Wilderness, Biodiversity, and Human Health

Daniel L. Dustin, Keri A. Schwab, and Kelly S. Bricker

Abstract—This paper illustrates how wilderness, biodiversity, and human health are intertwined. Proceeding from the assumption that humankind is part of, rather than apart from, nature, health is re-imagined as a dynamic relationship that can best be conceived in broad ecological terms. Health, from an ecological perspective, is a measure of the wellness of the individual and the ecosystem considered together. Health, at its core, is symbiotic in nature. To make the case, seven organisms are discussed that have great potential medicinal value for humankind if only their habitats are protected and preserved. Human-induced threats to those habitats are also examined to illustrate humankind's increasing power to change the face of the earth in cataclysmic ways. Finally, the importance of reducing the psychological distance that increasingly separates humankind from nature is emphasized if nature's biological storehouse of health-promoting properties--especially those contained in wilderness--is to be preserved.

Introduction

While acknowledging and respecting the intrinsic value of wilderness, the case we make for its protection and the biodiversity it contains is rooted in our belief that human health is inextricably intertwined with the health of the world's pristine natural areas. Our position is underpinned by our belief that humankind is part of, rather than apart from, nature, and that anything we do to compromise nature's health ultimately compromises the health of our own species. In the end, our lesson is straightforward. We must save wilderness if only to save ourselves.

D.L. Dustin is Professor of Outdoor Recreation Planning and Policy in the Department of Parks, Recreation, and Tourism at the University of Utah, Salt Lake City, Utah, U.S.A. FAX: 801-581-4930, e-mail: daniel.dustin@health.utah.edu. K.A. Schwab is Assistant Professor of Youth and Family Development in the Recreation, Parks, and Tourism Administration Department at California Polytechnic University, San Luis Obispo, CA, U.S.A. K. S. Bricker is Professor of Sustainable Tourism and Interim Chair of the Department of Parks, Recreation, and Tourism at the University of Utah, Salt Lake City, Utah, U.S.A.

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We focus on wilderness as it is largely understood in the Western industrialized world. When discussing the distancing of people from nature in modern life, we know we are not doing justice to indigenous peoples worldwide who relate intimately to their fundamental ground of being, and who often see themselves as "kin" with nature (Salmon 2000). Moreover, when reviewing the potential medicinal value of organisms living in wilderness, we also realize that wilderness offers a much wider range of health benefits for humankind, including clean air, fresh water, opportunities for spiritual renewal, etc. What we offer here is but one of many arguments for wilderness preservation, an argument we believe will resonate with people even if they are not wilderness enthusiasts.

We highlight seven groups of organisms found throughout the world that have great potential for combating human disease, organisms that are threatened with extinction by humankind's impact on their habitats. In each case, we describe the organism's potential medicinal value as well as its threatened status. We then tie the concept of ecosystem services to an ecological model of health promotion in a way that portrays human and environmental health as inextricably intertwined. Finally, we advocate for a kind of day-to-day living that safeguards biodiversity and enhances ecological health over the long run. Once again, the lesson is straightforward. If we want to realize the medical benefits hidden in nature's storehouse of biodiversity, we had best live our lives in a way that sustains biodiversity.

Much of what we say is derived from Chivian and Bernstein's (2008) Sustaining Life: How Human Health Depends on Biodiversity. As Chivian and Bernstein contend, scientists know the answers to a lot of questions about the relationship between biodiversity and human health. The challenge is to communicate that understanding to the world's citizenry in a way that resonates with them so they will change the way they, their families, businesses, communities, and governments conduct themselves. This is the interpretive challenge we undertake in this paper.

