Prehistoric Horticultural Practices on Easter Island: Lithic Mulched Gardens and Field Systems

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Food Production on Easter Island

Easter Island illustrates the importance of cultivation in support of large populations. Between the 9th and the 17th centuries an estimated 5000-10000 people were supported by their chiefs and kin groups including non-food producing members of society, such as the craftspeople who constructed, moved and erected the *ahu* and carved stone *moai*. Subsequent to the 17th century, as the centralized chiefdom gave way to competition among clans for leadership, warriors and competitors affiliated with the "Birdman cult" were also supported through cultivation of tuber and tree crops, the major means of subsistence for those who lived on Easter Island prior to European contact. Food production took on added importance as a subsistence practice, because terrestrial and marine faunal resources were reduced through exploitation that occurred between the 16th and 19th centuries (Ayres 1986; Steadman 1995) and possibly as a result of natural climatic changes between the 16th and 19th centuries (McCall 1993).

On Easter Island, during protohistoric times, techniques used for food production were described in reports and logs of early European voyagers visiting the island (La Pérouse 1799; Cuming 1827-28), and ethnographic descriptions of subsistence activities were recorded in the early 20th century (Routledge 1919; Metraux 1940). Archaeological surveys have identified architecture related to gardening (McCoy 1976; Cristino, Vargas and Izaurieta 1981). These eyewitness reports, studies and surveys contribute to the following view of prehistoric and early historic Easter Island agriculture. Easter Islanders raised chickens and Polynesian domesticates, such as *Dioscorea* yams, *Colocasia* and *Alocasia* taro, *Musa* bananas, *Saccharum, Cordyline, Curcuma*, and *Broussonetia* paperbark mulberry (used to make tapa cloth). These plants are derived from the cultigens brought from Southeast Asia (Zizka 1990). Easter Islanders also grew and used *Lagenaria vulgaris* gourds to hold water and the sweet potato, *Ipomaea batatas*, both of which had a South American origin (Yen 1974; Green 1999).

Early surveys (Ayres 1975; McCoy 1976; Cristino, Vargas and Izaurieta 1981) and more recent research by Vargas (1993) and Stevenson and Haoa (1998) have associated prehistoric agriculture with architectural features, such as walled *manavai* gardens, planting circles, small terraces, and meter-deep rock accumulations encompassing planting wells holding individual plants. However, according to early European visitors to the island, large areas on the West Coast of Easter Island had rectangular field systems (Cuming 1827-28; La Pérouse 1799). These visitors described earth mounds several meters in diameter, or depressions and furrows in which banana plants grew aligned in rows within rectangular field systems. La Pérouse also mentioned use of a field system where:

> "...this space abounds with a kind of herbage'...[covering] large stones lying on the surface. These stones, which were found very troublesome in walking, are a real benefit to the soil, because they preserve the coolness and humidity of the earth, and in part supply the salutary shade of the trees, which the inhabitants have had the imprudence to cut down, no doubt at some very distant period. This has exposed their soil to the burning ardor of the sun, and has deprived them of ravines, brooks, and springs." (La Pérouse ibid: p. 312)

These field systems and gardens, as described by La Pérouse, have not been identified as prehistoric features in the archaeological surveys carried out in early archaeological surveys.

Geoarchaeological Survey to Identify "Cultivated Fields" on Easter Island

In order to locate and define the field systems described by the first European visitors to Easter Island I began a geoarchaeological survey of the Te Niu area in 1996 (Wozniak 1996). I systematically collected soil samples from shovel test pits. During the sampling procedure I found that areas of level or slightly sloping terrain in the vicinity of residential sites had discrete patterns of surface rocks near the remains of residential sites. Several excavations in these rocky areas revealed that a layer of surface rocks covered an organically rich, anthropogenic soil containing materials added by humans. McFadgen (1980) terms this type of anthropogenic soil "*maori plaggen*" soil. Plaggen is a Dutch term, which refers to "plowed" soil. On Easter Island however, a fire-hardened digging stick (called an *oka*) and basalt spades, rather than plows, were used to open the soil surface in order to place cuttings of tuberous plants or trees into holes.

