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ON THE MORAL PERMISSIBILITY OF TERRAFORMING[1]

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Terraforming is a process of planetary engineering by which the extant environment of a planet is manipulated so as to produce an Earth-like ecosystem. This paper explores the ethical questions about the exploration of space and the exploitation of space resources that arise in the consideration of terraforming. I argue that space advocacy (including the pursuit of terraforming) and environmentalism are mutually beneficial endeavors. I show that the moral status of terraforming a planet, at least under traditional anthropocentric and non-anthropocentric positions, is sensitive to whether life exists on the candidate planet. I also examine several attempts—due to Holmes Rolston, Keekok Lee, Alan Marshall, and Robert Sparrow—to show that terraforming a planet would be impermissible even if the planet was not home to life. I argue that no attempt provides compelling reasons for the supposition that terraforming is morally impermissible.

I. INTRODUCTION

Terraforming is a process of planetary engineering by which the extant environment of a planetary body is transformed into an environment capable of supporting human inhabitants. The question I would like to consider in this paper is whether there is any reason to believe that the terraforming of another planet—for instance, the terraforming of Mars—is morally problematic. Topics related to the human exploration of space

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are not often discussed in philosophical circles. Nevertheless, there exists a growing body of philosophical literature dedicated to sorting out the moral implications of the use of resources from (and in) space. Most of this literature is produced as environmental philosophy. Questions of interest include: Are humans morally obligated to explore space? Are humans morally permitted to extract resources from celestial objects? What would the discovery of extraterrestrial life mean for the future of human space exploration, and how diligently must humans search for signs of such life? How might the exploration of space contribute to or detract from the solution of environmental problems on Earth? The central question of this paper—whether the terraforming of another planet is morally problematic—is of particular interest because in order to answer it one must say something about all of the other questions mentioned just now. It should come as no surprise, then, to learn that most of the philosophical literature on the topic of space exploration has focused on the terraforming question. This paper constitutes an assessment of this work.

I begin with a few remarks on the historical tension between space-advocates and environmentalists. The human exploration of space is a high-technology endeavor. An oft-voiced environmentalist criticism is that technology is the root of the current environmental crisis and more technology would only make matters worse. Moreover, environmentalists maintain that we should focus on learning more about Earth and Earth's ecosystems before spending large sums of money and expending much effort researching *other* planets (to say nothing about attempting to construct a whole new ecosystem on another planet). I argue that this tension is misplaced, and that the human exploration of space has much to contribute to our environmental education. It stands to reason that, by terraforming another planet, humans would learn something about the proper management of Earth's ecosystem. This, in turn, motivates my initial assessment that terraforming is morally recommended.

After a brief interlude on the technical viability of terraforming, I consider in broad-terms what traditional subdivisions in environmental philosophy have to say about the procedure. How the positions of anthropocentrism, individualistic non-anthropocentrism, and holistic non-anthropocentrism apply to the case at hand depends on whether there exists life of any kind on the candidate planet. On the assumption that life exists, non-anthropocentric views can provide the foundation for a moral injunction on terraforming. Meanwhile the anthropocentrist must decide

whether any scientific or aesthetic value that might inhere in the native life suffices to override the value of terraforming the planet. On the assumption that the candidate planet is lifeless, non-anthropocentric views have little, if nothing, to say. The anthropocentrist, however, can muster a case against terraforming on the grounds that the scientific or aesthetic value of the pristine planetary environment overrides the value of terraforming the planet.

The primary interest of this paper is considering the terraforming question under the assumption that the candidate planet is lifeless. A broad-termed discussion overlooks the potential for particular expositions of environmental philosophies to supply a positive or negative assessment of the morality of terraforming. Several authors have weighed in on matters. Those in favor of terraforming and related activities (at least when various conditions have been met) include Haynes (1990), McKay (1990), Fogg (2000), and Schwartz (2011). Those opposed include Rolston (1986), Marshall (1993), Lee (1994), and Sparrow (1999). Ultimately I portend no conclusion stronger than that which holds that terraforming is *not* morally prohibited, and so I confine my attention to those authors who attempt to show that terraforming is impermissible. My judgment is that no one yet has succeeded in showing that terraforming a lifeless planet is prohibited.

II. TENSION FROM THE ENVIRONMENTAL MOVEMENT

Space exploration has for quite some time been the subject of disapprobation from those espousing environmentalism. A persistent environmentalist sentiment is that humans have mismanaged and over industrialized Earth's resources. This malfeasance is made possible through the advancement of technology, allowing humans to exert an increasingly dominant influence over nature. Progress can only be made by changing society's *attitude* toward the environment. The pursuit of space exploration is an activity on a par with the highest technological endeavors and so does not represent any kind of meaningful progress in relation to the environmental crisis. "Why expend so much energy studying space," it is asked, "when there are so many problems to solve here on Earth?"

An emblematic case of this tension arose in the 1970's when the work of Princeton physicist Gerard O'Neill caught the attention of the United States government. O'Neill's findings indicated that it would be possible to construct miles-long cylindrical habitats out of resources extracted

from Lunar regolith. These habitats could be placed in orbit around the stable Lagrange-points of the Earth-Moon system, spun for gravity, and could house miniature Earth-like ecosystems capable of supporting thousands of human inhabitants. Colonists could be put to work creating and maintaining solar energy collectors that could beam solar energy to Earth without interruption. O'Neill's space colonies would therefore provide solutions both to the human overpopulation problem and to the energy crisis.

Environmentalists were not impressed with the promises of O'Neill's space colonies.[3] With one or two notable exceptions, reactions ranged from skepticism to outrage. The skeptical responses accused O'Neill of grossly overestimating the ease with which his colonies could be constructed, as well as overstating the ease with which humans could create stable Earth-like ecosystems inside these structures. Perhaps more germane to the present discussion is the sense of outrage present in some reactions. Lewis Mumford writes,

> I regard Space Colonies as another pathological manifestation of the culture that has spent all its resources on expanding the nuclear means for exterminating the human race. Such proposals are only technological disguises for infantile fantasies. (Brand 1977, 34)

Similar sentiments are expressed by Wendell Berry,

> For what is remarkable about Mr. O'Neill's project is not its novelty or its adventurousness, but its conventionality. If it should be implemented, it will be the rebirth of the idea of Progress with all its old lust for unrestrained expansion, its totalitarian concentrations of energy and wealth, its obliviousness to the concerns of character and community, its exclusive reliance on technical and economic criteria, its disinterest in consequence, its contempt for human value, its compulsive salesmanship. (ibid., 36)

Both Mumford and Berry can be understood as complaining that O'Neill's solution to the energy crisis fails to address what is in their eyes the real source of the trouble—the disrespectful and irresponsible attitudes society espouses towards the environment. Considerations such as these contribute to the tensions between environmentalists and space advocates that persist to this day.[4]

I maintain that these tensions are unjustified and that, far from contributing to environmental problems, the exploration of space has much

of value to add to the environmental movement. Consider the environmentalist's demand that humans spend more time learning how Earth's ecosystem works before committing large amounts of resources to the exploration of space. A reasonable question to pose in response asks by what means we are to acquire additional knowledge about the Earth. The simple fact of the matter is that, from its very beginnings, space exploration has been critical in expanding on our collective knowledge about the home planet. Satellite monitoring technology allows climatologists to observe climatic processes on a global scale (including the monitoring of the polar ice cap), zoologists to study large-scale herd movements, botanists to observe global forestation fluctuations, and oceanographers to chart the depths of the seas.[5] Our knowledge on matters would be much impoverished had humans dismissed space exploration as a technological boondoggle.

