A Sustainable Future for Humanity?

How Can Psychology Help?

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The sustainability of human life on Earth in the future is in danger. Human actions are producing many harmful and possibly irreversible changes to the environmental conditions that support life on Earth. This article summarizes major threats to Earth's environment, including global warming, ozone layer destruction, exhaustion of fisheries and agricultural land, and widespread exposure to toxic chemicals. Unless they are overcome, these changes will make human life increasingly miserable and eventually may make Earth nearly uninhabitable for future generations. These threats are caused by patterns of human behavior, particularly overpopulation and overconsumption. Urgent changes to human lifestyles and cultural practices are required for the world to escape ecological disaster, and psychologists should lead the way in helping people adopt sustainable patterns of living. Specific steps toward that goal are proposed in this and the following four articles.

Psychologists work to promote human welfare, and therefore they must be concerned about the issue of sustainability. Sustainability may be defined as using the world's resources in ways that will allow human beings to continue to exist on Earth with an adequate quality of life. A sustainable society has been described in the Brundtland Report of the World Commission on Environment and Development (WCED) as one that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 363).

Starkly stated, the issue is whether the world that is passed on to future generations and other creatures will be worth living in. The *World Scientists' Warning to Humanity*, which was signed by over 1,600 eminent scientists worldwide, described the problem as follows:

> A great change in our stewardship of the earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated. (Union of Concerned Scientists, 1993, p. 1)

Only in recent years has the topic of sustainability been recognized and acknowledged as a momentous problem for the future. Environmental scientists have recounted the threats to our planet in great detail (e.g., Hardin, 1993; Meadows, Meadows, & Randers, 1992). Psychologists have begun to describe the changes in human behavior that will be required to avoid or minimize these ecological threats (e.g., Gardner & Stern, 1996; Howard, 1997; Kempton, Darley, & Stern, 1992; McKenzie-Mohr & Oskamp, 1995; Winter, 1996). Specific features that would characterize a future sustainable society have been described in more detail (e.g., Brown, Flavin, & Postel, 1990; Roodman, 1999), and many organizations are beginning to work toward that goal.[1] As discussed below, psychologists and other social scientists have a crucial role to play in helping to achieve essential changes in the behavior of individuals, organizational groups, and nations.

This article and the four that follow it discuss a variety of helpful responses to the ecological crisis that has been caused by human activities. In much of this article, I summarize key features of the interconnected cluster of environmental problems that endanger the livability of Earth's environment. Most literate citizens are at least somewhat aware of them, but people typically are not well informed about their potentially cataclysmic nature. Global warming and ozone depletion are described in some detail, and other environmental threats are noted more briefly. Then, the causes of these problems are traced to two key aspects of human behavior: overpopulation and overconsumption. Finally, I discuss some specific ways in which psychologists can help people attack these problems.

The following four articles present a variety of perspectives on how psychology can be used to help overcome

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[1] Good sources for information on this topic are the Worldwatch Institute in Washington, DC (http://www.worldwatch.org) and Sustainable America in New York City (sustamer@sanetwork.org).

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the ecological crisis and reach sustainable patterns of human impacts on Earth. Howard (2000, this issue) first stresses that information, beliefs, and attitudes are contributors to wasteful societal systems, but then he notes that they are also factors that can potentially help to change political and economic systems that perpetuate wasteful lifestyles. In partial contrast, McKenzie-Mohr (2000, this issue) points out that campaigns to inform and change the attitudes of the public often have little effect on people's behavior, and he proposes community-based social marketing methods that are more likely to promote sustainable behavior. Stern (2000, this issue) advocates directing efforts where they will have the greatest environmental impact, and because corporations and organizations typically cause the bulk of environmental damage, he suggests that they generally are more important targets than are individuals. In this article, I agree with that point, also noting that decisions of corporations and governments often sharply constrain the behavioral choices that are available to individuals. However, in addition, I propose that basic changes in the underlying value systems of billions of people will be necessary in moving the world toward sustainability. In her article, Winter (2000) shows how various contending psychological theories can all offer valuable insights about ways to motivate people toward more ecologically sustainable patterns of beliefs, emotions, attitudes, and behaviors.

Although the conceptual approaches in these articles differ in part, they largely represent complementary views. Despite the differing perspectives that they adopt, all five authors agree that resolving the ecological crisis is a momentous and crucial task and that completing this task successfully will determine whether human beings and other species can continue to live on Earth with an acceptable quality of life.

Dangers to Earth's Environment

What sort of world are we headed toward? So far, the world order emerging is one almost no one wants. Human numbers are growing, forests are shrinking, species are dying, farmland is eroding, freshwater supplies are dwindling, fisheries are collapsing, rivers are constricting, greenhouse gases are accumulating, soot is contaminating the air, and lead is contaminating our blood. (Roodman, 1999, p. 170)

Global Warming and Climate Change Due to the Greenhouse Effect

When oil, gas, coal, wood, or other organic substances are burned, the carbon dioxide (CO_2) that is produced mixes into the atmosphere. This CO_2 is the most crucial of several gases that absorb infrared radiation from Earth and therefore reduce the amount of Earth's heat that can be radiated into space. In effect, these gases act somewhat like the glass roof of a greenhouse, which lets in warming sunlight but prevents warm air from escaping. As a result, the planet is warmed. Since the 1970s, there has been a vigorous scientific debate about the degree to which human activity, such as the burning of fossil fuels, is adding to the warmth of Earth's atmosphere. Although there are still a few unconvinced skeptics, the consensus view of the scientific community was stated in 1996 by the international body of atmospheric scientists called the Intergovernmental Panel on Climate Change (IPCC). Their cautiously worded conclusion that "the balance of evidence suggests that there is a discernible human influence on global climate" (IPCC, 1996, p. 5) is a statement that global warming due to the greenhouse effect is really occurring. Their "best estimate" is that by the year 2100, global warming will result in an increase in global mean surface air temperature of 2 °C (3.6 °F).

