Re: A Noosphere,
Book review of Pushing Our Limits by Mark Nelson
18 July 2018

Dear Editor,

The review misstates the purpose of Biosphere 2 and misunderstands its biogeochemistry.

To say that Biosphere 2's purpose was "...to examine the survival of humans..." repeats sensationalist media narratives that then declare Biosphere 2 was a "failure" because the system did not behave narrowly like a few assembled small slices of Earth. In the book preface, Nelson states the purpose - "Biosphere 2 was built to study how biospheres work, creating a laboratory for global ecological processes, to help ecology become an experimental science."

Nor was Biosphere 2 "... designed to replicate planet Earth" as the review states. There would be very little to learn had Biosphere 2 followed a "perfect" trajectory. A powerful way of learning comes from making a first approximation, observing the operational details of how that deviates from what you are approximating, making a second approximation, observing again and so on. That was the planned experimental program of Biosphere 2, intended to unfold over 100 years, but was terminated in 1994 by events beyond our control after less than 3 years of initial operation. In his book, Nelson also notes : "The first closure experiment was the 'shake down' mission; a trial run to find flaws, bugs, what we had to correct or change." Biosphere 2 was never intended to be a single trial with success or failure to be determined at the end of the first two years. As Nelson states, it "...was built to study how biospheres work..." Generically, "biosphere" refers to 3 essential characteristics -

1) Containing a diversity of ecosystems, genera and species capable of persistence, adaptation and evolution
2) Materially closed within negligibly small limits regarding the matter involved in life processes
3) Open to energy and information exchange beyond its boundaries.

The first approximation included representation of five natural biomes of Earth with attention paid to selecting enough diversity of species to provide robust food chains, plus two anthropogenic "biomes" (agriculture and human habitat). It was launched in September 1991 with a crew of eight to manage, observe and document the system. This was not a replicate of Earth and was never intended to be. There were vast differences.

The crucial biogeochemical calculation is that the 6 million mole atmosphere, initially at 352 ppm CO_2, held a mere 25 kg of carbon which, without CO_2 resupply, would be consumed by photosynthesis in less than 3 days. While it is true that plants growing in Earth's atmosphere have an inexhaustible supply of CO_2, Biosphere 2's atmosphere was isolated and 30 trillion times smaller (by mass).The rich, microbially respiring soil was the essential CO_2 source supporting plant growth. The plants, in turn, by photosynthesis produced oxygen for the microbes (and humans and animals) to consume. The problem was much more subtle than the review implies. It was to *dynamically match the release rate of carbon from soil with plant growth demand for carbon*, two independent processes. That concrete was an important CO_2 sink was a discovery**(1)**. The initial system configuration, which was only the first approximation, allowed 16 months operation before adjustment by a measured oxygen injection - remarkable for the first attempt to create such a complex system. Soil analysis **(2)** suggests the imbalance was a transient that might resolve in a few years.

The 1996 Cohen and Tilman article in Science criticizing Biosphere 2 is cited, but not the replies from myself, Mark Nelson and John Allen**(3)** which rebut those criticisms. [Copy also attached.] Cohen and

Tilman never contacted any of the team who conceived, designed, built and put Biosphere 2 into operation. By 1996, the project's history was being suppressed and falsified which Nelson describes **(4)** and as I know directly.

Regards,
William F. Dempster
Director of Systems Engineering for the Biosphere 2 Project, 1984 - 1994

References

1. Severinghaus, J. P., Broecker, W. S., Dempster, W. F., MacCallum, T., & Wahlen, M. (1994). Oxygen loss in Biosphere 2. *EOS, Transactions American Geophysical Union*, *75*(3), 33-37.

2. Torbert, H.A. and H.B. Johnson (2001). Soil of the intensive agriculture biome of Biosphere 2, *Journal of Soil and Water Conservation* 56(1):4-11.

3. Dempster, William F., Mark Nelson, and John Allen. "Biospherian Viewpoints." *Science* 275, no. 5304 (Feb. 28, 1997): 1247-1249.

4. Nelson, Mark. Pushing Our Limits: Insights from Biosphere 2. University of Arizona Press, 2018, pp. 240-242.