Moreover, direct observation of the planet is not the only way the exploration of space can add to our knowledge of Earth. It was not until humans had sent probes to Venus that we became aware of the effects of a runaway greenhouse effect (Cockell 2007, 82). It also stands to reason that the terraforming of Mars would provide important lessons for the proper management of Earth's atmosphere. The underlying suggestion is that engaging in *comparative planetology* is likely to inform us about the home planet.[6] I take this as *prima facie* evidence that terraforming Mars is morally recommended insofar as it is likely to contribute to the solution of environmental problems on Earth.

More practical considerations can also be raised. High launch costs require space vehicles to carry a minimal amount of mass; efficient use of resources is therefore a paramount concern for astronauts on missions. Agencies such as NASA are constantly tasked with creating new and improved technologies to more efficiently manage food production and waste disposal; techniques that often filter into commercial applications.[7] It would seem that in its current form, space exploration is more likely to facilitate the efficient management of resources than it is to encourage totalitarianism and contempt for human value. What is more, the environmental and economic impact of current space exploration is not very great and tends to be grossly exaggerated by its opponents (Schwartz 2011, 79–81).

Aside from the case of comparative planetology, none of these examples recommend terraforming *per se*, but they help to dispel the myth

that supporting space exploration and protecting Earth's environment are mutually incompatible activities. Quite the opposite conclusion is warranted: The exploration of space is vitally important for advancing our understanding of the home planet. Paul and Anne Ehrlich strike a similar chord in the following remark:

> Environmentalists often accuse politicians of taking too short-term a view of the human predicament. By prematurely rejecting the idea of Space Colonies they would be making the same mistake. (Brand 1977, 43)

One can very easily add that environmentalists would similarly be mistaken in overlooking the exploration of space as an important avenue for improving both our knowledge of, as well as our respect for the Earth.[8]

III. TERRAFORMING

It would be idle to inquire whether terraforming is morally problematic if such an endeavor belongs more to the realm of science fiction than to that of science fact. Nevertheless current research suggests that humanity possesses the technical capacity (though perhaps not the *economic* capacity) to begin the process of terraforming the planet Mars. I can only hope to provide a brief and informal account of how such an activity might be carried out; I point the interested reader to a bibliography of technical work maintained by the planetary scientist Martyn Fogg.[9]

The current mean temperature of Mars is well below the freezing point of water. Moreover, the atmospheric pressure is low enough so that any water that might melt would instead sublimate. As the presence of liquid water is a necessary condition for the production of an Earth-like ecosystem, the early stages of terraforming must involve procedures that thicken the atmosphere and raise the surface temperature. The Martian atmosphere is composed primarily of CO_2. Large amounts of frozen CO_2 can be found on the surface of the planet. CO_2 is a greenhouse gas—in sufficient quantities it is capable of trapping solar energy in an atmosphere. Increased amounts of CO_2 in Earth's atmosphere are thought to be contributing factors to global warming. But what is harmful in the case of Earth is beneficial for Mars, where the goal is to *encourage* a runaway greenhouse effect. By increasing the surface temperature, previously frozen CO_2 is released into the atmosphere, increasing the atmospheric pressure. As atmosphere pressure raises, a greenhouse effect induces warming,

which releases more CO_2 into the atmosphere, which further increases the atmospheric pressure, etc.

Initial warming can be produced in a number of ways. A conceptually simple option is to dust the poles of the planet, reducing surface albedo, causing the surface CO_2 to absorb increased solar energy and eventually sublimate into the atmosphere. Once warming has produced a satisfactory atmospheric pressure and surface temperature, water (in addition to that already frozen on the surface) can be collected on the planet by placing asteroids composed mostly of ice (available in the Main Belt in between the orbits of Mars and Jupiter) on collision courses with the planet. These impacts will have the added benefit of increased warming.

At this stage the production of an ecosystem can begin. Appropriately engineered bacteria can be begin converting the CO_2 atmosphere into one that contains suitable quantities of oxygen. More complex organisms can be introduced gradually. The paucity of native nitrogen is problematic for the development of plant-life, but this issue may be resolved by extracting nitrogen from other locations in the solar system (for instance, from the atmosphere of Titan, a moon of Saturn).[10] The creation of an ecosystem is perhaps the most daunting task of terraforming, and it would be foolish to suggest that humans, at present, have the requisite knowledge for carrying out this task. Nevertheless the entire process is predicted to occur on time scales of hundreds of years, leaving open the possibility of significant progress regarding our understanding of the functioning of ecosystems.

IV. ENVIRONMENTAL SUBDIVISIONS

My *prima facie* assessment of terraforming is that it is morally recommended insofar as it would contribute to our environmental education. This assessment presumes that humans are obligated to increase their awareness of and knowledge about Earth's environment. If that presumption is not granted, then my *prima facie* assessment is that terraforming is at least not morally problematic. Can this initial appraisal be accommodated by any of the traditional views in environmental philosophy?

The two principal subdivisions in environmental philosophy are anthropocentrism and non-anthropocentrism. Anthropocentrists believe that all natural values depend upon human valuers. Non-anthropocentrists believe that the natural world possesses value independently of any value bestowed upon it by human beings. Both of these broad subdivisions are subject to further refinements. Anthropocentrism divides up into

economic and non-economic views. Economic anthropocentrists must interpret all natural values in monetary terms; non-economic anthropocentrists are more permissive in their value metrics. Non-anthropocentrism divides up into individualistic and holistic views. Individualistic non-anthropocentrists believe that the unit of moral significance is the individual organism; holistic non-anthropocentrists believe that the unit of moral significance is the herd (or species, or ecosystem). This discussion is not intended to canvass all possible perspectives on the proper moral attitude toward the environment. Nevertheless enough has been said to extrapolate what denizens of the indicated positions are likely to say in response to the terraforming question.

IV.1. Non-Anthropocentrism

As I have described the view, non-anthropocentrists face a decision between centering value on individual organisms or on collections (herds, species, ecosystems) of organisms.[11] However, insofar as terraforming is concerned, the differences between individualistic and holistic non-anthropocentrists are largely irrelevant.