Ecosystem Services

The context within which we make our claims is commonly referred to as "ecosystem services." Generally speaking, ecosystem services refer to a complex array of symbiotic relationships that characterize the Earth's ecosystems. These relationships are typically broken down into four categories: provisioning services, regulating services, cultural services, and supporting services (Melillo and Sala 2008). They represent functions that different organisms play for one another in ecosystems characterized by biodiversity. Provisioning services include products obtained from ecosystems like food, fuel, and medicine. Regulating services include processes that clean air, purify water, mitigate floods, control erosion, and detoxify soils. Cultural services refer to nonmaterial benefits obtained from ecosystems, including aesthetics, intellectual stimulation, and a sense of place. Supporting services enhance all other ecosystem services and include functions like nutrient cycling, pollination, and seed dispersal. As we note throughout the paper, human-induced changes compromise the ability of ecosystems to deliver services across all four categories--an unwelcome turn of events for everyone--including the change agents.

Amphibians

We begin with gastric brooding frogs, an amphibious species discovered in the Queensland rain forests of eastern Australia in the 1970s. What is particularly intriguing about gastric brooding frogs is their unique reproductive system. The female gastric brooding frog swallows her fertilized eggs, hatches them in her stomach, and then regurgitates them as tadpoles through her mouth. What is highly unusual about this arrangement is that acids and enzymes common to digestive systems in all vertebrates' stomachs are muted in the female gastric brooding frog by secretions from the developing tadpoles that prevent the tadpoles from being digested by their mother. Understanding the chemistry of these secretions could have important implications for treating peptic ulcers in humans, a disease that affects more than twenty-five million people in the United States alone (Chivian and Bernstein 2008).

Unfortunately, within a decade of their discovery gastric brooding frogs disappeared from the face of the Earth. The exact cause (s) of the frog's extinction is unclear, but it is likely related to human induced impacts in the Queensland rain forests coupled with the frog's narrow habitat requirements that evolved over eons of time. While attempts are ongoing to reverse the extinction of gastric brooding frogs through cloning (ABC News 2013), it appears that any human medical benefits that might have been derived from studying their reproductive system have disappeared along with them. Their loss was humankind's loss.

Amphibians are the most threatened group of organisms on the planet. Of the approximately 6,000 known species, almost one-third are in danger of extinction due to loss of habitat, alien species, increasing exposure to ultraviolet B radiation, pollution, global climate change, and infection (International Union for Conservation of Nature and Natural Resources 2006). This is especially disconcerting for humans given that amphibians possess an enormous variety of biologically active compounds that hold much promise for their medicinal value. Additionally, amphibians have played a critical role in the advancement of biomedical research, including serving as models for how electricity works in our nervous system, tissue regeneration, embryonic development, organ transplantation, and cryogenics (Chivian and Bernstein 2008).

Beyond these provisioning services, amphibians also carry out critical regulating and supporting services in decomposing organic matter and nutrient recycling as well as predating on insects too small for birds and mammals (Chivian and Bernstein 2008). Their centrality to the healthy functioning of ecosystems is obvious, and we should do all we can to ensure the reversal of what some scientists have termed the "Amphibian Extinction Crisis" (Mendelson and others 2006).

Bears

Bears have long been prized for their medicinal value, especially in Asia. Bears are killed for their body parts, chiefly for the bile contained in their gall bladders. In the early 1900s scientists discovered that bear bile contained ursodeoxycholic acid (UDCA), a potent chemical that helps bears maximize absorption of their high fat diets to ensure they have adequate fat stores during their long periods of dormancy (Chivian and Bernstein 2008). UDCA has proven effective in treating primary biliary cirrhosis (PBC), an inflammatory, and often fatal, liver disease affecting women between the ages of 30 and 60 (Shi 2006).

