

Beyond Toxicity

Human Health and the Natural Environment

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Abstract: Research and teaching in environmental health have centered on the hazardous effects of various environmental exposures, such as toxic chemicals, radiation, and biological and physical agents. However, some kinds of environmental exposures may have positive health effects. According to E.O. Wilson's "biophilia" hypothesis, humans are innately attracted to other living organisms. Later authors have expanded this concept to suggest that humans have an innate bond with nature more generally. This implies that certain kinds of contact with the natural world may benefit health. Evidence supporting this hypothesis is presented from four aspects of the natural world: animals, plants, landscapes, and wilderness. Finally, the implications of this hypothesis for a broader agenda for environmental health, encompassing not only toxic outcomes but also salutary ones, are discussed. This agenda implies research on a range of potentially healthful environmental exposures, collaboration among professionals in a range of disciplines from public health to landscape architecture to city planning, and interventions based on research outcomes.

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Advances in the field of environmental health have taught us much about human health hazards. We know that air pollution can cause respiratory disease,¹ that heavy metals can cause neurotoxicity,² and that global climate change is likely to fuel some infectious diseases.³ Clearly, environmental exposures can threaten health.

But the natural environment, broadly conceived, can also enhance health. A well-recognized example is the many pharmaceuticals that derive from plants and animals—a compelling argument for preserving biodiversity.^{4–6} But another example is even more intuitive, both to clinicians and to laypeople. Contact with the natural world may be directly beneficial to health. If so, then the field of environmental health needs to extend beyond toxicity to consider possible health benefits. This article reviews the evidence for health benefits of the natural environment, and suggests some of the research and interventions that such a broader paradigm of environmental health might imply.

Links Between Health and Environment

Fifty years ago the World Health Organization defined health as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.” Does contact with the natural environment contribute to our “complete physical, mental, and social well-being”?

Many people appreciate a walk in the park, or the sound of a bird's song, or the sight of ocean waves lapping at the seashore. Even if these were only aesthetic preferences, they would be of interest, since they are so common as to seem nearly universal. As one environmental psychologist has written,⁷ “Nature matters to people. Big trees and small trees, glistening water, chirping birds, budding bushes, colorful flowers—these are important ingredients in a good life.” But perhaps these are more than aesthetic preferences. Perhaps we as a species find tranquility in certain natural environments—a soothing, restorative, and even a healing sense. If so, contact with nature might be an important component of well-being.

From an evolutionary perspective, a deep-seated connection with the natural world would be no surprise. Primate evolution began at least 65 million years ago, and the first hominids appeared as much as 5 million years ago. *Homo habilis* probably appeared 2 or 3 million years ago, and our immediate predecessor, *Homo erectus*, appeared about 1.5 million years ago. Human history as we now know it began during the neolithic period just 10,000 or 15,000 years ago, when the last great ice age

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ended, and global climate and ecology came to resemble those we know. Our *Homo sapiens* ancestors began to form settlements, cultivate crops, domesticate animals, dig mines, and even make art. If the last 2 million years of our species' history were scaled to a single human lifetime of 70 years, then the first humans would not have begun settling into villages until 8 months after the 69th birthday. Some people—aboriginal groups in Australia, South America, the Pacific Islands, and elsewhere—would remain hunter-gatherers until a day or two before the 70th birthday. We have broken with long-established patterns of living rather late in our life as a species.

For the great majority of human existence, human biology has been embedded in the natural environment. Those who could smell the water, find the plants, follow the animals, and recognize the safe havens, must have enjoyed survival advantages. According to biologist E.O. Wilson,⁸ "It would...be quite extraordinary to find that all learning rules related to that world have been erased in a few thousand years, even in the tiny minority of peoples who have existed for more than one or two generations in wholly urban environments." Wilson⁹ hypothesized the existence of biophilia, "the innately emotional affiliation of human beings to other living organisms." Building on this theory, others have postulated an affinity for nature that goes beyond living things, to include streams, ocean waves, and wind.¹⁰

The human relationship with nature, and the idea that this might be a component of good health, have a long history in philosophy, art, and popular culture, from ancient Greece to the New England transcendentalists (e.g., Nash,¹¹ McLuhan,¹² Mazel,¹³ and Murphy¹⁴). A century ago, the early American conservationist John Muir¹⁵ observed, "Thousands of tired, nerve-shaken, over-civilized people are beginning to find out that going to the mountains is going home; that wilderness is a necessity; and that mountain parks and reservations are useful not only as fountains of timber and irrigating rivers, but as fountains of life." Is there any evidence to support this view, and to suggest that contact with nature can function to enhance health? Evidence is available from four aspects of the natural world—animals, plants, landscapes, and wilderness experience.

