The Necessity of the Landscape Architect as a Voice in the Continued Dialogue on Space Exploration

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The aerospace community clearly recognizes the importance of fully ensuring the well-being of the humans involved in NASA's Evolvable Mars Campaign (EMC), and any other mission which involves a critical human component. This paper introduces the landscape architect as a generalist, a humanist, and a therapist, who is distinctly qualified to address some of the issues that arise in this discussion on habitability in space. The current role of the landscape architecture is to manipulate the outdoor environments we inhabit on planet Earth. The bluescapes, greenscapes, and greyscapes. This paper challenges that paradigm by introducing the notion of deadscapes. Deadscapes are (a) closed and finite indoor environments, or (b) foreign and extreme environments not conducive to sustaining any form of flora. This research explores how deadscapes can be transformed into restorative environments by using knowledge exclusive to the discipline; offering is introduced as a direct countermeasure against socio-psychological stressors caused by these Isolated and Confined Environments (ICEs), as outlined in aerospace's Human Factors Model (HFM). This theory is a statistically significant and predictive theory that will serve to augment the mental-health and well-being of astronauts, and their adaptation-to and performance-in new environments in space. ART asserts that there are four core components of restorative settings: (a) Being Away, (b) Extent, (c) Fascination, and (d) Compatibility; where each of these components hold a direct relationship between an individual crew member, the habitation, and the Marscape. Second, the theory is used to present design solutions that transfer the proven mental-health benefits of ART to discernable spatial interventions applicable to the EMC. Of particular note is a schematic long-term growth strategy for master-planning the settlement of Mars, that is derived directly from the core principles of ART.

Nomenclature

ART	=	Attention Restoration Theory (physiological and socio-psychological stress counter-measure)
EMC	=	Evolvable Mars Campaign
HFM	=	Human Factors Model (physiological and socio-psychological stresses)
ICE	=	Isolated and Confined Environment
Marcology	=	The amalgamation of all the data collected about Mars, from geology to nomenclature, etc.

I. Introduction

LANDSCAPE ARHITECTURE-ADJACENT disciplines such as Horticulture, Biosystems Engineering, and Architecture have been readily recognized and accepted as crucial collaborators within the Environmental Control and Life Support Systems (ECLSS) domain. The primary objective of this paper is to give merit to the landscape architect as another critical member of the discussion when it comes to solving the nuanced issues that arise when considering the grandiose objectives of human exploration and settlement beyond our own planetary body. The theoretical perspectives, approaches, and methodologies of that emerge from the discipline of landscape architecture can have very direct applications to these objectives. While there have been noteworthy proposals in aerospace wherein 'nature' is a significant aspect of the design – such as the Stanford Torus or the Bernal Sphere – it would be a mistake to think that the involvement of the landscape architect should stop with just some helpful or interesting ideas. Any of the disciplines that have been mentioned can formulate good solutions if provided with the

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proper tools, so the argument presented here is not that landscape architects are the only ones who can provide good solutions; rather, that landscape architecture can provide that foundational toolkit of insights that can be applicable to a range of problems.

The challenge landscape architects face in attempting to have their ideas heard by NASA and other agencies is no different from the problems that are faced by space-architects or other researchers in the Habitability domain; that is the problem of pitching our contributions as essential factors for mission success. That is not the goal of this paper. There are no illusions here that the aesthetic or socio-psychological solutions that landscape theory may afford are more important than research conducted by researchers in Life Support Systems Engineering and Analysis, or Human/Robotics System Integration, et cetera. Clearly, a hierarchy of importance needs to be maintained by NASA in allocating resources, to what degree importance should be placed on ideas proposed within this paper will be left up to the reader. However, what is essential to making that valuation is that the reader is relieved of two dangerous misconceptions about the discipline: (a) the premise that equates landscape architecture with *green space* or *nature*, and (b) the premise that landscape architecture in limited to the outdoors. These two false premises are a result of the discipline itself struggling to promote an accurate definition of our relatively young profession to the world. So then, the scope of the landscape architect's work is largely viewed as simply an off-shoot of architecture that is limited to designing the outdoor spaces of our urban or rural environments. Thus, the suggestion that we should be one of the first disciplines called on to masterplan of the first settlements of Mars, or to design the layout and program of an orbital greenhouse, is met with immediate apprehension because we a subconsciously rooted in these two false premises.

Yes, on the surface it may seem far-fetched that landscape architecture has a role to play in the discussion in these extreme, isolated, and confined conditions that are largely infeasible locations to grow flora; but again, it needs to be clearly stated that landscape architecture never has, and never will be limited to only working with green-materials. Furthermore, what is to prevent the integration of green-material into the indoor habitats of the astronauts living in these ICEs, other than the fact that that opposes our definition of what traditional landscape architecture entails? These enclosed systems with finite space may not seem as though they belong in the realm of landscape architecture, yet the theoretical perspective of this paper allows us to expand the definition of landscape architecture to include a typology of 'the closed and finite indoor system' as opposed to the typical condition of 'open and interconnected outdoor systems'. As we remove these false premises, we begin to expand our perspective to be able to address these uncommon and future environments, and develop the resources necessary to ensure the success of these complex systems. Again, this position of this paper is one that strongly advocates for a collaborative engagement of landscape architecture and more specialized disciplines – such as horticulture or biosystems engineering – because it will not be possible to achieve this success in isolation. Thus, the first major research problem revolves around a critical assessment of the current state of knowledge in landscape architecture, and noting the specific areas in which these theories and approaches overlap with the problems of adjacent domains.

II. A Seat At The Table

A. Enter the Landscape Architect: The Generalist

Landscape architecture is a discipline that is caught in a dichotomy. It is lodged in an ambiguous and estranged position that leaves other disciplines questioning whether landscape architecture is an art or a science. In a world that tends to construct binary oppositions as a means of simplification, operating suspended between the two domains leaves us unclaimed by either. However, putting aside this tendency to compartmentalize the functions of academic and professional domains, the landscape architect is fundamentally a generalist. Rather than being a detrimental point, this should be viewed as an advantageous position, where the dualism of the discipline has led to the cultivation a holistic tradition of both art and science. As the discipline has developed, there has been a repositioning of preference within academic research and instruction, which now privileges a scientific and rationalized approach to natural science, environmental management, and techniques of ecological restoration instead of the more traditional aspects of the humanities, design theory, or history. This refocusing is due in part to "the popular notion that subjectivity, poetry, and art are welcome in the private domains of the gallery or the library but are no match for the power of 'rational' instrumentality in 'solving' the real problems of the world is to understand these problems in terms that are somehow external to the world of symbolic communication and cultural values."[2]

2 Corner, J. "Ecology and Landscape as Agents of Creativity." The Landscape Imagination: Collected Essays of James Corner 1990-2010, edited by J. Corner and A. Bick-Hirsch, New York, Princeton Architectural Press, 2010, pp. 262.

"Through Yvonne Clearwater's initiative, the Space Human Factors Office at NASA-Ames defined habitability as: 'A measure of the degree to which an environment promotes the productivity, well-being, and situationally desirable behavior of its occupants'."[3] Now, landscape architecture has long promoted the tenets of *phenomenology* – i.e. the study of the subjective human experience – as a core philosophical consideration in the implementation of spatial design. This really seems to parallel the definition of habitability. Both have environmental elements that effect behavior largely through aesthetic, spatial, and sociological maneuvers. It then stands to reason that if aerospace's concepts of habitability and landscape's concepts phenomenology have areas of overlap, then there are also probable solutions that would apply across both that may not currently exist in each domain on its own. What is distinct to the landscape profession is not that there is any greater measure of creativity with regards to the way we approach a problem, the difference is that the scale at which we approach the problem is larger; both literally and figuratively. Literally, in the sense that the horticulturalist and architect may comfortably use scales up to 1:25 versus engineers who may go up to 1:2500, and landscape architects whose plans may range from enormous ecological scales back down to the minutiae of the architectural scale within the same project. Figuratively, the approach is greater due to the previously mentioned dichotomy of academia, where so much knowledge has been appropriated from so many other disciplines that it is often difficult to define what a 'typical' landscape project may entail. That is the distinct benefit: the interdisciplinary manner in which landscape architects can consolidate disparate information to form cohesive, systemic, and holistic solutions at a range of scales to fully address a problem relation to any environment humans inhabit.

B. Meeting the Landscape Architect: The Humanist

The underlying argument being made throughout this paper is that, while the feasibility of space exploration still rests heavily on advances in scientific understanding and technological progress, the success of these systems and of the overall mission is based on the human component. A post-robotic mission to Mars that involves humans must take into consideration the innate failings of humans with regards to physical, and socio-psychological stresses that impact the performance over time. NASA has slowly adopted a recognition that a measure of importance should be placed on human factors considerations – such as the socio-psychological and physical impacts that can be marginally negated through well-considered architectural design – and has extensive has extensive literature on space psychology and crew safety. Yet, the problems that are made apparent through this literature has only recently begun to be addressed through the concept of habitability. Rather, the solutions of habitability have only recently begun to break through the systemic resistance that is has met. That resistance may stem largely from the understandable need to place greater emphasis on the engineering challenges and constraints first, but may also have an element of bravado associated with it. That is to say that NASA seems very comfortable with its selection process, and may not see an immediate need for architectural aesthetics that promote a positive psychology, when it already has the most physically and mentally fit bodies available in the continental United States. This second element of resistance is one that truly needs to be addressed, because this is a problem that may not be a factor now, but will be a fundamental factor as soon as attention is focused on longer-missions, permanent settlements on other planetary bodies – particularly the Evolvable Mars Campaign (EMC).

