2019 article where the term astro-green criminology was first used (Takemura, 2019). This was not, however, Takemura's first work on outer space issues. Four years prior, Takemura (2015: 73-80) produced a Report for the Thirteenth United Nations Congress on Crime Prevention and Criminal Justice where, in Section Five, he discusses space debris under the perspective of *complexity green criminology* (CGC). This term is used to represent the complexity of issues which, together, are responsible for mass environmental harm. Applied to outer space, Takemura (2015) discusses the complexity of space debris accumulation and the myriad sources from which space junk is generated. Specifically, he focusses on anti-satellite testing, in-orbit collisions, Kessler syndrome, and reentry events. This work emanated from an even earlier publication which concentrated on linking space debris with CGC (Takemura, 2012). This was Takemura's very first publication on an outer space related topic and, while 'astro-green criminology' was not proposed, it is clear that space debris presented Takemura with an opportunity to link an escalating astro-environmental problem within an understanding of zemiology and environmental harm.

CGC is a term created by Takemura which emanated out of his earlier work on *complexity criminology* (Takemura, 2013) and *chaos criminology* (Takemura, 2002) respectively. Chaos and complexity criminologies are terms with similar meanings. Linked to the complexity of crimes, chaos criminology refers to the disorder inherent in criminal offending stemming from the complex circumstances under which crime can occur (i.e. the amalgamation of time, place, offender and victim). As Takemura (2002: 9) describes,

Adopting a chaos approach to conflict recognizes the normality of instability - what chaos theorists refer to as "far from equilibrium conditions" - and views flux, social disorganization, heterogeneity, diversity, and spontaneity as the expected manifestation of any complex system of interacting agents.

Takemura (2024; 2025) goes on to apply his earlier ideas around chaos and complexity criminologies to outer space concepts in his later works. In some ways, it is perhaps surprising that Takemura did not make the connection between chaos theory/criminology and apply it to outer space issues sooner. Chaos theory is an established branch of physics and mathematics used to make sense of the seemingly chaotic universe. As Sutter (2022: 1) writes, 'the truth [is] that we live in a chaotic universe that, in many ways, is completely unpredictable. But hidden deep within that chaos are surprising patterns, patterns that, if we are ever able to fully understand them, might lead to some deeper revelations'. Applied to criminology, chaos theory can be understood as the search for patterns of offending within the overall complexity of crime; crime hotspots and the geography of crime being classic examples. However, it took ten years between publications on conflict and chaos criminologies (Takemura, 2002) and outer space issues (Takemura, 2012).

Despite this, the intelligence of Takemura's (2019) seminal paper on astro-green criminology is that it proposed the novel use of green criminology as a perspective from which to view emerging outer space problems. Green criminology is synonymous with investigating environmental problems from a critical and zemiological stance, focussing on environmental harms in addition to environmental crimes (Lampkin, 2020). Takemura (2019) was the first to propose that outer space issues should be a focus for green criminologists, and coining the term *astro-green criminology* enabled green criminologists to start exploring anthropogenic interactions with outer space from a perspective of harm. Since Takemura's (2019) quintessential article, the number of research papers exploring astro-green criminological issues has proliferated, and in only a short period of time (see, for example, Burns & Lampkin, 2024; Cvetkovič, 2024; Eski & Lampkin, 2024; Lampkin, 2021; Lampkin & Carpio-Domínguez, 2024; Lampkin & McClanahan, 2024; Lampkin & Wyatt, 2022; 2023; Rothe & Collins, 2023; Tourangeau, 2022; Ziosi, 2024).

Although Takemura (2019) was the first to call for green criminologists to engage with outer space issues, and he was the first to make a clear connection between space (debris) and criminology, he was not the only scholar to draw connections between outer space and criminological issues in the period before his establishment of an astro-green criminology (Takemura, 2019). In 2015, Professor Tanya Wyatt briefly explored space debris and spent nuclear fuel as examples of hazardous wastes in her chapter on the *Brownness of Green Crimes and Harms* (Wyatt, 2015). Additionally, in 2018, Professor Eamon Carrabine momentarily discussed Earth-orbiting satellites as a representation of power, especially state, private and military power, in his work published in *Theoretical Criminology* (Carrabine, 2018). However, neither Wyatt nor Carrabine's main focus was outer space, and neither drew clear connections between emerging space issues and criminology. It is Takemura's (2019) clear focus on establishing an *astro-green* strand of criminology which is so significant and paved the way for future scholars to develop such ideas further in years thereafter.

