THE SURFACE ROCK GARDENS OF PREHISTORIC RAPA NUI

Alexander Baer
University of California, Berkeley

Thegn N. Ladefoged
Department of Anthropology, University of Auckland

Christopher M. Stevenson
Virginia Department of Historic Resources, Richmond, Virginia

Sonia Haoa
Hanga Roa, Rapa Nui, Chile

Recent archaeological work on Rapa Nui has challenged the widely held assumption that the bulk of prehistoric subsistence was derived from coastal locations. Early coastal plain surveys (Englert 1974; McCoy 1976) had cataloged thousands of archaeological features and sites, including the structural remains of *ahu* (religious platforms) and *moai* (statues), along with elite and non-elite residences, and walled planting enclosures called *manavai*. The later survey of Cristino, *et al.* (1981) showed, however, that structures and agricultural features were by no means exclusive to the coastal regions of the island, but were in-fact also spread throughout the interior of the island. Similar features as those found around the exterior were recorded and analyzed, but unrecognized throughout the island was a type of agricultural garden based around the deliberate surface coverage of stone fragments. First identified in the late 1990s by Wozniak (1996; 1998; 1999) and Stevenson (1997) Easter Island contains broad fields of fractured stone, creating surfaces (and occasionally mulched, sub-surface) of volcanic rocks. These constructed agricultural features called "rock gardens" involved a significant amount of labor, and once recognized have been identified throughout the island.

Despite the recognition of numerous rock gardens, the level of variability within these planting areas has not been firmly established. In the following, we analyze a sample of surface gardens to define different types of rock-based techniques. The spatial distribution of various surface garden types is assessed, showing a pattern in which labor-intensive features are located at lower elevations, while fields on a more extensive scale are found further inland and upslope. It is argued that both environmental and cultural factors influenced the form of construction and placement of these subsistence features.

Agriculture and Archaeology

From early historical sources, such as Cook (1777) and La Pérouse (1797), we know that large fields were under cultivation throughout the island, but the nature of these gardens remained a mystery. By the time ethnographers such as Routledge (1919) and Métraux (1940) arrived on the island the old ways of farming were a distant memory. It thus fell upon archaeology to explain the means by which the ancient Rapanui produced enough food to support the common population as well as the elite and their cadre of monumental architecture and statue builders. One of the first researchers to conduct extensive survey on the island was McCoy (1973; 1976), whose studies attempted to piece together various aspects of the history of Easter Island through analyses of settlement patterns. McCoy worked primarily in the southwestern region of the island, and identified numerous features through broad survey. Among the categories he defined were four different house forms, ovens, and rock shelters, along with *ahu* and various ceremonial structures.

Regarding agriculture, however, McCoy's research was far less assured. Of the 16 different categories identified, only *manavai* (small, walled enclosures for household subsistence production) were associated with agriculture. These distinct, freestanding features were the most visible agricultural structures McCoy's work was equipped to identify. McCoy was not ignorant as to the presence of other productive strategies, stating that broad, open-field systems existed in many of the areas between religious and habitation sites. He maintained that marine resources, birds, and potentially rats were important to the diet, but that the large cultivated areas likely provided the bulk of Rapa Nui's subsistence base. Like other archaeologists, however, McCoy had no means by which to demarcate or even record the extent or nature of these fields, and was thus limited to the anecdotal mention of their presence. This inability to identify field systems remained with Easter Island archaeology for years. Large regions suspected to have been under productive management were inferred by little more than the absence of structures.

The first large-scale survey of the interior of Rapa Nui was conducted by the University of Chile in the late 1970s and early 1980s (Cristino, *et al.* 1981; Vargas Casanova 1998; Vargas, *et al.* 2006). In these interior regions *manavai* were documented but other classes of agricultural features went unnoticed. In the 1990s, studies began to look at agriculture as a more central question in Rapa Nui's history. Assumptions held that increased agricultural yields during the culture's height had been accomplished exclusively along the coast through more intensive practices such as shorter fallow periods, closer tending, and the creation of features such as *manavai*. The work of Stevenson, Wozniak, and others, however, exposed a new means by which the Rapanui produced greater amounts of surplus. In a number of papers, Stevenson (1997) and Wozniak (1996; 1998; 1999), both together and with collaborators (Stevenson & Haoa 1998; Stevenson, *et al.* 1999; 2002; 2005), posited that layers of rock found on the surface and often mixed into the uppermost layers of soils were not the product of natural deposition, but instead a cultural practice to aid crops by retaining moisture and lessening wind damage.