Here is the problem in no uncertain terms: Humans are not machines, they get tired. When they get tired they make mistakes. In space, these mistake can – given a large enough sample – build up to a catastrophic failure. If the status quo is maintained – i.e. "We will just pick the most elite people and train them to never make mistakes" – we are left with a short-sighted measure for success. Humans fatigue both mentally and physically and need rest to recharge. The solution this paper proposes is the very convenient landscape concept of Attention Restoration Theory (ART); a four-part model acts that acts as a preliminary countermeasure in a significant, and more importantly, a predictable way. In 1985, NASA contracted Rockwell International (now Boeing-North American) to conduct a five-part systematic review of potential safety threats and hazards that the crew might encounter on the future International Space Station (ISS), called the Space Station Crew Safety Alternatives Study. Volume 3 focused on the Safety Impact of Human Factors, featuring the Crew Safety-Human Factors Interaction Model, which Cohen and Junge developed for the early Space Station program[4]. This model consisted of five fundamental topics regarding the survival and well-being of the crew on extremely long duration missions. These topics were Protocols, Crew Incapacitation, Task Related Issues, Critical Habitability and Personal Choice. They developed the interaction model in such a way that it could be *predictive* of the objective environmental or operation conditions and the creation of potential safety hazards.

3 Cohen, M. M., "Designing Space Habitats for Human Productivity," Journal of Aerospace, Society of Automotive Engineers, Vol. 99, No. 1, 1990, pp. 13.

4 Cohen, M. M., and Haeuplik-Meusburger S.. "What Do We Give Up and Leave Behind?" 45th International Conference on Environmental Systems. Bellevue, WA, ICES SC, 2015, pp. 4.

The intermediary steps between these two extremes of causality were the effects on human performance and the results of degraded or delayed performance. The model contains one stressor/milestone, one human performance milestone and one safety hazard threshold, with two intervening countermeasure points. The first opportunity for intervention is the countermeasure against stress. If this countermeasure fails, performance degrades. The second opportunity for intervention is the countermeasure against error. If this second countermeasure fails, the threshold of a potential safety hazard may be crossed[5].

That is to say that the physical limitations of the environment of the International Space Station, or other similar Isolated and Confined Spaces (ICEs), can directly affect the behaviour of the crew over extended periods of time, in such a way that life-threatening hazards can potentially arise. The section on Critical Habitability – which includes confinement, isolation, and separation from normative human society and nature – seemed to be the most significant concern and stressor on the well-being of the crew; "particularly in terms of what is lacking from the living and working environment"[6]. This seems like the correct place to introduce the idea that what is lacking is *greenscape* FIGURE 1.

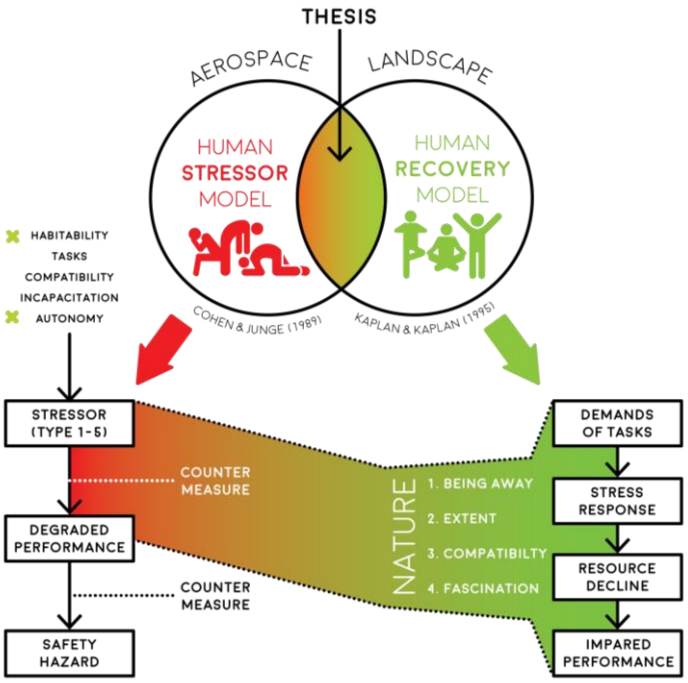

FIGURE 1. Attention Restoration Theory acting as a primary countermeasure to critical human stressors.

Cohen and Haeuplik-Meusburger recently suggested at the 45th International Conference on Environmental Systems that, "in terms of physical limitations of crew, countermeasures against stress should take into account ecological considerations in design and environment"[7]. This proposal stems from their exploration into integrating classical and impressionist paintings and other images as a countermeasure through which the common stressors – restricted diet, constant confinement, disconnection from the natural world, no separation of work and social life, no family life, and repetitive tasks – are mitigated. For example, considering whether physically incorporating Cezanne's *In The Forest* or Monet's *Water Lilies* into the space habitat would act as a sort of talisman to actively draw the viewer into the painting in a sort of other-body way, where the paintings or pieces of art would help compensate the Martian crew for their confinement? It is a lengthy philosophical exploration that we will move on from for two reasons: the first being that their hypothesis can be positively and undeniably confirmed through extensive quantitative and qualitative parallel studies in landscape architecture, the second being that it is a concept and effect that can be considerably enhanced through the design counter-measures that will be proposed in the section *Deadscapes: Design Ideas*.

C. Hearing the Landscape Architect: The Therapist

Without giving an extensive history of the links between landscape and health, it is sufficient to state that landscape architecture is the continuation, and disciplined study, of a tradition as old as civilization. The intuition of the ancient peoples and religions, lead them to hold foundational tenants that linked their societies to nature. While these foundational elements have receded in the face of industrialization in the past centuries, the intuition that landscape and health are inextricably linked, still hold strong. Frankly, in large part due to the forgetfulness and

5 Cohen, M. M., and Junge M. K., "Space Station Crew Safety: Human Factor Models," 28th Annual Proceeding of the Human Factors Society, Mofett Field, CA, NASA Ames Research Centre, 1984, pp. 1.

6 Cohen, M. M., Haeuplik-Meusburger, "What Do We Give Up and Leave Behind?," pp. 6

7 Ibid., pp. 20

hubris of humanity, we have thrown our own planet's ecology into irrevocable disrepair. Thus the considerations for surveying places within our solar system is not purely to feed the desire to explore, but also for not so distant necessity of establishing humanity in other places than an ailing Earth. The following excerpt from the work of Velarde, Fry, & Tveit – drawing on work by Cooper-Marcus & Barnes and Ulrich – succinctly describes the legacy:

> *Links between landscape and health have been observed for a long time and in many different cultures and societies. The belief that viewing vegetation, water and other natural elements can ameliorate stress and is beneficial for patients in healthcare environments dates as far back as the earliest large cities in Persia, China and Greece. In the Middle Ages, the first hospitals in Europe were infirmaries in monastic communities where a cloistered garden was an essential part of the environment used to bring relief to the ill. Through history, the connection between nature and healing was gradually superseded by increasingly technical approaches and the idea that access to nature could assist in healing lost much of its significance. However, in the last 25 years these traditional ways of linking nature and health effects have re-emerged as a topic of interest in the field of human health*[8].

There is much more detail that can be unfolded in all these historical precedents of early 'landscapes of health' to the modern society's reinvigoration regarding natural ecologies and 'green-consciousness'. Many design solutions can also potentially by derived from these Earth-based gardens and applied to the Marscape or other space habitations. To reiterate, this theory is not just about introducing 'green things' to improve the habitability of an space environment; it also provides a context for explorations that address the very dead landscapes of space that are not at all conducive to terraforming and will require finesse to address the spaces outside of the habitats as well as the insides.

III. Attention Restoration Theory

The weakest link in space exploration is human error. And the humble position of the author is that the aerospace industry needs a more reliable method through which this glaring problem can be countered. The need for a consistent way to manage stressors that could lead to a snowball of negative physiological and socio-psychological effects on the space crews, is paramount. By-and-large this is currently accomplished through the process of astronaut selection, psychosocial adjustment, group dynamics, rigorous simulation testing and psychological support while on mission. But this is not a sustainable method of prevention. Attention Restoration Theory can be used as that countermeasure. The knowledge of how to apply the principles of ART in physical manifestations is the primary contribution of the landscape architect.

D. Summary of Current Knowledge

As previously mentioned, there was a paradigm shift within the landscape architecture discipline, in the 1970-80s, away from traditional artistic elements towards a more robust science; where even the philosophical aspects of the underlying design theories were put the test. In Kara's psychological studies on landscape experience, we find that the quantity and quality of landscape perception and research underwent rapid change in this period; with most scholarly effort being put into empirical research that aimed to establish reliable and valid assessment methods of landscape perception[9]. "The field of landscape perception developed new concepts – e.g. scenic quality, landscape preferences, and visual attractiveness – discovered new methods, and accumulated research data to support its claims"[10]. A key concept that arose was the idea of Attention Restoration Theory (ART), pioneered by the environmental psychologists Rachel Kaplan and Stephen Kaplan in 1989, and subsequently built on and verified by others.

An comprehensive body of research evidence has accumulated in support of ART, dealing with the distinct ability of a *natural setting* to foster effective socio-psychological functioning and well-being. A concise summary of the progression of this theory can be drawn from Herzog, Maguire, & Nebel[11]:

8 Velarde, M. D., Fry G., and Tveit M., "Health Effects of Viewing Landscapes-Landscape Types in Environmental Psychology," Urban Forestry and Urban Greening [online journal], Vol. 6, 2007, pp. 200.

