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Introduction

Space: the final frontier. Humanity has long held a fond appreciation for this vast unknown, and it has been featured in both art and academia since the dawn of time. Scientific knowledge of both the Earth and the solar system have greatly advanced in the last seventy years since humanity launched its first object, a German V-2 rocket, into the atmosphere. This obsessive curiosity did not cease with the Lunar Landing, but instead increased ten-fold with dreams of extraterrestrial life and extraterrestrial living. As the day humans will set foot on Mars steadily approaches, humankind faces a daunting dilemma: how can life be sustained outside of Earth's orbit? While important, this question is not the focus of this paper. Arguably more important are discussions on how colonization can be achieved ethically. Although there are many opinions on this subject, the ultimate need for survival of the human race paired with preserving the abundance of celestial objects and the progression of scientific knowledge unveil that a compromise between conservation and preservation ethics is the best framework for ensuring humanity's survival while preserving galactic integrity.

Literature Review

Why is humanity so engrossed by concepts of space colonization? Is it curiosity that drives dreams of expansion or do we rely solely upon foundational needs for species survival to encourage biological and technological advancements? Current research highlights both, as well as geopolitics and existentialism, as driving forces behind extraterrestrial colonization. This literature review synthesizes and comments on common ideas from current research related to motivation and goals for expansion, exploratory timelines, opportunities for development, logistic concerns, and ethical considerations of interstellar immigration.

It is necessary to understand what rationales provide foundational support for discussions of upward expansion prior to analyzing the achievability of expansion itself. Biology, society, and existentialism influence motives for extraplanetary colonization. Assuming a purely biological motive, self-preservation and fear of extinction have caused humanity to begin to challenge natural limits and strive for immortality amongst the stars (Mautner, 2009; Slobian, 2015). These instinctual drives are further expressed in efforts to obtain valuable extraterrestrial resources to support terrestrial life on Earth, as shown by U.S. President Barack Obama's 2015 proclamation for mining asteroids for the benefit of the United States (Dunietz, 2017). While this proposal is certainly possible, the likelihood of resolving current planetary issues by outsourcing vital resources such as water and minerals is exceedingly low. Logically, humanity cannot overcome the immense issues that stand between survival and overuse of the Earth by simply obtaining resources from outer space. While it is true that additional resources obtained this way would reduce concerns of resource depletion on Earth, this would increase overpopulation and climate change if it is assumed that current trends will continue. This proposal does not address one of the largest contributors to the expansion argument: overpopulation. Global climate change and resource depletion, coupled with overpopulation, have exacerbated apocalyptic fears and led to conclusions that the creation of interstellar colonies is the only valid mechanism to ensure the

survival of the human race (Mautner, 2009; Schwartz, 2013; Williams, 2010). Trepidation, then, is one of the founding principles upon which the purpose of space colonization is based. The influence of apocalypticism is apparent in current discussions regarding expansion as well as projects focused on developing extraterrestrial travel and technology. In contrast, curiosity fuels cognitive motivations that center more on scientific study and opportunities to reform social and political systems by following utopian ideals (Schwartz, 2013; Slobian, 2015; Staff, 2007). Colonizing a celestial body would allow researchers to study areas previously exempt from human presence and develop a better understanding of the home planet Earth as well as the relationships humans have with both living and nonliving nature (Mester, 2009; Schwartz, 2013). Curiosity is synonymous with human experience, as is the desire for improvement. This opportunity for research would enable advancements in human understanding of ecology, physics, biology, and a plethora of other academic pursuits. Discoveries made in outer space could potentially be applied to life on Earth as well, thereby offering an empirically utilitarian benefit to the species. The creation of new societies in space would provide the unique opportunity to directly mold social and political structures, thereby allowing expression and experimentation of social and political reform as desired by many cultures throughout the world. For these reasons, curiosity is designated as another foundational principle driving space exploration and colonization. Lastly, international relations and competition, along with the desire for a higher purpose and more meaningful existence, complete the motivational analysis (Mautner, 2014; Slobian, 2015; Staff, 2007; Williams, 2010). The 'Space Race' of the 1960's demonstrated the competitive nature found in global superpowers pursuing out-of-atmosphere excursions. Space offers multitudinous opportunities to gain global power and prestige, as well as secure the safety of citizens. By recognizing current international tensions and relating them back to those expressed between China, USSR, and the United States prior to the first moon landing in 1969 it can be inferred that the prospect of space colonization is of interest to numerous countries worldwide. This mutual interest is furthered by perceived benefits of being at the forefront of the expansion effort, including but not limited to monopolizing power through technological advancements, heightened influence, and the security of a more stable future.

