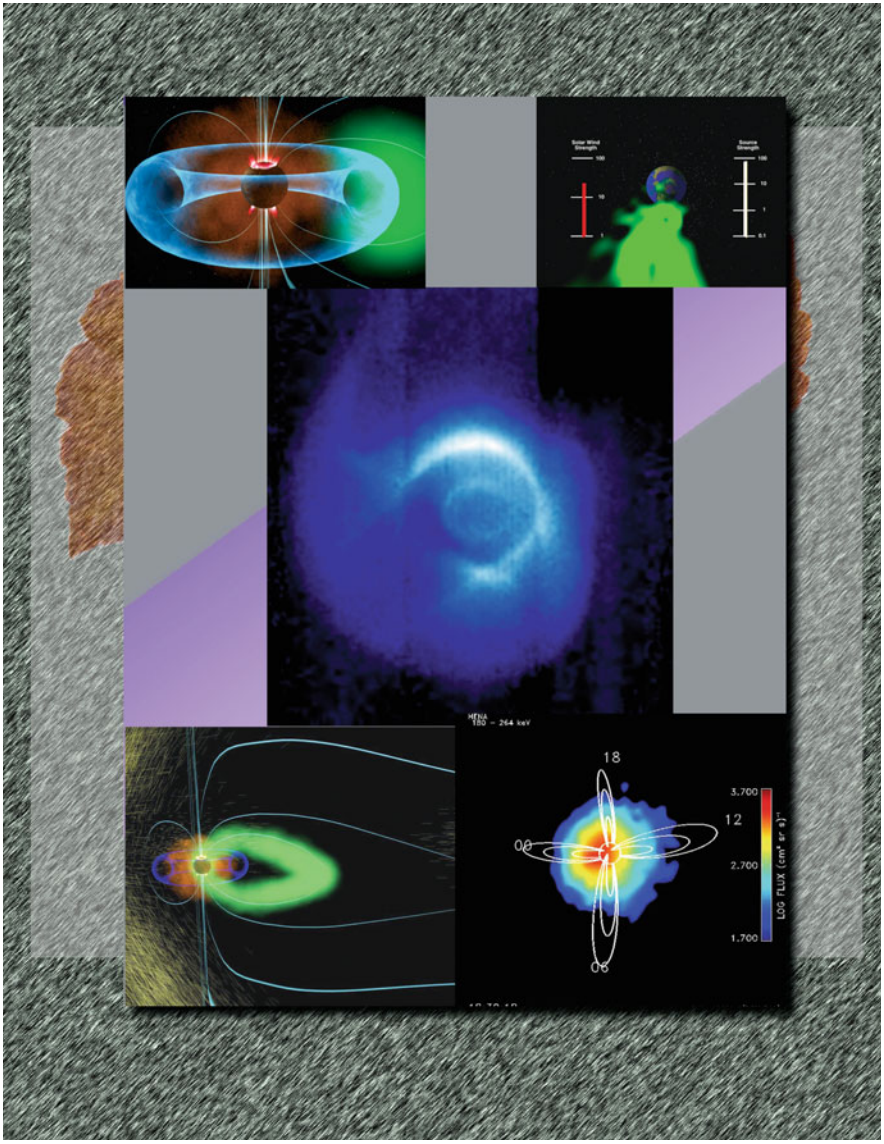
Chapter 2
Space Utilization: A Moral Imperative

G. Matloff et al., *Harvesting Space for a Greener Earth*,
DOI 10.1007/978-1-4614-9426-3_2, © Springer Science+Business Media New York 2014


HENA
180 - 264 keV
18
12
00
06
3.700
2.700
1.700
LOG FLUX (cm² sr s)⁻¹

"I saw the sudden sky
Cities in crumbling sand;
The stars fall wheeling by;
The lion roaring stand."
—From the poem "The Lion" by W. J. Turner

As citizens of the already-developed countries of the world grapple with their impact on the planet, so do those living in the rising economies of China, India, and Africa. But although it is relatively easy for those of us in the developed world to say we will make due with less consumption for the good of the planet, those in the developing world don't have that luxury. They need to consume more resources to have jobs, educate and feed their children, and to generally improve their quality of life. On a per capita basis, they don't want or need to be as profligate in their use of the world's resources as we've been, but there are so many of them that each using only using a small fraction (as compared to residents of North America, Europe, and Japan) of what their developed counterparts use will place dramatically increased stress on the global environment and the planet's resources.