Takemura's (2019) pioneering article was focussed on the emerging concern of space mining and the impact such activities might have on pristine natural space landscapes and future generations of humans. As such, this was the first attempt within criminology to explore outer space harms beyond the issue of orbital debris. In particular, Takemura (2019) realised the finite nature of Earth's resources and the subsequent attractiveness of outer space assets to fill that inevitable depletion, resources which could be obtained through extraterrestrial mining. This has led to other criminologists subsequently engaging with the issue of space mining (Lampkin & McClanahan, 2024; Lampkin & White, 2023; Rothe & Collins, 2025). As Takemura (2019: 7) writes: 'as many became concerned with depletion of natural resources on Earth, they began to pay more attention to available resources in outer space'. Takemura was clearly influenced by the work of Pelton (2017) and their ideas concerning a *gold rush* in outer space. As he writes,

New Space commercial activities will be keys to replacing fossil fuel energy and assisting with natural resource shortages which will become increasingly common by the end of the twenty-first century. Without the ability to access space resources our planet and the global economy could wither away under the weight of too many people and too little resources (Takemura, 2019: 8).

In particular, Takemura (2019) was very concerned with the *laissez-faire* nature of space mining regulation, and viewed the existing legal regime - and especially the 1967 Outer Space Treaty (OST) and 1979 Moon Agreement (MA) - as insufficient mechanisms for the prevention of harm from space mining activities. Instead, Takemura (2019) favoured the *Common Heritage of Mankind* principle proposed by De Cnudde (2015) as a mechanism for the protection of celestial bodies from anthropogenic space mining. This, for Takemura, was a fairer and more equitable position to approach space mining, as opposed to the alternative, free-use of outer space resources facilitated by the current international legal framework (OST and MA).

Takemura's (2019) coining of the term *astro-green criminology* also appears to have been inspired by Almár's (2002) earlier philosophical debate on 'astro-environmentalism' and the concept of planetary protection from human interference. Here, Takemura took a utilitarian approach to debates surrounding the purpose and philosophy of space exploration. As he writes, 'a balance must be found between the impact of any mission and the scientific results or other benefits which may be [consequently] obtained' (Takemura, 2019: 11).

Finally, and linked to astro-environmentalism and the Common Heritage of Mankind principle, is Takemura's (2019) focus on the *Wilderness Principle*. The consideration of outer space as a wilderness to protect, rather than a frontier to exploit, enabled Takemura to argue for the protection of outer space for the benefit of future human generations. For Takemura (2019: 14), conceptualising outer space as a valuable wilderness would help to facilitate space resource preservation, as well as keeping 'environmental hazards, human-made debris, nuclear weapons, and nuclear power out of space'. Such a reconceptualization again mirrors a utilitarian approach to space resource management, affording 'greater value to natural capital' over cultural and social capital (Takemura, 2019: 14). After all, for Takemura (2019: 14), outer space is 'a source of wonder and inspiration... [which] deserves to be preserved in its original pristine state, for its own sake and for future generations to enjoy'.

Takemura's (2019) paper on astro-green criminology is summed up succinctly and eloquently in his conclusion that 'in short, the time has come, however, for environmental concerns to be applied to developments in space' (Takemura, 2019: 12). It is in the conclusion that Takemura (2019: 15) specifically makes the call for an astro-green criminology:

At this moment, against the recent tendency of space exploration, space capitalism, we need to create a new discipline named 'astro-green criminology'. Humans have created environmental and ecological ruin on the planet, and now space debris is starting to pollute space around Earth. From this new perspective, if we need space exploration and space exploitation, they must be done in an environmentally and ecologically safe and sound manner which does not pollute outer space, create adverse effects such as climate change, or endanger life. We have no right to pollute and contaminate other planets (the Moon, Mars, asteroids and so on) through human space activities such as mining and colonization.

In doing so, Takemura sparked the interest of criminological scholars who have subsequently sought to expand and develop the astro-green criminological perspective (in particular, see Lampkin, 2021). However, Takemura continued to develop astro-green criminology in his own way, in his later works (Takemura, 2022; 2024; 2025). It is important to note that, in these works, Takemura continued to envision astro-green criminology as a radical and zemiological contribution to criminology and outer space studies, and he proceeded to link later ideas with earlier ones, especially around chaos and complexity green criminology.