Rock gardens are by no means unique to Easter Island and building on a substantial body of archaeological work, Stevenson, *et al.* (1999; 2002; 2005) and Wozniak (1998; 1999) correlated their findings on Rapa Nui with the practice of stone mulching in arid environments throughout the world. While Easter Island has slightly higher average levels of rainfall than many other locations at which this innovation is found, the island's reliance on dry land agriculture is a shared feature. Dry land agriculture, defined by its dependence on rainfall and a lack of irrigation, required maximal retention of moisture to best ensure the survival of crops. Lightfoot (1994a; 1994b) provides an excellent summary of rock based gardens, describing a variety of practices from throughout the world, dating as far back as 2000 BCE, in which stones were used in pits, mounds, terraces, ridges, as entire surface layers, and mixed into the top soil horizons. Within arid climates subject to erosion, the benefits conferred by this improved technology were numerous. Lightfoot's analysis, building on the work of both archaeologists and geologists, described how the practice increases the available moisture in the soil by reducing the evaporation caused by both wind and sun. Stones, both on and under the surface, also serve to maintain local layers of sediment, raise the overall soil temperature and increase the turbulence of airflow in the area. This lowers the wind velocity, limiting erosion and diminishing diurnal fluctuations in soil temperature. Together, these effects combine to produce an environment containing more of the available moisture and warmer temperatures with less oscillation. Rock gardens might also add to nutrient levels in the soil (Ladefoged, *et al.* 2005). Under these conditions plants are better able to germinate and grow, while achieving maturity at an increased rate (Lightfoot 1994a; b). Our limited monitoring shows that the temperature of the soil underneath lithic mulch is actually lower.

While rock gardens clearly require larger amounts of labor to construct, following their completion they would pay substantial dividends. After the initial input of effort required to break, gather, and spread or mulch all of the stones, gardens featuring rock coverage require less maintenance work as fewer weeds appear and rodents are less likely to reach and damage the crop (Lightfoot 1994). Upkeep is still required to maintain the gardens, but ultimately this technique creates sustainable planting areas that could have been used over generations, a form of "landesque capital intensification" (Kirch 1994).

These utilized stone fields were first noted by the explorer La Perouse (1797) in the late 1700s, but their modern recognition as agricultural features was not achieved until the 1990s. At the University of Chile's 2nd International Conference on Easter Island in 1996, the first mention of lithic mulching was made in a presentation by Joan Wozniak (1996). The first published account of rock gardens on Easter Island appeared in Stevenson's 1997 work on the upland agricultural complex of Maunga Tari. Although the idea was not developed, he noted, "Also present were large open field plantations, some of which are believed to be marked by large distributions of surface stone which would have helped retain soil moisture" (1997:142). In the following year, Stevenson and Haoa (1998) expanded on this idea and explained that the difficulties encountered by archaeologists attempting to identify gardens on Rapa Nui "most certainly reflected a European bias which defined agricultural fields according to the placement of stone walls and fence alignments.... The subtle distributions of stone materials which reflected past gardening activities were not investigated" (Stevenson & Haoa 1998:208). They argued that the European system of walls and alignments was never adopted on the island, but rather lithic mulching had become the means by which production was increased. They created a typology of agricultural features based on a set of common attributes including form, function, location, and associated elements. While useful in ordering the diversity in agricultural features, the Stevenson and Haoa (1998) typology was flawed. Their typology used terms such as "moderate density", which were not explicitly defined and were open to interpretation. More significantly, however, their classifications were based on a combination of morphological and functional traits, creating non-exclusive types.

At around the same time, Wozniak (1998; 1999) published the results of a four year study in which she assessed agricultural production throughout the coastal region of Te Niu. While more limited in overall area, her work in Te Niu and along the northern coast of Easter Island provided an in-depth look at localized production and identified a specific type of lithic mulching. She detailed a number of rock clusters featuring stacked layers of surface stones with rocks mulched into the earth below. Along with *manavai* and utilized natural windbreaks, Wozniak comprehensively detailed the local agricultural system as well as defining a new garden type. While the rock gardens identified by Wozniak at Te Niu indeed remain viable, further research has shown it to be but one of a number of agricultural adaptations practiced by the Rapanui.

In 1999, Stevenson, *et al.* (1999) co-wrote another work giving further details on gardens throughout Rapa Nui. They first identified signs of increasing labor and thus intensification throughout Pacific environments in general, noting that increased production often resulted from a growing population and a concurrent rise in the demands of the political elite. Stevenson, *et al.* (1999) then argued that Easter Island's five occupational phases and their associated levels of socio-political complexity could be seen not only in the creation of religious and habitation structures, but also in changing agricultural types. Stevenson, *et al.* (1999) amended the agricultural categories defined by Stevenson and Haoa (1998), but again their work failed to distinguish between morphological and functional traits, as gardens were defined separately by their rock sizes and locations.

In 2002, the system of defining gardens according to both their function and morphology was abandoned (Stevenson, *et al.* 2002). In its stead, the morphological form of each garden became a central factor, and six types were defined:

1) *Mulched Soils*: Subsurface sediments incorporating small stones designed to retain moisture, limit fluctuations in soil temperature, and prevent erosion.
2) *Veneer Surfaces:* A uniform layer of small stones measuring up to 30 cm thick. The rocks were broken off local basalt outcrops and specifically placed to allow for increased moisture permeation, reduced evaporation, and the prevention of weeds.
3) *Stacked Boulder Concentrations:* Similar to the veneer surfaces, boulder concentrations featured the addition of some larger stones to the ground coverage. These boulders, often stacked on one another, provided additional protection against the wind while maintaining the benefits of the veneer surface.
4) *Pu:* Depressions or holes within rocky surfaces. Mulch in the form of vegetation or ash would have been placed within the *pu* to encourage soil nutrition.
5) *Manavai:* Stacked stone garden enclosures, generally round and measuring between 2-6 m in diameter and 1.5 m in height. Used to protect taller plants from wind damage or as a bed for the growth of fragile crops prior to their transport to the fields.
6) *Planting Circles:* Small mulched pits ringed with stones, planting circles were usually no more than 1-1.5 m in diameter.

