PREHISTORIC AND RECENT LAND USE EFFECTS ON POIKE PENINSULA, EASTER ISLAND (RAPA NUI)

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INTRODUCTION

Since the first Polynesian settlers set foot on Rapa Nui, probably between AD 300 and AD 600, cultivation of plants and the development and adaptation of agriculture in the new environment became the key factor for a growing community and a flourishing culture. The biotic resources the people found on Rapa Nui were relatively poor due to the lack of diversity of edible and usable plants and animals, a consequence of its isolation in the Pacific Ocean. The people depended on the supplies they carried with them in their canoes as they did for hundreds of years while exploring the solitary Polynesian islands. And they depended of course on the abiotic resources as these set the limits for cultivation of plants and fruits. Key factors in this point of view were the availability of water and the fertility of the soils for growing plants, suitable climatic factors for the species cultivated, geomorphologic conditions that would allow farming and the availability of area for land use in relation to the population size.

There is no doubt in the present scientific discussion that the start of the Rapanui in their new environment was successful. The Polynesians probably brought a wide variety of nutritious plants to Rapa Nui as, for example, *kumara* (sweet potato, *Ipomaea batatas*), *taro* (Taro, *Colocasia esculenta*), *uhi* (yam, *Dioscorea alata*), *maika* (banana, *Musa sapientium*), *toa* (sugar cane, *Saccharum officinarum*) and *ti* (*Cordyline fruticosa*) (Flenley 1993 a, Stevenson et al. 2002, Zizka 1991, 1989). These plants were grown successfully over a long period. Their importance and success is evident by their inclusion in the local legends and reports by the first European discoverers in the 18th century. There were probably a few disappointments for the new Polynesian settlers with the introduction of plants for which the climatic conditions were not suited, as was perhaps the case for coconut palms (*Cocos nucifera*) and the breadfruit tree (*Artocarpus sp.*) (Bahn and Flenley, 1992, Métraux 1957).

The recent discussion is more open concerning the abiotic limits and risk factors, the needs for adaptations and modifications in agricultural land use and, finally, the resulting changes in the landscape on Rapa Nui.

Looking back into prehistory, Rapa Nui is often described as an "uncertain" environment with high risk factors and unpredictability with respect to agricultural land use conditions (Bahn and Flenley 1992, Hunt and Lipo 2001, Stevenson and Haoa 1999, Stevenson et al. 2002). Although the annual rainfall amount with an average of 1200 mm near Hanga Roa is high, many authors assume that water shortage was the main problem in ancient agriculture (and in the present). Seasonal and annual fluctuations of precipitation and high evaporation rates are considered as important factors limiting the availability of water in the soil. The higher elevations of the island above 200 m clearly profit from higher precipitation (Honorato 1991); however they experience more intensive exposure to wind, higher evaporation rates and decreased temperatures. These are discussed as hindering factors for agriculture. The water retention capacity of the soils is presently characterized as very low as the soils are of volcanic origin and therefore highly porous (Louwagie and Langohr 2002). Some authors assume these limiting factors also for the past and hypothesize that the early soil conditions, although practically unstudied until now, could not be expected to differ greatly from today (Stevenson and Haoa 1999).