Lithic Mulch

The term "lithic mulch" is used by Lightfoot (1994) to describe the use of a layer of gravel or rocks covering the surface of an agricultural soil. A thick surface layer of small rocks has a mulching property because it protects the soil from desiccation, water and aeolian erosion, and rapid fluctuations in soil temperature (Fairbourne 1973; Edwards, et al. 1984). Lithic mulching is a technique that is used to maximize food production under dryland conditions, such as those present on Easter Island. I am proposing that the surface layer of small rocks, which covers the maori plaggen soil horizon on Easter Island, is an artificially constructed, or artificially enhanced, agricultural innovation designed to increase food production, and that these rock layers constitute at least one type of field system used by Easter Islanders during the Prehistoric period on Easter Island (Figure 1). I refer to this rock layer as a "lithic mulch" and to the gardens as

"lithic mulch (-ed) gardens". Although lithic mulch was just one of the technological means used on Easter Island during prehistoric times to enhance food production, it was potentially one of the most important innovations.

During my survey on the Northwest coast of Easter Island, I found two dozen good examples of rock-covered maori plag-

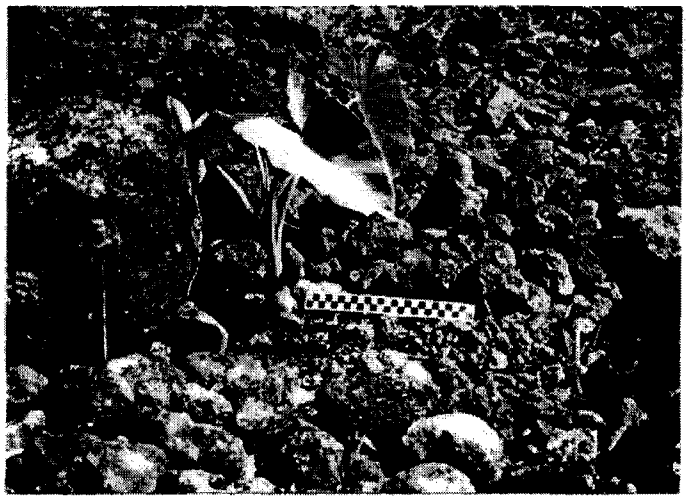

Figure 1. Photo of lithic mulch garden (feature EI 26-22a) containing an American-derived.

gen soils within the 500 by 1000 meter Te Niu project area. Of these, seven rock-covered areas were tested. All seven exhibited a subsurface horizon of maori plaggen soil. Non-rock covered areas were also tested. Only one of these exhibited a similar horizon. This test pit was situated within a residential site neighboring a rock-covered garden area. This site may represent an older garden area. Each of the discrete lithic mulch gardens extend over an area between 100 and 10,000 square meters. Approximately 10% of the total land surface in the project area is covered with these concentrations of small rocks. The use of small rocks as a mulch may have resulted from several factors that are present on Easter Island. Major determinants in the use of lithic mulch on Easter Island are: 1) the ubiquitous availability of vesicular or porous lava rocks, and 2) the prevailing climate conditions, especially the seasonal nature of precipitation and high rates of evaporation owing to the intense solar radiation received in the eastern South Pacific and the prevailing trade winds.

Easter Island experiences seasonal temperature and precipitation fluctuations. The average temperature varies by 10° C between summer and winter with the mean air temperature being 21° C. The mean temperature varies from 18 to 23° C between evening and midday. Topsoil temperatures may be 2-3° C warmer than the air temperatures. The average precipitation on Easter Island approximates 120 cm, however the annual rainfall varies between 50 and 200 cm (Wright and Diaz 1962). Evaporation rates are high owing to high solar radiation, constant winds that dry the soil, and intermittent light rainfall during much of the year.

Easter Island is predominately made up of numerous lava flows and volcanic ash in the form of tuffs. The basalts are described as hawaiitic or mugearitic; they have tholeiitic affinities and often contain phenocrysts of plagioclase, olivine and augite (Baker 1993; De Paepe and Vergauwen 1997). Porous vesicular basalt occurs when gases were trapped during cooling of the magma. As a result vesicular basalt contains a large volume of space within each rock which in turn holds moisture introduced from rainfall.

Description of Lithic Mulch Gardens on Easter Island

The lithic mulch gardens that I describe here are those fields I believe were first described by La Pérouse (1799). On Easter Island the lithic mulch layer covering prehistoric gardens is generally a 20-40 cm thick surface layer of small rocks over an anthropogenic (plaggen) soil layer that is 30 to 50 cm deep. This soil layer is in turn underlain by either a regolith or solid bedrock on gently sloping hillsides, or by a meter-deep, clay-rich soil horizon on level terrain at lower elevations. These deeper soils result from deposition of eroded sediments from higher elevations over several centuries. Figure 2A shows the profile of a typical excavation within a lithic mulched garden.

