

Isolated Refuges for Surviving Global Catastrophes
Seth D. Baum, David C. Denkenberger, Jacob Haqq-Misra
Futures 72: 45-56. This version 14 October 2015.
Preprint at: http://sethbaum.com/ac/2015_Refuges.html.

Background: Long-Term Civilization Success

The long-term success of human civilization is of immense importance because of the huge number of lives at stake, in particular the lives of countless future generations. A catastrophe that causes permanent harm to human civilization would be a similarly immense loss. Some measures taken pre-catastrophe could help people survive and carry humanity into the future. *This paper analyzes how refuges could keep a small population alive through a range of global catastrophe scenarios.* The paper considers desirable refuge design qualities and how they can be achieved.

Refuge Design Qualities

Several qualities could make refuges more successful at promoting long-term civilization success. *Isolation* would prevent the catastrophe and its aftermath from harming the refuge. *Secrecy* would protect the refuge from post-catastrophe outsider populations. *Self-sufficiency* would keep an isolated refuge successful. *Continuous population* in the refuge would ensure success even when catastrophe timing is unpredictable. *Accessibility* would enable people to get to the refuge if they're not already in it. *Desirability* would make people want to live in the refuge. *Pleasantness* would help people enjoy their time in the refuge. *Monitoring* of the outside world could help refuge inhabitants plan their actions, including when to leave the refuge. *A sufficient founder population* would ensure that the refuge inhabitants could repopulate the world. *Resources for civilization* could also help, such as agricultural seeds, tools, and libraries.

Surface Independence

The paper proposes surface-independence, meaning complete isolation from Earth's surface, as the gold standard for refuge excellence. Surface-independent refuges could be subterranean (located underground), aquatic (in water), or extraterrestrial (in outer space). A surface-independent refuge would have the best chance of protecting inhabitants from outside catastrophes. However, surface-independence poses some significant design challenges.

Food Provision

A surface-independent refuge would need to be self-sufficient in food. Food self-sufficiency could be achieved in several ways. Food could be stockpiled, though this could take up much of the refuge's space. Food could be produced via photosynthesis, which would additionally help refuge air quality, though it could reduce surface-independence. Finally, food could be produced via chemical synthesis, which is more energy efficient, though the foods may not be as pleasant.

Subterranean Waste Heat Rejection

For refuges built underground, excess heat would need to be rejected (i.e., removed) into the surrounding environment. Otherwise, the refuge would overheat. Waste heat could be rejected to the surface, into adjacent rock or groundwater, or by locating the refuge in glaciers.

Extraterrestrial Refuge Cost

Extraterrestrial refuges could provide an exceptional degree of isolation from Earth's surface, but they can also be very expensive. However, the cost could be reduced by "piggybacking" refuges onto space missions that would occur anyway for other reasons, in particular for science, politics, and commerce. In this way, extraterrestrial refuges could be a lot more cost-effective.