While the Stevenson, *et al.* (2002) classification is an improvement, these categories are still difficult to quantitatively assess, as, for example, there are no clear criteria by which to separate veneer surfaces from boulder gardens.

Stevenson, *et al.* (2002) examined two different regions of the island (Heki'i on the northeastern coast and Akahanga / Vaihu in the center of the southern coast), and analyzed the spatial distribution of garden types. They found that the dominant forms of agriculture in Heki'i were veneer surfaces and boulder gardens, although the hilltops of the lowland inland area tended to feature more mulching. *Manavai* were also located throughout, but as with all other garden types and structures, these grew less common further from the coast (Stevenson, *et al.* 2002:19). The distribution of features within coastal and lowland inland zones of Akahanga / Vaihu featured a very similar pattern of settlement and garden use as comparable areas in Heki'i, with veneer surfaces, boulder gardens, and *manavai* the dominant types of agriculture.

Higher on the slopes of Terevaka above the Akahanga / Vaihu area, however, the upland interior featured both a distinct environment and patterning. Ridges, swales, and large outcrops abound on the undulating volcanic slopes and provided shelter from the winds, and both veneer surfaces and boulder gardens were commonly found within these protected areas. *Manavai* and chicken houses were rare, but habitation sites demonstrated numerous houses with a high number of seemingly elite residences (Stevenson, *et al.* 2002:20).

In 2005 Stevenson, *et al.* (2005) published their work on the upland Vaitea area. They applied the typology of agricultural features and gardens proposed in 2002, while also recording the numbers of residential features. They again found the presence of boulder gardens and some mulching, but argued that these did not demand as much construction labor as the hilltop mulching found in La Perouse. This suggested a lower level of intensification with a greater focus on extensive farming. In the most recent analysis of agricultural production on the island, Stevenson, *et al.* (2006) interpreted a 100 m long stratigraphic profile in the lowlands at Maunga Orito. This is one of the first instances where different types of gardening techniques have been securely dated. They suggested that the landscape was first cleared for open gardens in the 12th century CE, and that veneer and boulder gardens were in use during the 17th century. The definition of these garden types was similar to those defined by Stevenson, *et al.* (2002).

In sum, in one of the first attempts to document agricultural feature classes, Stevenson and Haoa (1998) effectively defined some agricultural features in a similar manner to many previous studies (*e.g.*, McCoy 1976), but departed from convention in their recognition of lithic mulching and differential types of rock gardens. While their definitions of these gardens were flawed due to an over-emphasis on factors such as associated geomorphology rather than traits of the gardens themselves, the notion that typologies could be created based on a set of attributes was correct. Wozniak (1998; 1999) focused the research of lithic mulching by clearly delineating a single type of garden common throughout her small study area. She defined a specific size, level of surface coverage, and type of rock used, but although her work effectively described this type of garden, it proved to be only one of many rock garden varieties present on the island as a whole. Stevenson, *et al.* (1999) expanded upon the previous works by adding gardens with specific mulching characteristics to their typology, while original garden types such as household garden, lowland field, slope field, and hilltop field remained, boulder gardens and planting circles were now defined by their particular attributes. This work also attempted to explain the observed differences in garden types by positing that agricultural features, along with associated residential features, varied based on the changing socio-political climate. By 2002, research was even more focused on defining gardens based on their characteristics (Stevenson. *et al.* 2002). Although not defined empirically enough to allow for statistical analyses, the differential location of these features seemed to demonstrate alternate practices within various environments. Finally, Stevenson, *et al.*

(2005) used the 2002 typology to show that the range of agricultural types may have corresponded with the level of socio-political control exercised by elite managers, and Stevenson, *et al.* (2006) provided a rough chronology for some changing agricultural techniques.

These studies have contributed to our knowledge of past subsistence strategies on Easter Island, but each contains limitations. While Wozniak (1998; 1999) used an empirical definition, her scope was far too limited for island-wide application. Stevenson and Haoa (1998) and Stevenson, *et al.* (1999) lacked this empiricism, but also confused their typologies through mixing morphological and functional attributes. This problem may have been remedied in Stevenson, *et al.* (2002; 2005; 2006), but these works were still unable to create statistically significant demonstrations of the observed spatial patterning. In this work we seek to statistically distinguish different classes of gardens and indentify patterns in their spatial distribution.