Space advocates and environmentalists are cut from the same cloth. They have very similar long-term goals and the same basic moral principles guiding them. Life on Earth is precious; it must be preserved and protected for future generations of the planet's inhabitants, both human and nonhuman. Unfortunately, as we look at the challenges posed by rampant materialism, increased production (using up the planet's resources), and the commensurate increased pollution from the developing world, these two groups tend to take very different approaches to addressing these core problems. Worse yet, each group tends to view the other with suspicion and questions their motives and tactics. Space advocates tend to believe the environmentalists are motived by a political and economic agenda (tending toward the political left), while environmentalists tend to believe that space advocates are part of the military/industrial complex following a right-wing political agenda. Both are simplistic generalizations. If the two groups are serious about saving the planet then they need to put aside their political differences and work together. Environmentalists are working to stop very real and immediate environmental damage, but they don't have a long-term plan for saving the planet. Space advocates have the long-term solution to environmental stresses on the planet—the use of space resources—but tend to ignore what can be done in the short term, to buy time until the long-term solution can be implemented.

It is this long-term solution that motives the authors to write this book. We mirror the divide described above, with at least one of us leaning politically left and the other politically right. Yet we agree that must act now and plan for the future, if life on Earth is to have a chance. And we must work together on a just and moral foundation.

Since there have been people around to consider the notion philosophers and theologians have debated what constitutes morality. The word *morality* comes from Latin and refers to our notion of what constitutes right and wrong or good and evil. What constitutes a moral action varies dramatically from culture to culture, though many cultures share some common thought as to what is right and wrong. For example, most modern cultures believe that murder is not a morally acceptable method to settle a dispute and that theft is not a moral act. But even these seemingly simple moral judgments are far from universal, and anthropologists can undoubtedly find cultures on the globe that do not share these views.

We will put forth a moral concept upon which this book will stand. It is a concept that should have nearly universal appeal and should guide much of our decision making regarding both space and environmental policies. The moral statement that drives our thesis is deceptively simple. In fact, it is so simple that an entire company is built around it as both a trademark and a pithy statement: Life is Good™. The converse is also a moral assertion—that which leads to non-life is evil. And by "life" we mean communal life, not that of an individual animal or plant, although in the case of humans we believe the assertion is valid almost 100 % of the time. Those who seek to preserve life, human and nonhuman, are acting in a morally superior manner compared to those who seek to diminish or harm life. Often we must act on this moral principle in such a way that some life is harmed along the way to a more global solution that greatly preserves or improves the quality of life in general. These choices must be carefully considered in the context of whether or not they will improve the quality of life or maintain life in the "big picture" or on a scale beyond the immediate and obvious impacts to an individual.

We believe the moral decision that life on Earth is good drives those in the modern environmental movement to their activism. It is this same moral decision that motivates many space enthusiasts, activists, and professionals.

It is a moral declaration to say that life is good and better than non-life. Once this declaration is made, it is easy to see that in order for humans to prosper and be good stewards of the planet and its myriad life forms, they must stop destroying the environment that gives it life. But how do we accomplish this goal and maintain all of the positive aspects that come from our twenty-first-century technological civilization? The answer is pretty simple. We must place heavy industry, with all of its inevitable pollution, in a place that is already hostile to life and in which life will almost certainly never arise—in space or on the Moon. A space-based infrastructure is not only possible but also essential if we are to restore our home planet and turn it into a safe place to live, pollution free. This chapter explores the current environment of near-Earth space, so as to address concerns by some that our presence there will somehow pollute it.