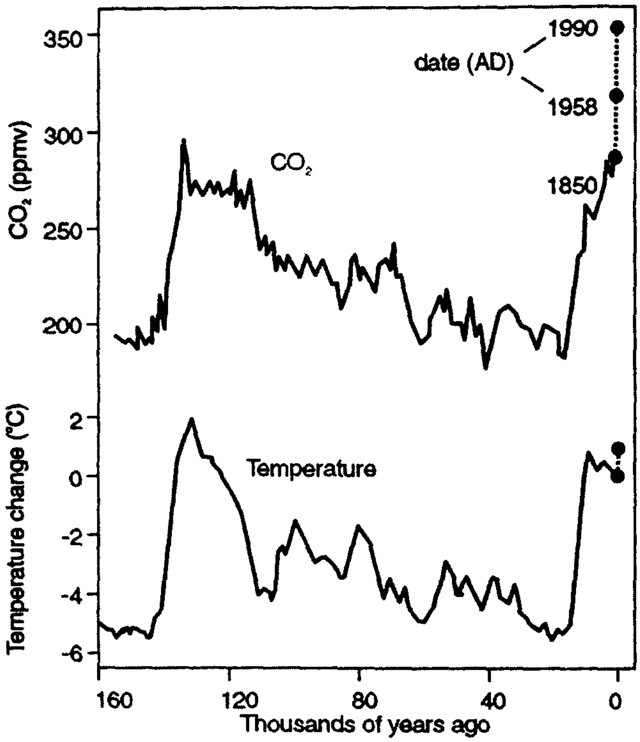
How much of a threat does this global warming present to humans and other life on Earth? To understand that, it is important to know about the levels of temperature and of CO_2 over Earth's history.[2] First, scientists know about prehistoric temperature levels from the fossil records of the kinds of plants and animals that lived in successive eras of time. Second, by drilling down two miles through the Antarctic ice cap, scientists have been able to determine the amount of CO_2 contained in the minute air bubbles trapped in layers of ice frozen 160,000 years ago. When the graph of the CO_2 levels is compared with Earth's temperature levels over this period, which included two ice ages, a dramatically close parallelism is evident (see Figure 1). In the ice ages, when Earth's average temperature was about 11 °F (6.1 °C) colder than it is now, the CO_2 levels were about 200 parts per million (ppm). For the past 5,000 years or so, Earth's temperature has been quite stable, and the CO_2 levels have been around 280 ppm. However, since the beginning of the Industrial Revolution around 1800, the heavy use of fossil fuels has increased CO_2 levels with an exponentially rising curve, to a level over 360 ppm in 1998 (see Figure 2).[3] In parallel, Earth's temperature has begun to rise—about 1 °F in the period since recording was initiated in 1860 (IPCC, 1996).

Since the IPCC's report was published in 1996, the signs of global warming have become increasingly clear. Worldwide, 11 of the past 16 years have been the hottest ones on record, with 1998 being by far the hottest to that date. The polar regions are warming particularly fast; for instance, Alaska is as much as 10 °F (5.6 °C) warmer now than it was in the 1960s (Hileman, 1999). Moreover, the research with ice cores has very recently revealed that temperature and climate changes are not always gradual; in fact, they can be extremely rapid when crucial thresholds are crossed. For instance, about 11,700 years ago, a huge 7 °F (3.9 °C) increase in the world's temperature occurred

[2] Increases in CO_2 (mainly from the burning of fossil fuels) are the major human contributor to the greenhouse warming effect. The 1992 estimates indicate that CO_2 is responsible for 64% of the total warming, while methane contributes 19% (some of which, like CO_2, also comes from the burning of organic substances), chlorofluorocarbons (CFCs) 10%, and nitrous oxides 6%. Together these four gases account for almost 90% of the greenhouse warming effect (IPCC, 1996).

[3] In the IPCC (1996) report, it was estimated that CO_2 levels would reach 500 ppm by 2100, even without a further rise in their rate of increase.

Figure 1
Parallelism of Earth's Atmospheric CO_2 Levels and Temperature Changes Over the Past 160,000 Years



Note. From *Laboratory Earth: The Planetary Gamble We Can't Afford to Lose* (p. 48), by Stephen H. Schneider, 1997, New York: Basic Books. Copyright 1997 by Stephen H. Schneider. Reprinted with permission.

within a period of 10 years and then stabilized for many centuries (Taylor, 1999). That fact shows what drastic changes to Earth's climate can occur when relatively stable equilibrium conditions are altered.

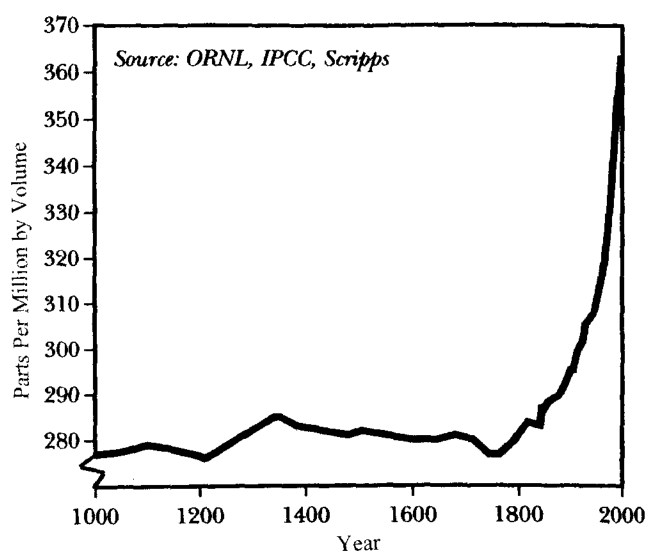
Although an increase of a single degree may seem unimportant, its effects can be dramatic. The results of global warming are not just a warmer climate. The extra heat—even an average increase of one or two degrees—can drastically change regional climates, and the type and size of effects will be different in different regions. In recent years, many extreme atmospheric events have been identified as probable results of global climate change: heat waves and droughts in the United States and Europe; gigantic fires in Indonesia, the Amazon, Mexico, and Florida; and extremely severe storms and historic floods in the Mississippi River basin, Africa, China, and Bangladesh (Flavin & Dunn, 1999). The U.S. insurance industry is beginning to take the increased occurrences of these catastrophes very seriously as a result of enormous financial losses from events such as Hurricane Fran in 1996 and Hurricane Floyd in 1999.