Stevenson (1997, Stevenson and Haoa 1998, Stevenson et al. 1999) and Wozniak (1998, 1999) reconstructed the evolution of the agricultural systems in many studies and analyzed very intensively the high diversity of agricultural techniques at different times and in different parts of Rapa Nui. The driving forces of the chronological and spatial development in the prehistoric agriculture on Rapa Nui seem to be clear: high requirement of food for a growing population and for extraordinary efforts in the unique stone culture (*moai* and *ahu*), difficult conditions for the supply of cultural plants with water and certain nutrients including phosphate and potassium (Louwagie and Langohr 2002, Wozniak 1999), unfavorable climatic factors (stronger winds, lower temperatures, strong insulation) compared to other Polynesian Islands and a very limited area on the small and isolated island. It is very probable that the expansion of farming accelerated the evolution of the agricultural techniques themselves in a feed-back system. In addition to the growing demand for cultivated land by a growing population which could have reached 10,000 or more, some authors see the main pressure for the spatial and qualitative evolution of the land use in the consequences of severe deforestation: enforced soil erosion and sudden changes of microclimatic conditions (Bahn and Flenley 1992). Stone mulching techniques, the use of natural and artificial depressions and the building of *manavai* and protective stone walls are examples of adaptations of farmland techniques to a changing environment (Stevenson et al. 2002). The potential influence of non-anthropogenic factors like natural climatic changes is still in discussion (Hunter-Anderson 1998, McCall 1993, Orliac and Orliac 1998).

PREHISTORIC SOIL STRUCTURE AND LAND USE CONDITIONS ON RAPA NUI – GAPS IN SCIENTIFIC RESEARCH

Among these aspects there are still significant gaps in the analysis of prehistoric conditions, limits and consequences of agricultural land use. Knowledge about past environmental conditions, particularly about climate and soils is very poor (Louwagie and Langohr 2002). Data on the prehistoric soil conditions are however essential for the assessment of ancient farming conditions and efforts. Was water in this naturally

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humid and temperate climate really a limiting factor at all times and in all places? Were the prehistoric soil conditions on Rapa Nui in fact the same as they are today, or were the soil conditions 1,500 years ago completely different from today? Did high porosity and low water retention capacity of the soils cause a negative pressure on the environment and agriculture in the past? Did the people manage their field systems in a sustainable manner and what role did soil erosion play in a span of about 1,000 years of land use in the pre-European time on Rapa Nui? Which effects did land use have on the soils *after* AD 1722 compared to the land use before?

Our recent knowledge of prehistoric techniques in agriculture is mainly based on archaeological evidence, namely stone structures which have been analyzed intensively particularly in the La Pérouse area, near the south coast of Rapa Nui (Stevenson 1997, Stevenson and Haoa 1998) and in the northwest of the island (Wozniak 1999, 2001). But did farming techniques also exist which were not related to these features and which are therefore difficult to detect today? Was the presence of stones an obligatory precondition for successful farming?

Based on very recent investigations (Mieth and Bork 2002) this paper will outline some new aspects and results in the historical analysis of land use and its consequences for the soils in the landscape of Rapa Nui, in particular for the Poike peninsula.

Figure 1. Aerial view of Poike peninsula with the investigation site, Cabo Cumming.

INVESTIGATIONS ON POIKE PENINSULA

Investigations were carried out on Poike peninsula, located in the far eastern end of Rapa Nui. The peninsula, with an estimated age between 2.5 and 3 million years is the oldest part of Rapa Nui. Its soils are described as particularly well developed, deep and fertile (Bahn and Flenley 1992, Zizka 1989). The surface is much less stony compared to other parts of Easter Island. The description of the prehistoric land use on Poike in the literature is very uncertain and sparse. While some authors assume that Poike in ancient times was mainly utilized as an agricultural area (Lee 1989), others suppose that there was no farmland use in the pre-European period (Métraux 1957, Stevenson et al. 2002, Stevenson and Haoa 1998). With respect to the assumed depth and fertility of the soils with only a low stoniness combined with the advantage of higher rainfall near the top of the 370 m high volcano Pu a Katiki, one may wonder why the peninsula would *not* have been used agriculturally. We will discuss this point later. That the peninsula has been intensively used as pasture for sheep and cattle since the end of the 19th century is certain. Grassland and plantations of introduced *Eucalyptus* trees mark the peninsula today.