Suppose life is discovered on a candidate planet. Terraforming would likely destroy the native life, which would harm individual organisms on a massive scale, and would also likely cause mass extinctions in all sectors of the native ecology. Thus, individualists could object that terraforming harms (or violates the rights of) the individual inhabitants, while holists could object that terraforming harms (or violates the rights of) entire species. In either case, a moral injunction on terraforming is recommended. At the time of this writing, there is no evidence that life currently exists on Mars. Should life be discovered, it will likely consist of microorganisms.[12] Non-anthropocentrists must decide whether microorganisms are due moral consideration. Microorganisms are clearly important to Earth's ecosystem, but perhaps only because of the role they play in maintaining the biosphere as a whole. Would a homogeneous microbial Martian population deserve the same moral status as Earthly microbes, even if it does not serve an ineliminable role in a more diverse ecosystem? I do not intend to answer this question. I raise it only to indicate that the non-anthropocentric permissibility of terraforming turns on how the question is answered. If Martian microbes are due moral consideration, then terraforming Mars would be impermissible. If Martian microbes are not due moral consideration, then, *ceteris paribus*, terraforming Mars would not

be impermissible. Non-anthropocentrists should welcome vigorous discussion on the moral status of microbial life.

Suppose a candidate planet is shown to be lifeless.[13] It is difficult to see how a non-anthropocentrist might possibly make a case for the impermissibility of terraforming. Non-anthropocentrists place value on living organisms (herds, species, ecosystems), and a sterile planet contains none of these things. Consider, for instance, the ecological maxim of Aldo Leopold's land ethic,

> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise. (Leopold 1949, 224–25)

This maxim contains essential reference to things called 'biotic communities.' A lifeless Martian environment may be the kind of thing that exhibits integrity, stability, and beauty, but *ex hypothesi* it contains no biotic communities. It follows that Leopold's land ethic is inapplicable to the present case.

Nevertheless non-anthropocentrism may not be forced into silence when confronted with the terraforming question. Non-anthropocentrism teaches a reverence for life and for living organisms and for the communities in which they reside. Terraforming a sterile planet would create a new environment for life to blossom and diversify. Therefore a case can be made that, if anything, non-anthropocentrists ought to *encourage* the terraforming of a planet, as doing so would propagate the diversity of life.[14]

IV.2. Anthropocentrism

As I have described anthropocentrism, proponents must decide by what metric natural values (ultimately interpreted as human values) are to be assessed. Economic anthropocentrists strive to interpret all values as monetary values so that they may implement cost-benefit analyses in determining courses of action. This view faces well-known problems concerning the coherence of assigning monetary values to items such as the life and physical and mental health of human beings, aesthetic experiences, etc.[15] Non-economic views attempt to remedy this shortcoming by permitting additional measures. For instance, a rights-based approach censures violations of basic human rights, even in circumstances in which the violation of rights would produce the best economic outcome. Non-economic

views can also accommodate the preservation of wilderness areas that could otherwise be used for commercial and industrial activities.

Assessing the permissibility of terraforming from the perspective of an economic anthropocentrist is a delicate matter. One would need to have rough estimates of the costs associated with terraforming, as well as an estimate for the monetary benefits associated with providing an entire new planet in which humans can live. Of course, these benefits would have to be weighed against the potential benefits of other courses of action. It strains credulity to suggest that we are currently capable of making the necessary computations to carry out a cost-benefit analysis of terraforming another planet—even of the terraforming of Mars. The costs *and* the benefits are likely to be very great, but for now little else can be said. In what follows, I will assume that non-economic natural values exist, such as scientific values and aesthetic values. The reader is free to interpret these values as economic values if she feels up to the task of converting them into monetary terms, in which case what I say below is neutral between economic and non-economic anthropocentrism.

Suppose again that life exists on the candidate planet. Regardless of its form, this life is likely to be prized for its scientific value. Should terraforming completely eliminate this native life, scientists would be deprived of the opportunity to study it and learn from it; who is to say what advances in biology and medicine would go unrecognized? Would the values associated with the scientific study of life native to the planet imply a moral injunction on terraforming? Faced with the threat of human extinction, the value of scientific study seems not so great compared to the needs of the entire human race. Should terraforming be the only option for species survival, it would appear to be something we ought to do. Short of this, it is unclear what should be said. But there is no need to force ourselves into an all-or-nothing decision. If the current biota on the candidate planet are capable of surviving in an Earth-like ecosystem, then there remains the possibility of preserving representative ecosystems on parts of the planet while allowing humans to inhabit the remainder of the surface.[16]

Suppose again now that there is no life on the candidate planet. If life once existed on the planet, then perhaps the value of studying the past traces of life would place an injunction on terraforming. If life had never existed on the planet, then *ex hypothesi* there would be no scientific value associated with the study of native biota. Nevertheless a completely (and

historically) sterile planet is not automatically terraforming fodder, even for anthropocentrists. The pristine environment on the planet is still likely to be of scientific interest to climatologists and mineralogists, to be sure, and many other types of scientists. Moreover, the pristine environment might be thought to possess aesthetic attributes, in which case its terraformation would mirror the commercial development of Mount Everest (or some other aesthetically pleasing landscape on Earth). But as in the case of the scientific value of life on the candidate planet, it is unclear how permanent of an injunction the presence of these additional scientific and aesthetic values places on terraforming. Threatened with humanity's demise, concerns of this sort fall away. Short of this, it is again unclear what should be said.

The moral appears to be that we ought to at least wait until science has developed a deep understanding of the native conditions (lifeless or otherwise) and the impact of human habitation on the planet before any serious attempt at terraforming is made. But this implies that we have some notion of what a "deep" understanding of the native conditions amounts to. Matters here are unclear. On the prospects for discovering life on Mars, Marshall writes,

> If a policy is implemented which restricts the exploration of Mars to sterilised unmanned missions in order to preserve any possible life, we will soon find ourselves asking the question: when do we finally decide there is no life on Mars and allow human exploration? After ten years of unmanned exploration? After one thousand? The trouble is that an unexplored environment can always be thought of as harbouring undiscovered life. Even after breaking open a million Martian rocks we can never be totally sure that Mars is devoid of living organisms. (Marshall 1993, 232–33)

Marshall answers that after a handful of missions to Mars, "it would be foolish to believe that we have enough information to rule out a 'life on Mars' hypothesis" (233). The point is granted; moreover one could encourage similar sentiments with respect to potential sites of scientific and aesthetic value on Mars and on any later terraforming candidates. These remarks counsel caution, but ultimately do not, I suggest, speak against the in-principle permissibility of terraforming.

V. NOVEL APPROACHES

The previous section did not offer a definitive answer to the terraforming question. Reasons for and against terraforming can be given by anthropocentrists and non-anthropocentrists alike. This suggests a certain deficiency in environmental philosophy; its standard views seem incapable of making any sort of meaningful progress on the moral status of terraforming. This theme is picked up quite often in the literature. Don MacNiven writes,

> …all the ethical theories we have been using to discuss environmental ethics have one feature in common. They are all geocentric (Earth-centred) theories which automatically exclude from the moral universe Mars, the solar system and indeed, the universe as a whole. This suggests that current ethical theories cannot adequately deal with the moral problems which projects like terraforming and ecopoiesis pose. (MacNiven 1995, 442)

Martyn Fogg reaches a similar judgment,

> The perceived problem with environmental ethics in its current form is that it is *geocentric* in context. The Earth is effectively viewed as a sealed box, transparent to incoming sunlight and outgoing heat. (Fogg 2000, 206).