In winter, when food is scarce, bears enter into a prolonged period of metabolic inactivity called "denning." They do not eat, drink, urinate, or defecate for three to five months. They recycle their bodily wastes in a way not found in any other animal. Understanding these chemical processes has important implications for the treatment of osteoporosis, renal disease, and Type 1 and 2 Diabetes in humans. Unlike humans, prolonged inactivity does not cause bears to lose bone mass [osteoporosis] (Floyd, Nelsen, and Wynne 1990); going without urinating for five months does not cause urinary waste toxicities in bears as it does in humans leading to renal disease and kidney failure in a few days (Chivian and Bernstein 2008); and the unique metabolic processes of denning bears discourages rather than encourages insulin-related problems that cause Type 1 and 2 Diabetes (Ahlquist and others1984; Cattet 2000). In sum, the manner in which denning bears manage the metabolism of fat in their bloodstream holds considerable promise for combating human diseases associated with increasing incidents of obesity.

Nine species of bears are listed on the International Union for Conservation of Nature and Natural Resources (IUCNN) Red List of Threatened Animal Species, including the Polar Bear, the Giant Panda, and the Asiatic Black Bear (Chivian and Bernstein 2008). Bears are particularly vulnerable to human-induced environmental impacts, especially as a result of human encroachment on bear habitat, pollutants, and global climate change. Indeed, the U.S. Geological Survey has predicted that two-thirds of the world's Polar Bears will be lost by 2050 due to global warming (U.S. Geological Survey 2007). Under the circumstances, the protection of bears and bear habitats is wise, if only to serve anthropocentric ends. Moreover, it should be understood that killing bears for their medicinal value in and of itself is a threat to their existence in some parts of the world.

Primates

Nonhuman primates are the closest relatives to our own species. Indeed, humans are part of the superfamily, Homonoidea, which includes gibbons, orangutans, gorillas, Chimpanzees, and Bonobos. Our biological similarity to nonhuman primates is astounding. Human DNA, for example, is almost identical with that of Chimpanzees, differing by a mere 1.3 percent (Chivian and Bernstein 2008). This closeness in anatomy, physiology, and behavior makes nonhuman primates critically important models for biomedical research.

Scientists have identified three areas of biomedical research on nonhuman primates that are vital to the advancement of human medicine: infectious diseases and the development of vaccines to combat them; neurological disorders; and behavioral disorders. Nonhuman primates played a pivotal role in developing the polio vaccine in the first half of the 20th century. More recently, they have been instrumental in work on Hepatitus B and C, Malaria, the Ebola and Marburg viruses, rotaviruses, and HIV/AIDS. Again, it is the biological similarity between humans and nonhuman primates that makes nonhuman primates so indispensable to biomedical research. This extends to neurological research as well because the brains of nonhuman primates come closest to our own in organization and complexity. The similarities have aided researchers in understanding the nature of Parkinson's Disease (Burns and others 1983) and Alzheimer's disease (Price and Sisodia 1994). Studying the behavior of nonhuman primates has also shed considerable light on mother-infant interactions, motivational states, and the nonhuman primate equivalent of human psychiatric states, such as depression and anxiety. Of greatest note, Jane Goodall's (1988) work in Africa has demonstrated that Chimpanzees have highly complex societies, experience deep humanlike emotions, use tools, and conduct wars.

It is likely that the closeness of nonhuman primates to our own species accounts for the international attention paid to them. That same closeness also explains the empathy, concern, and objections raised by animal rights activists over using nonhuman primates in biomedical research. Of more than 350 primate species, almost one-third are threatened, and of this one-third, more than half are considered Endangered or Critically Endangered by human practices. Controlled burns to clear land, logging, hunting, habitat encroachment, and climate change have all contributed to the gradual demise of nonhuman primate habitat across the globe. Given their biological proximity to humankind, and the crisis proportions of the threats posed by human induced changes in the environment, protecting nonhuman primate habitat is vitally important to the future of all the Earth's species, not the least of which is our own.

Gymnosperms

Gymnosperms are a group of common plants known for their exposed seeds. Among the oldest of plants, common gymnosperms include trees such as pines and spruces. Gymnosperms also include the conifers, of which there are 600species, trees that are widely used for home construction, paper pulp, and other provisioning services. Among the many medicines derived from gymnopserms are ephedrine, a compound used to treat asthma by dilating the respiratory track to make breathing easier, and isoproterenol, used to stimulate patients' heart rates when they experience heart blockage (Newman, Cragg, and Snader 2000). The bark of the Pacific Yew Tree, long discarded as useless in logging operations in the Pacific Northwest of the United States, has yielded the most important drug, paclitaxel, a drug that has been shown to be effective for inducing remissions in ovarian cancer (McGuire and others 1989).