Finally, and of ground-breaking importance, Takemura (2022; 2024; 2025) is one of the only social scientists to make a connection between their discipline (in this case astro-green criminology) and established areas of physics and astronomy. It has been argued that the social sciences and the physical sciences have remained largely separated and lacking interdisciplinarity when it comes to outer space (Pass, 2007). Takemura's most recent work breaks that trend by applying astro-green criminology to established theories within the physical sciences, which could be seen as novel *thought experiment*. The next section will discuss Takemura's (2022; 2024; 2025) application of astro-green criminology to such traditional theories in physics and astronomy, focussing primarily on the Fermi Paradox; the Drake Equation; the Dyson Sphere; and the Kardashev Scale.

3. The making of links between astro-green criminology and relevant areas of physics and astronomy

While Takemura's (2019) original article on astro-green criminology was centred around the issue of space mining, and earlier publications focused on orbital debris (Takemura, 2012; 2015), Takemura (2022) continued to expand upon astro-green criminology using *energy* as the catalyst for exploring the harms of space expansionism and extractivism. For Takemura, energy harvesting could be used as a mechanism to explain the complexity of astro-green criminology, and the disorder (and chaos) inherent in the theoretical and philosophical understanding of energy harvesting. Of particular importance is Takemura's (2022) grand claim that extraterrestrial intelligence, that being non-human and non-terrestrial, are likely already able to harvest energy (and especially, solar energy) in ways not yet known to humans. Takemura (2022) explains the

significance of this through the consideration of four relevant theories: the Fermi Paradox; the Drake Equation; the Dyson Sphere; and the Kardashev Scale. Each of these theories will now be explored in the context of how they have been perceived by Takemura, and how Takemura's interpretation of the theories have helped to develop the theoretical contribution of astro-green criminology.

3.1 The Fermi Paradox and the Drake Equation

According to Shkurko (2024: 1), the Fermi paradox refers to the idea that,

Life on Earth, as well as the emergence of intelligent life and modern civilization, is a natural process, and is not the result of an act of divine creation or another process beyond the scope of scientific concepts. If the Earth is not the centre of the world and an exception to the laws of the universe, then the emergence of life, including intelligent life, should not be a unique event and, given the enormous size of the universe, should be repeated with some frequency.

In short, the vastness of the universe renders it unlikely that humans are the only intelligent life form capable of travelling and communicating beyond the confines of their host planet. Enrico Fermi (an Italian-born, American physicist) pondered the question, if this is the case, then *where is everybody?* Why have humans not received communication from other intelligent beings elsewhere in the universe? (Takemura, 2022: 27). The answers to these questions still create disagreements between physicists and are well beyond the scope of this article. However, it is important to note that the Fermi paradox enabled Takemura to propose an *ultimate* astro-green criminology (UAGC), one that goes beyond immediate astro-environmental issues (such as orbital debris accumulation and space mining) to deeper theoretical considerations. UAGC is more existential in nature, and considers space environmentalism in the very long-term. Drawing upon the work of Professor Stephen Hawking (2018), Takemura (2022: 34) suggests that 'aliens might pillage Earth for resources' just the same way that native Americans suffered when Columbus plundered land in America in the 15th Century. For Takemura, this is the *ultimate* environmental catastrophe, terrestrial environmental destruction emanating from intelligent life forms in outer space.

To calculate the probability of intelligent life in the universe necessary for understanding Fermi's paradox, Takemura (2022: 9) employs the Drake Equation. Developed in 1961, Drake's equation states that,

$$N = R * f_g n_e f_1 f_i f_c L$$

N	The overall likelihood of an intelligent race contacting us.
R*	The average rate of star formation per year in our galaxy.
f_g	The fraction of stars suitable for life.
f_p	The fraction of stars with planetary systems.
n_e	The number of planets per system with conditions suitable for life.
f₁	The fraction of such planets that actually develop life.
f_i	The fraction of such cases where intelligence occurs.
f_c	The fraction of intelligent races with technological capability to communicate, and have the desire to do so.
L	The lifetime of such a civilization.

Table One: Adapted from Takemura (2022: 29) and Burchell (2006: 244), there are different iterations of the Drake equation, but all have the same goal of prediction.