I am not entirely convinced that the problem is one of geocentrism. As I suggested above, non-anthropocentric views are certainly capable of settling the terraforming question *on the assumption that the candidate planet is home to life*. Leopold's maxim does not speak of Earth as-such, but only biotic communities, which happen to exist in abundance on Earth. I see no reason why anyone should suppose that a Martian environment that is home to life should be excluded from the realm of biotic communities. If there is a problem of bias in environmental philosophy, it is one of *biocentrism*; environmental philosophies are largely inapplicable to "environments" that are not importantly related to living organisms. Traditional views falter because of the assumption that a candidate planet is *lifeless*, and not because such a planet is not identical to the Earth.

This lacuna has been noted, and a number of philosophers have attempted to fill it. Holmes Rolston, Keekok Lee, Alan Marshall, and Robert Sparrow have each argued that terraforming is morally prohibited; this section is devoted to examining their reasoning. Below I describe each view and argue that in each case, no good reason is given to suppose that terraforming is morally prohibited.

V.1. Rolston

On Rolston's view, the natural world is *projective*, and its "projects" include stars, comets, planets, moons, rocks, and rivers (Rolston 1988, 197). He claims that nature is "valuable intrinsically as a projective system… the system is of value for its capacity to throw forward (pro-ject) all the storied natural history" (198). Thus, nature is something like a creative agent, though it is neither sentient nor conscious. "Neither sentience nor consciousness are necessary for inventive processes to occur. The inventiveness of systemic [projective] nature is the root of all value, and all nature's created projects have value so far as they are inventive achievements" (ibid.). Rolston calls the inventive achievements of nature *formed integrities*, which are loci of non-anthropocentric value. The destruction of value is a *prima facie* case of wrongdoing, and *ceteris paribus* an action is wrong to the extent that it destroys something of value.

How do the above considerations apply to the case of space exploration? Rolston offers six guidelines for conduct in the solar system. We are to preserve and respect,

(1) Places spontaneously worthy of a proper name.
(2) Exotic extremes in natural projects.
(3) Places of historical value.
(4) Places of active and potential creativity.
(5) Places of aesthetic value.
(6) Places of transformative value. (Rolston 1986)

(1) is motivated by the thought that some of nature's projects "warrant particular respect or admiration," and that a defeasible test for when some particular place meets this condition is whether it excites our proclivity to name (172). (2) stresses the value of diversity. Rolston often claims that great value is attached to the fact that Earthly projects tend toward diversity (in species, for instance), and he does not view extraterrestrial diversity as different in kind; nature's projects are not limited to what is created on Earth. (3) is similar in spirit to (2). "Humans ought to preserve those places that have been more eventful than others…nature is a historical system, a book that writes itself…" (175). Formed integrities are not valuable simply because they exist, but also because of how they come into existence and what happens to them through time. (4) captures the idea that just as nature's projects are valuable, so too are the *processes* that produce things of value. (5) appeals to the idea that objects possessing aesthetic value ought to be preserved, and that in space "experiences

of the sublime hitherto unknown await us, and respect is demanded in the presence of the overwhelmingly sublime" (177).

(6) calls for the respect and preservation of places of transformative value, a concept articulated in Norton (1987). The basic idea is that certain experiences of the natural world have the capacity to alter a person's basic values. A common example involves a trust-fund recipient who spends most of her time shopping and whose primary goals in life revolve around money. On a whim she decides to attend conservation meetings and begins to visit wilderness areas. After some time she begins to find that she is no longer satisfied by shopping and instead enjoys excursions into wilderness areas. She reaches the judgment that her new, nature-oriented values are *superior* to her old, money-oriented values. Wilderness areas thereby *transform* her values, and so possess *transformative* value. According to Rolston,

> We can reduce human provinciality with the diverse provinces of solar-planetary nature. In space, so much is scrambled—what counts as day or night, year or season, hot or cold, up or down, bizarre or normal, what counts as land, sea, sky, the feel of gravity. These disorienting, unsettling discoveries will expand our juvenile perspectives…. These will prove *radical* places…in the nonanthropic sense that they *uproot* us from home and force us to grow by assimilating the giddy depths and breadth of being. (1986, 178)

Space wilderness areas afford many opportunities for the transformation of values, and so ought to be preserved.

Rolston's proscriptions encourage caution and noninterference. It stands to reason that terraforming–in particular, the terraforming of Mars—violates all six of Rolston's criteria. Mars is evidently a place worthy of a proper name. Since no two planets in the solar system are very much alike, Mars constitutes a kind of extreme environment. The Martian surface is the product of long-term geological evolution; Mars has "stories" to tell. The geological evolution of Mars is surely not finished; it is the domain of natural creativity. The pristine Martian environment is a place of great natural beauty. Finally, the experience of Mars in its pristine state is bound to cause any explorers to pause and reconsider their attitude toward nature. All of these considerations recommend a moral injunction on terraforming.

Nevertheless matters are not so clear. Places are far too easily attributed proper names. The student section at the Jack Breslin Center on the

campus of Michigan State University has been given the name the "Izzone." It strains credulity to suggest that this act of naming is morally significant. Near-Earth asteroids are often given proper names; does that imply they are off-limits for human development? Rolston seems to appreciate the difficulties involved (173), nevertheless it sounds strange to say that terraforming Mars is prohibited because the proper name 'Mars' has been given to the planet. Some more robust reason is surely required.

Although Mars might be thought of as an extreme environment relative to our solar system, we should not forget that the universe is a place that stretches on for millions upon millions of light years, and contains billions upon billions of stars, many around which planets orbit. There is no reason to think that the Martian environment is anything but ordinary when observing the natural world in its entirety. For similar reasons, the terraforming of Mars would not imply the irreplaceable loss of a place of transformative value.[17]

The remaining criteria (3–5) are equivocal. It is granted that Mars possesses historical value, in Rolston's sense. The historical "stories" of Mars are in the past, and cannot be destroyed by future actions (although evidence of these stories surely can be destroyed). Terraforming would only alter the surface conditions of the planet, and would not likely alter its past geological record. Furthermore, terraforming would simply be another chapter in the story of Mars, and Rolston gives no reason to think that this new chapter would detract from previous chapters. Suppose humans discovered that Mars had previously been terraformed by a long-extinct alien race. It stands to reason that such a discovery would *add* historical value to the planet. Why suppose, then, that terraforming would constitute unjustified human interference in the natural history of Mars? (Consider this question from the perspective of an alien race uncovering our ruins on the planet in the distant future).