In Te Niu, the lithic mulch cover is made of locally available vesicular and tuffaceous basalt rocks. These rocks tend to be porous; they are discoid to sub-rounded in shape. Rock sizes are predominately between 5 and 20 cm in diameter. Occasionally larger boulders sit in or upon the smaller rocks. The density of rocks in the mulch layer measured in one of the garden areas is equivalent to 0.34 m^3 per m^3 of sediment or 34% of the total volume. The soil interspersed among the rocks of the mulch layer is a pale brown silt having a loose texture.

The anthropogenic soil layer under the mulch cover also contains rocks but the rock volume is reduced to 6.9% of the total volume. The size of the rocks also diminishes with depth. The soil in the plaggen layer is homogeneous in color and texture. It is dark brown in color, rich in organic material and is light and porous in texture. The plaggen layer often contains charcoal fragments. Radiocarbon dating of charcoal obtained from rock-mulched garden areas indicates that the soils in these gardens have been used for cultivation since at least A. D. 1200.

The addition of charcoal is termed "manuring." (La Pérouse 1799; McFadgen 1980). La Pérouse described the protohistoric manuring of the garden soils. "The natives collect the grass and other vegetables, which they heap together and burn for the sake of the ashes, as a manure" (La Pérouse 1799, p. 318). In addition, the plaggen soil of Easter Island gardens often contains flake debitage of obsidian and fine-grained basalt, coral, marine shells, and red scoria, materials and items which would have been transported to the Te Niu area from elsewhere on the island or from the ocean 100 m below.

The plaggen horizon in lithic mulch gardens is supported either by a mineral-rich rocky soil resulting from the weathering of bedrock in the shallow soils on sloping hillsides (regolith), or by a clay-rich horizon on level terrain. The mineral horizon is usually more brightly colored soil. It is typically a yellow-brown or mottled yellow and orange-brown and it often containes a larger volume of rocks than the overlying plaggen horizon. The mineral horizon has a gravelly, clayey consistency. It does not contain charcoal fragments, but often contains small (less

than 5 cm diameter) organic-rich pit features, which protrude into this horizon from horizon above. These pit features represent the remains of roots protruding down from the plaggen layer.

Those gardens placed on the deep soils that had formerly supported forests tend to exhibit a narrow transition zone between the plaggen layer and the lower, yellow, clay-rich horizon. This transition zone and the top of the yellow horizon contain long pores about 5 mm in diameter extending vertically from the bottom of the overlying plaggen horizon. These pores, which are lined with carbonaceous material, appear to be the remnants of the extinct palm trees of Easter Island.

In contrast, the soil in the walled *manavai* garden has no lithic mulch cover but it does have a stratigraphy similar to the shallow garden soils (Figure 2B). This includes a plaggen layer, which has pit features that also extend into the lower regolith horizon. However, in place of the lithic mulch, the layer on top of the plaggen horizon consists of dark brown sediments that have a granular ped structure typical of mollic soils which form under a mat of grasses. Grasses replaced the forest biota on Easter Island (Flenley et al. 1991).

Discussion

Easter Island lacks permanent streams; therefore irrigation to increase agricultural production has not been an option. The successful cultivation was and is solely dependent upon rainfall, fertility of the soil, and protection of plants and soils from extremes of climate. The soils derived from weathering of lavas on Easter Island are potentially fertile (Wright and Diaz 1962). Tuber crops thrive on a nutrient-rich soil supplied with phosphates produces during weathering of basaltic soils, so long as nitrogen, carbon and potash are provided in the form of ash or charcoal that aids in the release of phosphates from the insoluble form present in the soil. The benefits of a lithic mulch include: the maintenance of soil moisture within the root layer, protection of the soil from wind and water erosion, encouragement of a healthy microflora and fauna providing humic nutrients to the crop plants, and a reduction in extreme temperature fluctuations around roots and tubers (Wilson 1983). The rock layer also inhibits weeds from taking hold within the garden area, and would appear to be a deterrent to crop destruction by intruding rodents and chickens.

