# A Noosphere

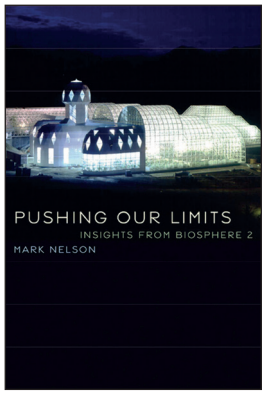
**Pushing Our Limit: Insights from Biosphere 2**. Mark Nelson. University of Arizona Press, 2018. 304 pp., illus. $22.95 (ISBN: 9780816537327 paper).

Long critical of the scientific design of Biosphere 2, I was prepared to dislike this book. Instead, I found it an enjoyable read describing what was accomplished in the $150 million experiment (1991–1993), the trials and tribulations of the eight biospherians, and the implications of their sojourn for the better management of planet Earth. Biosphere 2 represents the first attempt to create a *noosphere*, described in 1926 by the Russian biogeochemist Vladimir Vernadsky as a world merging the technosphere and the biosphere.

After graduating from Dartmouth College and founding the Institute of Ecotechnics in Santa Fe, Mark Nelson worked on various projects of sustainable agriculture. At age 44, he joined the team of biospherians chosen to live in Biosphere 2, an ambitious experiment funded by oil man Ed Bass, of Texas, to examine the survival of humans in an artificial 3-acre enclosed "biosphere" designed to replicate planet Earth. Mark was in charge of communications, the wastewater recycling system, and various agricultural endeavors. When he was released in 1993, he completed graduate degrees at the University of Arizona (MS) and the University of Florida (PhD), under the tutelage of his spiritual mentor, H. T. Odum.

In individual chapters, Nelson walks us through the daily life of the biospherians in the closed environment: what they did, what they ate (sweet potatoes, bananas, and beets), their health (lower weight and cholesterol), how they relaxed (music and weekly banquets), and how they interacted (sometimes poorly). All in all, Nelson thinks back with some nostalgia about his days inside the experiment and what has happened to it since.

The biospherians were true locavores; they grew everything they ate and knew its provenance. All of this was done from water recycled within the structure and without the use of exotic chemicals. The book provides some interesting tables summarizing the agricultural production and its dietary caloric contribution. Over their 2-year experience, the biospherians produced a diet averaging 1823 kilocalories per day, or 83 percent of their necessary caloric intake.




Beyond the emphasis on producing food for its inhabitants, Biosphere 2 also contained small wilderness "biomes" to represent tropical rainforest, savanna, desert, mangrove swamps, and coral reefs. Some of these—for instance, the desert—were failures, but others thrived and even provided additional food to the inhabitants. Perhaps overly ambitious, the wilderness biomes provided "the beauty, diversity, and wonder of natural areas that are important for human happiness and well-being." Human intervention was an accepted feature of ecosystem management in Biosphere 2 to keep some species from overtaking the rest. Rank growth of morning glory and an abundance of ants and cockroaches were tamed manually—the latter fed to chickens and returned to the food chain.

The experiment was designed without obvious cost constraints. Nevertheless, their cost in the early 1990s prohibited the use of photovoltaic panels. Therefore, Biosphere 2 was never disconnected from the grid, from which it drew enormous amounts of power, especially for cooling in the Sonoran desert climate. Like the Earth, Biosphere 2 was closed with respect to materials but an open system with respect to energy.

Nelson articulates some interesting lessons in biogeochemistry. Carbon dioxide in the atmosphere of Biosphere 2 showed seasonal fluctuations resembling those at Mauna Loa, albeit with concentrations about tenfold higher. With only small pools of carbon and water inside the Biosphere, these materials had a short mean residence time as they cycled through various reservoirs in the system—atmosphere, plants, soils, and humans. The short mean residence times meant that mistakes anywhere quickly showed up everywhere inside the structure. The biospherians were quick to recognize the effects of their actions and to know that their successful persistence in the closed environment required an immediate response—their lives depended on it. Nelson notes that planet Earth provides bigger biogeochemical reservoirs that add some capacitance to the system.

Within Biosphere 2, the store of soil carbon was 5000 times greater than that in the atmosphere, compared with the two-to-one ratio of these reservoirs on Earth. Nelson describes the rationale to supply an organic-rich soil in the agricultural sector, overlooking that in most cases, soil organic matter is merely useful but not essential to soil fertility and plant production. Almost any thoughtful biogeochemist could have predicted what happened: A huge consumption of $O_2$ by microbial respiration of the soil organic matter imperiled the survival of the biospherians. It was merciful that the unweathered concrete of the structure

absorbed a fair amount of the emitted $CO_2$, or high atmospheric concentrations might have also doomed the entire effort. Even so, oxygen had to be resupplied to the system, a major flaw in the goal to be self-sustaining.

The book struggles with what constitutes science: observational and descriptive versus experimental. Ecology has a long history of the former, but a growing corpus of replicated experimental work is now found in studies ranging from small lakes and forests to large areas of the ocean. Without replicates, Biosphere 2 provided only a description of what happened in its closed environment, and strong inferences of cause and effect were impossible.

The Biosphere 2 experiment has been roundly criticized (see *http://dx.doi.org/10.1126/science.274.5290.1150*), but it is worth noting that descriptive work underlies nearly everything we know about global change ecology. Biosphere 2 did not leave an indelible footprint on Earth-system science, but the history of its ambitions as recorded here is too valuable to lose.

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