A similar response can be made against the suggestion that the pristine Martian environment is beautiful and so ought to be preserved. Would the outcome of terraforming Mars not itself be an object of beauty? It would, in a sense, be an *artifactual* environment. But that is only a criticism of terraforming if human-created beauty is inferior to nature-created beauty. According to Rolston, the burden of proof is on those who suppose that terraforming would augment the beauty of Mars (Rolston 1988, 201). If this burden can be met, terraforming is not impermissible for aesthetic reasons.

The duty to respect and preserve places of active and potential creativity is problematic in application. The problem is that a site of active creativity can always be thought of as a site of potential creativity, and it is subsequently unclear whether, if they are capable, humans should insure the continuation of active creativity, or foster the conditions that promote potential creativity. Consider the following example:[18] Suppose humans were to discover that an asteroid is on a collision course with the Earth, and were it permitted to strike the planet, it would cause the extinction of human beings along with most of the other life on Earth. Now Earth is certainly a place of active creativity, and to that extent it warrants our protection. However, it is not altogether unreasonable to suppose that were the asteroid permitted to strike the planet, new forms of life would evolve, much as the asteroid collision thought to be responsible for the extinction of the dinosaurs led to the dominance of mammal life and the evolution of human beings. In this sense, Earth is a place of potential creativity. What ought we to do in this situation? Does the current active creativity of the Earth count for more than its potential creativity as a home for new life? Or is it the other way around? Rolston gives us no way of answering such questions.

The terraforming case is essentially no different; replace Earth with Mars and the asteroid with human beings. Because Mars is the product of projective nature, it counts as a place of active creativity. Owing to the potential for Mars to support Earth-like ecosystems, terraforming unveils Mars as a place of potential creativity (and, post-terraforming, as again a place of active creativity). Which sort of creativity counts for more? Someone in Rolston's position is not forced to answer this question in any particular way. But then considerations of active and potential creativity do not unveil terraforming as necessarily morally prohibited.

In sum, Rolston's criteria make no clear pronouncements about the morality of terraforming. I conclude that Rolston has not shown that terraforming is morally prohibited.

V.2. Lee

Lee specifically addresses the deficiencies of biocentrism, writing that,

> …if 'terraformation' is to be rejected out of hand either as moral permission or duty, then one must develop a conception of intrinsic value

> which is not necessarily tied up solely with the fate of biotic Nature. This means that an environmental ethics, which is not Earthbound but capable of defending other planets against human control and domination, must confront the issue of abiotic or inanimate Nature as a locus of intrinsic value. (Lee 1994, 92)

Her account of the value of nature begins with analysis of the abiotic value of Earthly environments. She demurs from attributing any sort of anthropic purposes in nature, claiming that "Earth…did not come into existence and/or continue to exist to serve human purposes" (ibid.). Although nature may have instrumental value to humans and other living organisms, nature does not exist *for* humans and other living organisms. This amounts to Lee's "No-Teleology Thesis." Lee also notes that environmental processes have the capacity to carry on independently of human beings; nature is autonomous. This is her "Autonomy Thesis." In connection with the thesis that nature is independent of human beings is the idea that human beings are completely dependent on nature, and so "there is a distinct asymmetry of causal dependence between humans and Nature" (93). This constitutes Lee's "Asymmetry Thesis."

Lee takes her three theses to refute the idea that human beings are in any sense justified in feeling superior to nature; one is not in a position to assert the superiority of oneself over something on which one's existence depends. Rather, humanity's dependence on nature suggests that humans occupy a position of *weakness* in comparison with nature. It follows that in the presence of nature,

> …we humans should be filled with awe, that is, with reverential fear and wonder. Wonder is called for as the thing we behold is so marvellous and remarkable. And reverential fear, because not only is Nature a marvel but also because it has power over us, as on it our very existence depends. (94)

The No-Teleology and Autonomy theses counsel wonder, and the Asymmetry thesis counsels reverential fear or humility. What moral implications hold?

> Awe and humility would then dictate that we should maintain a respectful distance from Nature. We should be careful not to make excessive demands of any kind upon it, not only those to sustain ever-increasing consumption but even those which express our 'love' for it. (94–95)

Lee maintains that her three theses apply to Mars, and that terraforming would violate our duty to keep a respectful distance from the planet. It is reasonably clear that Mars satisfies the No-Teleology and Autonomy theses. If any planet can be thought of as created *for* human beings, that planet would have to be the Earth; once it is granted that Earth does not exist for humans, it verges on nonsense to claim that Mars exists for humans. Similarly, *pace* solipsism, the existence of Mars is independent of the existence of human beings.

However, it is not obvious why Mars satisfies the Asymmetry Thesis. Earth's environments satisfy Asymmetry because human beings depend for their existence upon the Earth and its resources. Life on Earth also depends largely on solar energy, and so it is quite plausible to maintain that the Asymmetry Thesis applies to Earth's sun. But it is not clear that human beings are dependent on the planet Mars. In what way does Lee suppose that Mars satisfies Asymmetry?

> Earth's atmosphere, its biosphere upon which human survival and flourishing depends, in turn depends on Mars and other planets in the solar system rotating and exerting gravitational pull on one another in certain ways. So while the existence of humans depends on the existence of Mars, the existence of the latter would not be affected should humans, as a species on Earth, become extinguished. (98)

Lee's point is that were Mars to disappear from the universe, Earth's orbit around the Sun would be affected (the planet would begin orbiting closer to the Sun, possibly heating the planet beyond the point at which human life can survive). That is the sense in which human life depends on Mars.

I should think this a queer kind of dependence. It is granted that life on Earth depends on the existence of *some* planet/s of appropriate mass/es and appropriate orbital position/s and velocity/ies.[19] And so life on Earth depends on *some* planet playing the "Mars role" in our solar system. That is perhaps a reason to suppose it would be morally wrong to blow Mars to smithereens. But Lee claims that Mars satisfies the Asymmetry Thesis in a way that supports the conclusion that *terraforming* is morally prohibited. But I can make no sense of the idea that human life depends upon Mars' current surface and atmospheric conditions. The Asymmetry Thesis lends no support to the conclusion that *terraforming* is impermissible.

Even if this point is not granted, Lee's account of humility is questionable. We ought to approach nature with humility in part because humans

are unjustified in feeling *superior* to nature. Why? Because it is wrong to suppose that one is superior to another that is not dependent on oneself. This principle is highly suspect. I have never committed murder. However, many people have murdered, and I am not aware of any murderer who depended for their existence on myself. Am I nevertheless prohibited from judging myself superior (morally speaking) to a murderer? Intuitively I am perfectly justified in doing this, but Lee's account of humility says otherwise. Perhaps this example misses the point. Lee's interest is in refuting the notion that humans could ever be justified in *dominating* nature. Lee can consistently maintain that I am justified in finding myself to be *morally* superior to a murderer but that nevertheless I am not justified in dominating the malefactor. That I have never myself committed murder does not qualify me to decide the murderer's fate. Her point is that it is not for humans to decide what happens to the natural world. Seen in this way the terraforming question turns into an issue about whether terraforming would exhibit an unjustifiable domination of nature. Such activity is unjustifiable when,

> …humans from their mistaken exalted position…continue to act in ways that would undermine Nature's functioning integrity [where] the results could be such that the last laugh, so to speak, would be on us humans. We might find ourselves eliminated, while Nature itself might reach a new and different equilibrium. (94)

This strikes me as evidence that humans should not engage in large-scale projects that run a great risk of catastrophic failure. Perhaps this implies that it would be impermissible to initiate the terraforming of Mars at the time of writing, but this does not imply that it would never be permissible to terraform Mars. If humans were in a position of reasonable confidence with regard to the outcome of terraforming, it would not be appropriate to call such confidence unjustified domination or dismissive arrogance. Provided the process of terraformation involves reasonable caution, its implementation is consistent with maintaining humility toward nature.