Threats to gymnopserms come mainly from unsustainable harvesting, pests, and global warming. A poignant example of the harm that can be done to an otherwise healthy ecosystem comes from Alaska's Kenai Peninsula, where from 1987 to 2000, 90 percent of the White and Lutz spruce trees were wiped out by the North American Spruce Bark Beetle, a beetle indigenous to the region, but historically non-threatening. Scientists have determined that global warming

led to greater beetle survival and dryer forest conditions resulting in reduced spruce tree sap production, which compromised the trees' defenses against the beetles (Egan 2002; Holsten and others 1999). Similar stories abound, including the devastating effects of White Pine Blister Rust in Montana's Glacier National Park and Bob Marshall Wilderness, killing about half the White Pines in both areas, and the Mountain Pine Beetle, which has done considerable damage to Whitebark Pine trees in the Yellowstone ecosystem (Gibson 2006). In the first instance, an early 20th century infection has finally wreaked havoc (McDonald and Hoff 2001), and in the second instance global warming accounts for the damage (Keane, Morgan, and Menakis 1994; Kendall and Keane 1994). In both instances, human beings have been the principal instruments of change threatening ecosystem biodiversity.

Cone Snails

Moving from land-based organisms to water-based organisms, we begin with cone snails, of which there are approximately 700 species. The most common cone snails live in shallow waters associated with coral reefs and mangroves. The medicinal value of cone snails is derived mainly from their production of highly toxic peptides, compounds which have proven very effective for treating pain. Indeed, one conopeptide, ziconotide, is believed to be 1,000 times more potent than morphine, the standard treatment for severe pain (Bowersox and others1996). Moreover, unlike opiates, which can lead to addiction and often result in higher tolerance levels requiring higher doses, pain treatments derived from conopeptides do not lead to addiction or increased tolerance. Conopeptides are now relied on for patients whose pain no longer responds to opiates.

While cone snails are not considered to be threatened per se, the habitats they reside in, coral reefs and mangroves, are quickly being degraded around the world. Marine biologists estimate that 20 percent of the world's coral reefs are damaged beyond repair and an additional 50 percent are in danger of collapsing (Wilkinson 2004). Mangroves are in even more jeopardy as 50 percent of the world's supply has been cleared for wood, development, and aquaculture (Spalding, Blasco, and Field 1997). The potential opportunity cost for human health, should cone snail habitats be totally destroyed, resides in the fact that each of the 700 species of cone snail creates approximately 100 to 200 distinct peptides, so there may be as many as 70,000 to 140,000 peptide toxins in all. To date, scientists have studied only 100 or so conopeptides for their medicinal value (Chivian and Bernstein 2008). Obviously, the potential for cone snail peptides to contribute to biomedical research and human health has hardly been tapped. Ongoing work suggests that conopeptides may be effective in treating spasticity secondary to spinal cord injury, clinical depression, urinary incontinence, and cardiac arrhythmias, to name but a few of the medicinal possibilities. As Chivian and Bernstein conclude, "of all the families of organisms on Earth, cone snails, the Conidae, may contain the largest and most clinically important pharmacopoeia of any in Nature" (p. 264.)

Sharks

Sharks present yet another watery example of an organism that may have tremendous medicinal value for humans, if only they and their marine environments are protected over the long run. Long maligned by humans as vicious predators, there are approximately 400 known species of sharks, and their numbers are dwindling rapidly by overharvesting. Scientists estimate, for example, that 75 percent of the large coastal and open ocean sharks in the northwest Atlantic Ocean have disappeared in the last 15 years (Baum and others 2003). Sharks are harvested for their meat, fins, and cartilage. Shark fins are especially prized in Asian countries, where customers pay top dollar for shark fin soup.