The Drake equation allowed Takemura (2022) to demonstrate the complexities of existential questions and that the prospect of an astro-green criminology is one that excites, inspires and draws attention to larger scientific problems (like the search for extraterrestrial intelligence, or SETI) that could have an impact on Earth's environment. This topic creates debate because we often conceive of natural resource management from an anthropogenic perspective (i.e.

who owns, controls and plunders Earth's resources), but the Fermi Paradox and Drake Equation offer a vulnerability to the human species, suggesting control could be easily lost to extraterrestrial life forms.

3.2 The Dyson Sphere, Dyson Swarm and Kardashev Scale

Historically, green criminologists have been adept in exposing environmental harms and crimes emanating from fossil fuel production (see Atilés & Rojas-Páez, 2022) and energy generation in its myriad of forms (Stretesky et al., 2013). However, a certain amount of energy is needed in contemporary society and all forms of energy generation incur some amount of environmental harm or carbon cost. This is a problem for green criminology, which has been criticised for not proposing enough solutions to the environmental problems that it exposes (Lampkin, 2020). Takemura's (2022: 29-30) exploration of the Dyson Sphere, while at times difficult to read, can be interpreted as a radical attempt to overcome problems associated with the non-renewability of finite natural resources extractable from terrestrial energy generation, through (instead) investigating space-based solutions to Earth-based energy problems.

Originally developed by Freeman Dyson in 1960, the Dyson Sphere describes a star-orbiting, planet-sized cylindrical mega-structure purpose-built to harness the sun's energy and return it to Earth for use in everyday life. Other iterations include a globe structure that would totally encapsulate a star (and thus its energy), or the more feasible Dyson Swarm. This describes a constellation of star-orbiting satellites specifically built and designed to harness solar energy for terrestrial consumption. Takemura (2022: 30-31) then goes on to discuss similar energy thought experiments through consideration of the Kardashev scale which describes the ability of a civilisation to harness resources at different rates. This has an impact on the ability of such civilisations to travel and communicate beyond the confines of their home planet. For Takemura (2022: 32),

This challenge for innovative, imaginative, creative, and bold SETI will remain open for at least a couple of decades to come. Among other things, it will help understanding the prospects and pitfalls of the future of humanity itself, hopefully contributing to a new ecological and ethical consensus necessary for the long-term survival and prosperity of our species.

Dyson and Kardashev-inspired energy solutions are used by Takemura (2022), in the same way as the Fermi Paradox and Drake Equation, to signal future topics for astro-green criminology of an *ultimate* nature. This shows how larger, existential problems and questions can be of relevance to astro-green criminologists, through engaging in exciting and inspiring thought experiments. This is particularly true (and important) when considering the long-term survival of the human species in millennia to come, on a planet which contains only finite resources. These issues have also been discussed in-depth recently by renowned criminologist Dr Yarin Eski (Eski, 2023; Eski & Ugelvik, 2025) through the lens of *astrocide*, adding to the existential development of criminological research on outer space.

4. Discussion: from astro-green criminology to space criminology

Thus far, this article has sought to honour and value the contributions of Professor Noriyoshi Takemura's pioneering early research, especially the coining of the term *astro-green criminology*, and for encouraging scholars to ask bigger, deeper, more meaningful and existential questions about how the Earth environment and its resources may be impacted by both humans and non-humans in the long-term. This article has also explored how green criminology has been criticised for its concentration on the exposure of environmental destruction, as opposed to solutions for overcoming such problems (Lampkin, 2020). Takemura's work invites scholars to go beyond the short-term interests associated with space expansionism and to consider the long-term threats to Earth and space environments, through engaging thought experiments (like the Drake Equation, Fermi Paradox Dyson Sphere and Kardashev Scale). This encourages us to think about the solutions to astro-green problems now, before they materialise *en masse*. Contemporary work on *astrocide* (recently defined as 'the prospective crime of destructive exploitation and/or total

annihilation of celestial bodies, planetary ecosystems, and extraterrestrial life') can be seen as an early response to thinking about mass space harms, considering how astrocide can be thought of, conceived, and prevented (Eski & Ugelvik, 2025: 1).

Takemura's (2019) original contribution to astro-green criminology stressed the importance of prohibiting space mining which, for him, risks environmental destruction in outer space. This mirrors contemporary and historical Earth-based destructive mining practices, like those for coal, oil and other fossil fuels and precious minerals. Although Takemura did not specifically use the term *astrocide*, he was clearly troubled by the potential of space mining to have lasting, irreversible consequences for pristine space environments. Astrocide is therefore a term that can be used to describe Takemura's worst fears.