Methodology

To provide insights into the spatial distribution of explicitly defined types of surface rock gardens we analyzed data from a four month long CONAF-sponsored survey in 2004-2005. The survey was conducted in quadrants 11, 17-20, 29, and 30, a region previously examined by Cristino, *et al.* (1981; also see Vargas, *et al.* 2006), and while many of the sites located over 25 years ago were once again found, numerous others could not be rediscovered due to changing environmental conditions and the damage caused by domestic sheep, cattle, and horses. Conversely, however, many new features were found thanks to the exposure of certain areas and the recognition of garden types unknown prior to the work of Stevenson, Wozniak, and others. Both new and old features were recorded by a GPS data dictionary designed with a wide range of feature types. This dictionary was created in an effort to maximize consistency by standardizing logging methods, and included a range of religious, residential, and agricultural features and their associated metric and non-metric characteristics. To further ensure consistency, certain types of features were logged exclusively by individuals specialized in their identification, and all the agricultural features analyzed in this study were recorded by the senior author.

The survey did not involve contiguous coverage of the entire uplands, rather more limited zones were recorded (Figure 1). The results presented here are based on 12 discrete garden survey zones with a total area of approximately 234 hectares. For analytical purposes, the garden survey zones were classified into four elevation categories (0-100 m, 100-200 m, 200-300 m, and 300-400 m), with everything above 200 m generally corresponding to the upland area classified by Stevenson, *et al.* (2002, 2005).

One shortcoming of previous research on agriculture is the lack of empirically defined classes. Types such as *pu*, *manavai*, and planting circles were effectively described in Stevenson, *et al.* (2002, 2005), but some garden types remained unclear. Distinctions were never made that could delineate boulder gardens from veneer surfaces, nor these types of surface coverage from the gradual mix of stones into a lithic mulch. For the current study, gardens were not defined by *ad hoc* classification, rather the traits of each were recorded, thereby allowing for later statistical analyses. Unfortunately, subsurface testing to determine the level of mulching was outside the scope of this research, and as such cannot be assessed. Instead, different surface gardens were identified based on their shared attributes.

To understand and quantify the variability in rock gardens, the previously defined veneer surfaces and boulder gardens were eschewed in favor of a numerical identification based on each garden's attributes. Many aspects of the gardens, including size, associated features, and location were recorded, but for purposes of defining a typology we focused on the percent of surface coverage and the breakdown of different rock sizes. Surface coverage generally ranged between 50 and 100%, although exceptions below 50% were recorded if they presented a distinct area within a region otherwise devoid of rock cover. Following this, the size of stones was classified based on geological definitions. Pebbles measured 5 cm or less, cobbles between 5 and 20 cm, and boulders above 20 cm. Through the use of percentages, the previously difficult distinction between either veneer surface or boulder garden was eliminated. In its place, more precisely defined garden types allowed for statistical analyses and empirically-based conclusions.

Six types of gardens were distinguished based on their composition of variously sized stones as well as surface coverage. Types 1, 2, and 3 all feature a disproportionate amount of either pebbles, cobbles, or boulders, while Types 4.1, 4.2, and 4.3 all contain a similar range of stone sizes, but vary widely in their surface density. All six were analyzed for their association with elevation using a number of different computer programs (SYSTAT 10, Plot, SPSS, Excel, and ArcGIS). Chi-square analyses were done in SPSS to demonstrate differences between the observed and predicted numbers of gardens in various ecological conditions. Tests that resulted in a two-tailed, asymptotic significance <0.05 were considered significant, demonstrating a pattern not due to random chance. ArcGIS was used to establish spatial relationships between the types of gardens and elevation zones.

Results

In total, 288 gardens were recorded throughout the 234 hectare garden survey area. In an effort to statistically identify garden types, the differential distribution of rock sizes was assessed. Borrowing a model for the definition of soil types used in geology, the three percentages of pebble, cobble, and boulder (dubbed simply small, medium, and large) were plotted against one another, along with the frequency of each tripartite point. Figure 2 presents this four dimensional graphic as a standard ternary plot. As points within the triangle grow