Lithic mulch gardens represent an innovative technology that allowed Easter Islanders to meet both their subsistence requirements and

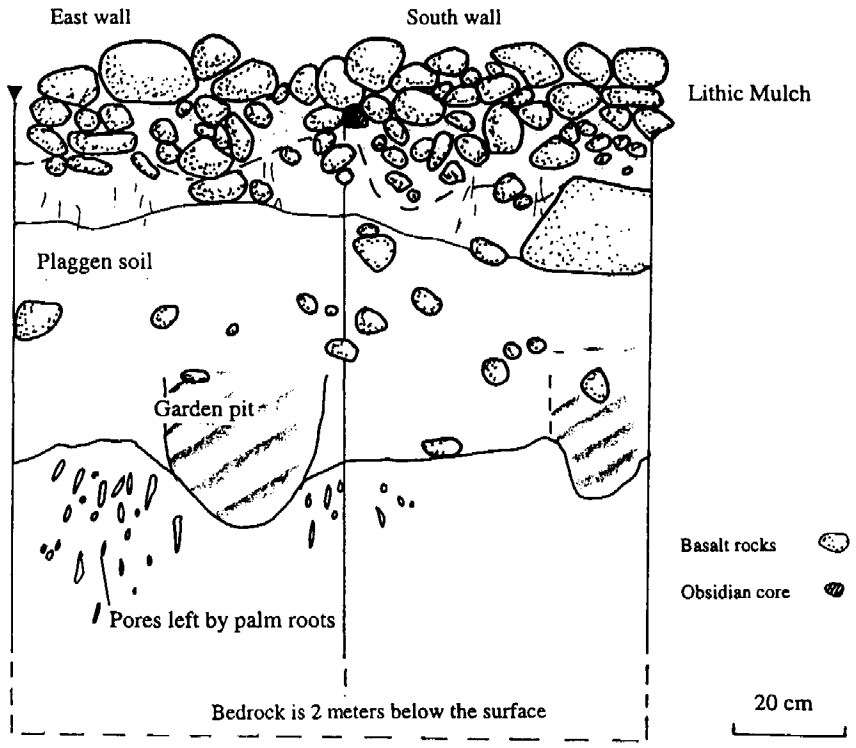

Figure 2A. Profile of typical excavation within a lithic mulch garden. The east and south walls of this 60 x 60 cm excavation unit are illustrated. The unit is located within feature EI 26-7a. Lithic mulch forms a 30-40 cm deep surface layer over a plaggen soil. Two distinct pits of darker soil are present within the plaggen horizon. The clay-rich horizon below the plaggen soil containes pores representative of palm root casts. The depth of bedrock is 1.8 to 2.0 m below the surface at this site. This garden feature is 30 x 60 m.

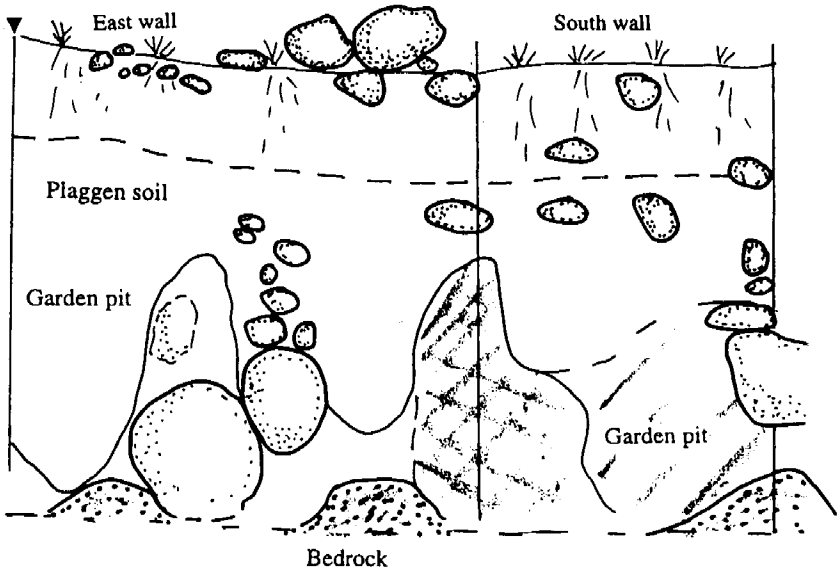

Figure 2B. Profile of an 80 x 50 cm unit within a *manavai* garden. The excavation unit iliustrated here is located in feature EI 26-36. There is an organically rich surface horizon containing a mat of grass roots over homogeneous plaggen soil having several pit depressions in the east wall. One large garden pit having a darker charcoal-rich soil is obvious in the south wall of this profile. Bedrock lies less than 1 m below the surface.

their social obligations during the prehistoric period. Islanders increased agricultural production through the retention of soil moisture, the encouragement of a microflora and microfauna that could provide a nutrient-rich growing medium, and the prevention of soil erosion. Lithic mulch gardens also represent a means by which intensification of food production in a dryland environment could be accomplished (Stevenson, et al. 1999, in press).

