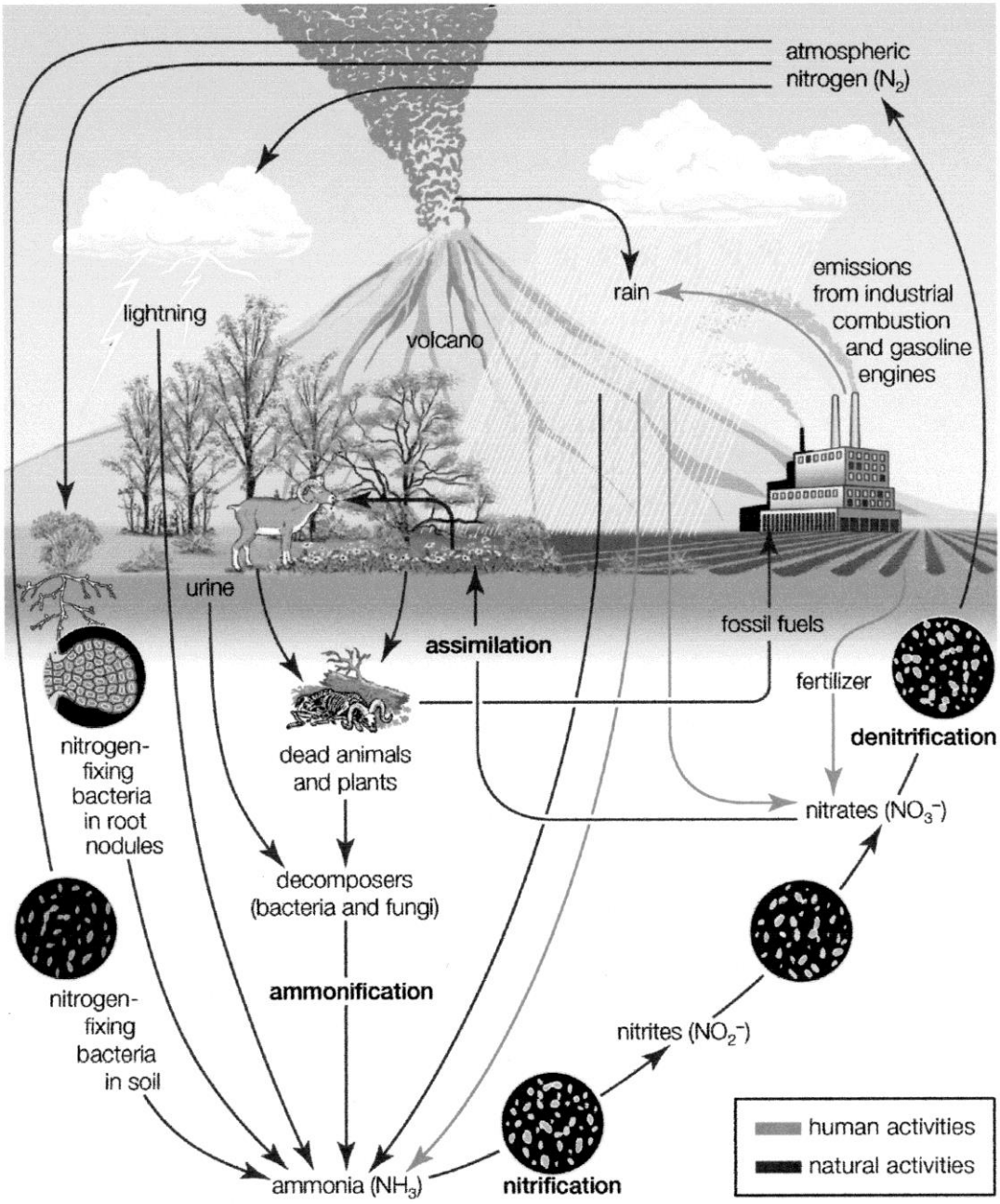
Holbrook, J. Britt and Carl Mitcham, eds. *Ethics, Science, Technology, and Engineering: A Global Resource*, 2nd ed. Farmington Hills, MI: Macmillan Reference USA, Cengage Learning, 2015. vol. 2, pp. 27-31.

ECOLOGY

The word *ecology* is derived from the Greek *oikos*, "household," and *logos*, "reason," thus indicating the logic of living creatures in their homes. Although *oikos* originally indicated only human households, as a term coined in 1866 by Ernst Haeckel (1834-1919), *ecology* names a biological science similar to molecular biology or evolutionary biology, though often thought to be less mature, that studies organism-environment relations. Closely related to ecology in this sense are conservation biology and environmental science. Ecology, the science, studies ecosystems at multiple levels and scales in space and time. Ecosystems have proved to be often quite complicated and resist analysis. Experiments in the field can be difficult, and the systems may be partly chaotic.

In part because of such complications, ecology has become the focus of a particular set of discussions related to science, technology, and ethics. The term *ecological ethics* may, for instance, call for doing ethics in the light of what ecologists have found in their studies of the world. Perhaps it is appropriate, at times, for humans to imitate the way ecologies themselves function, or look toward ecosystems as fundamental goods to be appreciated and preserved. Given these associations, ecology can also feed into a worldview or philosophy.