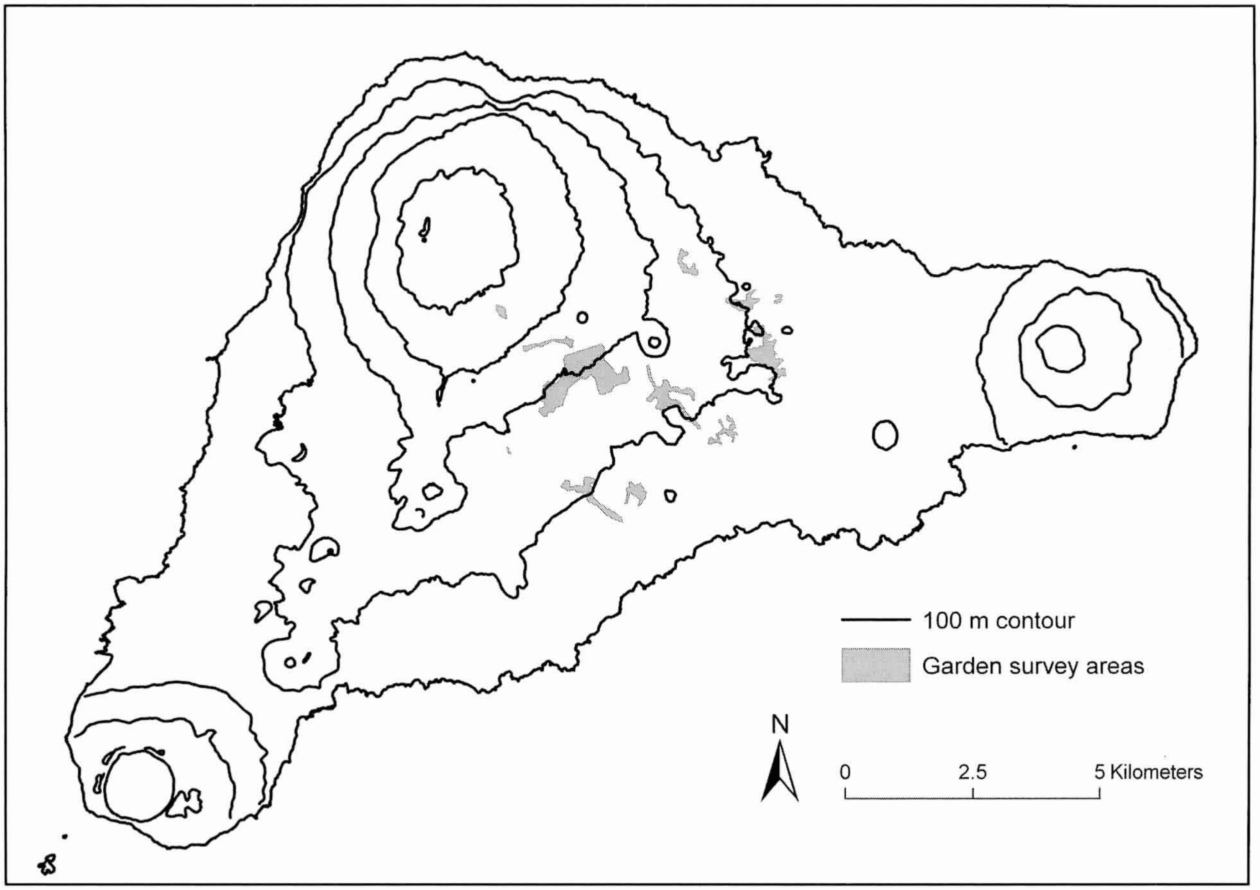

Figure 1. The distribution of 12 garden survey zones and 100 m contours on Easter Island.

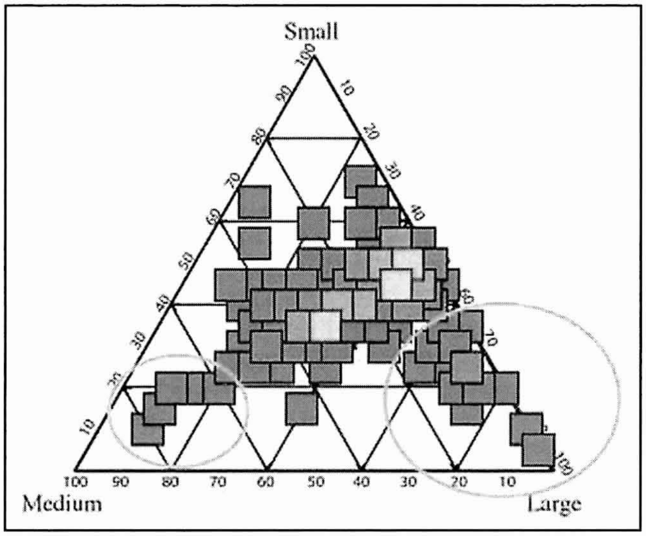

Figure 2. Ternary diagram demonstrating clusters of rock gardens based on their composition of small, medium, and large sized stones. Lighter squares indicate higher frequency. Circles define two distinct groups of gardens.

closer to any corner they represent a more extreme favoritism towards a single size of stone over the other two. This plot shows a large group in the center, dominated largely by medium and small stones. There are, however, two distinct outlying groups which stretch away from the core towards the various corners. The first of these, in the lower right, features higher numbers of small stones, while the second, in the lower left, contains a disproportionately higher amount of large stones. These outlying groups (Types 1 and 2) effectively correspond with the "veneer surfaces" and "boulder gardens" previously identified by Stevenson, *et al.* (2002).

In Figure 3 the percentages for small and medium stones of individual gardens are plotted along the X and Y axes, respectively. The percentages of large stones are not shown in this figure, but can be determined by considering the two axes. The Z dimension of Figure 3 depicts the amount of surface coverage present in the individual gardens. The top-down appearance of Figure 3 is similar to the ternary diagram of Figure 2, showing a crescent shaped distribution, with the area to the lower right indicative of smaller dominance, lower left demonstrating larger stones, and the top left reflecting more medium sizes. The advantage of this projection comes in the utility of the Z axis which reflects surface coverage.