Domains of Nature Contact

Animals

Animals have always played a prominent part in human life.¹⁶ Today, more people go to zoos each year than to all professional sporting events.⁸ A total of 56% of U.S. households own pets.¹⁷ Animals comprise more than 90% of the characters used in language acquisition and counting in children's preschool books.¹⁸ Numerous

studies establish that household animals are considered family members; we talk to them as if they were human, we carry their photographs, we share our bedrooms with them.¹⁹ An estimated 50% of adults and 70% of adolescents confide in their animals.¹⁷

A wide body of evidence links animals with human health. In a study in a Melbourne cardiovascular disease risk clinic,²⁰ nearly 6000 patients were divided into those who owned pets and those who did not. Among men, the pet owners had statistically significantly lower systolic blood pressure, cholesterol, and triglycerides than the non-pet owners. Among women, a similar trend was observed. These findings did not appear to be due to differences in exercise levels (say, from dog walking), diet, social class, or other confounders. In a 1995 study,²¹ 369 survivors of myocardial infarction were followed for 1 year. Of these, 112 owned pets and 257 did not. The dog owners had a 1-year survival six times higher than that of the non-dog owners, and this benefit was not due to physiological differences. (Cat owners showed no such advantage.)

Investigators in Cambridge, England²² followed 71 adults who had just acquired pets, and compared them with 26 petless controls, over a 10-month period. Within a month of acquiring the pet, the pet owners showed a statistically significant decrease in minor health problems. In the dog owners (but not the cat owners) this improvement was sustained for the entire 10 months of observation. In another study, this one in the United States,²³ 938 Medicare enrollees were divided into pet owners and non-pet owners. The pet owners, especially the dog owners, had fewer physician visits than non-pet owners. Moreover, stressful life events were associated with more doctor visits among the non-pet owners, but not among the pet owners, suggesting that owning a pet helped mediate stress.

The role of animals in helping people handle stress has been tested specifically. In one study,²⁴ patients about to undergo oral surgery were randomly assigned to one of five conditions: a half-hour looking at an aquarium, with or without hypnosis; a half-hour looking at a picture of a waterfall, with or without hypnosis; and a half-hour of sitting quietly. The patients' comfort and relaxation during surgery were graded independently by the oral surgeon, the investigator, and the patients themselves. The most relaxed patients were those who looked at the aquarium, irrespective of whether they had been hypnotized. The patients who looked at the waterfall picture were almost as relaxed, but only if they had been hypnotized first. Otherwise, they had low relaxation scores, as low as those of the control patients. In another study,²⁵ 45 women were exposed to a stressful stimulus alone, in the presence of a human friend, and in the presence of their dog. Their autonomic nervous system responses to stress, such as heart

See
related
Commentary
on pages 241
and 243.

rate, were measured. The stress response was marked when subjects were alone, and even more marked when a friend was present. But having a dog present significantly reduced the stress response. Animal facilitated therapy in the treatment of psychiatric conditions is now well established.²⁶

Evidence such as this supports the conclusion of animal researchers Alan Beck and N. Marshall Meyers¹⁷: “Preserving the bond between people and their animals, like encouraging good nutrition and exercise, appears to be in the best interests of those concerned with public health.”

Plants

People feel good around plants. In the 1989 National Gardening Survey of more than 2000 randomly selected households,²⁷ 50.1% of respondents agreed with the statement, “The flowers and plants at theme parks, historic sites, golf courses, and restaurants are important to my enjoyment of visiting there,” and 40.0% agreed with the statement, “Being around plants makes me feel calmer and more relaxed.” Among residents of retirement communities,²⁸ 99% indicate that “living within pleasant landscaped grounds” is either essential or important, and 95% indicate that windows facing green, landscaped grounds are either essential or important. Office employees report that plants make them feel calmer and more relaxed, and that an office with plants is a more desirable place to work.²⁹ In urban settings, gardens and gardening have been linked to social benefits ranging from improved property values to greater conviviality (e.g., Patel³⁰). Psychologist Michael Perlman³¹ has written of the psychological power of trees, as evidenced by mythology, dreams, and self-reported emotional responses.