Sharks are also the apex predator in the open ocean, so as the shark population declines, rippling effects are felt up and down the food chain. Indeed, the precipitous decline in the shark population along the United States' eastern seaboard is thought to have led to the demise of the Bay Scallop fishery, including the destruction of North Carolina's century-old bay scallop beds (Myers and others 2007).

The potential medicinal value of sharks remains largely speculative. Shark cartilage has been studied for its potential anticancer properties, and squalamine, an aminosterol found in shark tissue, has been shown to be an effective antibiotic for a variety of bacteria (Moore et al., 1993), as well as showing some promise for the treatment of age-related macular degeneration (Garcia and others 2005). Because sharks are among the earliest vertebrates dating back 400 to 500 million years, their immune systems have received increasing scientific attention. Sharks have evolved a highly adaptive immune system, which allows them to fend off a wide range of threats. The implications for human health are equally wide ranging, including potential benefits for organ transplantation.

The wantonness with which the shark population has been treated is cause for alarm. Overcoming stereotypical portrayals of sharks as unfeeling man-eaters has led to a cultural bias against sharks that should be reversed. Sharks are far less of a threat to humankind than bees and lightning, and what can be learned from sharks stands to benefit human beings in countless medical ways.

Horseshoe Crabs

Finally, horseshoe crabs are remarkable for a host of reasons. They have four eyes as well as six other light-detecting organs, one of which can be found in the tail, six pairs of legs, and blood that turns a brilliant cobalt blue when exposed to air (Chivian and Bernstein 2008). Horseshoe crabs can be found along the Atlantic Coast of North America and the shores of Southeast Asia. They are harvested for their shells, which are pulverized and used for fertilizer, and as bait for eel and whelk fisheries. Additionally, the eggs of horseshoe crabs are a popular food source for migratory shorebirds.

The blood of horseshoe crabs is prized for its contributions to biomedical research. For decades, scientists have known that horseshoe crab blood kills bacteria, and that blood has been used to develop antibiotic therapies. Additionally, horseshoe crab blood contains several novel molecules that may contribute to the treatment of other major diseases, including HIV/AIDS, leukemia, prostate cancer, breast cancer, and rheumatoid arthritis. Horseshoe crab blood has also been instrumental in developing an extremely effective test that detects endotoxins in humans, a critically important diagnostic tool (Levin, Tomasulo, and Oser 1970). Finally, horseshoe crab eyes have played a critical role in better understanding human vision (Graham, Ratliff, and Hartline 1973).

The principal threat to horseshoe crabs is overexploitation through fishing. It takes horseshoe crabs about a decade to reach maturity and out of approximately 90,000 eggs laid per female each breeding season, only tenor so survive, making the species particularly vulnerable to overfishing. Overharvesting in the Pacific Ocean has led to increasing pressure to exploit Atlantic stocks. A decline in horseshoe crabs has also had rippling effects on migrating shorebirds, who rely on the horseshoe crab eggs to fuel their bi-annual 10,000 mile journeys. One species, in particular, the North American Red Knot, is on the verge of extinction because of the rapidly dwindling numbers of horseshoe crab eggs in Delaware Bay along their route from Tierra del Fuego at the southernmost tip of South America to the Arctic Circle (Morrison, Ross, and Niles 2004). Once again, the horseshoe crab example illustrates the intricate and often delicate web of life that supports ecosystem services in biologically rich marine environments, environments that are continually being degraded by short-sighted human actions.