Through close examination of Figure 3, six garden types have been identified. Two have been previously mentioned, as their locations indicate a tendency towards smaller rocks in the lower right, and larger rocks in the lower left. A new outlying group is also present in the top left corner, especially noticeable due to its high level of surface coverage. The three final groups all fall within the central cluster. Stone sizes within this area tend to be relatively similar, but we have defined three types within these based on level of surface coverage. This was done with the premise that the amount of labor involved in the construction of these gardens may vary, possibly indicating differential levels of intensification. To facilitate statistical analyses these six different forms have been divided by their numerically distinct characteristics. Types 1-3 all feature distinct size distributions, while types 4.1-4.3 were defined as such based on their similar size divisions and differential surface coverage.

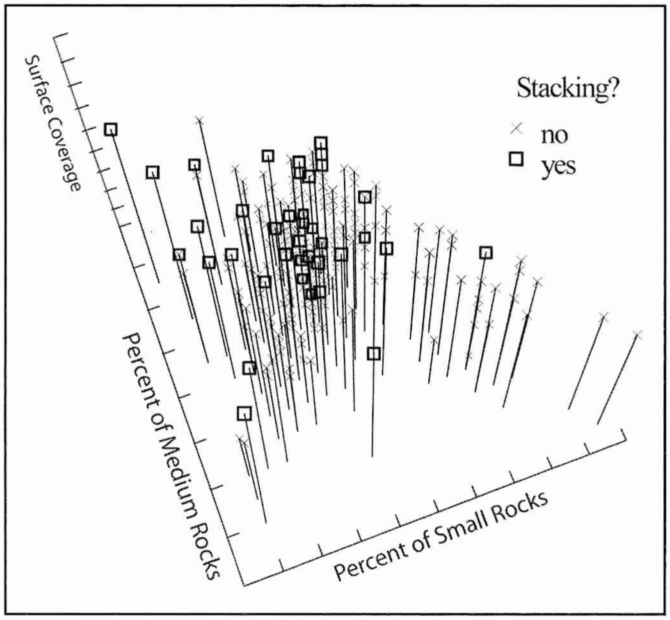

Figure 3. Distribution of rock sizes within gardens. The X and Y axes represent small and medium rocks, leaving the remaining percentage of large rocks to be extrapolated. Z axis represents surface coverage. Stacking indicates at least three layers of piled rock and often coincides with high surface coverage. The two gardens identified in the ternary plot are visible here, along with another small group in the top left featuring high surface coverage and a low percentage of small rocks.

Type 1: Type 1 is dominated by smaller stones (<5 cm) and features a moderate amount of surface coverage. It corresponds most closely with Stevenson, *et al.*'s (2002) definition of veneer surface. The range of small stones is 60-100%, medium is 0-35%, and large is 5-40%. Surface coverage is between 30 and 100%, but is dominated by percentages of 65-75%.

Type 2: Type 2 is comprised of boulders, again with a moderate surface coverage. This generally correlates with the definition of a boulder garden (Stevenson, *et al.* 2002). The range of small stones is 0-30%, medium is 0-30%, and large is 40-100%. Surface coverage is between 50 and 100%, but is dominated by percentages of 65-75%.

Type 3: Type 3 is mostly medium stones with a low level of small pebbles. Surface coverage is high, often with multiple layers of stacked stones. Given enough stacked stone and the presence of any pits, this type may occasionally have been a collection of *pu* (as defined in Stevenson, *et al.* 2002). The range of small stones is 0-20%, medium is 40-100%, and large is 0-60%. Surface coverage is between 50 and 100%, but is dominated by percentages of 85-90%.

Type 4.1: Type 4.1 includes generally equal amounts of small and medium stones with a slightly lower level of boulders. Surface coverage is low. The range of small stones is 20-55%, medium is 35-60%, and large 0-45%. Surface coverage is between 45 and 60%.

Type 4.2: Type 4.2 includes generally equal amounts of small and medium stones with a slightly lower level of boulders. Surface coverage is medium. The range of small stones is 10-55%, medium is 25-70%, and large is 0-65%. Surface coverage is between 65 and 85%.

Type 4.3: Type 4.3 includes generally equal amounts of small and medium stones with a slightly lower level of boulders. Surface coverage is high. The range of small stones is 25-50%, medium is 15-70%, and large is 0-60%. Surface coverage is between 90 and 100%.

In addition to these definitions, each of the six categories has been ranked for its level of labor investment per unit of land. Types 1, 3, and 4.3 are each dominated by stones, which Stevenson, *et al.* (1999) hypothesizes would have been individually broken off larger outcrops, carried, and placed to create the observed surface coverage. This would have likely created a growing area capable of yielding a surplus beyond what was required at the household level, but the extra expenditure of initial labor is unlikely if individuals were only practicing subsistence farming. While their high surface coverage would have lowered rodent presence and meant less weeding, the amount of effort required for their construction and maintenance was high, possibly implying elite demands and managerial oversight. Much as Stevenson, *et al.* (2002) defined veneer surfaces and *pu* as intensive forms of production, types 1, 3, and 4.3 have been identified as requiring the highest amount of labor input. Type 4.2 features would require a moderate amount of rock and moderate to high surface coverage. They are therefore classified as medium levels of labor investment per unit land. Types 2 and 4.1 represent the lowest level of intensification. Stevenson, *et al.* (2002) proposed many boulder gardens were opportunistic, and may not have required the movement of much stone, while the low surface coverage of 4.1 indicates a similar lack of labor. These garden types likely represent a more extensive rather than intensive form of agriculture.