Most of us think of outer space as being empty. If we are comparing space starting at about 200 km above our heads and extending far outward, to what it is like around us on Earth, then *empty* seems to be the appropriate word. For all practical purposes, to most humans, space is empty. (When we refer to space in this context, we are referring to that which is separate and apart from a planet, comet, or asteroid. Of course, the total volume of space occupied by planets, comets, and asteroids is so small in comparison to the rest that it is inconsequential overall.) In space, there is no atmosphere to breathe, no potable water to drink, and not much else in significant quantity—at least from the average human being's perspective.

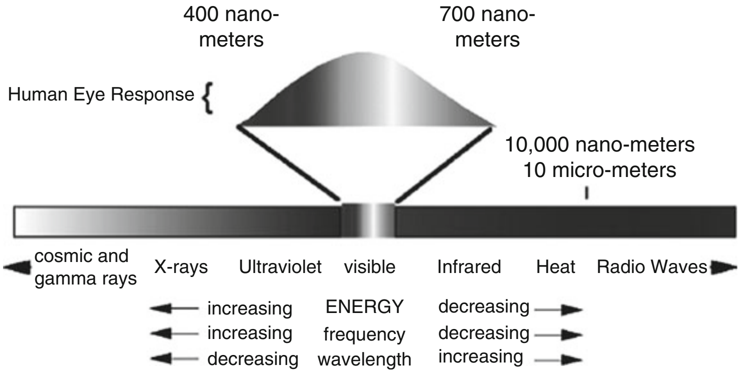


Fig. 2.1 The Sun emits light at many wavelengths, only a small fraction of which can be seen by the human eye. This portion of the spectrum is known as "visible light" (courtesy of the Universities Space Research Association)

However, in the 50 years of space exploration, scientists have learned that space is far from empty, and most of what is found in space is directly antithetical to life. To begin with, the entire Solar System is bathed in sunlight. We depend on the light emitted by the Sun to sustain us. But this light is only a small part of the total electromagnetic radiation ("light") emitted by the Sun. We see only this part because our dense atmosphere filters out most of the rest. The Sun emits light at several wavelengths, from infrared to extreme ultraviolet. The part of the Sun's spectrum that we see is only a very small part of the emitted spectrum and is aptly called "visible light" (Fig. 2.1). By definition, the other parts of the spectrum are invisible to our eyes, but not to our scientific instruments.

Over the past several years, there has been much discussion about solar ultraviolet light. It is this part of the spectrum that causes people to tan and sunburn—in many cases, subsequently causing skin cancers. Fortunately for us, most of the ultraviolet light from the Sun is filtered at high altitudes by atmospheric ozone. There are multiple wavelengths of light that are considered to be part of the ultraviolet spectrum. They are divided into two types: ultraviolet A [UVA] and ultraviolet B [UVB]. The amount of UVB light that penetrates through the atmospheric ozone decreases rapidly with increased ozone concentrations. The converse, unfortunately, also applies: decreased ozone will dramatically increase the amount of UVB reaching the surface of Earth. UVA passes roughly unhindered through the atmosphere.

Since the 1980s, and mostly likely beginning earlier, a global decrease in atmospheric ozone density was observed, with especially large depletions occurring near Earth's poles. The large depleted regions near the poles were dubbed "ozone holes," and their existence was blamed on the human-caused emissions of ozone-depleting chemicals such as chlorofluorocarbons. This depletion was of concern because increased UVB exposure would increase the number of people getting various cancers. It is also thought that increased UVB would do significant harm to plankton in the oceans, with damaging ripple effects felt throughout the food chain that depends on plankton. Also, several crop species are thought to be UVB sensitive, with death or significantly reduced yields resulting from increased exposure. Global environmental action was taken in the 1990s to reduce human emission of ozone-depleting chemicals so as to mitigate further ozone depletion.

Solar ultraviolet radiation acts as a sterilizer and quickly kills any unprotected life. In fact, ultraviolet sterilization is used commercially to kill bacteria in swimming pools and in air purification systems. In space, there is no atmospheric ozone to filter any of the UVB, and ultraviolet radiation from the Sun is deadly.