9 Kara, B. "Landscape Design and Cognitive Psychology," Procedia Social and Behavioural Science [online journal], Vol. 82, 2013, pp. 289.

10 Kara, "Landscape Design and Cognitive Psychology," pp. 289.

11 Herzog, T. R., Maguire C. P., and Nebel M. B., "Assessing the Restorative Components of Environments," Journal of Environmental Psychology [online journal], Vol. 23, 2013, pp. 159.

Earlier work is reviewed by Kaplan (1995). More recent studies include Kaplan (2001), Korpela, Hartig, Kaiser, and Fuhrer (2001), Kuo, Bacaicoa, and Sullivan (1998); Kuo and Sullivan (2001), and Taylor, Wiley, Kuo, and Sullivan (1998). There have been studies dealing with the distinctive benefits of restorative settings (Herzog, Black, Fountaine, & Knotts, 1997) and, as we shall see below, with the proposed features of such settings. Some of the most compelling work has linked the beneficial effects of nature with its effects on attentional capacity (Wells, 2000; Taylor, Kuo, & Sullivan, 2001), including two studies pinpointing a mediating role for directed attention in the relation between natural settings and beneficial outcomes (Kuo, 2001; Kuo & Sullivan, 2001).

There are "three main kinds of health effects have been identified in these studies: (a) short-term recovery from stress or mental fatigue, (b) faster physical recovery from illness, and (c) long-term overall improvement on people's health and well-being"[12]. The Kaplans state that the foundation of the constructs central to ART came from the work of William James as far back as 1892. This idea of *voluntary/directed attention* versus *involuntary attention* was meant to suggest that there are activities that do not in themselves explicitly attract attention, but are important to attend nonetheless. This leads to the idea that to exercise any aspect of your will to accomplish a task requires some amount of effort. The more intensive or prolonged the use of *directed attention*, the more the effort is compounded; leading to fatigue of the mechanisms that serve it. In this literature authors are usually referring to the person's mental function as being in a state of *mental fatigue*, but this may also be accompanied by *physical fatigue*[13]. *Restoration* has been defined as ''the process of renewing physical, psychological and social capabilities diminished in ongoing efforts to meet adaptive demands"[14]. ART asserts that there are four properties or features of restorative settings: *Being Away*, *Extent*, *Fascination*, and *Compatibility* FIGURE 2.

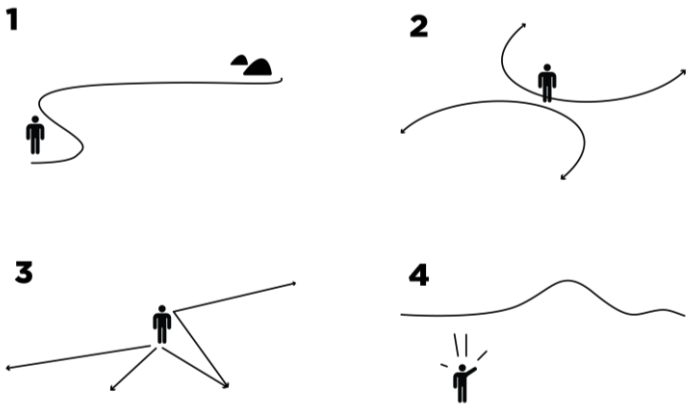

FIGURE 2. Central components of ART: Being-Away, Extent, Compatibility, Fascination.

Kaplan's Attention Restoration Theory model holds a view similar to that of Cohen's Human Factors Model, where the consequences of mental fatigue can be serious: leading to inaccuracy, impulsivity, irritability, and incivility. Recovery of effective functioning is enabled by settings that have key properties as discussed below. Such settings are known as *Restorative Settings*/*Environment* – the term environment should not be confused with meaning '*natural'* in all cases. The benefits of a deeply restorative experience include clearing away of mental noise, recovery of directed attention capacity, and enhanced ability to reflect on issues of importance"[15]. Both quantitative methods and qualitative methods have been used in the literature, and both are valid approaches, with the strength of the conclusions varying based on the methodology and particular design of the study. Generally, the best predictive model is still the original four-component ART.

It is important to note that the Health Council of the Netherlands and Dutch Advisory Council for Research on Spatial Planning Nature and the Environment hold that if a subject perceives that he/she feels better, this is an indicator of a positive health effect regardless of verifiable physiological changes[16]. And with respect to the conditions the crew of a Mars habitat or space vehicle will contend with, the perception of benefit is as important as measurable physical or socio-psychological markers. Zube, Sell, and Taylor categorize the main trends in landscape

12 Velarde, M. D., Fry G., and Tveit M., "Health Effects of Viewing Landscapes-Landscape Types in Environmental Psychology," Urban Forestry and Urban Greening [online journal], Vol. 6, 2007, pp. 199

13 Kaplan, S. "The Restorative Benefits of Nature: Toward an Integrative Framework," Journal of Environmental Psychology [online journal], Vol. 15, 1995, pp. 169-182.

14 Staats, H., and Hartig T., "Alone or With A Friend: A Social Context for Psychological Restoration and Environmental Preferences," Journal of Environmental Psychology [online journal], Vol. 24, 2004, pp. 200.

15 Herzog, Maguire, and Nebel., "Assessing the Restorative Components of Environments," pp. 159.

16 Velarde, Fry, and Tveit, "Health Effects of Viewing Landscapes-Landscape Types in Environmental Psychology," pp. 209.

perception research in terms of four paradigms: the expert, the psychophysical, the cognitive, and the experiential[17]. These concepts overlap to create a holistic view of landscape as not just spatial environment or physical application, but as an effector involving "the flow of experiential qualities, images, thoughts, and meanings. It is a bodily experience and takes place in time and space"[18].

E. Central Components

1. Being Away

The first component that Kaplan & Kaplan describe as being necessary in a restorative environment is 'being-away'. This refers to settings that call on mental content different from that ordinarily elicited. The idea is that avoiding well-worn mental content allows one to avoid the use of 'directed attention' required to support the activation of such content[19]. If we could use the phrase: "getting away from it all" – whether through physical relocation or mentally through a change in task – it allows the fatigued direct attention to rest. For an environment to be restorative, there needs to be a tangible change of scenery and/or an escape from the aspect of life that is the cause of directed attention and routine action – "such as distractions, obligations, and pursuits of purposes and thoughts"[20] FIGURE 3.

FIGURE 3. *Greetings From Mars* by Julien Mauve ©2015.

There is a tendency to frame this and the other central components of ART as *urban (or built)* versus *natural*, because that is the common condition on Earth. However, in the new Marscape we discard the familiar notion of urbanity altogether. This may seem to be a hindrance to drawing parallels from this model; but again, it is simply a tendency that arises from simplification of the concept. For even in the foundational material – and subsequently in further study – Kaplan clarifies that "the sense of being-away does not require that the setting be distant. Natural environments that are easily accessible thus offer an important resource for resting one's directed attention"[21]. In fact, Scopellitia & Giuliania expand this through their research; "being-away refers to a change of scenery and experience from everyday life. But what seems to be necessary for an environment to be restorative is to afford a conceptual rather than a physical distance from the ordinary. A new environment is not restorative in itself. It becomes restorative if it promotes a change in one's thoughts from the pressures and obligations of everyday life"[22]. In a quantitative study, Herzog, Maguire, & Nebel posed this question to participants to illustrate the concept of being-away: "Sometimes even when you are very near home it can feel like you are far away from everyday thoughts and concerns. How much does the setting have that feeling of being away?"[23]. And to put it a different way: if a person was to always work in one room for 8 hours a day, how nice would it feel to leave the room and just pace the hallway for 15 minutes?

This is the most essential aspect of the theory for the aerospace community to take hold of; because it can dictate changes from the minute scheduling of an astronaut's day, to large master planning strategies for a Martian settlement over the next 50 years. If there is anything to remember from this paper it is this: one *cannot* be restored

17 Zube, E. H., and D. G. Pitt. "Cross Cultural Perceptions of Scenic and Heritage Landscapes," Landscape Planning [online journal], Vol. 8, 1981, pp. 69.

18 Kara, "Landscape Design and Cognitive Psychology," pp. 289.

19 Herzog, Maguire, and Nebel., "Assessing the Restorative Components of Environments," pp. 159.

20 Laumann, K., Garling T., and Morten K., "Rating Scale Measures of Restorative Components of Environments," Journal of Environmental Psychology [online journal], Vol. 21, 2001, pp. 31

21 Kaplan, "The Restorative Benefits of Nature: Toward an Integrative Framework," pp. 174.

22 Scopellitia, M., and Giuliania V., "Choosing Restorative Environments Across the Lifespan: A Matter of Place Experience," Journal of Environmental Psychology [online journal], Vol. 24, 2004, pp. 424.

23 Herzog, Maguire, and Nebel., pp. 162.

in the same environment that causes one stress! The restorative space does not have to be large or distant, but it *must* be separate.