What has been called the environmental or ecological crisis seems to rest on assumptions about or commitment to the goodness of ecosystems in the face of threats to their continuing vitality from pollution or other phenomena. Ecology thus becomes mixed with ethics in urging that humans ought to find a lifestyle more respectful or harmonious with nature. As the founder of wildlife



The nitrogen cycle, essential to many important ecosystem processes that support life on Earth. What has been called the environmental or ecological crisis seems to rest on assumptions about or commitment to the goodness of ecosystems in the face of threats to their continuing vitality from pollution or other phenomena. **ENCYCLOPEDIA BRITANN1CA/GETTY IMAGES.**

management, Aldo Leopold (1887-1948), argued: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold [1949] 1968, 224-225). Since the United Nations Conference on Environment and Development (1992), the focus has been a sustainable economy based on a sustainable biosphere. More recently, some have claimed that we have entered the Anthropocene epoch. The focus in the new millennium needs to shift to human-dominated ecosystems, which now cover more of Earth's land surface than do wild ecosystems (McCloskey and Spalding 1989; Foley et al 2005).

LEADING CONCEPTS

Leading concepts in ecology involve *ecosystems* (a term coined by Arthur G. Tansley [1871-1955] in 1935), a succession of communities rejuvenated by disturbances, energy flow, niches and habitats, food chains and webs, carrying capacity, populations and survival rates, diversity, and stability. A main claim is that every organism is what it is where it is, its place essential to its being, the "skin-out" environment as vital as "skin-in" metabolisms. Early ecologists described organism-environment relations in terms of homeostasis, equilibrium, and balance. Contemporary ecologists give a greater role to contingency, flux, dynamic change, or even chaos. Others emphasize self-organizing systems (autopoiesis).

As subsequent studies have shown, any ecological stability is not simply homeostatic but quite dynamic, and may differ with local systems, the level of analysis, and over time. There are perennial processes—wind, rain, soil, photosynthesis, competition, predation, symbiosis, trophic pyramids, and networks. Ecosystems may wander or be stable within bounds. When unusual disturbances come, ecosystems can be displaced beyond recovery of their former patterns. Then they settle into new equilibria. Ecosystems are always on a historical trajectory, a dynamism of chaos and order entwined.

ECOLOGY, TECHNOLOGY, MANAGEMENT

How far can human environmental policy be drawn from ecology? The question raises classical is/ought concerns about moving from facts to values, and worries about the naturalistic fallacy. Perhaps ecology, a "piecemeal" science, can offer no more than generalizations of regional or local scope, and supply various concepts (such as eutrophication of lakes, keystone species, nutrient recycling, niches, and succession) for analyzing particular circumstances. Humans could then step in with their management objectives and reshape ecosystems consonant with cultural goals. Humans have rebuilt their natural environments since agriculture began, with increasing intensity in modern high-tech industrial agriculture. Human agriculture, construction, and mining move more earth than do the natural processes of rock uplift and erosion. Humans are now the most important geomorphic agent on the planet's surface (Wilkinson and McElroy 2007).

Certainly humans have always had to rest their cultures upon a natural life-support system. The human technosphere is constructed inside the biosphere. In the future, this could change; the technosphere could supersede the biosphere. The natural sciences would be increasingly replaced by the sciences of the artificial, as in computer science, or materials science (as with Teflon), or engineered biotas. Edward Yoxen has celebrated the prospect: "The living world can now be viewed as a vast organic Lego kit inviting combination, hybridisation, and continual rebuilding.... Thus our image of nature is coming more and more to emphasise human intervention through a process of design" (1983, 2, 15).

Ecosystem management (if not more global, planetary management) appeals alike to scientists, who see the need for understanding ecosystems objectively and for applied technologies, as well as to landscape architects and environmental engineers, who see nature as redesigned home, and finally to humanists, who desire benefits for people. A good thing in nature may not be a good in culture, and vice versa. Viruses kill people; people's cities kill wild animals. The combined ecosystem/management policy promises to operate at systemwide levels, presumably to manage for indefinite sustainability of ecosystems and their outputs alike. Such management sees nature as "natural resources" at the same time that it has a "respect nature" dimension. Christian ethicists note that the secular word *manager* is a stand-in for the earlier theological word *steward,* and also that the biblical "dominion" involves more cultivating a garden Earth than conquering and controlling it.

At the same time, ecosystem management has been criticized as an umbrella idea under which different managers can include almost anything they wish, because what one is to manage ecosystems for is left unspecified. They might be managed for maximum sustainable yield, for equal opportunity in the next generation, for maximum biodiversity, or for quick profit. Nevertheless, there usually is the idea of fitting human uses into ongoing ecosystem health or integrity. There is less overconfidence than with those who view nature as a vast Lego kit and seek to redesign the planet. This is often a matter of managing human uses of their ecosystems with as much care as one is managing, or revising, wild nature.