Current technology does not allow for human interstellar travel past Earth's Moon. However, recent advancements offer an encouraging outlook for further exploration in the not so distant future. It is estimated that spacecraft carrying humans could arrive on Mars as soon as 2025 and interstellar mining initiatives may be operational by 2020 (Dunietz, 2017; Slobian, 2015). While it is improbable that an initial human exodus will occur prior to the year 2050, proper preparations must be made to limit unnecessary mortality when the time arrives for life to spread to the stars. It is also important to address potential timelines for after a colony is established to provide the best outcomes for success. One such timeline for consideration is the life of the sun. The sun is estimated to grow into a red giant star and engulf the Earth in five billion years, but life on Earth is expected to cease within one billion years due to increases in global temperature and radiation from the expanding sun (Scudder, 2015). This will need to be considered alongside timelines for resource depletion by colonies; if potential colony populations are not thoroughly analyzed for carrying capacity, resources within the solar system could be exhausted in as little as five-hundred thousand years (Mautner, 2009). With extensive analysis, colonies could be developed to remain within boundaries set by carrying capacity and develop into fully functioning hominid homes. However, this would create contention within society. Who would determine who could immigrate to space and who would be left on Earth? Would a type of celestial 'Hunger Games' ensue, with different factions of society fighting for the right to

survive through expansion into space while the rest of humanity is left to extinction alongside the home-planet Earth? Or perhaps initial colony populations would be filled with scientists and their families operating as an experimental group to determine how to best survive outside the Earth's atmosphere? What may happen cannot be determined as of yet, but many potential problems must be addressed to ensure humanity does not simply damage another celestial body in the place of Earth. The resolution of overuse and overpopulation lies in recognizing factors that contribute to the problem and resolving them to protect the health of the home-planet. For this proponent of survival to work effectively, technology must advance hand-in-hand with ecological responsibility. Only once humanity has developed the skill and motivation to significantly reduce or remove impacts from its presence can it seek to settle in the stars.

While the argument that resources including water and unrefined fuel and building materials could be extracted from celestial bodies for use on Earth has already been addressed, it can also be argued that humanity should relocate to these resources rather than remove them. Relocation would theoretically resolve overpopulation on Earth and enable species survival by allowing humanity more control of its biological future (Mautner, 2009; Schwartz, 2013), however, this could result in an interstellar arms race and increase tension between global powers (Williams, 2010). Countries could potentially be pitted against one another to compete for the best astral real-estate. In this case, relocation would not cure the current global political climate but rather move it to a new location: Space. A location in which countries may race to arm moons and asteroids surrounding their new homes with ballistic missiles and nuclear weapons for use against, or protection from, their neighbors. By assuming that extraterrestrial expansion will resolve all the problems on Earth, humanity runs the risk of reiterating the Cold War with more powerful weapons and a less secure environment. Foundational to the desire to expand is the idealistic hope that a new planet will provide a new start for humanity. Pursuing Martian colonization as a solution to current problems on Earth is an ill-founded quest that may distract from solving those very issues (Williams, 2010). Fleeing the home-world Earth in favor of a new planet will not resolve global difficulties because the planet is not the problem—humanity is. A species that damages and degrades its home to support itself is parasitic in nature, and only moves to a new host once it has taken all that it can from the original. Similarly, humanity will flood the galaxy like a plague destroying everything in its path if expansion is done incorrectly. Unless pollutive practices, destructive agriculture and infrastructure designs, and exploitive ethics are negated, humanity will simply kill planet after planet in its galactic conquest to find a suitable home. Only once the species has advanced socially, biologically, technologically, and has learned to live in harmony with its environment can prospects of colonization be realized. The question then becomes a matter of ethics: is it better to fix Earth at the expense of humanity or to start over and risk destroying another home? Mankind must determine its ethical obligation to Earth before considering its ability to successfully sustain the very society responsible for destroying its homeland on a new planet.