Differential usage of gardens was identified in the four elevation zones of 0-100, 100-200, 200-300, and 300-400 m (Tables 1 and 2). The area surveyed in each zone is accounted for when comparing the actual number of observed gardens with the expected number generated by SPSS. A chi-square statistic indicates that gardens are differentially distributed across the zones of elevation (Chi-Square= 23.11; df= 3; Asymp. Sig.< .001). The elevation zone of 0-100 m contains significantly more gardens than would be expected given the area of that zone. Moving up-slope, the area between 100-200 m has fewer gardens than expected, although not by a large margin. The 200-300 m zone contains fewer gardens than expected, and the 300-400 m zone contains almost the exact number of gardens as expected.

The distribution of the different types of gardens also varies according to elevation. The limited numbers of Type 2 gardens are found at all elevations, as is the case for both Types 4.1 and 4.2. Intensive garden Types 1, 3, and 4.3, however, all demonstrate spatial patterning. Each of these garden types is found almost exclusively within the elevations below 200 m, indicating human agency in their placement rather than a random distribution.

Conclusions

Rapa Nui surface rock gardens can be classified according to the surface percentage of small, medium, and large stones, and the extent to which the surface was covered. We defined six types of surface gardens based on explicit and measurable criteria. These six types of gardens can be ranked in terms of the energy required for their construction. The analysis suggests that differential forms of agriculture were practiced at different elevations. In general there was a higher density of gardens in the coastal lowlands (below 100 m) than would be expected through chance. In addition, agriculture in the lowlands (below 200 m) was generally more intensive in nature. In contrast, upland agriculture was less intensive (garden types 4.1 and 4.2, and to a lesser extent, type 2) than that practiced in the lowlands.

This patterning is likely a function of rainfall and temperature associated with various elevation zones. Rainfall increases about 100 mm for every 100 m rise (Vargas Casanova 1998). This means that the range of available moisture between the lowland gardens around the 100 m elevation mark and those around 400 m is approximately 300 mm, likely representing enough of a difference to warrant alternative practices. A difference of a few hundred millimeters of rain would have seriously affected the daily functioning of farms in the uplands versus the lowland, and perhaps more importantly, would have had significant effects on production during periodic annual droughts. Although decreasing temperature and rising winds at higher elevations present a drawback to agriculture on the slopes of Terevaka, these would have been offset by the increased availability of moisture and the general benefits afforded by the rock coverage. With sufficient water, extensive fields, with an emphasis on size rather than intensive labor, can be utilized, minimizing labor while maximizing production through sheer volume. On the other side, more intensive gardens would have been utilized at lower altitudes to maximize production in dryer environments. This would again have been achieved by retaining moisture, particularly in periods of diminished rainfall, regulating soil temperature, and limiting the presence of unwanted rodents.

By explicitly defining criteria for monitoring variation in agricultural practices it is possible to begin to understand how populations employed different subsistence strategies. It is clear that production was not focused solely on the coast, rather a range of agricultural features are distributed throughout the island. The differences in the types and densities of features reflect the intersection of environmental constraints set within a socio-politically defined structure. A combination of intensive lowland agriculture and extensive upland plots were utilized to fund the subsistence and surplus needs of the local population.

Acknowledgements

This research was enhanced through discussions with Mara Mulrooney, Bruce Floyd, Melinda Allen, Roger Green, Simon Holdaway, Sarina Pearson, and Peter Sheppard. The authors would also like to thank an anonymous reviewer for editorial comments. The research was partially funded by grants from CONAF, the Easter Island Foundation, the Earthwatch Institute, and the University of Auckland.

Published by Kahualike, 2008

References

Cook, J. 1777. *A Voyage Towards the South Pole and Round the World (1772-75)*. 2nd ed. London: Strahan and Cadell.

Cristino, C., P.V. Casanova, & R.I. San Juan. 1981. *Atlas Archaeologico de Isla de Pascua*. Santiago: University of Chile.

Englert, S. 1974. *La Tierra de Hou Matu'a. Historia y Ethnologia de la Isla de Pascua*. Santiago: Ediciones de la Universidad de Chile.

Kirch, P.V. 1994. *The Wet and the Dry: Irrigation and Agricultural Intensification in Polynesia*. Chicago: University of Chicago Press.

La Pérouse, JFGd. 1797. *A Voyage Round the World, 1785-88 by the "Boussole" and "Astrolabe"*. London: Robinson.

Ladefoged, T.N., C.M. Stevenson, P. Vitousek, & O. Chadwick. 2005. Soil Nutrient Depletion and the Collapse of Rapa Nui Society. *Rapa Nui Journal* 19(2):100-105.