Beyond the coining of the term astro-green criminology, this article has also analysed Takemura's (2022) concept of an *ultimate* astro-green criminology to tackle the more radical and futuristic elements of space harms and crimes which threaten terrestrial life and resources. This revolutionary and thought-provoking work is unique within criminology, and it challenges academic researchers, theorists, and students of astro-green criminology to do more than confront immediate threats, and to also consider existential threats and longer-term hazards. This is, unfortunately, where astro-green criminology becomes limiting. While space expansionism poses many environmental threats to both terrestrial and extraterrestrial locales, it also presents new criminological concerns of a non-environmental nature. In order to address this problem, a new area of focus has emerged out of astro-green criminology in recent years, namely *space criminology*. Space criminology is most simply conceived as the study of criminological issues relating to outer space activities and industries. This is a wide field of study that not only encompasses astro-green criminology and space-environmental concerns, but also traditional criminological issues like state crime, corporate crime, victimisation, and how civil and criminal law intersects with space expansionism.

Space criminology can therefore be seen as the ultimate triumph of Takemura's pioneering work on astro-green criminology. It has enabled harm to be the primary focus of study, regardless of whether that harm impacts humans or non-human entities. However, space criminologists must be wary about how they continue to develop the discipline. They must not become fixated on orthodox criminological issues alone, such as how violence or interpersonal crimes might be addressed in outer space. While such issues are important and are being increasingly discussed in space criminological circles (Eski & Lampkin 2024; Lampkin & White, 2023; Sachdeva, 2023), the importance of the environmental impact of space expansionism must not take a back seat. If it does, Takemura's concerns about the ecological impacts of space mining and space expansionism may be forgotten.

Ultimately, space criminology is an umbrella term that facilitates the study of social and environmental harms as they pertain to outer space. Therefore, academics and researchers can use space criminology as a mechanism and platform to discuss space-based harms. However, they may also choose to continue employing the term astro-green criminology whenever preferred. Astro-green criminology may, for instance, be particularly useful for those critical and radical green criminologists who wish to advocate for more extreme measures to protect terrestrial and extraterrestrial environments from anthropogenic harms, mirroring Takemura's call for a prohibition of space mining practices. Regardless of terminology (astro-green criminology or space criminology), the focus of enquiry for criminologists must be how to prevent harms (environmental or otherwise) occurring from impending space expansionism and space warfare.

5. Conclusions and futures: prohibition or critical alignment?

This article has celebrated the importance and significance of Professor Noriyoshi Takemura's work pioneering and developing astro-green criminology. While the space industry continues to develop, and looks set to expand operations in several key areas in the near future (such as mass satellite and constellation infrastructures in Earth orbit; space mining; space tourism; extra-terrestrial settlement and communication), this article is a reminder of the value of criminology to conversations about space expansionism (Rothe & Collins, 2025).

Ultimately, Takemura (2019) advocated for a prohibition on space mining. However, such radical calls are unlikely to be successful in practice, particularly when we understand the legal and jurisprudential uncertainty of space expansionism, where activities may often take place in areas beyond national legal jurisdiction. Instead of point-blank prohibition, perhaps more can be achieved through advocating for inter-disciplinary work and alignment between criminologists and those in space industries. As such, space criminologists could best be seen as undertaking the role of a *critical friend*, one that provides an expert, critical voice in policy and decisions about space development and futures. In such a position, criminologists can then offer advice and guidance that promotes a less harmful human (and state-corporate) relationship with outer space working towards more sustainable space futures.

While some green criminologists (mainly on the radical criminological wavelength) may wish to see the prohibition of harmful environmental activities, perhaps there is more value in allowing and enabling space development for the betterment of the Earth (and extra-terrestrial) environments. Much can be achieved, for instance, in using satellite technologies to track terrestrial weather patterns, to monitor climate change, and to see how celestial bodies have changed over time. These valuable activities would not be possible without anthropogenic space technologies. The task of astro-green criminology and space criminology is to ensure vital infrastructures are undertaken safely, sustainably, and in a fair and justice manner. This is the astro-green criminology envisioned by the early scholars of this area (Takemura, 2019; Lampkin 2021; Lampkin & White, 2023; Eski & Lampkin, 2024; Lampkin & Takemura, 2025), and in doing so, perhaps 'we can prevent the same mistakes in space as we have on Earth' (Takemura, 2019: 7).

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