These huge climate changes can greatly disrupt worldwide agricultural production and cause the spread of tropical diseases like malaria (Martens, 1999). In addition, they are warming oceans and beginning to melt the polar ice caps. If this trend is not stopped, the thermal expansion of ocean water and the added water from the ice caps will in turn raise ocean levels. The IPCC's (1996) best estimate is a resulting half-meter rise in ocean levels by the year 2100, with relatively large regional variations. A one-meter rise, which is about the amount of the IPCC's highest estimate, would flood huge areas of low-lying coastal land, inundating many island nations and the heavily populated river delta areas of Bangladesh, China, Egypt, and Nigeria (McGinn, 1999). A more extreme estimate is that the melting of the West Antarctic ice sheet would produce a five-meter rise in sea level, flooding much of Miami, New Orleans, New York, and many other seacoast cities in the United States (D. Schneider, 1997). The best assessment is that the many and varied effects of climatic change that are touched on above are already underway, and no one knows whether they can be prevented, stopped, or reversed.

Loss of Much of the Ozone Layer

Earth's ozone layer, many miles up in the stratosphere, serves a protective function, shielding Earth from most of the ultraviolet radiation from the sun. Excessive ultraviolet rays cause skin cancer in humans and similar injuries to

Figure 2
Atmospheric Levels of Carbon Dioxide From 1000 to 1997



Note. From "Reinventing the Energy System," by C. Flavin and S. Dunn, in L. R. Brown, C. Flavin, H. French, J. Abramovitz, S. Dunn, G. Gardner, A. Mattoon, A. P. McGinn, M. O'Meara, M. Renner, D. Roodman, P. Sampat, L. Starke, and J. Tuxill (Eds.), *State of the World 1999* (p. 26), 1999, New York: Norton. Copyright 1999 by Worldwatch Institute. Reprinted with permission.

animals and plants, including damage to many crops and to the plankton that form the base of the ocean food chain. In recent years, there has been much publicity about the annual appearance of a "hole" in the ozone layer over the southern polar regions and up to Australia and New Zealand, as well as a similar although smaller ozone depletion areas over the northern Arctic regions and temperate-zone areas of both the Northern and the Southern Hemispheres (IPCC, 1996). This thinning of the protective ozone layer has been shown to have a damaging impact on world fisheries as well as on human, animal, and plant health (e.g., Teramura, 1986; van der Leun, 1986; Worrest, 1986).

Since the first scientific report on damage to the ozone layer, published in 1974, research has shown conclusively that this damage is mainly caused by the release of CFCs, which are also the third-largest contributor to the greenhouse effect. The 1995 Nobel prize in chemistry was awarded for discovery of the facts that CFC molecules, when they float up to the stratosphere, release chlorine atoms, and that each chlorine atom will persist there for 50–100 years and destroy about 100,000 ozone molecules. CFCs, such as Freon, have been used all over the world as refrigerants in air conditioning systems, as solvents, and as foam-blowing agents for making insulation. They were also used as propellants in aerosol cans until that use was banned in the 1980s. In 1987, most of the nations of the world came together to sign the Montreal Protocol, which required industrial nations to halt the production of CFCs by 1996 and to gradually phase out other ozone-destroying chemicals as well (French, 1997).

The Montreal Protocol and its subsequent strengthening amendments provide a prime example of how nations can unite to combat long-term environmental threats. As a result of these international agreements, the total amount of chlorine in the stratosphere is now gradually decreasing (French, 1997; IPCC, 1996). In response, the ozone layer is expected eventually to replenish itself over a period of about 50 years. If this happens, it will be one of the first large-scale success stories in humans' preservation of Earth's atmospheric resources.

Deforestation and Species Extinction

By contrast, destruction of tropical and temperate rain forests is increasing at an alarming pace. Only 22% of the world's original forest cover still remains in large tracts of relatively undisturbed, ecologically intact natural forests—mostly in the Amazon, Canada and Alaska, and Russia (Bryant, Nielsen, & Tangley, 1997). Between 1960 and 1990, destruction of these old-growth forests increased drastically, particularly in the tropics. Worldwide, one fifth of all tropical forest cover was cut down during this period, with Asia losing one third of its tropical forests (Abramovitz, 1998). In the tropics, the major cause of deforestation is clearing or burning for agriculture, livestock grazing, and human settlements. In other areas, contributing factors are large-scale logging (for both timber and paper) and gathering of fuelwood for industrial purposes and for family use.

The world's forests play a crucial role in the ecosystem, absorbing a large proportion of the harmful CO_2 emissions and also helping to regulate the planet's climate and rainfall. Where forests have been cut or burned down, flooding, eroding land, clogging of streams and rivers, changing rainfall patterns, and rising temperatures are typical results. Sustainable forestry practices such as tree farms and more efficient wood and paper production methods could prevent much of this destruction of old-growth forests, and increased recycling of wood, paper, and other forest products could preserve still more of Earth's precious forest cover (Abramovitz & Mattoon, 1999).

Forests also shelter a majority of Earth's plant and animal species, and deforestation is a primary factor in the decimation that is making at least 1,000 species extinct each year (Tuxill, 1999). The famous zoologist E. O. Wilson has estimated that continuing the current rate of ecosystem destruction could lead to the extinction of more than half of all the plant and animal species on Earth by the end of the 21st century (Rensberger, 1999). Although much of Earth's biodiversity is concentrated in tropical forests and coral reefs, species extinction is occurring rapidly in developed countries as well, and the data are firmer there because of much fuller scientific study. On the basis of the established scientific knowledge, the World Conservation Union has estimated that the United States has the largest number and percentage of plant species threatened with extinction of any country (4,669 species, or 29% of its plants; Walter & Gillett, 1997). As has often been pointed out, biodiversity has great value to humans as a source of new and genetically desirable food stocks and medicines and of plants and animals that are resistant to various diseases and pests (Tuxill, 1999). Thus, extinction of these species constitutes an incalculably large loss to the world.

Exhaustion of Fisheries, Agricultural Land, and Water Supplies

Unsustainable practices are ruining the productivity of ocean fisheries and of agricultural land. Huge mechanical trawlers and other factory-type fishing vessels have essentially wiped out whole populations of fish and then moved on to exploit other less desirable species. Overfishing has led to decreasing annual catches in 11 out of 15 of the world's most important oceanic fishing areas and in 69% of major fish species. Catches of some fish species have plunged as much as 70% or 80% (McGinn, 1998). Also, pollution from city sewers, from factory toxic wastes, and from runoff of agricultural pesticides and fertilizers has poisoned more than half of the world's coastal ecosystems—areas that historically have been among the most productive fisheries, where shellfish live and many other species breed and spawn (e.g., Horton & Eichbaum, 1991).