Cultivation techniques designed to meet the needs of feeding people resulted in the loss of the vegetation cover that had formally helped shade the soil surface. This alteration of the forest ecosystem would have had a negative affect on an already semi-dry environment. If climatic changes then transpired, as may have occurred during the Little Ice Age when local changes in temperature and precipitation occurred throughout the world (Cole 1996; Kreutz, et al. 1997; Mann et al. 1998), then the increased stress would have altered the already marginal productive capacity of Easter Island. An increased use of lithic mulch could have provided a means of food production during periods of environmental stress, such as those which accompanied forest-clearing, local weather changes caused by recurring El Niño events, or global climatic changes such as the Little Ice Age. Lithic mulch gardening was therefore most beneficial during the last 500 years, when the population is estimated to have reached its maximum size and dependence upon cultivation for subsistence became imperative owing to diminished food procurement from other sources (Ayres 1986; Steadman 1995).

There is evidence that lithic mulch gardening is not a unique strategy for food production found only on Easter Island. Lightfoot (1994) has reported at least twelve instances of gravel or rock mulch used in various locations worldwide where rocks are abundant and precipitation is minimal. Rock mulches were used by the Hohokom and the Anasazi of the American Southwest, the Maori of New Zealand and on the island of Hawai'i. Gravel mulches were used prehistorically in the Negrev and on the leeward sides of the Andes. The technique of rock or gravel mulching was suggested for use in the dry portions of the Western United States by Rodale (1949) and by the USDA, who experimented with the technique for row crops on the leeward side of the Rocky Mountains (Fairbourne 1973).

Was the construction of lithic mulch gardens on Easter Island labor intensive? Does the presence of these extensive gardens suggest that chiefly intervention was necessary for their construction? It seems more likely that Easter Islanders took advantage of debris flows and the disintegrating lava flows rather than building a rock layer where no rocks were present. The homogeneous nature of the rock cover in many of the garden areas however, indicates that Easter Islanders enhanced the level terrain and concave geomorphic features that are most favorable as gardening locations owing to the deeper accumulation of soils and the favorable hydrologic dynamics of these areas.

The most supportive evidence for use of lithic mulch comes from the ethnohistoric references, such as the comments of La Pérouse (1799). Traditional farmers on Easter Island today use rocks as mulch around individual plants. They are able to identify various rock covered areas in remote places on the island as locations in which to plant occasional banana trees, taro, or many of the historically introduced American cultigens. At the same time they may not recognize as potential garden areas many of the same morphological characteristics of those garden areas in other locations, namely those identified in the geo-archaeological study, as part of the extensive prehistoric or early historic field systems. In part this is due to the increased importance of cattle raising and the use of field systems which can be easily plowed with tractors for the cultivation of historically introduced crops grown from seeds, such as maize, beans, and cabbage.

SUMMARY

European visitors to Easter Island had described field systems in the 18th century. The 1996 geoarchaeological survey of soils was made on the northwest coast of Easter Island to search for those fields and to identify the characteristics of garden soils on Easter Island. During the soil survey, surface accumulations of small rocks that formed a discrete lithic layer covering an anthropogenic (maori plaggen) soil horizon, were found. The anthropogenic soils display archaeological, structural and textural evidence indicating that they had been used as garden areas. Wood and grass ash had been added as a "manure" to enhance soil fertility. The charcoal and obsidian fragments found within the plaggen horizon, were dated to between A. D. 1200 and A. D. 1850 (callibrated dates).

Ethnohistoric references and the use of traditional gardening methods by some 20th century Rapanui farmers support the geoarchaeological data. With the identification of lithic mulch gardens as archaeological features, a reassessment of the island-wide survey is in order so that we may better determine the temporal and spatial extent of the use of island soils for food production. ❖

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