2. Extent

The second proposed component of restorative settings is 'extent'. According to Kaplan, extent is a spatial construct that comes easily in the distant wilderness, although it is not necessarily held to that environment and can be a factor in any spatial environment. "Even a relatively small area can provide a sense of extent […]. Extent also functions at a more conceptual level. For example, settings that include historic artifacts can promote a sense of being connected to past eras and past environments and thus to a larger world"[24]. "A setting has extent if it has sufficient content and structure that it can occupy the mind for a period long enough to allow directed attention to rest. Such settings are characterized as being 'whole other worlds'"[25]. Kaplan says that there are two sub-properties to extent, which are *connectedness* and *scope.* 'Scope' refers to the environment that is extended in time and space, so that it is perceived to be possible to enter and spend time in it; whereas 'connectedness' refers to the constituent parts of a space forming a cohesive greater whole[26]. In Herzog, Maguire, & Nebel's study, they posed the question to research participants; "Sometimes even a small setting can feel like a whole world of its own. It can seem like there is enough room to get completely involved in the setting and not even think about anything else. How much does the setting seem like such a 'whole other world'?"[27]. Put another way: if an individual were in a small room for a number of hours but that room had a few paintings or a book of Sudoku puzzles, would they be able to get lost in the painting or puzzles for an extended period of time?

What is interesting about this new Marscape is that the component of extent is almost universal in the landscape. Save for the robotic probes, it is untouched by human hands. One could contend that the selection process of the crew of the first manned mission to Mars will select those that would see this expanse as sublime, rather than desolate; that they would revel in the opportunity to be humanity's first ambassadors and explorers, rather than feeling abandoned and apart from mankind. So then, in talking about the application of extent, it is actually more noteworthy to consider the habitat itself as somewhat of a barrier to the new world they have inhabited. The habitat is their tether to survival, but in the respect that it is their primary location of living and working, the 'natural' Marscape just 'outside' would act as a reprieve and alleviation from the routine setting they find themselves in daily. Furthermore, the consideration of extent can apply to the habitat itself particularly as it grows – recall the sub category of connectedness. By all apparent indications, the scientific community views the Marscape, and other planetary bodies we may explore, only as a resource. There is not an apparent consideration that this so-called 'hostile' landscape can in fact work as a respite – and even recreational – place for the crew if approached and designed correctly. This foreign wilderness is fascinating, not only as a scientific research site, but as a design challenge for creating a completely unique restorative environment. So then the Marscape needs to be accessible to the astronauts not only as they conduct research in the field, but also must be available to them in the capacity that allows for relaxation, contemplation, or secondary social spaces separate from the habitat itself that provides the element of extent. Congruently, the same should be said for the interior of habitat module. "A restorative environment is perceived as a whole in which all elements are coherently related. Second, it is perceived extended enough to engage one's mind, because it promises much more to explore than what is immediately perceived"[28]. This idea of exploration is almost an inherent quality of the Marscape, and leads directly into the next central component, 'fascination'.

3. Fascination

Beginning with Herzog, Maguire, & Nebel's simplified question that illustrates 'fascination': ''How much does the setting draw your attention without any effort on your part? How much does it easily and effortlessly engage your interest?"[29]. This third proposed component refers to e*ffortless attention*, and is sub-divided into what we can call *soft/quiet* or *hard/loud* fascination. This component is essential for restoration because the theory distinguishes between directed/voluntary and involuntary attention. "Involuntary attention does not demand mental effort and is attracted by stimuli having a 'directly fascinating quality'. Directed attention, on the other hand, demands mental

24 Kaplan, pp. 174.

25 Herzog, Maguire, and Nebel., "Assessing the Restorative Components of Environments," pp. 160.

26 Laumann, Garling, and Morten, "Rating Scale Measures of Restorative Components of Environments," pp. 31.

27 Herzog, Maguire, and Nebel., pp. 162.

28 Scopellitia and Giuliania, "Choosing Restorative Environments Across the Lifespan: A Matter of Place Experience," pp. 424.

29 Herzog, Maguire, and Nebel., pp. 162.

effort that can be depleted"[30]. Typically, natural environments qualify as soft fascinations, because while they do hold the attention, it is involuntary; a moderately intense and aesthetically pleasant stimulus which does not interfere with the possibility for internal reflection and self-contemplation. Natural patterns are encoded into one's mental-DNA, thus processing these patterns is not dramatic nor mentally tiresome to attend to; thereby allowing the depleted directed attention to recover.

It is possible that the unfamiliarity of the foreign Martian landscape will be subtly off-putting in terms of the complete desolation and absence of life; however, it can be hypothesized that the landscape itself has geological and morphological parallels to locations on Earth, and thus will act in the traditional manner of low involvement in terms of fascination. In some respects, when the crew must conduct research within the landscape, a hard fascination comes into play, requiring concentrated involvement with the Martian ecology and thus supporting restoration to a lesser extent. Remember, the component of being-away requires that the restorative environment be separate to the frequent or commonplace environment; so then the areas of fascination – and by extension, restoration – will fluctuate based on the area in which a working environment is currently present. This means that we need to have designated spaces for restoration and unfettered fascination that is adjacent to the living-working environments where fascination will be present at a reduced level.

4. Compatibility

The last component of a restorative setting is 'compatibility'. "The natural environment is experienced as particularly high in compatibility. It is as if there were a special resonance between the natural setting and human inclinations"[31]. Researches conclude that a setting is compatible if there is a good fit between an individual's purposes or inclinations and the kinds of activities supported, encouraged, or demanded by the setting. Put simply, compatibility refers to the degree of fit between the individual's predispositions and the actions required of the environment. So then a setting could be compatible on one level and incompatible on another. This continuum ranges from very general activities – such as the freeness of movement – down to specific tasks – such as collecting core-samples of the Martian surface strata. One might also have several inclinations at roughly the same level, and the setting could be compatible for some of them but incompatible for others[32]. Thus, conceptualizing this central component is probably the most complex of the four.

The first Mars inhabitants will be researchers, and as such, will have individual and group goals that are directly connected to the marcology. Furthermore, the selection of these researchers will follow NASA's rigorous selection process, ensuring that the inclinations of the individual would be highly compatible with the environments they are being placed in. What may be interesting in this Marscape is that many of the instinctual behavioural patterns relating to the natural setting on Earth – such as the 'predator role' in the observation of other flora and fauna, and the idea of needing areas of 'prospect and refuge' in relation to potential elements of danger – will be non-existent. This may initially lead to a sort of cognitive dissonance and unease that may act as a stressor to the crew, however, they may abate over time. These basic instinctual roles will also still exist in-part – e.g. locomotion across the landscape, domestication of a foreign place, and survival skills. As long as some of these natural behaviours are maintained, these patterns should lead to increased compatibility with the Martian landscape. For the sake of continuity, the Herzog et al. study yielded the following question to help define of compatibility: "Settings can either help you feel comfortable and at ease or they can make it hard to do so. How much does it seem like the setting would make it easy for you to feel comfortable and at ease?"[33]. This ease-of-comfort is the kernel that parallels the objectives of NASA, the AIAA, and the subsets of researchers that promote the concepts of habitability – specifically, to provide supportive and comfortable living and working environments and enjoyment of life, in full recognition of the technical challenges presented by the environment.

F. Advances in the Theory

But of the dozens of subsequent studies based on Kaplan & Kaplan's theory, many considered fracturing the four basic components into additional rating scales to isolate the minutiae of other testable experiential factors. However, they either failed to be predictive of behaviour, or were redundant in terms of yielding a distinct actionable direction in landscape design. For the purpose of applying ART to the discourse on counter-measures towards human stressors in space habitation, we will skirt a large portion of literature that deals with the intricacies of the advanced correlative models, so as to focus on those factors that can apply directly to our discussion.

30 Laumann, Garling, and Morten, "Rating Scale Measures of Restorative Components of Environments," pp. 32.

31 Kaplan, "The Restorative Benefits of Nature: Toward an Integrative Framework," pp. 174.

32 Herzog, Maguire, and Nebel., "Assessing the Restorative Components of Environments," pp. 160.

33 Ibid., pp. 162.

The basic conclusion of ART is that, "a significant part of the satisfaction derived from nature does not require being in the natural setting, but rather having a view of it. These studies that have shown health benefits related to experiencing nature have been based on opportunities for noticing and observing it, rather than on performing activities in nature"[34]. A note must be made at this point that this model is usually quantitatively and qualitatively tested as 'the natural' versus 'the urban' environment. Those are the dominant typologies of Earth that this model applies to. On the other hand, the conditions of Mars and space are not only un-built, but the natural environment is alien, foreign to our common understanding of what constitutes nature. It is here, again, that the reader must be dissuaded from the instinct to assume that, because of these differences, the ART model would not correlate with the Martian environment. As the central components of the model have been presented, it should be apparent that the model is not restricted to any particular spatial application, but relates more to mental states and behaviours that result from any particular *shift* in environment. Put another way, it is not the base-states of the environment one is in that dictates whether it is a good or bad environment; likewise, it is not the presence or absence of 'green-material' that defines a restorative environment but whether or not there are 'elements of restoration' that exist in that environment. These elements of restoration are being-away, extent, fascination, and compatibility, and they manifest themselves predominantly through natural settings.