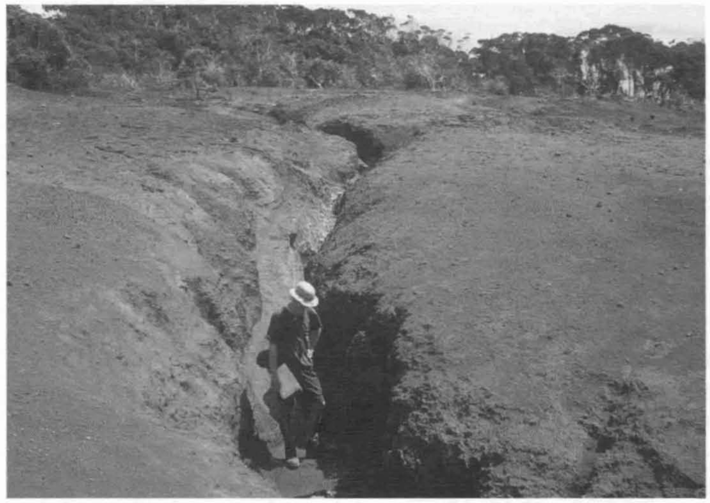

Figure 2. Gully on the eastern side of Poike near Cabo Cumming.

Figure 3. Badlands on Poike with gullies and soil remnants in tiny "*inselbergs*".

Our investigations were carried out in the most extended erosion area on Poike which is situated near Cabo Cumming, the easternmost cliff of the peninsula (Figure 1). This area is characterized by well-differentiated soil and sediment sequences that allow detailed analysis. Near the coastal cliffs the landscape is dominated by red sediments that have been exposed following complete erosion of the soil. Gullies have been carved into the volcanic bedrock (Figure 2). Local remnants of the soil are of significance in these badlands – namely tiny hills with a flat top ("*inselbergs*") that have survived the erosion events over time (Figure 3). The tops of some of these hills carry relics of partly eroded *ahu*. These *ahu*, some *moai* and the famous cave, 'Ana o Keke, are amongst a total of 586 detected archaeological sites on Poike (Vargas et al. 1990). These sites, as well as widespread obsidian artifacts on the soil surface near the cliff coast, indicate that this peninsula was not an insignificant place but probably used for settlements and farm land, as we will discuss. But much of this cultural value is lost today, mainly through erosion. And even the remnants of the archaeological sites are in bad shape and highly endangered by the ongoing erosion process. Apart from the ecological studies on Poike, there exist only very few recent archaeological studies for this area.

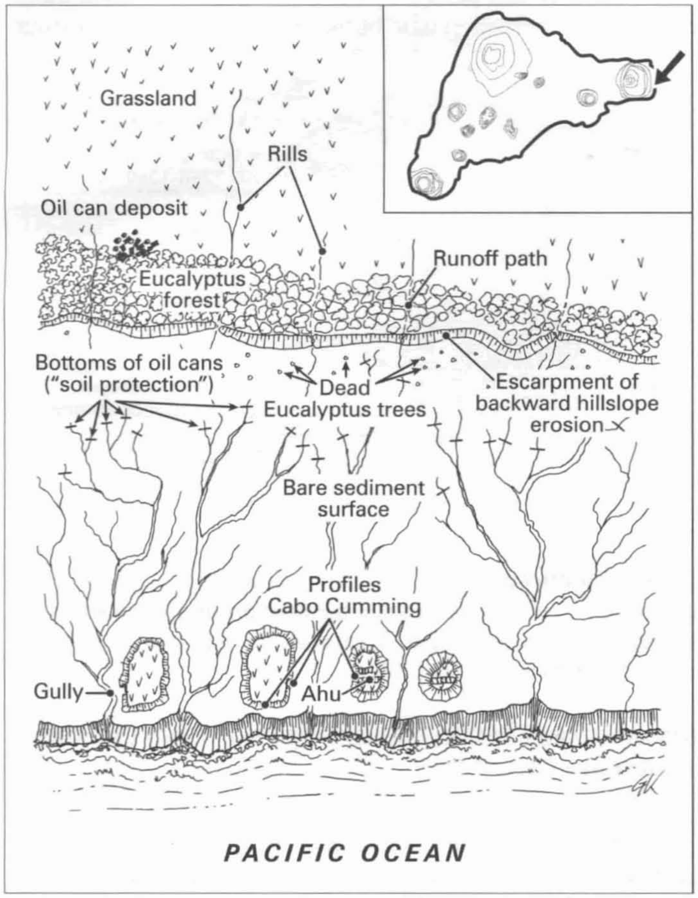

Figure 4: Landscape, erosion features and investigation sites at Cabo Cumming.