Editing a 1989 *Scientific American* issue on "Managing Planet Earth," William C. Clark identified two central questions: "What kind of planet do we want? What kind of planet can we get?" (Clark 1989, 47). Over great stretches of Earth, evolutionary and ecosystemic nature

has been diminished in favor of engineered design. Nature is at an end. The principal novelty of the millennium is that Earth will be a managed planet. Humans will make it a better home for themselves.

ECOLOGICAL LIMITS?

Such claims raise concerns about how far nature can and ought to be transformed into humanized nature. Ecologists are likely to fear the arrogance rather than to celebrate the expertise of such planetary engineers. Much transformation is the positive result of human managerial successes: widespread irrigation, agricultural production, electric power. But just as often there are unintended, undesired results: The seeds of exotic weeds are carried afar on ships and trains; the landscape is increasingly weedy. Toxic, nondegradable agricultural chemicals seep into the nooks and crannies of all nature. Industrial production and mass consumption produces global climate change. The "dominion" mentality is what led to the ecological crisis; more clever dominion, the ultimate technological fix, is a dangerous myth. A widely accepted idea here is that humans will always require "ecosystem services" (Millennium Ecosystem Assessment 2005). People should think of humans as fitting themselves into a sustainable biosphere, as members of a larger community of life on Earth, as a better logic of our being at home on Earth.

But, critics rejoin, the community of life on Earth is already human-centered; this is the fact of the matter. The end of nature may be, in its own way, a sad thing; but it is inevitable, and the culture that replaces nature has many compensating values. Humans too belong on the planet. With the arrival of humans, and their technologies, pristine nature vanishes. Nature does not vanish equally and everywhere, but there has been loosed on the planet such a power that wild nature will never again be the dominant determinant of what takes place on the inhabited landscapes.

Should this rebuilding of humanity's Earth home be thought of as a sort of dialectic: nature the thesis, culture the antithesis, and the synthesis a humanized nature? Possibly, but there is a still better ecological model: that of an ellipse with two foci. Some events are generated under the control of a culture focus: society, its economics, its politics, its technologies. Under the other focus, nature, some events take place in the absence of humans—wild, spontaneous, ecological, evolutionary nature (in parks, reserves, and wilderness areas).

From a larger ecological perspective, a domain of hybrid or synthetic events is generated under the simultaneous control of both foci, the result of integrated influence from nature and culture. Human labor and craft put natural properties to use in culture, mixing the two to good effect in agricultural, industrial, scientific, medical, and technological applications. *Symbiosis* is a parallel biological word

Lest technologists become too arrogant, there is a sense in which nature has not ended and never will. Humans stave off natural forces, but the natural forces can and will return, if one takes away the humans. Nature is forever lingering around. Nature bats last. In, with, and under even the most technologically sophisticated culture, there is always this once and future nature.

ECOLOGICAL IS AND OUGHT

Scientists and ethicists alike have traditionally divided their disciplines into realms of the *is* and the *ought*, facts and values. No study of nature, it has been argued, will tell humans how they ought to behave. But this neat division is challenged by ecologists and their philosophical and ethical interpreters. There may be goods (values) in nature that humans ought to consider and care for. Animals, plants, and species, integrated into ecosystems, may embody values that, though nonmoral, count morally when moral agents encounter them. Ecology invites human beings to open their eyes and to appreciate realities that are valuable in ways humans ought to respect.

Ecological or environmental science may thus inform environmental technology and environmental ethics in subtle ways. Scientists describe the order, dynamic stability, and diversity in biotic communities. They analyze interdependence, or speak of health or integrity, perhaps of resilience or efficiency. Scientists describe the adapted fit that organisms have in their niches. They analyze an ecosystem as flourishing, as self-organizing. Strictly interpreted, these are only descriptions; and yet they embody already quasi-evaluative terms, perhaps not always but often enough that by the time the descriptions of ecosystems are in, some values are already there, putting constraints on what we think might be appropriate human technological development of such areas.

Ethicists can with considerable plausibility also claim that neither conservation, nor a sustainable biosphere, nor sustainable development, nor a well-managed planet, nor any other harmony between humans and nature can be gained until persons learn to use Earth both justly and charitably. These twin concepts are found neither in wild nature nor in any science that studies nature, nor in any technology as such. Those who celebrate entering the Anthropocene may claim that environmental ethics now needs to think more about how to adapt, with equity and fairness, to novel anthropogenic ecosystems than about conserving the inherited biosphere (Thompson and Bendek-Keymer 2012). One needs human ecology, humane ecology, and this requires insight more into human nature than into wild nature. True, humans

cannot know the right way to act if they are ignorant of the causal outcomes in the ecosystems they modify. And they cannot act successfully without technology. But there must be more, and here ethics is required to keep science, technology, and life human and humane on this, humanity's home planet.

SEE ALSO *Anthropocene; Biodiversity; Deforestation and Desertification; Ecological Economics; Ecological Footprint; Ecological Integrity; Ecological Restoration; Environmental Ethics: Overview; Rainforest; Sustainability and Sustainable Development; United Nations Environment Programme.*

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