Indeed, the concept that plants have a role in mental health is well established. Horticultural therapy evolved as a form of mental health treatment, based on the therapeutic effects of gardening.³² It is also used today in community-based programs, geriatrics programs, prisons, developmental disabilities programs, and special education.³³ In prisons, although rigorous evidence is not available, observers have noted that gardening has a “strangely soothing effect,” making “pacifists of potential battlers,”³⁴ and seeming to decrease the numbers of assaults among prisoners.³⁵

Could contact with plants also contribute to healing from physical ailments?³⁶ There is a memorable passage in Oliver Sacks’ 1984 account³⁷ of his recovery from a serious leg injury. After more than 2 weeks in a small hospital room with no outside view, and a third week on a dreary surgical ward, he was finally taken out to the hospital garden:

This was a great joy—to be out in the air—for I had not been outside in almost a month. A pure and intense joy, a blessing, to feel the sun on my

face and the wind in my hair, to hear birds, to see, touch, and fondle the living plants. Some essential connection and communion with nature was re-established after the horrible isolation and alienation I had known. Some part of me came alive, when I was taken to the garden, which had been starved, and died, perhaps without my knowing it.

Sacks³⁷ credited his garden contact with an important role in his recovery, and mused that perhaps more hospitals should have gardens, or even be set in the countryside or near woods.

Swee-Lian Yi³⁸ was aged 29 when she suffered a severe stroke, and was hospitalized in New York’s Rusk Institute for rehabilitation. Like Sacks, she found her first visit to the hospital greenhouse a turning point. “It was when I walked through that building, perfectly quiet, filled with green and growing plants and the sweet smell of healthy soil that my anxiety began to ebb away. In its place came a tranquility I had not experienced since the day of my stroke.”³⁸ In fact, hospitals have traditionally had gardens as an adjunct to recuperation and healing, and despite the depredations of managed care, notable examples survive in many parts of the country.³⁹ Perhaps this time-honored practice reflects an ancient recognition that proximity to plants, like proximity to animals, may in some circumstances enhance health.

Landscapes

Natural landscapes may have a similar effect. Returning to an evolutionary perspective, human history probably began on the African savanna, a region of open grasslands punctuated by scattered copses of trees and denser woods near rivers and lakes. If this sounds like the choicest real estate in most cities and towns, that may not be a coincidence. As E.O. Wilson⁹ points out, “certain key features of the ancient physical habitat match the choices made by modern human beings when they have a say in the matter”—a pattern that repeats in parks, cemeteries, golf courses, and lawns. “It seems that whenever people are given a free choice, they move to open tree-studded land on prominences overlooking water.”

Could evolution have selected for certain landscape preferences? Perhaps. According to Wilson,¹⁰ “A crucial step in the lives of most organisms, including humans, is selection of a habitat. If a creature gets into the right place, everything else is likely to be easier. Habitat selection depends on the recognition of objects, sounds, and odors to which the organism responds as if it understood their significance for future behavior and success.” For example, many birds use patterns of tree density and vertical arrangement of branches as primary settling cues; presumably these cues are correlated with such crucial information as

food availability, concealment from predators, and other benefits. For early humans, a place with an open view would have offered better opportunities to identify food and shelter and to avoid predators, than a spatially restricted setting. But not too open a view: Clumps of trees would offer hiding places in a pinch, and, like streams and lakes, might also signal the presence of prey for the hunter.⁴⁰ Going further, perhaps the ability to identify relaxing, restorative settings, and the capacity to recover from fatigue and stress, could also have been adaptive.^{40,41} If you can run away from a saber-toothed tiger, your survival is enhanced. But if, having run away, you can get to a peaceful place, relax, and gather your strength, that may further enhance your survival. Perhaps individuals who chose such settings gained a survival advantage.⁴⁰

There is considerable evidence that people's aesthetic preferences conform to this scenario. When offered a variety of landscapes, people react most positively to savanna-like settings, with moderate to high depth or openness, relatively smooth or uniform-length grassy vegetation or ground surfaces, scattered trees or small groupings of trees, and water.^{42,43} Notably, these findings emerge cross-culturally, in studies of North Americans, Europeans, Asians, and Africans (e.g., Hull and Revell,⁴⁴ Purcell et al.,⁴⁵ and Korpela and Hartig⁴⁶).

