

Greenhouses as the Source of Rare Lunar Resources.

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In 2010 I led a team that designed a second generation lunar base (after the man in a can camping period ends) that could be built by 2069. This was for an Architectural contest. My team decided that our entry had to house 60 people on rotating 1 year deployments, be built 90% of locally available materials, feed itself with a mostly vegetarian diet and pay for itself. We tied for first place in the category of technical feasibility and elegance.

The base turned out to be 40% greenhouse, of which there were 2 types. One was for plants that thrive in the current high oxygen atmosphere of present day Earth. The other was for plants that evolved in a substantially higher carbon dioxide atmosphere and thrive at CO₂ levels too high for human respiration. The two types of plants have different kinds of photosynthesis.

Most of the plants that are a staple on Earth are of the more ancient variety. Increasing the CO₂ level has an effect similar to adding fertilizer. They grow twice as fast or twice as big.

In this paper, I will explore the question of what you would grow in lunar greenhouses and why. Part of the paper will deal with nutrition, both staple foods and items intended to avoid various conditions associated with vitamin and protein deficiencies. Medicines, including anesthetics, stimulants, hallucinogens and herbs will be the focus of a second part of the discussion. A third part will deal with other materials needed or desirable. These include fibers, those *for fabric and cloth* (from canvas and towels to linen and gauze); *paper* (cardboard and bags to toilet paper and coffee filters); *cordage* (rope to thread); *wicker* (furniture to baskets); *fuel* and *alcohol*; glue and other *adhesives*; *waxes*; *perfumes*; *nets*; *cleansers* (from soap to vinegar); *padding and stuffing*; *grease, oil, and lubricants*; *resins*, paint, turpentine, inks and dyes; *sealants*; gaskets; and some especially important plants that can supply

several needs (like rubber, fruitwood, hemp, bamboo, and peanuts).

Furthermore, in the stark and even bleak, lifeless lunar environment, the idea of going to rest or picnic in a garden, with fragrant oxygenated air, lush greenery and colorful succulent fruits and vegetables, make the greenhouses oases. These spaces restore the spirit and assuage homesickness for Earth.

In the situation where delivering a pound of material from the Earth will cost \$5000-10,000, the acquisition of seeds and bacteria are among your most promising investments. The mass to be transported is minuscule compared to the yield over a few generations. For example, a cantaloupe or strawberry growing from a seed produces hundreds of seeds in or on a single fruit. Each of those seeds can become an equally prolific source of more seeds, that can then rapidly fill the available space. An apple seed multiplies in a different but equally impressive way over a longer period.

ISRU must include the resources that become available due to the foresight of those first adventurers. On Earth those who plant an olive tree do not live long enough to see its fruit. But it is a given part of the environment for those who arrive at a later date.