Nevertheless Lee can retreat and maintain that, in principle, the Asymmetry Thesis is unnecessary, and that the No-Teleology and Autonomy theses alone support her conclusion.[20] Of course, the Asymmetry Thesis is an important component in demonstrating that humans ought to approach nature with reverential fear or humility. So the inapplicability of the Asymmetry Thesis to the Martian atmosphere means that humans are

not necessarily forced to approach the Martian environment with humility; nevertheless they still may be required to find pristine Mars a place of wonder and awe.

In the case of Earth's environment, awe is called for because "we know that causes and effects in the biosphere are nonlinear, leading to complex interdependence between its parts, and that our increasingly powerful technology produces effects which can and do upset its delicate functioning integrity" (ibid.). The sheer scale and complexity of the natural world inspires awe, and demands that humans explore nature from a respectful distance. I am not convinced that the property of being awe-inspiring is a sufficient condition for a policy of non-interference. An example supports this suspicion. The world economy is nonlinear and features complex interdependence between its parts. Moreover, public and private market activity has the capacity to produce wild fluctuations in the global market. There seems little impediment to concluding that, owing to its complexity and delicacy, the world economy is awe-inspiring. But many regard economic interference as a moral duty, especially in circumstances where the market misallocates society's resources. For instance, governments levy taxes to ensure more or less just distributions of goods, and this is not obviously problematic. I offer this example as evidence that there is no logical link between those things which are awe-inspiring and those things for which interference is prohibited. Lee might respond that although there is no link in general between awe-inspiration and non-interference, the fact that something is awe-inspiring *together with* the assumption that the thing is a part of *nature* implies a policy of non-interference. However, Lee does not offer any reason (other than those already discussed) for granting this kind of special status to nature.

Lee does not explicitly discuss what is awe-inspiring about the Martian environment. She reminds us that Mars was not created for the use of human beings but provides no details about what features of the Martian environment are to be held responsible for inspiring awe. She merely asserts that awe would be an appropriate attitude to adopt toward Mars, inferring that "any attempt to go beyond cognitive understanding would constitute a violation of our recognition that it has a value entirely independent of ourselves which ought to constrain any impulse we may have to make it over to our own design" (98). I am willing to grant that Mars is awe-inspiring, but as I argued in the last paragraph, establishing this fact

does not suffice to show that interfering with the surface conditions of the Martian environment is morally prohibited. Absent a clearer articulation of what is awe-inspiring about Mars, Lee's conclusion does not follow.

Lee's account of natural values holds that nature ought to inspire a sense of awe and humility, which demands that we humans keep a respectful distance from it. I have argued that the Martian environment does not satisfy the conditions under which one is required to embrace humility. I am willing to grant for the sake of argument that the Martian environment possesses awe-inspiring features. Nevertheless I have argued that there is no logical connection between awe-inspiration and a policy of non-interference. It follows that considerations of awe and humility do not unveil terraforming as morally prohibited.

V.3. Marshall

Marshall portends a view according to which the abiotic Martian environment is intrinsically valuable. He claims that this view is a natural extension of the process of expanding the scope of moral consideration. "An extension of human ethics to animals and thence to other organisms if taken to the next step would include an extension of ethics to abiotic objects…even if they do not contribute to a living ecosystem" (Marshall 1993, 234). Marshall does not produce a theory of intrinsic value but instead rests content to appeal to already developed accounts, such as Rolston's preservationist view discussed above. At a minimum, Marshall believes that we have a duty to preserve representative portions of pristine space environments (235).

I do not see that Marshall's view raises any issues not already discussed above. His position is in jeopardy to the extent that other views that countenance intrinsic value are problematic. Nevertheless it should be a useful aside to rehearse briefly some of the standard problems associated with intrinsic value views, if only to motivate Robert Sparrow's aversion to such views.[21]

The principal concern with intrinsic value is epistemological. McArthur and Boran ask what criteria decide the relative value of intrinsically valuable objects (MacArthur and Boran 2004, 152). Surely not all natural objects and environments are created equal. If humans are confronted with situations in which one environment must be sacrificed to preserve another, how are they ensure that the environment they elect to

preserve is in fact the most worthy of preservation? Other similar questions demand answers,

> How much relative value is attributed to different kinds of individuals? Are a plant and a human equally valuable, or not? If not, is a community of plants more valuable than one individual human? Than two? Than three? Is an abiotic entity, like a landscape, more valuable than a microbe, or not? If it is, how much more valuable is it, and when will a community of microbes have rights that trump a landscape's? Will they or should they ever? (153)

McArthur and Boran claim that these questions are "too controversial to be resolved" (ibid.). One might contest whether their pessimism is warranted. My goal, however, is not to endorse their criticism of intrinsic value, but instead to present a succinct account of why someone might eschew the postulation of intrinsic natural values.

V.4. Sparrow

Sparrow attempts to show that terraforming is morally prohibited from the perspective of agent-based virtue ethics. *Agent-based* virtue ethics is contrasted with *agent-focused* virtue ethics. Agent-focused virtue ethics embodies the traditional position of Aristotle, according to which right action is secured through habituation to the virtues. Agent-based virtue ethics holds that an action is right or wrong according to whether its performance demonstrates a virtuous or vicious character. Sparrow elaborates,

> Rather than virtue allowing us to perceive the right action, which is made right by some complex set of facts about the world, right actions are right *because* they are virtuous. On this understanding, what makes a given action right or wrong is simply the character of the agent. (Sparrow 1999, 231)

As an example, "that increasing the happiness of others is good, stems from the fact that it is the sort of activity that benevolent people, whom we admire, engage in" (ibid.). This example is supported by the claim that it is often much easier to identify cruel or benevolent individuals than it is to give general characterizations of cruel or benevolent actions.

Sparrow's goal is to expose terraforming as an activity that demonstrates a vicious character. His principle reason for preferring this strategy is his belief that,

> The only other possible source of obligation on us is the hypothetical and mysterious intrinsic value, which complex inorganic systems are sometimes said to possess. Given the many problems which beset claims about intrinsic value, the virtue ethical approach is at least worth a try. (231–32)

Thus Sparrow wishes to avoid countenancing intrinsic value, and he views his agent-based virtue ethics approach as the only viable alternative. His approach is claimed to possess an important additional benediction; the agent-based approach "avoids the need for *any* account" of natural value (232). If that is right, then the viciousness of terraforming can be demonstrated without appealing to natural values.