Taken as a starting point, the Kaplan & Kaplan theoretical perspective emphasizes the restorative potential of an environment as a "perceived quality". Thus, if the perception of the physical properties of a place can be manipulated to better fit the basic needs and basic inclinations of a person, the predictive power of the model states that these places will be more preferred and more restorative. These preferred place are usually natural environments but not necessarily. The work of Staats, Kievieta, & Hartig looked at making a methodological improvement to the ART by attempting to standardize the "behavioural perspective" from which the preference rating was given. That is to say that since different behaviours require different amounts of directed attention, then one's perception or attitude at any given time affects the behaviour. Where the traditional model is called the *Preference-Model*, they introduced the *Expectancy-Model*. Much like the HFM, in the Preference-Model, an attentionally fatigued person has difficulty concentrating, suffers from increased irritability, and is prone to errors on cognitive tasks. Using the components of being-away, extent, fascination, and compatibility, they can select a different environment that does not require reliance on directed attention; resting the inhibited mechanisms to recover the capacity to direct attention[35]. The differentiation of the Expectancy-Model being that "the attitude toward a behavior is based on (a) the likelihood that a behavior will have specific outcomes, and (b) the evaluation of those outcomes."[36] This adds an element of reality – and is more applicable to Mars – because it introduces the magnitude that human perception plays in the discussion. Scopellitia & Giuliania highlight this fact, stating that "past research on restorativeness has emphasized mainly the potential of natural environments. In our hypothesis, built environments are also likely to be recognized as restorative places […] Focusing on restorative experiences more than on environments alone, attention is drawn on the relative importance of the four restorative components proposed by 'Attention Restoration Theory'"[37]. Combining these two hypotheses – that perception directly affects the quality of restoration, and that what we consider to be traditionally natural environments are not necessarily the crux of what constitutes a restorative environment – then a well designed Martian settlement – that is one that considers the physical properties and perceptual components of ART – could be an effective, sustainable, restorative environment for the inhabitants without the need for any terraforming or greenery. Obviously, the addition of greenscape and bluescape would increase the capacity for restoration – as noted in the notes on compatibility – but they are not essential.

To further solidify these propositions, it should be noted that this is not just one study. Scopellitia & Giuliania conducted a review of literature, and summarized the findings of Staats et al., Purcell et al., Hernandez et al., Shaw, Kleiber, and Haworth, who all came to the same conclusion. In these studies, participants were shown beautiful natural environments, together with unattractive built ones – which often had no apparent restorative physical qualities (an industrial zone, for instance) – yet correlations to the positive restoration potential of both typologies were made[38]. This raises the issue that the restorative quality of different types of natural and built environments have less to do with the environments themselves than the context in which they are presented. Put simply, whether you are shown a pretty natural place or an ugly built place, both can be restorative if they are different than the

34 Velarde, Fry, and Tveit, "Health Effects of Viewing Landscapes-Landscape Types in Environmental Psychology," pp. 201

35 Staats, H., Kievieta A., and Hartig T., "Where to Recover From Attentional Fatigue: An Expectancy Value Analysis of Environmental Preference," Journal of Environmental Psychology [online journal], Vol. 23, 2003, pp. 147.

36 Ibid., pp. 152.

37 Scopellitia, M., and Giuliania V., "Choosing Restorative Environments Across the Lifespan: A Matter of Place Experience," Journal of Environmental Psychology [online journal], Vol. 24, 2004, pp. 423.

38 Ibid., pp. 434.

current place you are in. Furthermore, "restorative experiences have strong affective implications: relaxation [in particular] has been shown to be always the most important component […] In addition, the time-budget is an important variable in making restorative experiences both more relaxing and more exciting"[39]. Again this overlaps very directly with the sentiments regarding specific stressors presented in the Human Factor Model.

A final potentially promising topic is the 'social context' of restoration. "Being in the company of a friend may alter expectations about outcomes of a given behavior, the evaluation of those outcomes, and so attitudes and preferences"[40]. Staats and Hartig found that, having company always lead to increased restoration likelihood during leisure activity, in all instances both urban and natural; except in instances where 'safety' was controlled for in the analysis and not a concern to the participant. That is to say that solitude is only preferred when there is a guarantee of safety, and that difficult of dangerous passages of terrain or a lack of orientation and/or unfamiliarity, are deterred by the presence of another than can safeguard against risky circumstances. Having company while visiting a recreational environment may help a person feel safe as it reduces the overall directed attention of the restorative environment if that environment is unfamiliar[41]. How does this relate to the Marscape? Well, as we talked about in the compatibility section, the cognitive dissonance cause by the complete lack of discernable life would be softened if explored with a partner. While the researchers may intellectually know there is nothing out there that can hurt them other than an accident in the landscape itself, the unfamiliarity may still subconsciously affect their attention and cause fatigue.

IV. EMC Practical Applications

G. Earth-Based Analogues

The 'Goldilocks Zone', 'Habitable Zone', or 'Life Zone' is the narrow distance from a star wherein an orbiting planetary body may be able to sustain a carbon-based form of life. We are lucky that Earth is such a place that is conducive to sustaining life. These life sustaining conditions range from highly hospitable – these are the places that have grown into substantial urban settlements – to highly inhospitable. This paper is dealing with something even more extreme than that. An utter lack of discernable life and very limited opportunities to sustain life in the space beyond our atmosphere. But due to human instincts towards survival and our innate ability to create and innovate, even these extreme environments can be adapted through design to accommodate human living while assuring safety and even comfort. The drawback is that, in the most extreme cases, life is restricted to within these tiny habitats. These isolated and confined environments and their surrounding natural-yet-extreme conditions are important analogues from which various hypotheses, testing, and solutions can be drawn to make the EMC more viable and reliable[42]. Socio-psychologists Dudley-Rowley et al., analysed human behaviour in various ICEs in the early 1990s; from arid deserts – on the more manageable end of the spectrum – to Antarctic stations, submarines, and orbital space stations FIGURE 4.

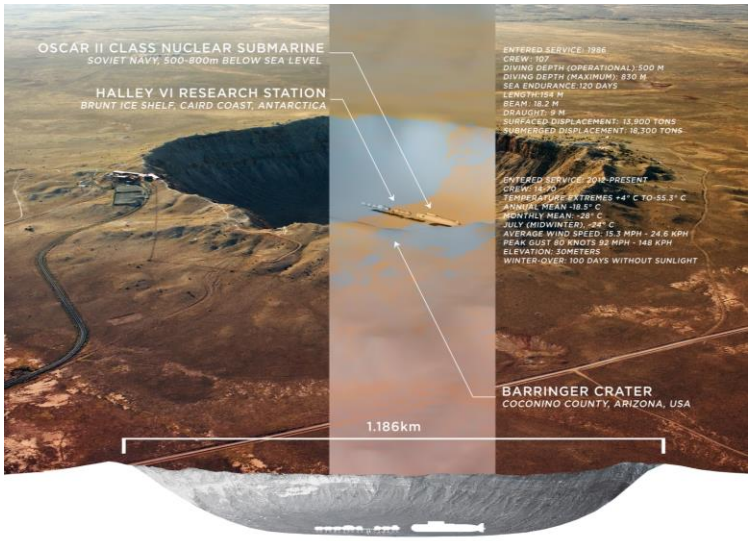

FIGURE 4. Comparison of a nuclear submarine and an Antarctic research station within a 1km diameter crater.

Following the establishment of the first permanent Antarctic research base in 1958, a number of studies were conducted to study the effects of this ICE. These studies focused almost purely on the

39 Ibid.

40 Staats, Kievieta, and Hartig, "Where to Recover From Attentional Fatigue: An Expectancy Value Analysis of Environmental Preference," pp. 156.

41 Staats, and Hartig, "Alone or With A Friend: A Social Context for Psychological Restoration and Environmental Preferences," pp. 199-211.

42 Kozicka, J., "Architectural Problems of a Martian Base Design as a Habitat in Extreme Condition," Dissertation, Department of Technical Aspects of Architectctural Design, Gdnask University of Technology, Gdansk, Poland, 2008.

physiological changes evidenced in 'winter-over' adaptation – approximately the yearly period of no-return off the continent. "Those that did address psychosocial factors tended to focus on the negative or pathological problems of psychological adjustment to Antarctic isolation and confinement, with persistent findings of depression, hostility, sleep disturbance, and impaired cognition"[43]. Studies conducted over the past four decades by Dr. Larry Palinkas, have proposed four distinct characteristics to psychosocial adaptation in ICEs: (a) adaptation follows a seasonal or cyclical pattern, (b) adaptation is highly situational, (c) Adaptation is social, and (d) adaptation can also be 'salutogenic' – meaning it has a 'positive effect' for individuals seeking challenging experiences in extreme environments[44]. This reinforces the notion that crew selection is paramount as a preventative measure to stressors in ICEs; but it does not completely eliminate it, nor the need for increased habitability. Filtering-out pathological tendencies that could affect an individual in this environment or their effect on the group dynamic over time, does not eliminate these issues, but simply reduces it. So when considering that the duration of space exploration missions in the near future are going to be much longer than in any of these baseline studies, we need to increase the habitability of these ICEs to alleviate the compounding effect of the physical and mental stressors.

H. Site Selection

Recently, NASA's EMC mapped out a step-wise approach for exploring Mars and has begun to identify Exploration Zones (EZs) on Mars that would support multiple human crews as they live and conduct research there on a permanent basis. These EZs take into consideration a number of variables, primarily safety in term of accessibility in relation to the number of potential high-value scientific gains available in nearby Regions of Interest (ROIs). These discussions on how these considerations will be defined and developed are still on the ground-level as the first conference on *First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars* was just held in October 2015. Here is the first demonstration of how ART can be applied to an aerospace problem, because it can be used to classify and narrow the list of potential landing sites, recommending the best siting based on a system of humanistic values that overlaps with the existing scientific values FIGURE 5.