This effect may extend beyond aesthetics, to restoration or stress recovery. Research on recreational activities has shown that savanna-like settings are associated with self-reported feelings of "peacefulness," "tranquility," or "relaxation."⁴⁰ Viewing such settings leads to decreased fear and anger, and enhanced positive affect on the Zuckerman Inventory of Personal Reactions.⁴⁷ Moreover, viewing nature scenes is associated with enhanced mental alertness, attention, and cognitive performance, as measured by tasks such as proofreading and by formal psychological testing.⁴⁸⁻⁵⁰

The same results emerge from studies that directly consider conventional health endpoints. In 1981, Ernest Moore, a University of Michigan architect, took advantage of a natural experiment at the State Prison of Southern Michigan, a massive depression-era structure.⁵¹ Half the prisoners occupied cells along the outside wall, with a window view of rolling farmland and trees, while the other half occupied cells that faced the prison courtyard. Assignment to one or the other kind of cell was random. The prisoners in the inside cells had a 24% higher frequency of sick-call visits, compared to those in exterior cells. Moore could not identify any design feature to explain this difference, and concluded that the outside view "may provide some stress reduction." Like prisoners, employees with views of nature at work report fewer headaches (as well as less job pressure and greater job satisfaction) than those without such a view.⁵²

Similar observations have come from health care

settings. A short 1984 paper in *Science*⁵³ bore the provocative title, "View through a window may influence recovery from surgery." Like the Michigan prison study, this study also took advantage of an inadvertent architectural experiment. On the surgical floors of a 200-bed suburban Pennsylvania hospital, some rooms faced a stand of deciduous trees, while others faced a brown brick wall. Postoperative patients were assigned essentially randomly to one or the other kind of room. The records of all cholecystectomy patients over a 10-year interval, restricted to the summer months when the trees were in foliage, were reviewed. Endpoints were the length of hospitalization, the need for pain and anxiety medications, the occurrence of minor medical complications, and nurses' notes. Patients with tree views had statistically significantly shorter hospitalizations (7.96 days compared to 8.70 days), less need for pain medications, and fewer negative comments in the nurses' notes, compared to patients with brick-wall views.

Other evidence is available from therapeutic settings. In a study of dental patients,⁵⁴ researchers placed a large mural of an open natural scene on the wall of a dental waiting room during some days, and removed it on others. On the days when the mural was visible, dental patients had lower blood pressure and less self-reported anxiety than on the days when it was taken down. In a study of psychiatric in-patients,⁴⁰ patients were exposed to two kinds of wall art: nature scenes such as landscapes, or abstract or symbolic art. Interviews suggested more positive responses to the nature scenes. Moreover, in 15 years of records on patient attacks on the wall art, every attack was on abstract art, none on a nature scene. (No information was provided on how many of the psychiatric patients were artists or art critics.) Viewing landscapes and related nature scenes, whether genuine or in pictures, seems to have a salutary effect.

Wilderness Experience

Wilderness experiences—entering the landscape rather than viewing it—may also be therapeutic. David Cumes^{55,56} has described "wilderness rapture," including self-awareness; feelings of awe, wonder, and humility; a sense of comfort in and connection to nature; increased appreciation of others; and a feeling of renewal and vigor. These outcomes are often cited in favorable accounts of so-called wilderness therapy for psychiatric patients⁵⁷⁻⁶⁰; emotionally disturbed children and adolescents⁶¹⁻⁶³; bereaved people^{64,65}; rape and incest survivors⁶⁶; and patients with cancer,⁶⁷ end-stage renal disease,⁶⁸ post-traumatic distress syndrome (PTSD),⁶⁹ addiction disorders,^{70,71} and other ailments.⁷²

Most documented examples relate to mental health endpoints. A group of emotionally disturbed boys aged

5.5 to 11.5 years attending an outdoor day camp was compared to a group of similar boys not attending the camp.⁷³ The campers' self-ratings and teachers' ratings of their emotional adjustment were significantly better than those of the controls, although neither parents' ratings nor scores on formal psychological testing showed an improvement. A group of adolescents being treated for depression, substance abuse, or adjustment reactions improved on measures of cooperation and trust following a wilderness experience, while controls did not.⁵⁸ Psychiatric in-patients showed improvements in coping ability and locus of control following a wilderness adventure program.⁵⁹ In-patients at the Oregon State Mental Hospital showed improved function and greater probability of discharge following wilderness adventure programs.⁵⁷ In a convenience sample of more than 700 people who had participated in 2- to 4-week wilderness excursions, 90% described "an increased sense of aliveness, well-being, and energy," and 90% reported that the experience had helped them break an addiction (defined broadly, from nicotine to chocolate).⁷⁴

While this literature is more extensive than the literature on plants and animals,⁷⁵ several limitations make it difficult to interpret.^{76,77} Much of the published research comes from proponents with a personal or commercial interest in wilderness experiences, such as companies that market adventures. Much of the research refers to structured trips or summer camp programs rather than to the more general phenomenon of contact with wilderness. To the extent that such research seems to show benefits, this may be due to the vacation quality of the experience, to the psychological value of setting and achieving difficult goals, and/or to the group bonding that occurs on some such trips, rather than (or in addition to) a direct effect of wilderness contact. Few studies have been randomized, and selection bias can rarely be excluded. Blinding of subjects has been impossible, and blinding of investigators has not been attempted.