Pursuing cosmic expansion provides many opportunities for both social and scientific growth. For instance, reality TV shows depicting daily activities and research findings can be recorded and broadcast back to Earth to increase social support and understanding of Martian civilization. Technical advancements may also be used to establish power plants that can collect solar energy in the outer atmosphere—where it is strongest—and transport it back to Earth (Slobian, 2015; Schwartz, 2013). These examples highlight the immense potential for implementation of alternative energy, eco-friendly practices, and knowledge growing enterprises

on Earth as a direct benefit of expansion. On the other hand, the human race will have to adapt to the extraterrestrial environment in order to survive and reap the benefits of expansion. These adaptations may arise biologically through evolution if given enough time but could possibly result from intentional manipulation of the human genome as well. Using this method, colonists could be modified to possess photosynthetic organs or be temperature and radiation resistant to allow for civilization in previously inhospitable environments (Mautner, 2009; 2014). While this would allow humanity to settle more quickly and with less impact on astral objects by offering an eco-friendlier approach to colonization, it could yield a plethora of damages and lives lost due to the process of perfecting gene modification. Genetic alteration is a complex and ill-understood science and pushing for expansion too quickly may result in providing inadequate time for research to be conducted safely. This could yield mutations that act differently in space than on Earth, interfere with basic life-sustaining functions, or alter the human mind and body past the point of recognition. Even worse, human experimentation and subsequent violations of human rights could incur hundreds of thousands of deaths as the hominid genome is manipulated. Altering the basic structures that make up a person opens the door to a variety of additional concerns: what constitutes a human? Are some hybrids more deserving of certain rights than others? Where is the line between acceptable and unacceptable alteration drawn and who will be responsible for enforcing it? All things considered, the impacts of genetic alterations and their expressions are not understood enough at this time to allow for significant progress in this area, and the risks associated with the abuse of basic rights and segregation based upon mutation are too high for justification. Time and further study are required to develop a safe and efficient method for surviving the harsh environments of outer space without imperiling the human species in part or in its entirety.

Each of the prior concepts must be considered when contemplating the ethical ramifications of galactic settlement. There are numerous perspectives relating to the morality of colonization, but each can be generalized as following a conservation or preservation-based mindset. Life-centered ethics argues that the perpetuation of living beings in all habitats is most important, and that humanity is morally obligated to use outer space as a means to proliferate life regardless of the environmental impacts (Mautner, 2009; 2014). In contrast, preservation centered ethics disapprove of anthropocentric values and assert that the extraterrestrial environment is uniquely valued because it is free from human presence (Mester, 2009; Schwartz, 2013). This ethic advocates for utilizing celestial bodies for research purposes in the least invasive manner possible and prioritizes saving Earth, humanity's current home, over colonizing another planet (Mester, 2009; Williams, 2010). Both ethics offer valid points relating to the morality of space travel, yet neither offers a direct answer that secures species, science, and safety as necessary for expansion efforts to be successful.

Discussion

Ethical considerations are often overlooked in the analysis of space colonization. This is due, in part, to the very active and elaborate science-fiction culture that permeates those interested in this subject. Media portrayals encourage the imagination to run wild with exploratory thoughts directed at how colonization can be achieved and what may be discovered as a result rather than if colonization should occur. Because of this, land ethics are a key component in identifying appropriate actions regarding celestial bodies and their management. Should they be utilized for human survival and thereby changed to best support this species? Or should they be preserved for their aesthetic and inherent values? These questions introduce the

two governing theories of land-based ethics: Conservation and Preservation. Conservation advocates for the responsible use of resources and allows for human interaction as part of the environment. In contrast, preservation promotes that natural landscapes and ecosystems must be managed apart from human impact and protected for the enjoyment of future generations.