Lightfoot, D.R. 1994a. The Agricultural Utility of Lithic-mulch Gardens: Past and Present. *GeoJournal* 34:425-437.

Lightfoot, D.R. 1994b. Morphology and Ecology of Lithic Mulch Agriculture. *Geographical Review* 84:172-186.

McCoy, P. 1976. *Easter Island Settlement Patterns in the Late Prehistoric and Protohistoric Periods*. New York: The Easter Island Committee.

McCoy, P. 1973. Excavation of a Rectangular House on the East Rim of Rano Kau Volcano, Easter Island. *Archaeology and Physical Anthropology in Oceania* 8:51-67.

Métraux, A. 1940. *Ethnology of Easter Island* - Honolulu: Bishop Museum Bulletin 160, 1940

Routledge, Katherine. 1919. *The Mystery of Easter Island*. London: Sifton, Praed and Co.

Stevenson, C.M. 1997. *Archaeological Investigations on Easter Island, Maunga Tari: An Upland Agricultural Complex*. Los Osos: Easter Island Foundation.

Stevenson, C.M. & S. Haoa. 1998. Prehistoric Gardening Systems and Agricultural Intensification in the La Pérouse Area of Easter Island **in** *Easter Island in Pacific Context, South Seas Symposium - Proceedings of the Fourth International Conference on Easter Island and East Polynesia* (C. Stevenson, G. Lee, & F.J. Morin, eds.); pp. 176-189. Los Osos: Easter Island Foundation.

Stevenson, C., J. Wozniak, & S. Haoa. 1999. Prehistoric Agricultural Production on Easter Island (Rapa Nui), Chile. *Antiquity* 78:801-813.

Stevenson, C., T. Ladefoged, & S. Haoa. 2002. Productive Strategies in an Uncertain Environment. *Rapa Nui Journal* 16(1):17-22.

Stevenson, C., T. Ladefoged, S. Haoa, & A.G. Terra. 2005. Managed Agricultural Production in the Vaitea Region of Rapa Nui, Chile **in** *The Reñaca Papers: VI International Conference on Easter Island and the Pacific* (C. Stevenson, J.M. Ramirez, F.J. Morin, & N. Barbacci, eds.); pp. 125-136. Los Osos: Easter Island Foundation.

Stevenson, C.M., T.L. Jackson, A. Mieth, H.R. Bork, & T.N. Ladefoged. 2006. Prehistoric and Early Historic Agriculture at Maunga Orito, Easter Island (Rapa Nui), Chile. *Antiquity* 80:919-936.

Vargas Casanova, P. 1998. Rapa Nui Settlement Patterns: Types, Function and Spatial Distribution of Household Structural Components **in** *Easter Island and East Polynesian Prehistory* (P. Vargas Casanova, ed.); pp. 111-130. Santiago: Instituto de Estudios Isla de Pascua.

Vargas, P., C. Cristino, & R. Izaurieta. 2006. *1000 Años en Rapa Nui: Arqueología del Asentamiento*. Santiago: Editorial Universitaria, S.A.

Wozniak, J. 1996. Settlement Patterns and Subsistence on the Northwest Coast of Easter Island: A Progress Report. Paper presented at the 2nd International Conference on Easter Island, University of Chile.

Wozniak, J. 1998. Settlement Patterns and Subsistence on the Northwest Coast of Rapa Nui **in** *Easter Island in Pacific Context* (C. Stevenson, G. Lee, & F.J. Morin, eds.); pp. 161-175. Los Osos: Easter Island Foundation.

Wozniak, J. 1999. Prehistoric Horticultural Practices on Easter Island – Lithic Mulched Gardens and Field Systems. *Rapa Nui Journal* 13(4):95-99.

Manuscript received July 16; reviews sent to authors July 21; revised manuscript accepted August 29.

Table 1. Total Area Surveyed in Each of the Four Elevation Zones.

Elevation Zone (m)	0-100	100-200	200-300	300-400
Area of elevation zone surveyed (m^2)	700,578	1,221,015	382,239	36,426

Table 2. Both the Observed and Expected Frequencies of Each of the Six Garden Types Within the Four Elevation Zones.

garden type	OF of garden in 0-100 m zone	EF of garden in 0-100 m zone	OF of garden in 100-200 m zone	EF of garden in 100-200 m zone	OF of garden in 200-300 m zone	EF of garden in 200-300 m zone	OF of garden in 300-400 m zone	EF of garden in 300-400 m zone
1	20	7.8	6	13.6	0	4.2	0	0.4
2	10	6	10	10.4	0	3.3	0	0.3
3	3	6	2.7	3	4.7	0	1.5	0.1
4.1	15	16.8	36	29.2	5	9.1	0	0.9
4.2	50	44.9	74	78.3	21	24.5	5	2.3
4.3	20	8.1	6	14.1	1	4.4	0	0.4
TOTAL	121	86.2	135	150.3	27	47	5	4.5

OF = observed frequency; EF = expected frequency