Despite these limitations, many published accounts do suggest some benefit from wilderness experiences. Mental health has been more studied than somatic conditions, and short-term benefit has been demonstrated more than long-term benefit.

There is evidence, then, that contact with the natural world—with animals, plants, landscapes, and wilderness—may offer health benefits. Perhaps this reflects ancient learning habits, preferences, and tastes, which may be echoes of our origins as creatures of the wild. Satisfying these preferences—taking seriously our affiliation with the natural world—may be an effective way to enhance health, not to mention cheaper and freer of side effects than medications. If so, then medicine and the other health professions will need to articulate a broad vision of environmental health, one that stretches from urban planning to landscape architec-

ture, from interior design to forestry, from botany to veterinary medicine.

The Greening of Environmental Health

A paradigm of environmental health that includes health as well as illness, has implications in at least three arenas: research, collaboration, and intervention.

Research

Clinical and epidemiologic research in environmental health addresses many variants of the same question: Is there an association between exposure and outcome? We need a research agenda directed not only at exposures we suspect to be unhealthy, but also at those we suspect to be healthy, and at outcomes that reflect not only impaired health, but also enhanced health. If people have regular contact with flowers or trees, do they report greater well-being, better sleep, fewer headaches, reduced joint pain? Do inner city children who attend a rural summer camp have better health during the next semester of school than their friends who spent the summer in the city? Do patients with cancer or AIDS survive longer, or have fewer infections, or less pain, or higher T-cell counts, if they have pets? Do gardens in hospitals speed postoperative recovery? Can psychotherapy that utilizes contact with nature—known as ecopsychology⁷⁸—have an empirical basis? If any of these therapeutic approaches shows promise, which patients will benefit and what kinds of contact with nature have the greatest efficacy and cost effectiveness?

Research questions like these pose challenges of defining and operationalizing unfamiliar variables. Landscape architects, horticulturists, and environmental psychologists work with the exposure variables, but physicians and clinical investigators do not. Similarly, the outcome variables that reflect health instead of disease are less familiar, and need to be developed and validated. These challenges offer broad opportunities for methods development and hypothesis testing.

Collaboration

Environmental health specialists, from researchers to clinicians, have long recognized the need to collaborate with other professionals. We work with mechanical engineers to build exposure chambers, with chemists to measure exposures, and with software engineers to apply geographic information systems to health data. If we turn our attention to aspects of the environment that may enhance health, we need to open collaborations with a broad range of professionals, such as landscape architects to help identify the salient features of outdoor "exposures," interior designers to do the same in micro-environments, veterinarians and ethologists to help us understand more about human rela-

tionships with animals, and urban and regional planners to help link environmental health principles with large-scale environmental design.

Intervention

Finally, as we learn more about the health benefits of particular environments, we need to act on these findings. On the clinical level, this may have implications for patient care. Perhaps we will advise patients to take a few days in the country, to spend time gardening, or to adopt a pet, if clinical evidence offers support for such measures. Perhaps we will build hospitals in scenic locations, or plant gardens in rehabilitation centers. Perhaps the employers and managed care organizations that pay for health care will come to fund such interventions, especially if they prove to rival pharmaceuticals in cost and efficacy.

On the public health level, environmental health has a long history of providing data, and advocating action based on these data to achieve control of environmental hazards, such as more protective air pollution regulations, lower automobile emissions, safer pesticide practices, and cleaner rivers and streams. In the same way, we need to act on emerging evidence of environmental health benefits. Environmental health could be a factor in zoning decisions, transportation planning, and regional development strategies. Environmental health could appear in the curricula of schools of architecture and civil engineering. We take for granted that health experts play a prominent role in the Food and Drug Administration and the Environmental Protection Agency, but how about the National Park Service or the local zoo? As we learn more about the health benefits of contact with the natural world, we need to apply this knowledge in ways that directly enhance the health of the public.

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