Sparrow argues that terraforming would demonstrate two kinds of vices: aesthetic insensitivity and hubris. Terraforming would demonstrate aesthetic insensitivity because,

> Destroying the unique natural landscape of an entire planet to turn it to our own purposes reveals us to be vandals and brutes. It shows that we lead impoverished lives, being unable to respond appropriately to the beauty which is in the world (and on the worlds) around us. (233)

He adds that "the presence (and neglect) of beauty is necessary to demonstrate the existence of the vice," and "this account of the vice of aesthetic insensitivity would be most powerful if we possessed an objectivist account of beauty" (234).

The concession to an objectivist account of beauty is necessary because if humans decided that the Martian environment was not beautiful, terraforming Mars would in no way represent the destruction of something beautiful and thus would not exhibit aesthetic insensitivity. He claims that we are obligated to respond to aesthetic facts that "make no reference to facts about humans at all" (235). Speaking bluntly, this move is a mistake. Sparrow is on record as seeking to avoid the "hypothetical" and "mysterious" intrinsic value. But the objectivist account of beauty he proposes as underlying claims of aesthetic insensitivity is just as troublesome. If objective beauty is not related to felt preferences, then we are faced with direct correlates of the epistemological difficulties facing intrinsic value views. What is demanded are answers to aesthetic variations of the questions raised by McArthur and Boran (2004) including: How much objective beauty is attributed to different kinds of individuals? Are a plant and a

human equally objectively beautiful, or not? If not, is a community of plants more objectively beautiful than one individual human? Than two? Than three? Is an abiotic entity, like a landscape, more objectively beautiful than a microbe, or not? If it is, how much more objectively beautiful is it, and when will a community of microbes have objective beauty that trump a landscape's? Will they or should they ever? (153) *These* questions seem too controversial to resolve. But Sparrow must resolve them in order to show that terraforming is objectively wrong on his view. I don't see what reason he has for believing that these problems are any more tractable than those facing the intrinsic value views he finds so problematic. Thus his criticism of terraforming based on aesthetic considerations fails on its own terms.[22]

Sparrow portends two conceptions of hubris. According to the first conception,

> …acts of hubris are usually large, dramatic, and unprecedented acts. They are usually punished by disaster. The pride and the fall go hand in hand. The possibility of disaster, then, of failure which would bring us low, operates as a sign of hubris. Terraforming certainly involves the possibility of catastrophic failure. Given the scale of the project and the amount of energy involved, failures are likely to be disastrous. Instead of a habitable planet, we may produce one with a poisonous atmosphere or without water or lashed by continual typhoons. Indeed, given the amount of resources and human effort which would need to be dedicated to terraforming, anything other than complete success would be a disaster. (1999, 237)

And, according to the second conception of hubris,

> …we might attempt more directly to flesh out the idea of our own proper human place…to gain a sense of possible limits to the ambitions which are appropriate to human beings… A proper place is one in which one can flourish without too much of a struggle. It is one that we can live in and sustain. It is a place in which one fits and does not appear uncomfortable or out of place.
>
> It is prima facie implausible to suggest that Mars is our proper place. The vast amount of effort required for us to sustain a presence there, even to the point of entirely transforming the planet, indicates that it is not a natural environment for us… If we have to wear space suits to visit and to completely remodel it in order to stay, then it's simply not our place… [A species' proper place] is a place which nur-

> tures them, in which they grow up, reproduce and which offers them some semblance of safety. (238)

Thus actions demonstrate hubris when they involve the *possibility* of catastrophic failure and when they involve a species attempting to reside in an area that is not its proper place. Would terraforming exhibit either variety of hubris?

In order to satisfy the first conception of hubris, terraforming must involve the possibility of catastrophic failure. Sparrow worries that one mark of failure is that we might produce a poisonous atmosphere. But poisonous to whom? Mars' current atmosphere is primarily CO_2 and contains only trace amounts of oxygen, which is to say that Mars' current atmosphere is *already* poisonous—at least to human beings. Robert Haynes points out that if humans fail to effect warming to a degree sufficient for producing a warm and thick atmosphere, the "physical conditions on the planet would revert ultimately to something similar, if not identical, to their present state" (Haynes 1990, 174). Moreover, even if an attempt to terraform Mars was anything other than a "complete success" it does not follow that the result would be a catastrophic failure. Our scientific understanding of the universe is not a history containing only great successes. Failure is a part of the scientific process. Failure, even in the case of terraforming, would provide valuable lessons for biologists, geophysicists, and climatologists and would leave humanity better prepared to terraform other worlds—something that humans surely must do if they are to seek out new places to live before the burnout of Earth's sun.[23] I grant that human beings at present are not fully prepared to pursue the terraforming of Mars. However, no one that I know of defends the idea that human beings ought to implement the terraforming of Mars today. Sparrow uncharitably overstates the risks associated with a responsible and cautious approach to terraforming, and subsequently fails to expose it as an action that necessarily involves his first conception of hubris.

Sparrow alleges that terraforming Mars violates the second conception of hubris because humans belong in their proper place—something that Mars is not. Unfortunately Sparrow's account of what it is for something to be humanity's proper place is incapable of supporting this judgment.[24] Consider the criteria that a proper human place is one in which humans can flourish without too much of a struggle, one where humans do not require great efforts to sustain themselves, and one where humans

do not require protective gear to go outside. If these are *necessary* conditions, then most of Earth is classified as not a proper human place. There are many places on our planet where humans struggle on a daily basis. (Who decides what counts as too much of a struggle?) There are many places on Earth where staying alive requires great effort. And there are many places on Earth where a person without protective clothing would die if exposed to the elements for too long of a time.

Consider also the criteria that our proper place is a place that nurtures us, allows us to grow and reproduce, and provides us with safety. These appear somewhat less problematic as necessary conditions, but arguably they still rule out many places on Earth. Might it be more charitable to interpret Sparrow's various criteria as (individually or jointly) sufficient conditions? I don't see how this would help his case, for it must be recalled that the Earth is not a place that automatically nurtures us and provides us with safety. A large part of the reason that Earth provides for us in so many ways is that we have developed a large-scale industrial society that produces nearly all of our consumable resources. But the result of the successful terraformation of Mars would be a place that provides for us in similar ways. This means that if Sparrow's criteria are interpreted as sufficient conditions (as they must be in order to avoid judging most of Earth as off-limits), they are singularly incapable of appraising post-terraformed-Mars as not one of humanity's proper places.