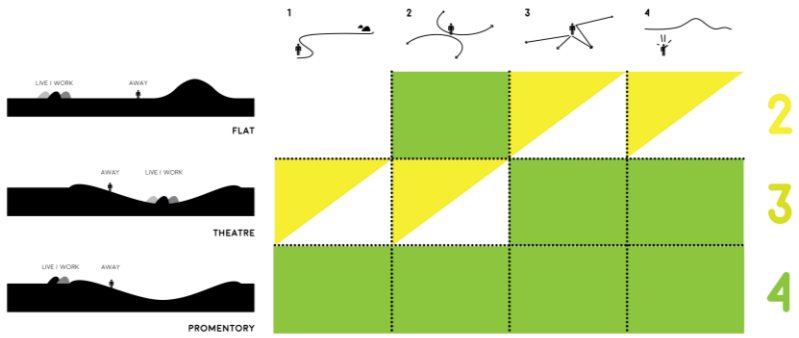

FIGURE 5. Matrix of Preferable Siting Considerations

Attention restoration theory can be used in combination with some more specific traditional landscape architecture theory that addresses issues of morphology – i.e. the study of the shape and transformation of geological and planetary landform features – to develop a classification and preferential analysis of different landing site options and considerations. Given the limitations of space and the amount of context needed to explain these theories fully, only give a cursory summary of the findings are shown here. That is that there are really only four landform typologies on Mars at a regional scale – that is, the contextual scale of city-planning here on Earth – that would affect the restoration potential of a future Martian settlement. Those are (a) Mountain, (b) Valley, (c) Crater, and (d) Plain. All of the proposed sites fall into one of these four typologies. From there, each landing site – whether it be 'Noctis'[45], 'Meridiani Planum'[46,47], or 'Aram Chaos'[48] - the landscape architect can then conduct a more

43 Ibid., pp. 71.

44 Ibid., pp. 72.

45 Lee, P., Acedillo S., Braham S., Brown A., Elphic R., Fong T., "Noctis Landing: A Proposed Landing Site/Exploration Zone for Human Missions to the Surface of Mars," First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars, NASA Technical Reports Server, Mofette Field, CA, NASA Ames Research Centre, 2015, 2015. pp. 1-2.

46 Cohen, B. A., and Seibert M. A., "The Land of Opportunity: Human Return to Meridiani Planum," First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars, NASA Technical Reports Server, Mofette Field, CA, NASA Ames Research Centre, 2015, 2015. pp. 1-2.

47 Clarke, J. D., Wilson D., and Smith H. D., "First Landing: Southern Edge of Meridiani Planum," First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars, Mofette Field, CA, NASA Ames Research Centre, 2015, pp. 1-2.

48 Sibille, L., Mueller R., Niles P. B., Glotch T., Archer P. D., and Bell M. S. "Aram Chaos: a Long Lived Subsurface Aqueous Environment with Strong Water Resources Potential for Human Missions on Mars," First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars, NASA Technical Reports Server, Mofette Field, CA, NASA Ames Research Centre, 2015, 2015. pp. 1-2.

holistic landscape architecture analysis of the physical, phenomenological, and programmatic questions that could be answered through design. When we consider the central components of ART, we find that being away, extent, compatibility, and fascination are all affected by the physical morphology of a site. For example, siting the settlement near Noctis Labyrintus will be much more fascinating than siting it in the flat desert of Meriniani Planum. Or taking into account the landscape theory concerning 'prospect and refuge', we would find that situating the settlement on the rim of Victoria Crater would be much more satisfactory than situating it at the base of the crater. Researchers should not just be considering the scientific value of these EZs, but also the psychological effects that the morphology of one site has over another. At least in the beginning of humanity's exploration of the Moon-Mars system, we must choose the absolute best targets. Ones that do not fulfil both scientific and humanistic values should be left until later. The potential for sublime visual experiences in various parts of the Marscape would aid in the creation of a natural restorative experience for the first Martians. The potential for interesting landscape interventions on Mars will be unparalleled due to the shear novelty that it provides; this is the argument for why other landscape architects will find this endeavour appealing. Think about it: the pure visual interest of establishing a habitat within the crater of a distant planet with the rim rising around you, is the stuff of pure fascination that has fueled science fiction for a century. So the issue of siting the first settlements should not be taken lightly.

Deadscapes: Design Proposals

I. Growth Strategy

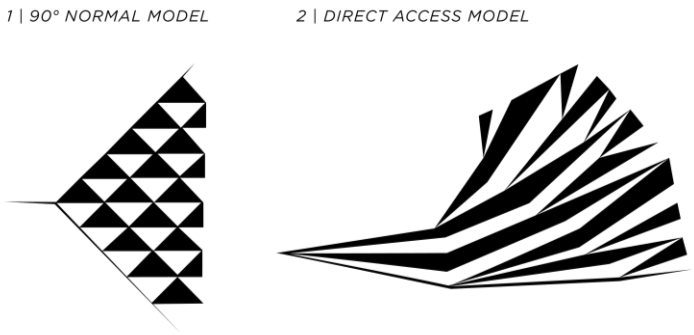

FIGURE 6. Model of the dendritic growth strategy.

In framing these scenes of a world to come, it does us well to think beyond just the first landings to a hundred years from now. That is a particular skill of the landscape architect. Consider Frederick Law Olmstead, the prolific U.S. parks designer who was involved in the country's first coordinated system of public parks and parkways, including Central Park and the country's oldest state park Niagara Falls Reservation. The foresight to create these occlusive pockets of nature in prime areas of future development speaks to a mentality that is useful as the cosmos are explored. The second major contribution parallels the thought processes of Olmstead and offers a growth strategy for master-planning the settlement of a Martian community that is derived directly from the core principles of ART. Using primarily the principle of being away, each arm reaches out from the landing site towards a target ROI in a dendritic (tree-like) fashion; splitting when it meets obstacles to find the most direct path to the target area. The idea is that at every split, an imaginary line is created down the middle of the resulting new branches; where the area to the left is always live-work – either permanent habitats, semi-permanent or temporary outposts, and field research will occur in this area – and the area to the right is always restorative – whether that is a garden that is programmed for contemplation and relaxation, or social space and recreation FIGURES 6. As the areas in between two arms begin to reach a closure point – either due to many obstacles in the EZ, or much further in the future where a substantial population has been reached – the area left over is designated for future terraforming and agricultural purposes FIGURE 7. This schematic diagrams – much like the vision of Olmstead and other avant-garde models proposed in the architecture realm – is meant to convey a future that is a century away. These ideas are meant to provide an initial foray into the realm of possibility, and present a vision for the applications for this work. This is only the ideas of one author, and given the opportunity, an array of even more skilled individuals should be able to take these building blocks and fabricate even more creative and effective solutions are both aerospace and landscape architecture push forward in our respective fields.

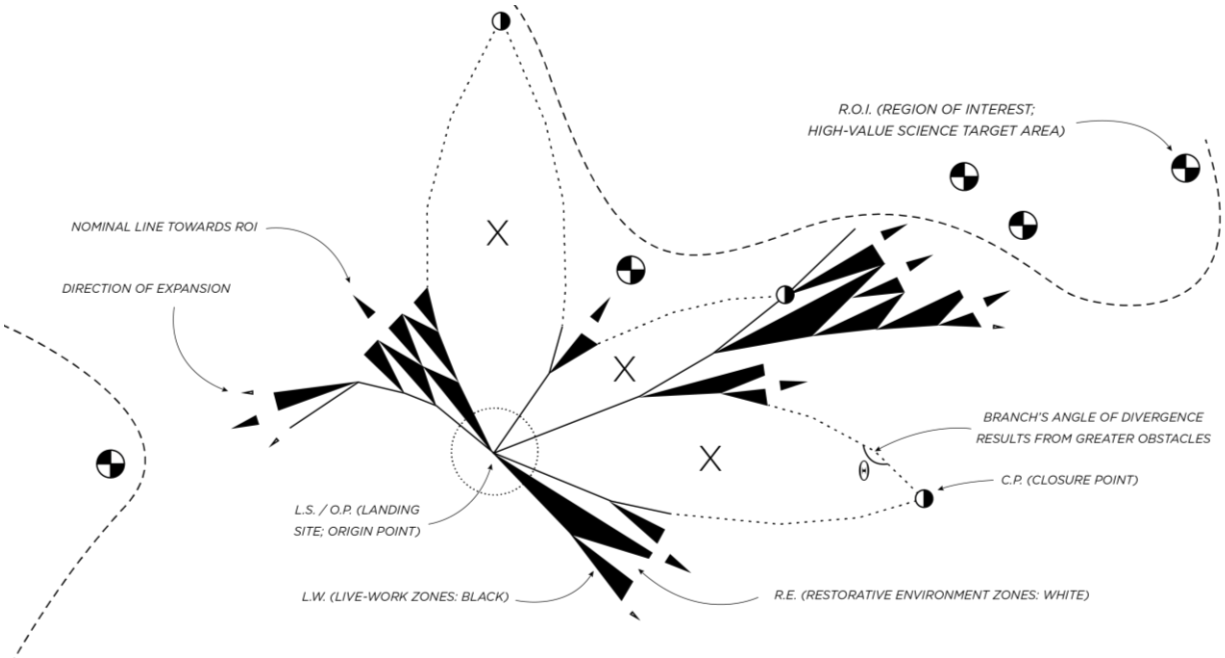

FIGURE 7. Schematic design of the dendritic growth strategy.