In addition to visible and ultraviolet light, the Sun emits many other forms of radiation. High-energy electrons and protons continuously stream from the Sun; this stream is commonly called the solar wind. The Sun emits these particles with velocities between 200 and 800 km/s, depending on where you are relative to the Sun's equator and the solar activity cycle. When these charged particles encounter matter, such as living tissue, they deposit their energy as they slow down and stop therein. These particles have a lot of energy, and the slowing-down process does significant damage to any living tissue in which it occurs. Even short-term exposure to unfiltered sunlight can cause mutations and cancer. Moderate to long-term exposure results in significant cell damage and death.

And it gets worse. In addition to this somewhat steady stream of charged particles coming from the Sun, there are periodic bursts of intense high-energy radiation, called solar energetic particle events, that blast lethal storms of charged particles outward from the Sun to the outermost regions of the Solar System, each packing enough energy to cause human death within minutes to hours of exposure.

Fortunately, our Earth once again protects us from this danger. Earth's relatively strong magnetic field acts as a radiation shield, deflecting all but the most energetic of these particles away from the surface of the planet. (Charged particles, when moving through a magnetic field, experience a force acting on them, in this case, a deflecting force.) Our thick atmosphere, which has the approximate stopping power of 10 m of water or 4 m of concrete, absorbs most of the remainder (Fig. 2.2).

On Earth, we go blithely through our days during these storms, blissfully unaware of the hellish inferno blasting through space a mere few hundred kilometers above our heads.

Across the globe, the average temperature does not vary by much, providing a reasonably stable thermal environment for all sorts of life. Where seasonal variation does occur, life, in general, has adapted to it, growing during the warmer summer months, hibernating during the colder winter months. In author Les Johnson's adopted hometown of Madison, Alabama, the average temperatures range from a low of about 29° Fahrenheit in January to a high of 89° in July. Most residents of north Alabama adapt quite nicely to this range of 60°. Thanks to the complex biosphere of Earth, with enormous oceans and a thick atmosphere to average out and regulate thermal effects, 60° temperature variations in the course of a year are typical for Earth's nontropical, nonpolar regions, which are usually mild and for which life has readily adapted.

In space near Earth, without an atmosphere or ocean, the temperature can vary from +200 to −200°F as quickly as an object moves from being in sunshine to being

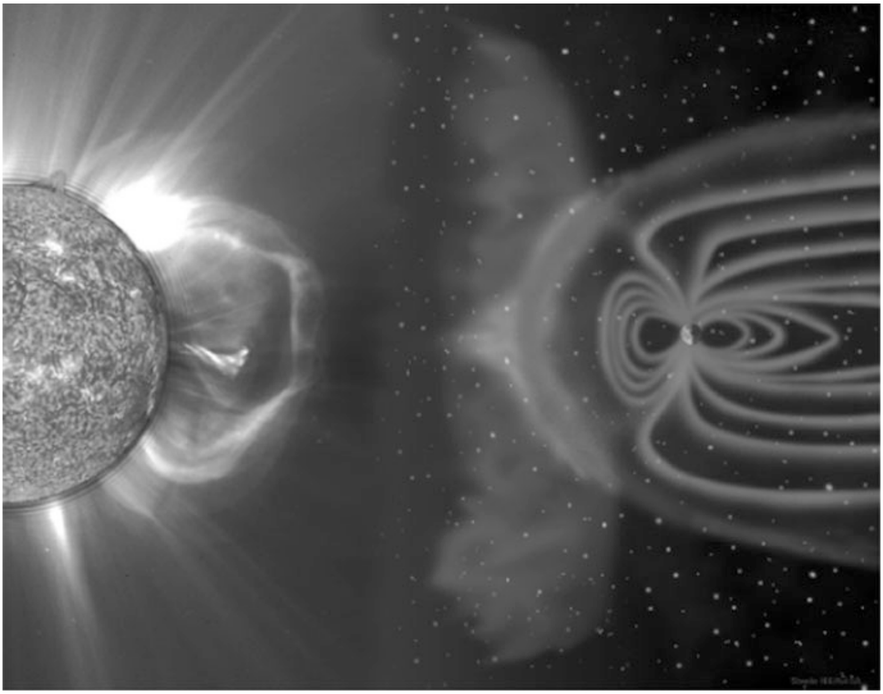


Fig. 2.2 Earth's magnetosphere, depicted here, acts as a shield against all but the most energetic cosmic rays, preventing them from reaching the surface of Earth in great quantities (courtesy of NASA)

in darkness. Most forms of life would either freeze to death or be cooked in these 400° temperature swings.