Similarly, impaired agricultural productivity has resulted from many shortsighted practices. The world's grain-growing area reached a maximum in 1981 and has since decreased 6%. The loss of cropland is largely due to degradation resulting from erosion as well as to construction of housing. Although agricultural productivity per acre increased greatly in the years since 1950, its growth rate diminished sharply since 1990 to 1.1% per year. Because Earth's population is increasing much faster than that, world grain consumption per person decreased by 7% between 1984 and 1998 (Brown, 1999). Unsustainable agricultural practices, including the destruction of tropical rainforests for marginal pastureland, have led to erosion and loss of topsoil worldwide (Abramovitz, 1998; Brown, 1995).

Depletion of underground aquifers is a major threat to agriculture, especially because about 40% of the world's food is grown through irrigation (Serageldin, 1995). Water tables have been falling on every continent, as much as 5 to 10 feet per year. A prime example is the unreplaced draw-down of groundwater from the huge Ogallala aquifer under the U.S. Great Plains. Many major rivers, such as the Colorado River and China's Yellow River, are diverted so heavily that they now run dry before they reach the sea (Brown, 1999). Moreover, water disputes between adjacent countries have led to international security issues and wars, and they are likely to produce increased conflict in the future (WCED, 1987, p. 293).

Acid Rain and Toxic Pollution of Air and Water Supplies

Acid rain has been killing many fish species and other plant and animal life in many lakes and rivers, in regions ranging from the U.S. Northeast and Canada to Florida to Europe and Russia. Acid in rain and clouds comes from the burning of coal and oil, which sends invisible plumes of sulfur and nitrogen oxides into the air. These are dissolved in clouds and return to the earth in rainfall, which at times can be as acidic as vinegar. A major U.S. governmental scientific assessment called the National Acid Precipitation Assessment Program (NAPAP, 1991) determined that when the pH value of lakes and rivers drops to 5.0 (100 times as acidic as the neutral level), most water plants cannot survive and most fish species die out. In many countries of the world, rainfall is frequently as much as 50–100 times more acidic than that, reaching pH values of 3.0–3.5. As a result, many thousands of lakes and rivers in the eastern United States have lost their major forms of aquatic life (NAPAP, 1991, pp. 17–46). Careful studies in Canada and Scandinavia have shown that tens of thousands of their lakes are strongly acidified and unable to support most species of fish (French, 1990; Government of Canada, 1991).

Acid rain can also burn and weaken trees, although the degree of damage is controversial. A high-end estimate was given by a summary study of European countries, which concluded that acid rain had damaged 75% of the forests in Europe, with an overall annual loss of $30 billion (Brown, 1993, p. 6). Even clearer harmful effects on forests and crops come from ground-level ozone, a pollutant that can stunt plant growth and reduce yields by as much as 50% for some crop species (NAPAP, 1991, p. 55). Together, ozone, acid rain, and other forms of pollution can combine to weaken and damage both forests and crops, making them more susceptible to injury from insects, diseases, and natural climatic stresses (NAPAP, 1991).

Additional byproducts of burning fossil fuels are carbon monoxide (CO) and tiny particulates, both of which are major ingredients of smog, as are the sulfur and nitrogen oxides mentioned above. Both CO and particulates are major health hazards that contribute to lung cancer and other respiratory diseases (Flavin & Dunn, 1999; World Health Organization, 1992). In China alone, the burning of coal is estimated to kill 178,000 people prematurely each year. Auto exhaust accounts for well over half of the air pollution in California (Motavalli, 1999a), and the World Health Organization has reported that in several European countries, smog from car exhaust kills more people each year from respiratory or heart ailments than are killed in road traffic accidents (Reaney, 1999).

Toxic pollution of drinking water supplies is also a worldwide problem. In mining, toxic chemicals such as mercury and cyanide are used to separate the metal from the ore, and rain carries many of these poisons into rivers. Logging erosion also clogs and contaminates many rivers around the world, as do agricultural fertilizer and pesticide runoffs. Manufacturing wastes are even more toxic. Acids and toxic chemicals often leach from garbage landfills down into underground water supplies (Gardner & Sampat, 1999). As a result, many wells have been declared unsafe in the United States, and over 8% of U.S. communities reported violations of one or more drinking water health standards in 1996, the most recent year for which reports are available (Environmental Protection Agency, 1999). Of course, many other industrialized countries are even more badly affected, and 25% of people in developing countries have no source of clean water (O'Meara, 1999).

Human Exposure to Toxic Chemicals

Human genetic and hormonal damage and cancers have been traced to exposure to toxic chemicals such as dioxin. Dioxin is a byproduct stemming from the manufacture of various chlorine-containing chemicals such as pesticides, from the bleaching of paper with chlorine, from the incineration of plastics and paper, and from the burning of fossil fuels. Dioxin is actually a family of chemicals that are extremely dangerous carcinogens and that have been building up to alarming levels in the body tissues of most Americans (Schecter, 1994). In addition to being carcinogens, dioxins are potent disruptors as well as mimics of the female hormone estrogen (Colborn, Dumanoski, & Myers, 1996). When given to pregnant female rats at a critical point in their pregnancy, a single tiny dose of dioxin did marked damage to both male and female pups' reproductive systems (Gray & Ostby, 1995). When the male pups matured, they showed diminished sexual behavior and a 40% to 50% reduction in sperm count (Peterson, Moore, Mably, Bjerke, & Goy, 1992). These animal findings probably have the same theoretical basis as a new and little-known research phenomenon in men. Careful studies in many countries have shown a nearly 50% loss in the average sperm count observed in men worldwide during the last 50 years. The animal findings as well as research with humans suggest that this is due to the widespread use of chlorinated chemicals all over the world in those years (Colborn et al., 1996; Sharpe & Skakkebaek, 1993). A 1999 summary report from the U.S. National Research Council has confirmed the dangers to health and immune system functioning of both humans and animals posed by these hormone-disrupting chemicals in the environment (Committee on Hormonally Active Agents in the Environment, 1999).