J. Outside: The Marscape

The current role of landscape architecture is to manipulate the outdoor environments we inhabit on planet Earth. We can call them *bluescapes*, *greenscapes*, and *greyscapes*. This thesis challenges that paradigm by introducing the notion of *deadscapes*. Deadscapes are (a) closed and finite indoor environments, or (b) foreign and extreme environments not conducive to sustaining any form of flora. This is the natural evolution of landscape practice; where the first three terms cover every environment we have on Earth, and deadscapes encompasses all the residual environments that the discipline does not traditionally manipulate and any future environments beyond Earth. This research explores how deadscapes can be transformed into restorative environments by using knowledge exclusive to the discipline – namely ART. In FIGURE 8, a number of layers of data are shown. The reason this diagram is important is that these layers are more than just a preliminary analysis of the marcology; rather this is the totality of the information we have about the planet. In the architectural disciplines, there is the ability to take site-analysis to an absurd level of minutiae, because on Earth the networks of interactions in any particular place are virtually endless. If so desired, architects could consider the historical artifacts of a site, the political context, a particular species of bird that nests on the site, the watersheds in the regional scale that feeds through the site, the telecommunication

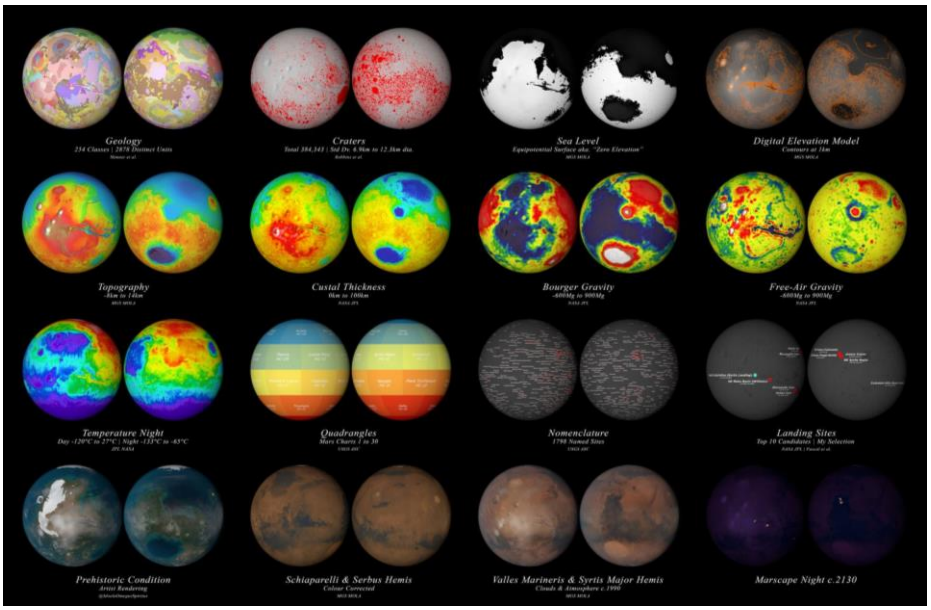

FIGURE 8. The Deadscape of Mars

'glocalities' that overlay onto the direct social interactions of the people in the site, et cetera. It goes on and on. But on Mars, these layers are the totality of existing elements that would factor into the analysis of a site prior to initial human contact. There is nothing else to consider. This is a deadscapes. But in this desolation there is also a beauty that is hard to put into words. Architects would call this innate beauty *'genus loci'* which comes from Latin, and means, the distinctive atmosphere or pervading spirit of a place. This doubles back to the idea of phenomenology mentioned earlier. So to settle this place is to create an oasis for human life, not just in a desert, but in death.

We cannot make the same mistakes in the environments of other planetary bodies as we made on Earth; so the responsible planner will question to what extent provisions will be made when considering how ART can be physically implemented in the Marscape either through its (i) manipulation, (ii) accentuation, or leaving it (iii) undisturbed. From the landing site to the regional ROIs, as time wears on, these settlements will grow from one habitat to two, to four, to eight, leaving some sort of impact on the Marscape. This raises the underlying question of whether settlement, and later terraforming, are ethical endeavors? Most issues regarding the ethics of terraforming are both well-argued and well-countered[49]. For the purpose of this paper, the author leans towards the argument for terraforming, provided it is done responsibly. So then, one can discard 'iii' and proceed on the premise that manipulating the Marscape in some way is necessary, and that all care will be taken toward preventing contamination of potential life or deeply disturbing the native Marcology. With that said, 'ii' is one degree removed from 'iii', and mainly focuses on minor interventions that leave some semblance of human intervention to subliminally indicate to the crew they are in a safe place that can be called home. Subtle elements of design in the landscape will act as wayfinding – i.e. mental mapping or navigation – points, or artifacts of familiar things from Earth that add to the feeling of compatibility[50] – e.g. lighting interventions are my primary design explorations at this time. Finally, 'i' true landform manipulation or other traditional landscape architecture interventions are unrealistic on a short time scale (i.e. 10-50yrs) without an established industrial sector on Mars. However, smaller scale manipulations that are able to be carried out by the settlers might be feasible in the short-term; e.g. rock gardens or xeriscape – which are a style of landscape design requiring little or no irrigation or other maintenance. It would be nice to design a modern a true 'land-art' piece that would establish humans on Mars for millennia to come, in a way harkens back to Stonehenge. But on the other hand, simple artifacts – such as a staircase leading down a crater or a roadway demarcating frequent traffic lanes – can be just as effective at changing the context of the area. This is because these elements arise from a cascading pattern of frequency, convenience, necessity, and then permanence; and by extension, an element of permanence denotes safety and cements an environment as a true home.

K. Inside: The Module

The primary goal of designing the interior of the Mars habitat, was to explore how greenscape and bluescape could be integrated through either (i) full integration, (ii) an interstitial space, or a (iii) separate module, to create a more habitable and restorative environment for the crew. After reviewing so much literature, it should be clear that 'i' should be eliminated completely, and the focus placed primarily on (iii). The reason for filtering out a fully integrated green system is, again, the fact that restoration cannot occur successfully in the same environment where the stressors occur. So then the restorative space has to exist in a place that is not the ordinary and monotonous space of everyday living; otherwise that would make the only location for effective restoration would be the exterior Marscape. Likewise, while I do like the idea of 'ii and interstitial space' – as was proposed for the *Mars Ice House* by SEArch/Clouds AO[51] and the Gamma Base by Foster+Partners[52], the winning designs of the NASA and America Makes sponsored competition 3D Printed Habitat Challenge for Mars[53] – the connectedness to the primary living-module is convenient, but not as strong in terms of being-away.

1. Greenscape

Recent research conducted by the German Space Agency into the use of greenhouses in extreme environments show that for people living in isolated locations, greenhouses factor into several layers of health to a greater relative degree than people in an accessible place. Since the pioneering Oasis greenhouse on Salyut 1 – which was the first space station of any kind, launched by the Soviet Union in 1971 – research into the feasibility of growing plants for

49 For a concise summary of arguments on either side, read Appendix C of: French, R. H., "Environmental Philosophy and the Ethics of Terraforming Mars: Adding the Voices of Environmental Justice and Ecofeminism to the Debate," Dissertation, University of North Texas, Ann Arbour, UMI Dissertation Publishing, 2013, pp. 1-140.

50 Rockman, M., and Steele J., "The Colonization of Unfamiliar Landscapes: Archaeology of Adaptation," London, Routledge Press, 2003, Chaps. 2-3.

51 SEArch & Clouds Architecture Office, Sept. 2015, http://www.marsicehouse.com/ [cited 07 March 2016].

52 Foster+Partners. NASA 3DP-012. Sept. 2015. http://smg.fosterandpartners.com/mars/#/ [cited 07 March 2016].

53 National Aeronautics and Space Administration, Design Competition Finalists, 2015. http://3dpchallenge.tumblr.com/ [cited 07 March 2016].

food or oxygen production in exploration-class missions was accumulated from almost every space programme (Salyut, IR, ISS and STS). These plant growth facilities have been included on space stations for science experiments, but have resulted in additional data regarding the psychological benefit of taking care of and interacting with plants inside the spacecraft environment[54]. For example, the stories go that early during the Salyut missions, astronauts experimented with plants and 'designed' their own little greenhouses. Robert Zimmerman writes that "Salyut 6 cosmonaut Valery Ryumin 'had a green thumb' and 'turned the space station into a veritable jungle by growing [plants] in empty film cassettes, equipment casings, and food containers hung everywhere on the station's walls'"[55]. Another astronaut, Wubbo Ockels, on his mission STS-61-A, designed a personal greenhouse out of a piece of plastic foam in a plastic bag with a zipper, and a knife for making holes into it. After a few days the leaves grew a few centimetres and he said that "they had a little party and everybody ate a small amount of fresh food". These events recall recent scenes from the popular 2015 book-to-movie blockbuster adaptation, *The Martian*; and suggests a level of "importance and relevance of […] gardening activities of cosmonauts. As well, it indicates the immediacy of the growing environment and ease of incorporating plants into astronauts' daily lives, no matter if highly structured as part of experiments, or just for personal interest and health"[56]. "Individually owned plants can provide companionship and comfort to an individual spacefarer in ways unique to that person. On Salyut 1, the first flax seed sprouts were tended to devotedly by crew members Viktor Patsayev and Vladislav Volkov. 'These are our pets,' were Patsayev's words. 'They are our love,' said Volkov"[57]. Those eight words drew such a visceral reaction from me when I read them, and perpetuating these feelings for all explorers to come is truly the purpose of this research. Even more recently, Captain Scott J. Kelly, tweeted during his record 340-day mission, "My favourite colour is blue. But it's green I miss most."