The first theory supports terraforming as a means to create habitats suitable for life on inhospitable planets. Terraforming allows people to change an environment that is unfavorable to one that is capable of supporting life. This method can be used to create or strengthen an atmosphere, fertilize soils, form a water cycle, and even manipulate the landscape to be more like Earth. It essentially rewrites the ecosystem of the host planet to be as identical as possible to that of the home planet. Current research shows that meteorite soils are fertile enough to harbor bacteria, algae, plant cultures, and even shrimp hatchlings (Mautner, 2014). This evidences the potential for terraforming success in the effort to colonize Mars, a previously hostile environment. Panspermia, the process of spreading bacteria and other microorganisms to celestial bodies, operates as an aspect of terraforming that allows life to develop. This would be one of the initial steps to creating a suitable environment on the Martian surface, because it would enable plant growth and thereby oxygenate the atmosphere. While a lengthy process, terraforming would theoretically allow life on Mars and could be the first step towards galactic residency. This proposal highlights a biocentric, or life-centered, ethic focused on proliferating living organisms including humans, animals, plants, microbes, and biotic landscapes. However, it does not consider the intrinsic or aesthetic values of the host planet, but rather focuses on the instrumental value of potential areas for colonization. It trades the non-living or living nature of the host planet for that of Earth, thereby destroying its original state, and is anthropocentrically focused. Conservationists may argue that this is acceptable so long as it is viewed as necessary and that some celestial bodies are left in their original states. On the other hand, preservationists may assert that this is an entirely immoral act because it places known ecosystems as higher in importance than astral ones, which could not be restored or recreated after being terraformed.

The second opinion supports preserving galactic integrity and prioritizing the care and rehabilitation of Earth above expansion to other planets. This approach is more holistic and asserts that extraterrestrial nature has inherent value because it is free from human impact and should remain so (Mester, 2009). Under this ethic, nature may be used for research and further development of current establishments but should not be interfered with or changed in any way. During an interview with Nicola Davis from *The Guardian,* renowned astrophysicist Neil DeGrasse Tyson asserts that, “If you had the power of geoengineering to terraform Mars into Earth, then you have the power of geoengineering to turn Earth back into Earth.” (Davis, 2016). Supporters of this ethic fear that expansion will lead to the destruction of yet another planet and will simply be a repetition of mistakes made on Earth rather than a lasting solution to human pollution. Mismanagement of the Earth should be corrected instead of neglected in favor of a ‘New Earth’, and research should focus on rehabilitating the home planet instead of expanding the bounds of human exploration. Conservationists, however, may argue that this proposal does not consider the ramifications of remaining on Earth; Overpopulation cannot be resolved by eco-friendly behavior and no amount of recycling will extend Earth’s lifetime past that of the Sun. While reproduction can be strictly controlled, the risk of creating a global dystopia centered on government control is too high and negates the very foundations of human values such as freedom and independence.

Conclusion

When considering all arguments equally, no action can be deemed ethical. This is because each proposal is countered by contrasting values. To remedy this, one ethic must be identified as universally superior and accepted; only then will arguments for or against space colonization find a basis for viable discussion. The best way to approach this conflict is with compromise and the overall support of conservation-based ethics.

While pollution can be remedied, and the Earth may be restored, overpopulation cannot be countered without human rights violations. Therefore, expansion is necessary for the ethical treatment of human beings. However, this does not justify the eradication of extraterrestrial nature and must be done with preservative ethics in mind to ensure boundaries are set and respected. Both sides must compromise and cooperate for celestial expansion, and species survival, to succeed. To ensure this compromise, it is recommended that current efforts be redoubled on rehabilitating the Earth and correcting environmentally detrimental behaviors. Once life on Earth is secured and hominids have developed the practices and technology necessary to live with little negative impact on their environment, focus can then be shifted to the stars. Policies and procedures should be developed to protect the host planet while allowing humans to both conduct research and live on astral bodies. Preliminary colonies may be established on celestial objects determined to be the most hospitable for life with the least amount of necessary intervention once the Earth's carrying capacity has been reached or exceeded. This can be done by identifying a small number of young planets and systems to colonize while protecting the potential for development of life on others and leaving some strictly for research and observation. Each colony should undergo extensive resource depletion and carrying capacity studies to ensure it will not eventually destroy the host, and plans can be developed for the creation of secondary colonies as population increases. Following this method, humanity's survival is supported while allowing for galactic protection and integrity without inhibiting the progression of scientific knowledge.

It is human nature to explore and exploit natural resources in favor of convenience, but it does not have to be this way. With time, energy, and dedication, humanity can learn to live in mutualistic harmony with its surroundings and thereby ensure its survival. By utilizing both conservative and preservative ethics, mankind can realize its dreams of reaching for the stars by taking hold of responsible exploration and habitation practices. One planet is no longer large enough to support this species; thus, extraterrestrial expansion must be done responsibly, and ethically, to protect both the future of humanity and the future of the universe.

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