As an example of cancer risk, exposure to various pesticides has been linked to individuals' development of non-Hodgkin's lymphoma, a type of blood cancer seen with rapidly increasing frequency (Hardell & Eriksson, 1999). Pesticide residues on many fruits and vegetables grown and sold in the United States are often above levels that the Environmental Protection Agency specifies as safe for young children (Burros, 1999). Other threats from toxic substances include mercury levels in fish from the Great Lakes and the Baltic Sea that make the fish unsafe for human consumption (McGinn, 1999). A brand-new potential danger is the unknown health consequences of eating food products (potatoes, corn, soybeans, wheat, etc.) that have been genetically modified by new, untested gene-splicing biotechnology. Because these techniques are so new, no one knows the degree of risk that they may present to human health, or to worldwide gene stocks through displacement of current varieties of organisms and transfer of damaging characteristics to weeds or pests. However, scientists and government agencies overseas are alarmed, as illustrated by strongly worded statements by England's Prince Charles (Prince of Wales, 1998, 1999). Many countries (e.g., Japan, Korea, Australia, and New Zealand) have passed laws requiring special labeling of genetically modified foods (Petersen, 1999), and Canada has refused to allow use of a genetically altered milk hormone in its dairy herds (Morris, 1999). Although U.S. government agencies have so far resisted mandatory labeling, many companies such as Heinz and Gerber baby foods and Kirin beer have announced that they will not use genetically modified grains (Lagnado, 1999).

Additive or Synergistic Effects

Each of the above threats to Earth's environment and to human health may be devastating by itself. Together, their effects are apt to be even more catastrophic. Trend lines show that most of these problems are steadily getting more serious, and their combined effects will subject Earth's environment to multiple stressors in the future. In addition, they may act together synergistically in mutually augmenting, interactive ways to create a combined effect much greater than their additive effects. For instance, the effects of global warming are already being aggravated by the spread of tropical diseases to formerly untouched areas; the effects of climate change are likely to be magnified by depletion of underground aquifers; deforestation not only affects climates but also pollutes streams and ruins many fisheries; toxic pollution of air and water supplies damages human health at the same time that exposure to endocrine-disruptive chemicals impairs people's resistance to diseases. Beyond these interactive effects, there is also the risk of possible discontinuities in environmental responses to stressors. That is, if some threshold is passed, conditions may change very rapidly, as in the recent destruction of some oceanic fisheries or the very rapid change in Earth's temperature 11,700 years ago.

In short, humans are conducting a massive experiment on Earth's environment by their patterns of behavior. As various scientists have pointed out, "we have only one earth on which to experiment" (Stern, 1992, p. 271), and that experiment is a "planetary gamble we can't afford to lose" (S. H. Schneider, 1997, p. iii). Unfortunately, in light of current trends, the United Nations expects 20% of the world's population (nearly two billion people) to become "environmental refugees" by the year 2020 because of environmental damage in their areas, destruction of cropland, lack of water, and so on (George, 1993).

Centrality of the Social Sciences

In thinking about environmental problems such as the ones described above, it is essential to realize that they are not solely technical problems, requiring simply engineering, physics, and chemistry for their solution. There is a crucial role for the social sciences in these problems, because they are all caused by human behavior, and potentially they can all be reversed by human behavior.[4] Of course, "human behavior" here includes the behavior of groups, organizations, and nations, as well as individuals. Another key point is that these problems are so urgent that much more must be done to reverse them (cf. Oskamp, 1995a). They are examples of human beings' strong propensity to overuse natural resources by pursuing their own individual or group short-term self-interest rather than acting in the long-term common interest of the world—a tendency that Hardin (1968) termed the "tragedy of the commons."

Although there are uncertainties about the scale and time frame of the threats to Earth's environment, the only safe approach to them is to follow the *precautionary principle* (Hileman, 1998; Montague, 1998). In part, it states:

> Corporations, government entities, organizations, communities, scientists and other individuals must adopt a precautionary approach to all human endeavors. . . . When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. (Montague, 1998, pp. 1–2)

The Swedish government has adopted the precautionary principle as part of its chemical management laws (Wahlstrom, 1999). A closely related corollary of this approach is the *polluter pays principle*: Whatever person or organiza-

[4] That is, the effects can be reversed unless they have crossed some threshold that makes them irreversible in a human, rather than geological, time span.

tion pollutes the environment must pay for the resulting damages.

Many national governments, particularly ones in Europe, have become concerned over the global dangers of environmental pollution and degradation. The United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, in 1992, focused world attention on these problems, and its participants agreed on a plan of action for addressing them, called *Agenda 21*. Progress on these goals is being monitored by the United Nations Commission on Sustainable Development and by national agencies and citizen watchdog groups in many nations (Bartelmus, 1994). However, progress has been sporadic and slow at best, and the U.S. government has frequently played an obstructive role. For example, the 1997 international summit meeting in Kyoto, Japan, which was held to establish enforceable goals for nations to reduce the greenhouse gas emissions that are producing global warming, was impeded by U.S. government proposals that advocated minimal goals. As a result, the conference set only very weak and distant targets and established no enforcement mechanisms (Fishel, 1998; Lemonick, 1997).

Fortunately, opinion polls from many nations show that most people have high levels of concern for environmental problems. In the United States, proenvironmental attitudes hit an all-time high in the 1990s, and a large majority of people call themselves "environmentalists" (Dunlap, Gallup, & Gallup, 1993; Kempton, Boster, & Hartley, 1995). Yet, surprisingly, at this time of high public support for environmental preservation, strong forces in the U.S. Congress and in many state legislatures are bent on reversing the environmentally protective legislation enacted in the past 30 years. This attack is being supported by much of big business, such as oil and mining companies, cigarette manufacturers, and drug companies, with the claim that they are merely opposing unnecessary and wasteful government regulations. Unless voters are vigilant in registering their views, they are likely to see even more cutbacks in the United States' environmentally protective laws, regulations, and budgets. Even worse, international trade rules that have recently been developed and enforced by the World Trade Organization to achieve "free trade" among nations are overriding and nullifying many national laws and regulations that were passed to protect the environment and public health, such as those regarding product safety labeling and bans on dangerous products like asbestos, lead, or meat from animals treated with carcinogenic hormones (Puckett, 1999; Wallach & Sforza, 1999).