If you go out on a clear night in the middle of August, you have a pretty good chance of seeing a shooting star, more accurately called a meteor. If you know where and when to look, you will likely see several meteors. It is during this time that the Perseid meteor shower occurs, a result of Earth's passing through the trail of pea-sized debris left behind by comet Swift-Tuttle. Harmless to us on the surface of the planet, these small pieces of cosmic dust and ice hit the atmosphere at 60 km/s and quickly burn up, leaving a glowing trail across the night sky. The Perseids are a harmless, beautiful sight, unless you happen to be above the protection of our dense atmosphere.

If you are in space or on the Moon, these pebbles traveling at 60 km/s are more deadly than a speeding bullet (which travels at only about 0.8 km/s). When being hit by a bullet, a fist, or a car, what matters is not the overall speed but the kinetic energy of the impactor. For the most part, the energy transfer from the impactor to you determines how much damage you sustain. Kinetic energy is the energy associated with the motion of a body, and the amount of kinetic energy depends on both the mass of the object and the square of its velocity. In practical terms, this means that you can double the amount of damage done by doubling the mass of the projectile and simply keeping its speed constant. However, if you double its speed, you do not double its kinetic energy; you increase it by a factor of 4. A bullet shot from a gun on Earth will have only a fraction (about 0.017 %) of the energy of that same bullet moving with the speed of a Perseid meteor. It will therefore do only a fraction of the damage caused by being at the wrong place at the wrong time and getting hit by a meteor!

Granted, the probability of getting hit at any given time is low. There are only so many meteors, and space is very big. But once you factor in the frequency and damage potential of the larger impactors, such as asteroids, the risk begins to rise sharply. Getting hit with a large rock moving at tens of kilometers per second is like having a bomb dropped on you, or worse. (See Chap. 14, in which we discuss the threat from near-Earth objects and how one object impacting Earth is thought to have ended the reign of the dinosaurs.) The bottom line is that we live in a cosmic shooting gallery, and getting hit by any of these objects would be the perfect definition of a bad day.

One aspect of space that is foremost in most people's minds when they think of life in space is vacuum. What happens to living things in the vacuum of space? This is an easy question to answer. Unlike depictions in many science-fiction movies, the human body does not inflate like a balloon and explode when exposed to vacuum, nor does the blood boil or immediately freeze. You may not even immediately lose consciousness. But unless you get back under pressure very quickly, you will most assuredly die—from asphyxia.

If you were to step out on the surface of the Moon and somehow survive the vacuum, you would still have to worry about the continuous exposure to solar radiation in all its forms, such as visible light, ultraviolet light, and infrared light, as well as the charged particles in the solar wind and those resulting from solar energetic particle events. This radiation can quickly reach levels that even a moderately protected human could not survive. Next, you would have to protect yourself from the extreme heat during the 14-day lunar day and the extreme cold of the 14-day lunar night. (The Moon rotates more slowly on its axis than does Earth. One lunar day is therefore equal in length to 14 Earth days. We see only one side of the Moon because its rotation rate corresponds to the rate of lunar revolution about Earth.)

If you are standing on the Moon, you are standing on what may be the deadest place in the nearby Solar System. The Moon is blasted by intense solar radiation, remains in vacuum, and is alternatingly cooked and frozen on a regular basis. There is probably not a deader environment anywhere close by in the Solar System and certainly not anywhere on Earth (Fig. 2.3).