Can Sparrow reply that I have missed the point? It seems possible for him to grant that *were* human beings to be successful in terraforming Mars that it would subsequently be one of humanity's proper places. Can he nevertheless claim that the *initial act* of terraforming is wrong because Mars is not *currently* a proper human place? I think this possibility is defeated by some of the considerations that I have already raised. Earth was not originally a place that provided for human beings in the ways that Sparrow claims qualifies Earth as our proper place. Human intervention was necessary for producing the relatively cozy living conditions in which many humans find themselves. If this intervention is not a demonstration of hubris in the case of Earth, why suppose that it would be hubris in the case of Mars? To be sure, one could cite our poor track record concerning the management of Earth's natural resources as evidence that we are not mature enough to begin settling another planet, but that is only a temporary impediment. No in-principle reason has been given to suppose that terraforming would demonstrate the kind of hubris Sparrow has in mind.[25]

Sparrow's aesthetic objections to terraforming fail because they depend on an unarticulated objective account of beauty that promises to be just as problematic as the intrinsic value views he seeks to avoid. His first conception of hubris applies only to projects at risk of catastrophic failure, and the facts do not appear to indicate that a cautious approach to terraforming would fit the relevant criteria. Finally, his second conception of hubris depends on a notion of a proper human place that is incapable of showing that Mars is not our proper place without also showing that most of the Earth is not our proper place either. Conversely, if Earth qualifies as one of our proper places, there is no impediment to viewing Mars in a similar light. I conclude that Sparrow has not shown that terraforming is ultimately morally problematic.

VI. CONCLUSION

I have examined a number of attempts to show that terraforming a lifeless planet is morally reprehensible. I have argued that none of these attempts is ultimately successful. I have therefore succeeded in my ambition to show that terraforming is not morally prohibited, at least in reference to the extant literature. I am willing to defend a somewhat stronger conclusion, that terraforming is morally recommended, for the reasons given in the second section. Terraforming another planet would provide valuable lessons for the intelligent management of Earth's biosphere. Environmentalists have for some time maintained the acquisition of this kind of knowledge as a moral duty. Absent unforeseen objections and anthropocentric considerations of scientific and aesthetic value, terraforming is project we ought to keep in mind as space technology improves.

Sara Reiman asks a rather simple question: Is space an environment? (Reiman 2009). Alas, in philosophy, simple questions seldom have simple answers, and Reiman's question is no exception. In one sense, space is clearly an environment; space is a place in which things exist and in which events occur. But this is not a sense of the term that is ordinarily thought to involve moral import. After considering many of the same views discussed in this paper, Reiman eventually settles on virtue-ethics as the best way to guide human conduct in space, and so avoids having to answer her own question. If my criticism of Sparrow is correct, then this approach is called into question. Nevertheless, Reiman's closing remarks bear repeating:

> …in the context of space exploration…the costs of research are extremely high and discoveries made can change our world-view for-

> ever. The environmental ethics of space will necessarily be different from the environmental ethics of Earth, but can still provide valuable views and philosophical tools for assessing questions related to the exploration and exploitation of space. The ethics of space exploration should be scientific, philosophical ethics. (87)

To that, I say, Amen.

I do not pretend to have ended any debates. Far from it—the debate, I dare say, is just beginning. Even if it remains unacknowledged, the future of humanity lies in space, and it is high time philosophers begin treating space-related topics with the attention, care, and scrutiny that they deserve. I hope the reader is left with the impression that I have advanced the discussion in some tangible way.

NOTES

1 An earlier version of this material was presented as a talk to the Working Group on Science and Society, sponsored by the Humanities Center at Wayne State University in February, 2012. I would like to thank those in attendance for comments and discussion; Travis Figg and Alex Gromak, in particular. I have also benefited tremendously from discussion with Gonzalo Munévar, who has graciously granted me access to drafts of his unpublished book *The Dimming of Starlight*. Thanks to Gonzalo Munévar and Travis Figg for commenting on a previous draft.

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3 This drama is rehearsed in Brand (1977).

4 For discussion, see McQuaid (2010).

5 I owe these examples to Cockell (2007, 67–88).

6 This suggestion is elaborated and defended in (Munévar, in press).

7 For more examples see Cockell (2007, 89–110).

8 For an argument that exploring extrasolar planets would increase (rather than decrease) our reverence for Earth, see Cockell (2006).

9 http://www.users.globalnet.co.uk/~mfogg/biblio.htm.

10 This and related issues raise questions about the morality of using space resources in general. See Schwartz (2011). Thanks to Travis Figg for raising this issue.

11 A view that holds non-living objects as the source of value is, technically speaking, a non-anthropocentric view. The next section considers a number of such views; for the moment I am confining my attention to those views that place value on living organisms.

12 Owing to the difficulty of *completely* sterilizing probes sent to the planet, perhaps we will find Martian life of our own creation! See Cockell (2005).

13 Let us not overlook how daunting of a task this is. The existence of life on a planet can be confirmed by observing *a single* native microbe. The non-existence of life on a planet can only be confirmed by uncovering *zero* native life forms on and in the *entire* planet. If it is decided that native life ought to be preserved, then a serious question is raised concerning how cautious and how diligent humans must be in searching for native life on a candidate planet. For discussion, see Haynes (1990, 178), and Marshall (1993, 231–33). In this paper I am simply assuming, as convenient for dialectical purposes, that life does (or does not) exist on the candidate planet.

14 Notwithstanding views according to which life in nature is valuable only to the extent to which it is autonomous. For one such view, see Katz (1996).

15 For discussion, see Norton (1987, chapters 2–6).

16 For steps toward implementing this idea, consult Cockell and Horneck (2004 and 2006).

17 Travis Figg suggested in conversation that although Mars may not be unique on galactic scales, it might nevertheless be the only environment of its kind that humans are capable of visiting, implying that Mars has unique potential as a place of transformative value. So the transformative value of Mars may counsel preservation after all. A general aside on transformative value: The transformative value of an environment is predicated on the capacity of the environment to cause a person to claim that her values have improved after having experienced the environment in question. One might wonder whether such a person is entitled to objectively assert that her new values are superior to her old values. One can't say that her values are superior because she now appreciates nature where before she did not, that would just beg the question. She could very easily have had a contradictory experience and concluded that her old monetary-values are superior. I fail to see how such an outcome is prohibited unless one is prepared to countenance some antecedent source of natural value.

18 What follows is drawn from Schwartz (2011, 74–75).

19 Even here, it depends on how permissive we are in engaging in counterfactual analysis. Is it not physically possible that the materials that eventually became our solar system produced just one planet which orbited its star at just the right distance to evolve life?

20 This possibility was brought to my attention by Alex Gromak.

21 In what follows, I draw from MacArthur and Boran (2004).

22 Schwartz observes that space-advocates are more likely than others to recognize beauty in space, undermining Sparrow's belief that terraforming would fail to involve the recognition of beauty (2011, 82–84).

23 It would also leave humanity better prepared to re-attempt the terraformation of Mars, should the need arise. Thanks to Gonzalo Munévar for making this point.

24 What follows is drawn from Schwartz (2011, 84–86).

25 As Sparrow appreciates: "The arguments above, because they proceed via our character, still fall short of justifying a total injunction on terraforming… If, for instance, terraforming were a project undertaken with genuine reluctance, in full knowledge of what was being destroyed, because no alternative existed for the survival of the human race, then it would not demonstrate hubris…" (1999, 239–40).

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