The Threat of Population Growth

The most central source of Earth's environmental problems is human population growth. Figure 3 shows the fantastic growth of the world's human population. For millions of years of human existence, the number of people on Earth remained small, eventually reaching one billion around 1830; it then took 100 years to reach two billion in 1930. It took only 30 years to reach three billion in 1960 and only 15 years to reach four billion in 1975. In 12 years, the total reached five billion in 1987, and in another 12 years, it hit six billion in 1999 (Brown & Flavin, 1999; David, 1994).

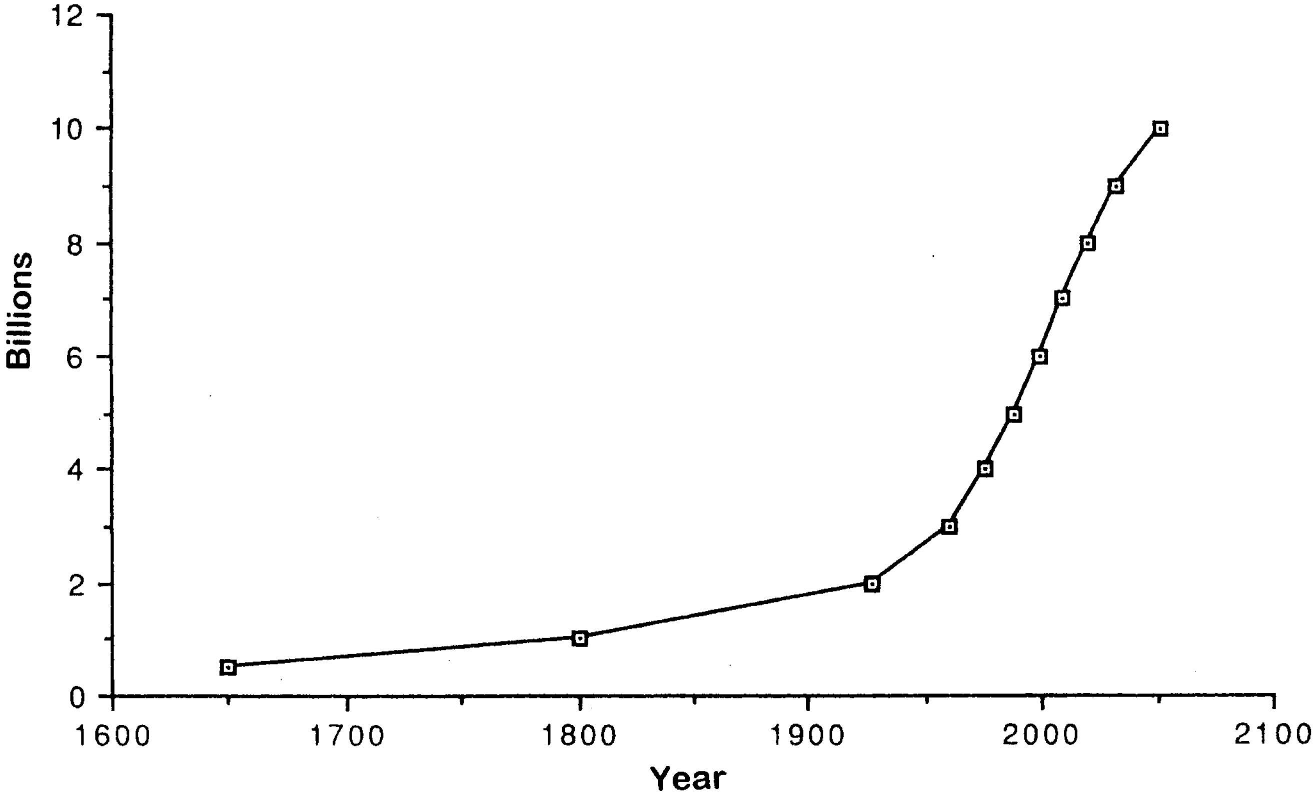
This geometric growth curve of population is a very dangerous one, and obviously this trend cannot continue much longer. Moreover, the huge population increases have already brought miserable living conditions, malnutrition, and illness to about half of the people of the world. If human population growth is not controlled voluntarily, it will eventually be controlled coercively. The death rate *will* catch up with the birth rate—through starvation and famines, through diseases (e.g., AIDS, which is already ravaging Africa), or by wars and genocide (Hardin, 1993).

No one knows exactly how many people Earth can support, but some environmental scientists have concluded that Earth's long-term carrying capacity may have already been overshot (Cohen, 1995; Hardin, 1993; Meadows et al., 1992). For instance, in a study by Pimentel, Harman, Pacenza, Pacarsky, and Pimentel (1994), it was estimated that Earth may only be able to support three billion people in perpetuity (about half the number of people alive today) and can only support one to two billion people if they are to live in "relative prosperity." That conclusion means that the people living today are literally stealing vital life resources from their future descendants.

Population control is clearly one of the key prerequisites of a sustainable society. Family planning is an area where psychologists have contributed important research findings, and family planning programs have been disseminated widely in many nations (cf. Severy, 1993). Among the many population-control factors that have been studied, an important incentive to limiting family size has been found to be increased economic opportunities for women (Abernethy, 1993).

Partly as a result of family planning research and activism, the world's rate of population growth has decreased somewhat. In about 30 fortunate nations, population totals have fully stabilized, and fertility rates have dropped to replacement levels (about 2.1 children per woman) in 40 more countries, including the United States, China, and much of Western Europe. However, when the replacement level is reached, these national populations will continue to grow sharply for at least a generation because they include very large numbers of young people who will reach childbearing age and have children in the following 30–40 years. Considered as a whole, the world's population is still increasing by 80 million people every year. Moreover, in many developing nations, birth rates have dropped too little to forestall extreme population growth, and the immigration of refugees as a result of wars, poverty, or environmental degradation frequently exacerbates the problems of fertility-based population growth. By 2050, population totals are predicted to double or even triple in Pakistan, Nigeria, Iran, and Ethiopia, and India is expected to become the world's most populous nation (Brown & Flavin, 1999).

Figure 3
World Human Population Growth Since 1650



Note. From The Population Reference Bureau, Inc., Washington, DC. Reprinted with permission.