Without human intervention, space is anti-life. With the possible exception of the bacterium *Deinococcus radiodurans*, no life as we know it can survive in this hostile environment without the artificial protections such as those that we humans devise for our space explorers. Given that there is no air or water to pollute, no ozone to deplete, no climate to change, no environment to harm with the radioactive by-products of our nuclear power plants (the radiation from the Sun makes our pitiful human radioactive output seem truly minuscule by comparison), and no

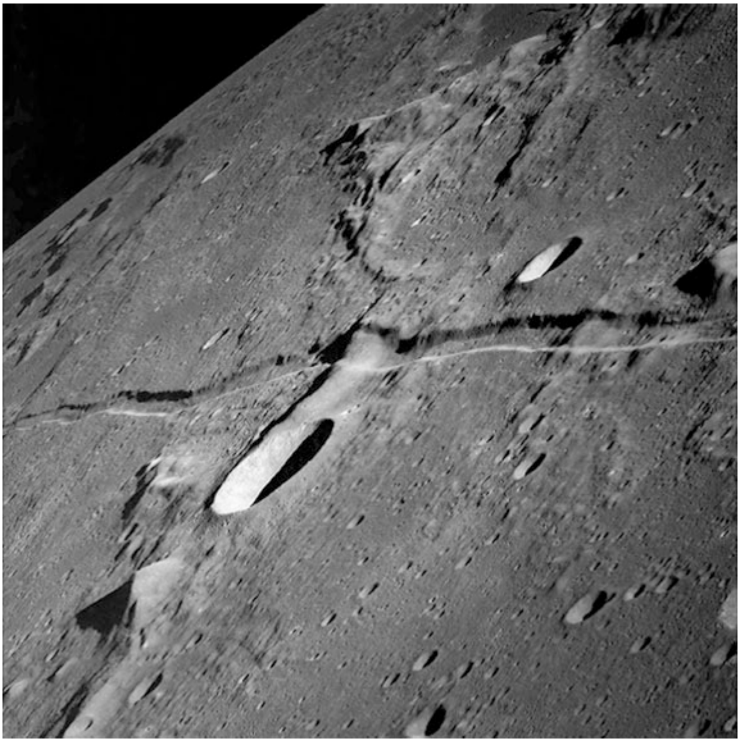


Fig. 2.3 The Moon is a dead environment, without any life—until we go there and build our cities and factories (courtesy of NASA)

ecosystem to clutter with our waste products, what can we humans possibly do in space to make it more anti-life than it already is? Absolutely nothing.

In fact, the argument can be made that by expanding the realm of human activity to space, including all the processes and products that on Earth would be called pollution and pollutants, we will be creating new places for life to exist and thrive. Such expansion would be a thoroughly positive moral choice. Our industrial plants will have to have breathable air and drinkable water, they will have to have artificial protection from solar radiation in all its forms, and they will have to regulate the temperature so that human life can survive and thrive. We will be creating "green" ecosystems from desert, and the inevitable by-products of our civilization, the pollutants, will not harm any ecosystem in any way. We should not be profligate and wasteful by any means. Our explorers and industrialists will not want to waste anything that has potential use, because it simply will be too expensive to replace. Recycling should be the norm and only after all other options are exhausted should we discard our waste into the space environment.

It may now be difficult to believe, but before 1992, the only planets we knew existed were in our own Solar System. Since then, about a thousand planets circling other stars have been found. Given that there are well over 250 billion stars in our