Humankind's Role in Changing the Face of the Earth

The common denominators in all seven of these stories are human-induced impacts that threaten other species and their habitats. Humankind's ability to change the face of the earth in dramatic and often cataclysmic ways has increased significantly in the last two centuries (Thomas 1956). A species that was once at home in nature now finds nature to be "outside" of its day-to-day comings and goings, particularly in the Western industrialized world. Urbanization and advancing technology serve as buffers between human beings and the natural world, resulting in an increasing sense of physical and psychological detachment from humankind's fundamental ground of being. This disengagement comes at the same time human beings assume more and more power to affect nature in positive and negative ways. Under the circumstances, the environmental philosopher Max Oelschlaeger's proposition that humankind is nature's way of keeping track of itself (Oelschlaeger 1991), that nature has evolved a self-reflective organism that has the capacity to step outside itself, reflect on its circumstances, and change its ways takes on more and more import. While it is clear that nature can do without our species (Weisman, 2007), it is equally clear that our species cannot do without nature. It is time to exercise restraint and extend ethical consideration outward to other species and the Earth in its entirety, if only for selfish human-centered reasons (Dustin 1997).

Ecological Model of Health Promotion

These seven organisms are merely illustrative of the vast potential that a biologically diverse planet offers human beings to advance medical knowledge. As the architect Buckminster Fuller observed, "Nature is trying very hard to make us succeed, but Nature does not depend on us. We are not the only experiment" (Chivian and Bernstein 2008, p. 163.) The challenge facing humankind is to step down from its anthropocentric pedestal to assume a more humble station among the Earth's creations, and to live life in a way that honors and protects the larger web of life.

To assist in this educational process we now tie the concept of ecosystem services to an ecological model of health promotion (Dustin, Bricker, and Schwab 2010) to illustrate how organisms throughout nature work cooperatively to deliver provisioning, regulating, cultural, and supporting services. As Figure 1 shows, at the heart of a healthy planet is biodiversity. In its fullest expression, a biologically rich planet sustains itself through an intricate web of ecosystem services, of which our species, homo sapiens, is but one of countless service providers and consumers. The star and directional arrows all point toward interactions and interdependencies that serve as channels for ecosystem services to be delivered back and forth to sustain the web of life. To be truly healthy, the Earth's ecosystems must be characterized by reciprocity based on an appreciation of the symbiotic nature of things. Just as amphibians, bears, nonhuman primates, gymnosperms, cone snails, sharks, and horseshoe crabs all play their parts in the give and take of things, so, too, must humans play their part. As Aldo Leopold (1949) reasoned, we must willingly assume our role as plain members and citizens of the larger community of life. This requires jettisoning the hubris that has characterized humankind over the ages and replacing it with a more humble perspective regarding our place in the vast scheme of things.

Figure 1—Ecological model of health promotion.

Health should be understood as a dynamic relationship that can best be conceived in broad ecological terms. Health, from an ecological perspective, is a measure of the wellness of the individual and the ecosystem considered together. The individual cannot be healthy independent of the condition of the larger ecosystem, and the larger ecosystem cannot be healthy independent of the condition of the individuals constituting it. Healthy individuals require healthy families, healthy families require healthy communities, healthy communities require healthy nations, healthy nations require a healthy planet, and so on. Health, at its core, is symbiotic in nature (Schwab, Dustin, and Bricker, 2009).

An ecological model of health promotion illustrates that human health and environmental health are part and parcel of the same thing. We cannot have one without the other. That is because humans are part of nature after all, and what is good for one is good for the other and what is bad for one is bad for the other. Amphibians, bears, nonhuman primates, gymnosperms, cone snails, sharks, and horseshoe crabs may not understand this, but humans can and must understand this if our grand experiment is to last. What distinguishes our species from the rest is self-awareness. We have the ability to step outside ourselves, reflect on our circumstances, and make changes when necessary. We have the capacity to mend the errors of our ways. That, if anything, is what separates us from our fellow mortals. Our ongoing challenge is to put our self-awareness to work in service of the larger web of life, plain and simple.