The Trap of Overconsumption

The second main source of Earth's environmental problems is overconsumption of natural resources—a widespread pattern that is like an addiction to unsustainable consumerism (cf. Clinebell, 1998). This rampant consumerism is typically encouraged by officially sanctioned and culturally accepted beliefs that perpetual economic growth is necessary for "progress" and for social and political stability. In this process, we in the affluent, industrialized nations are often exhausting the natural resources of the poorer developing nations by our overuse of energy, minerals, timber, and so on. The most extreme example is the United States. With only 5% of Earth's population, the United States uses about 25% of Earth's commercial energy, and we use it only about half as efficiently as Japan (Flavin & Dunn, 1999). Together, the industrial nations of the world have about 20% of the world's population, but they consume about 85% of the world's paper and automobiles (United Nations Development Programme, 1998). The level of use of the world's resources by a nation has been termed its *ecological footprint*. Authorities have estimated that increasing the rest of the world to the resource-use level of the United States and Canada would require the land and other natural resources of three Earths, an obviously impossible ambition (Wackernagel & Rees, 1996).

The result of worldwide overconsumption of Earth's resources is that traditional supplies of many materials are being used up rapidly. An important factor contributing to overconsumption is the fact that economic indices of supposed progress, such as the gross national product, include many items that are actually losses—for example, the money made from depletion of natural resources and the expenses of cleaning up pollution of air, water, and land. Thus, they give us false signals about purported increases in human welfare (Daly, 1996, p. 41). A key example of overconsumption is the fact that petroleum production has expanded greatly in the last 25 years, but known reserves have increased only slightly, with the result that world oil production will probably peak and begin to decline around 2010 (Campbell & Laherrere, 1998; Flavin & Dunn, 1999). Because much of the industrialized world runs on oil, this will have a dramatic impact on many aspects of life.

Similarly, escalating demands for metals have led manufacturers to use lower and lower grade supplies. Currently, producing a ton of copper requires removing over 100 tons of earth and excavating 100 tons of ore—with drastic ecological effects (Gardner & Sampat, 1999). Modern nations have also extensively substituted manufactured synthetic materials such as plastics and chemicals for natural metals and fibers. However, these synthetics are mostly made from petroleum, further decreasing oil reserves, and organic chlorine products have been shown to have many dangerous ecological and health effects (e.g., Colborn & Clement, 1992; Misch, 1994). Also, plastics persist for centuries in trash and landfills without disintegrating.

The solution to these worldwide overconsumption problems is twofold: (a) reducing overall consumption and (b) shifting to universal reuse of products (e.g., resale, remanufacturing, or sharing) and recycling their constituent materials when the product's life ends (Gardner & Sampat, 1999). These changes would constitute a revolution in modern Western production and consumption practices, but there are enough successful examples of these needed changes to point the way to producers and consumers alike. For instance, Xerox now leases most of its office copiers and remanufactures them when the lease expires, aiming to reuse 84% of its machines and recycle 97% of its materials. In Germany, a 1991 law requiring manufacturers to take back and recycle all packaging material (plastic, cartons, etc.) has already resulted in lower first use of materials and an 86% recycling rate. In Denmark and other countries, neighboring industries have banded together to use waste products from one company as inputs for nearby ones (e.g., warm water from a power plant is used in fish farms, and the fish farm's sludge fertilizes croplands). Substitution of materials can also reduce or eliminate ecological and health threats. For instance, three quarters of American newspapers are now printed with soy-based, biodegradable inks rather than mineral products, and starch or sugar can be used in place of petroleum in making plastics (Gardner & Sampat, 1999).

Some psychologists have been productively involved in studying patterns of resource consumption and reuse. Energy conservation methods have been extensively studied (e.g., Katzev & Johnson, 1987). Research has shown that one-time investments, such as buying more efficient cars or installing home insulation, can save dramatically more energy than repeated minor actions, such as turning down thermostats or turning off lights (Gardner & Stern, 1996). Resource conservation and recycling have also been the focus of much research. Studies in some U.S. suburbs have shown dramatically high rates of participation in local recycling programs but have also demonstrated a potential for recycling much more (e.g., Oskamp, 1995b).

How Much Behavioral Change Is Needed?

A clear conclusion from the above information is that we have to stop damaging our environment (e.g., by polluting the air and water, overdrawing water supplies, dumping toxic and nuclear wastes, and overconsuming natural resources). We have to transform the current destructive patterns of human behavior into ones that are sustainable over the centuries ahead. In particular, because of the greenhouse effect, we have to sharply reduce the use of fossil fuels and use them much more efficiently. The Environmental Protection Agency has estimated that avoiding global climate changes will require a 75% decrease in CO_2 emissions, and thus of fossil fuel use, continuing over many decades (Lashof & Tirpak, 1989). Because the United States is not only the largest user of energy but also the most wasteful, our nation's behavior change is critical to the world.

A way to estimate the environmental impact of major changes in relevant human activities has been suggested by Paul and Ann Ehrlich (1991). They proposed the formula $I = P \times A \times T$, where I is the environmental impact of activities; P is the size of population, which is important because each additional person uses more resources; A is affluence per person, a variable which results in more consumption of natural resources and more waste products; and T is technology, which can lead either to environmental damage or to lower use of natural resources if the technology is more energy- and resource-efficient. Changes in population, affluence, and technology can be tracked over the years, and their product will roughly indicate the overall impact on the world as an ecosystem.

A useful example of the IPAT formula takes 1987 as a baseline, because that was the year when the WCED published *Our Common Future* (often referred to as the Brundtland Report) as a blueprint for "sustainable development" in the decades ahead. This widely publicized report estimated that by the year 2050, the world's population would have doubled to about ten billion people, its technology would be about twice as efficient as it was in 1987 (meaning half as much resources or energy would be used per unit of production), and the world economy would have expanded by 5 to 10 times (this figure divided by the doubled number of people would indicate affluence per person). The economics of this scenario may sound good, but its environmental impact would be terrible! These estimates for 2050 yield an increased environmental impact on Earth of 2.5 to 5 times the 1987 level, a major increase (Olson, 1995):

$$I = P \times A \times T$$

$$I = 2 \times 2.5\text{–}5 \times .5 = 2.5\text{–}5.$$

Because some environmental scientists have concluded that the world's current population may already have overshot the planet's long-term carrying capacity and thus be reducing Earth's natural resources and waste-handling capabilities that will be available to future generations (e.g., Pimentel et al., 1994), it is clear that an impact 2.5 to 5 times as great as in 1987 is *not* a sustainable level of environmental impact. Thus, although the WCED report was hailed as a hopeful pointer toward sustainability, it actually demonstrated how much more has to be done to stabilize, let alone decrease, humanity's impact on the world's environment. This can be done in any or all of three ways: by reducing the world's population, decreasing affluence per person, or increasing efficiency in resource use. Decreasing affluence is definitely not an attractive option (particularly to third-world countries that aspire to first-world standards of living), so gradual decreases in population and very large increases in technological efficiency appear to be the most desirable goals to pursue (cf. Ausubel, 1996). For humanity to achieve a sustainable future, increases in technological efficiency will have to be much greater than the doubling envisioned by the WCED's Brundtland Report.