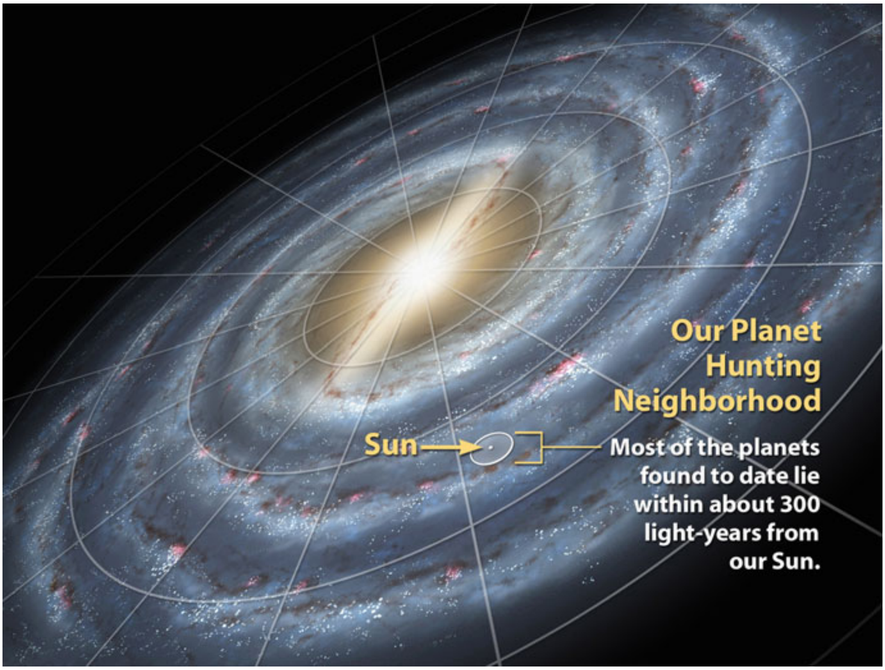


Fig. 2.4 So far, the only extrasolar planets found are within a very small part of the Milky Way Galaxy (image courtesy of NASA/JPL)

Milky Way Galaxy, and that all we've found so far are within only a few light year of Earth, we can estimate that there are hundreds of billions of planets yet to be found in our galaxy alone. Figure 2.4 shows the region of space within which all of the 'found' planets reside. As you can see, we have a lot more space to explore!

As our technology advances,[1] there is little doubt we will find more planets and be able to better understand the ones we find. Perhaps there some that could support

[1] There are various techniques used to find planets circling other stars. The most common is the *Doppler method*. A star's gravity tugs on its planets, keeping them in orbit around the star. But the planet, also having mass, tugs also on the star. The star is far more massive, so the effect of the planet pulling on it is quite small. But not so small that it cannot be detected. As the planet orbits the star, the star also moves in its own orbit around the center of mass of the star/planet system. Using telescopes, we can detect the resulting variations in the star's velocity as it moves either toward or away from Earth as a result of the planet tugging on it by measuring the Doppler shift of the starlight. Just think of the sound a train makes as it is approaching you and then as it moves away. The pitch, or frequency of the sound, changes depending upon its motion relative to where you are standing. This also happens with light, and we have telescopes sensitive enough to measure it.

Another way to find extrasolar planets is by measuring the decrease in brightness of a star that results when a planet crosses in front of it along the line-of-sight between the star and Earth. When a planet crosses in front of its parent star, the observed brightness of the star decreases temporarily.

human life, but let's not bet on them being found anytime soon. The ones found so far don't appear to be hospitable to life as we know it. And, even if we do find other 'Earths' out there, we are nowhere near having the capability to visit them.

Since we don't know of any other place where life exists, let alone life as we know and depend upon here on Earth, we should be doing everything in our power to protect and preserve it for all of its inhabitants. There is only one environment that matters, and we should not hesitate to use space and space resources to preserve it.

We have a moral obligation to develop space resources and to foster space industrialization. To not do so is ultimately anti-life and an immoral act of omission.

From measuring the intervals in which this occurs and the amount of dimming, we can estimate both the size and the star-to-planet distance. This is called the *transit method*.

There are other ways to detect extrasolar planets. An excellent reference is The Laboratory for Atmospheric and Space Physics at The University of Colorado at Boulder, http://lasp.colorado.edu/education/outerplanets/exoplanets.php#detection.

http://www.springer.com/978-1-4614-9425-6

Harvesting Space for a Greener Earth
Matloff, G.; Bangs, C.; Johnson, L.
2014, XV, 277 p. 120 illus., 88 illus. in color., Softcover
ISBN: 978-1-4614-9425-6