Researchers in the astronautics domain recognize that artificial biospheres and greenhouses will be essential for future human space exploration and will be integrated into interplanetary and extra terrestrial planetary habitats. Dr. Fred Davis researches low-pressure controlled food production environments for NASA and commented that,

> *"a greenhouse at a U.S. Antarctic base which supplies salad bowl crops is 'one of the most popular places on the base, where crew members will retreat from the cold, white, barren, snow-capped landscape to recharge, rest and nap in hammocks stretched across the green visual of live, growing, green plants […] Small wonder that the greatest pastime in the U.S. is gardening. It will also be an important activity as humankind colonizes space during the 21st Century'*[58]

Other than nutritional and LSS functions, the benefits of greenscape in space are multi-dimensional, vital, and necessary components of any future Mars Habitat. It has been demonstrated that microgravity doesn't pose any restriction to the growth of plant life, but is limited instead by limited space programming in orbital habitats as well as the accompanying automatic environmental control and monitoring systems. The ability to grow vegetation within an controlled environment on Mars and the hypothesis that it will be viable to terraform at some point in the future, is fairly strong. A Japanese research team from the Institute of Space Astronomical Science and the Space Agriculture Task Force, have published an extensive body of work that is not terribly technical to read, but too extensive to effectively summarize[59]. It is fascinating work that highlights a variety of conceivable scientific schemes for pressurized Martian greenhouses for space agriculture, and deserves a full read by anyone interested in the subject. It provides the most foundational information for my design explorations.

Now here is the initial basis for the interior intervention: we do not need to grow real plants in the habitat to yield the desired restorative effects. If a simple painting in a separate module can meet the minimum requirements of restoration – this specifically has been confirmed by numerous studies – then it stands to reason that either virtual reality or artificial plants can be used to greater effect. By combining artificial plants or a virtual reality system with a few living plants, the crew could actively garden the living plants in the Ultra Green Habitat Module (UGHM) while also having the immersive experience that virtual reality or a wall of artificial plants can afford. The point

54 Hauplik-Meusburger, S., Peldszus R., and Holzgethan V., "Greenhouse Design Integration Benefits for Extended Spaceflight," Acta Astronautica [online journal], Vol. 68, 2010, pp. 86.

55 Hauplik-Meusburger, S., Paterson C., Schubert D., and Zabel P., "The Road Less Travelled: Greenhouses and Their Humanizing Synergies," 63rd International Astronautical Congress. Naples, Italy, 2012, pp. 3.

56 Ibid., pp. 5.

57 Ibid., pp. 10.

58 Hauplik-Meusburger, Paterson, Schubert, and Zabel, "The Road Less Travelled: Greenhouses and Their Humanizing Synergies," pp. 9

59 Read Chap. 18: Yamashita, M., Hashimoto H., and Wada H., "On-Site Resources Availibility for Space Agriculture on Mars," Mars Prospective Energy and Material Resources, edited by V. Badescu, Springer-Verlag Berlin Heidelberg, Bucharest, 2009, pp. 517-542.

here is to establish a temporary solution that works in lieu of being able to reliably cultivate plants in an ICE. It is not being suggested that only virtual or artificial plants are used, but rather that they are used in conjunction with as many real plants as possible. While current artificial plants are not indistinguishable from real plants, certain improvements can be made with some research and development into better fabrication to close the gap of accurate mimicry. To better understand what those distinguishing elements are, an informal and preliminary study was conducted that presented 100 participants – with backgrounds in landscape architecture as well as untrained laymen – with 50 visual (not physical) samples of artificial, virtual, and real plants. This yielded an average percentage of 44% correct answers, with the greatest loading of incorrect answers on the artificial plants. Almost half of the participants, prior to the poll, stated that they were very familiar with plants, yet the average score was only 11 points above guesses made at random; which was lower than hypothesized. Follow up responses that to gauge the method in which participants determined the nature of the exhibits are listed as follows in order of importance: (a) arrangement and the context in which the flora was presented, (b) imperfections in the design. Some elements that were not tested, but would be a factor in increasing the mimicry of physical samples, include (c) texture and responsive material[60], and (d) movement. What is interesting in how much people rely on context to make the assessment; one participant stated very aptly that, "context is everything. I believe it is real if its setting seems real". This highlights the importance of arrangement as a principal factor in increasing the preference towards plants in, instances where they are being used in an 'unnatural' setting. If they can be arranged in a natural way in an unnatural setting, the setting itself feels more compatible with one's conceptualization of the space.

It can be argued that virtual reality may be the more immediately viable tool – providing a range of potential environments and with advances such as the Oculus Rift, it is highly immersive – yet, with a little research and development invested into artificial plants, they could also have applications in many instances down the road. In terms of the application the EMC, a modest timeline would be (a) a 10yr plan (post-First Landing) that would utilize a combination of real, artificial, and virtual plants to fill the UGHM, (b) a 10-50yr plan would introduce greenhouses if the standard of 'ultra-green' restorative spaces can be met from a technical standpoint, and (c) a 50+yr plan would begin to consider terraforming.

2. Bluescape

Another very interesting aspect is the concept of *bluescape*. The term 'blue space' or 'bluescapes', summarises all visible surface water as a parallel to green space; this is not as a sub-category of greenscape. "Water is one of the most important physical, aesthetic landscape elements and possesses importance […] but the relationship between water and health in current literature is only investigated in the field of environmental toxicology and microbiology, not explicitly in the research field of blue space and human well-being"[61]. With that said, the experimental and cross-sectional studies that have quantitatively and qualitatively measured its effects, found that it has a greater benefit than even greenscape. Controlling for water, images of natural and built spaces all increased in preference and were more frequently associated with more positive affect that those without water. This passage by in the paper called *Blue Space*, cites the work by Kaplan & Kaplan, Ruback, Pandey, & Kohli; Lange & Schaeffer; Luttik; Solomon; and Waite – is a boiled-down insight into the established humanistic connection we have with bluescape:

> *The role freshwater plays in our physiological health is clear. We can survive only a few days without it. The role water plays in our psychological health is far less obvious. We know that aquatic environments were revered in many ancient societies (e.g. Egypt, Greece, Rome) and that such reverence continues today. Many religions promote ritual washing and/or immersion and specific aquatic environments continue to have spiritual importance: For example, the Ganges in Hinduism, the Well of Zamzam in Islam and Lourdes in Roman Catholicism. At a secular level people are prepared to pay more for houses and hotel rooms with views of water, and aquatic environments are a frequent aspect of people's favourite places, preferred leisure destinations recollections of positive childhood activities (Blue space: The Importance of Water for Preference, Affect, and Restorativeness Ratings of Natural and Built Scenes[62].*

60 Reyssat, E., and Mahadevan, M., "Hygromorphs: From Pine Cones to Biomimetic Bilayers," Journal of the Royal Society Interface [online journal], 01 July 2009, pp. 1-7

61 Volker, S., and Kistemann T., "The Impact of Blue Space on Human Health and Well Being: Salutogenic Health Effects of Inland Surface Waters," International Journal of Hygiene and Environmental Health [online journal], Vol. 214, 2011, pp. 449.

62 White, M., Smith A., Humphreys K., Pahl S., Snelling D., and Depledge M., "Blue Space: The Importance of Water for Preference, Affect, and Restorativeness Ratings of Natural and Built Scenes," Journal of Environmental Psychology [online journal], Vol. 30, 2010, pp. 482.

The researcher Veronica Strang noted that since water is associated with body requirements – both from the aspect of composition, sustenance, and cleanliness – it has therefore been a symbol of purity, expressed in human mental and spiritual life; ubiquitous in religious history as a 'sacred substance'[63]. People love the sounds of water, and great importance is attached to the variety and special nature of these sounds, ranging from calm, laminar flows to energetic, roaring sounds. The context of blue space is an important measure for human perception. As we have read, the addition of bluescape to any environment increases its visual rating[64]. But the tested hypothesis most interesting of all the sources reviewed – and particularly beneficial to the design program of this Martian habitat – is that although "scenes containing some water were rated more positively than those without, the extra benefits of a greater proportion of water were minimal. Consequently, the extent of aquatic features in a built environment may be less important than their mere presence"[65]. The very importance of this conclusion is that we do not need much flowing or standing water to have the same effect as an Olympic pool of it. Hopefully, the recurring slope lineae recently verified on Mars will lead to humans being able to access water in the future; leading to a range of possibilities for integrating bluescapes into spaces to make them more restorative.

V. Conclusion

Landscape is a culturally shared environment. On Mars, this will be a wholly novel and extraordinary phenomenological experience. To share a world with only a handful of other people in the entirety of human history; to be *a Martian*. Landscape architecture it is a discipline of high complexity that bridges the gap between the artistic imperative and the scientific one. This flexibility allows us to approach open-ended problems differently. I hope that this critical essay and proposal advocating for the integration of restorative environments in future discussions of the EMC, has been a convincing exploration of themes that can contribute to the knowledge and discussion of space exploration with regards to human habitability. It is my desire that this conversation flourish and become an iterative, continued, and fruitful dialogue between our domains.

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63 Ibid., pp. 484

64 Volker, and Kistemann, "The Impact of Blue Space on Human Health and Well Being: Salutogenic Health Effects of Inland Surface Waters," pp. 454.

65 White, Smith, Humphreys, Pahl, Snelling, and Depledge, "Blue Space: The Importance of Water for Preference, Affect, and Restorativeness Ratings of Natural and Built Scenes," pp. 480.

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