Improving Technological Efficiency

An example of how technological improvements can dramatically decrease both natural resource depletion and environmental pollution can be found, paradoxically, in the area of automotive transportation (e.g., Brown & Flavin, 1999; Flavin & Dunn, 1999; Hornblower, 1999). Cars and trucks have rightly been called "environmental menaces"—they are largely responsible for the increasing exhaustion of the world's petroleum reserves, for air pollution in cities around the world, and for the increase in CO_2 that causes the greenhouse effect and global warming. The current U.S. fondness for gas-guzzling sport-utility vehicles (SUVs) is exacerbating all of these problems. However, hopeful new developments will probably lead to the eventual demise of gasoline-powered internal-combustion vehicles. First, electric cars, which can greatly decrease world oil consumption and pollution, are already on the U.S. market. Next, *hybrid* cars that decrease pollution and increase fuel efficiency to about 70 miles per gallon by combining gas engines and electric motors have been sold in Japan since 1997 and will be on sale in the United States in 2000 (Motavalli, 1999b).

A historic further step will be vehicles, such as buses that are already in service, that run on fuel cells. Fuel cells are electrochemical power sources that combine hydrogen and oxygen to generate electricity, and they eliminate the air pollution from vehicle tailpipes because their only exhaust product is pure water. Thus, the dominant vehicle fuel for the future will probably become hydrogen, after the necessary production and distribution facilities are built, and the world can look forward hopefully to a resulting major decrease in air pollution and CO_2 discharges. Flavin and Dunn (1999) foresee a "historic shift to a civilization based on the efficient use of renewable energy and hydrogen"—an investment in a "livable planet" (p. 40).[5]

How Can Necessary Behavioral Changes Be Accomplished?

Facts in the preceding sections lead to the conclusion that social scientists and common citizens alike should be working toward the twin goals of better population control through family planning programs and of greatly increased technological efficiency in the use of energy and nonrenewable natural resources. Contrary to these goals, many economists and business leaders believe in perpetual growth and try to persuade people that expansion in population and nonrenewable resource use can continue indefinitely. But remember the geometric curve of population growth—it cannot!

Achieving a sustainable society will require basic changes in the behavior of most of the world's peoples, and aiding those changes is an important task for psychologists. In this process, it is important to realize that people's individual behavioral choices are typically sharply constrained by the limited options that social institutions and organizations impose. For instance, although electric cars and even fuel-cell vehicles have been made for years, most consumers cannot buy one because manufacturers are only producing a small number of them. Social scientists need to work on changing institutions and organizations in ways that will strongly encourage proenvironmental options and behavior.[6]

Such changes in society's organizational and institutional patterns will need to be motivated and supported through changes in some basic values. The United States in particular has a strong value of human mastery over nature (e.g., Kluckhohn & Strodtbeck, 1961), which is well illustrated by the injunction in the book of Genesis (I: 28; King James Version): "be fruitful and multiply, and replenish the earth, and subdue it: and have dominion over . . . every living thing that moveth upon the earth." That value needs to be changed to one of harmony with nature—focusing on what will benefit all people and the whole world in the long run.

What positive motivations can be appealed to in this effort? The following articles in this section present a number of approaches to this basic issue (Howard, 2000; McKenzie-Mohr, 2000; Stern, 2000; Winter, 2000). As a start toward answering that question, I have elsewhere suggested six possibilities (Oskamp, 2000), which I list briefly here:

- *Voluntary simplicity* as an overall, committed lifestyle is a movement aimed at sustainable living patterns—"living lightly on the earth" (Elgin, 1993).
- A variety of *specific, concrete actions* can be effective in reducing resource use. Everyone can take some such actions easily—for example, installing energy-efficient lighting or buying an energy-effi-

[5] Of course, even nonpolluting automobiles will still contribute to other environmental problems such as urban sprawl, traffic gridlock, and inhumane commuting times. It is also true that a hydrogen-based economy will still create some pollution at the hydrogen production facilities, but the facilities will produce far less pollution than do millions of vehicles' exhausts, and the pollution will not be concentrated in densely populated metropolitan areas.

[6] Examples might include the development of "green taxes" that favor resource conservation and the setting of limits on the environmentally destructive actions of corporations.

cient car. For specific advice, see Brower and Leon (1999).

- *Providing clear behavioral norms* can help guide proenvironmental actions. Particularly important examples are relevant laws and regulations, such as auto smog checks and federal fuel-efficiency standards for vehicles.
- *Focusing technological advances toward proenvironmental goals* and emphasizing the extreme amount of increased efficiency that is necessary for sustainability can move people in a proenvironmental direction (cf. Olson, 1995).
- Use of carefully *organized group activity* can help reduce or prevent environmental damage. In such efforts, the mass media are very important allies, because the polluters are very often governments or powerful corporations that can ignore individual complaints. Yet, at the same time, the media's constant theme of consumerism needs to be rejected.
- The achievement of sustainable living patterns should be emphasized as a *superordinate goal* that all nations and peoples can share (Sherif, Harvey, White, Hood, & Sherif, 1961)—a *war against the common enemy* of an uninhabitable Earth.

Conclusion

The idea of a war against the common enemy of an uninhabitable Earth seems to me a crucial one for mobilizing the widespread public support needed to accomplish the huge changes necessary for a sustainable society. This kind of a worldwide campaign can use William James's (1911) concept of a "moral equivalent of war" as the motivational force underlying steps toward the goal of sustainability. Environmentalists need nothing less than this level of fervor if they are to change worldwide patterns in time to forestall environmental disaster.

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