Wilderness and Everyday Life

Perhaps the biggest challenge we face in trying to get the world's citizenry to appreciate the interconnections and interdependencies described in this paper is to help them see in a close-up and personal way how ecosystem services actually work, how things seemingly distant and far removed from our everyday lives are, in fact, connected to each of us in very direct and meaningful ways (Dustin 2003). This 'vision' problem is at the heart of the interpretive challenge. As Freeman Tilden observed in his first principle of interpretation, if the message we are trying to deliver does not resonate with something within the experience of the visitor, it will appear sterile (Tilden 1957). How then should we proceed?

In "Thermus Aquaticus and You: Biodiversity, Human Health, and the Intepretive Challenge" (Dustin, Schwab, and Bricker 2010), we tell the story of DNA testing through the eyes of exonerated prisoners, a potential circumstance to which almost everyone can relate, and then gradually fill in the back story with a series of scientific events that led to the DNA testing technique. The story takes us back to the establishment of Yellowstone National Park in 1872 and the protection of scalding geyser basins that were the source of tak polymerase, a heat resistant enzyme instrumental in DNA testing that was extracted from Thermus Aquaticus, a heretofore unknown bacterium that remained undiscovered until the late 1960s. Had Yellowstone not been set aside and protected as a national park by President Grant in 1872, who knows if the scientific discovery that led to DNA testing would ever have been made. It is a poignant story about the benefits that can accrue to human beings when nature's biodiversity is safeguarded in the form of parks, open spaces, and wilderness areas.

We need more stories like this that overcome the challenges presented by time and space as obstacles to understanding ecosystem services. Our lives are continually affected by natural forces we can neither see nor hear, yet that perceptual problem is no excuse for denying their impact on the quality of our lives or the quality of all life on Earth. We are proximal beings affected by distal forces, and we must improve our vision so that we might better see these forces at work. This is the interpretive challenge that Chivian and Bernstein (2008) leave their readers with, and this is the challenge we must take up if we are to demonstrate the relevance of wilderness to everyday life.

In the end, reducing the perceptual distance between wilderness and day-to-day living is critical to the protection of the planet's biodiversity (Dustin 2003). We have to do a better job of showing how the ways in which we live our individual lives in urban conclaves impact wilderness and how the existence of faraway wilderness impacts our urban lives. In an age when people are rapidly distancing themselves from their biological moorings, reconnecting them with nature is increasingly important. Children who are exposed to nature grow into adults who care about nature (Chawla 1998), while children who are not exposed to nature grow into adults who are indifferent to nature (Louv 2005). Moreover, educational philosophies like "Leave No Trace" and "Minimum Impact," which are touted as responsible environmental orientations for conducting ourselves in pristine nature must be incorporated into our daily living habits such that we reduce our collective carbon footprint on the Earth and its store of limited nonrenewable natural resources in significant and lasting ways (Cachelin, Rose, Dustin, and Shooter 2011; Cachelin, Paisley, and Dustin 2009). Learning to live within our means and drawing less on the Earth's rapidly dwindling stock of ecosystem services has to be part of any long range plan for socially and environmentally responsible living, as well as finding self-fulfillment in social and interpersonal relationships, and in intellectual, emotional, and spiritual growth rather than in the consumption of finite material possessions (Dustin, McAvoy, Schultz, Bricker, Rose, and Schwab 2011).

Conclusion

As Sigurd Olson reminds us in Reflections from the North Country, the greatest achievement in our flight to the moon is "a picture of the earth, a living blue-green planet whirling in the dark, endless void of space, and the realization that this is home" (Olson 1977, p. 59). From space there are no political, cultural, or social boundaries. From space there are no ideological schisms. From space there is only one ecological reality within which we must learn to live our lives (Dustin 1991).

In this paper we have illustrated how the Earth's organisms depend on one another to sustain themselves. To behave as if human beings are somehow outside of or beyond this intricately woven web of life is wrong-headed. We are a part of, not apart from, nature, and we are obliged to abide by nature's laws. And while people might someday prefer to live on other planets, for now the Earth is our only home, and we would do well to conserve its biological treasures accordingly.

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