Four Dimensional Landscape Analysis

Soil formation, soil erosion and land use dynamics in an archaeological context have been analyzed by field work on Poike in 2002 which resulted in detailed analysis of erosional forms, soil and sediment profiles. Figure 4 shows the investigation area near Cabo Cumming. Soil profiles were analyzed in detail at the edges of the tiny flat hills in the erosion area. A stratigraphy with phases of soil formation, soil erosion and cultural development was established. Charcoal samples were taken and dated by ^{14}C analysis. From the detailed analysis of individual soil and sediment sequences, the identification of key slopes and catchments allowed the modeling of the erosion processes in larger areas (Bork et al. 1998).

Based on this four-dimensional landscape analysis, the chronological and spatial dynamics of soil formation under different vegetation, the processes of soil erosion and soil deposition under different land use and weather conditions, and finally the influence of different cultural events could be reconstructed and interpreted. The results are surprising for the area of the Poike peninsula and may give some new insights into the discussion of influences on, and effects of, the prehistoric land use on Rapa Nui.

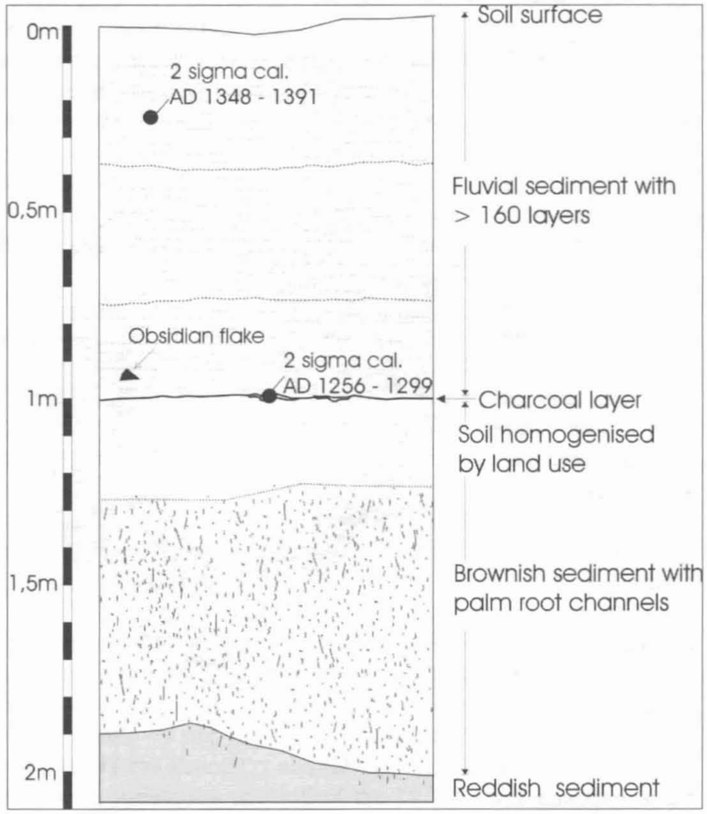

Figure 5: Soil profile Cabo Cumming 1, Poike peninsula.

Analysis of Soil and Sediment Sequences

The stratigraphy of a typical soil and sediment sequence in the area (profile Cabo Cumming 1, Figure 5) documents the evolution of the environment. The bottom of the profile, about 2 meters below the recent soil surface, is marked by a reddish sediment that dominates today on the surface of the severely eroded areas of Poike. On top of the reddish sediment the profile shows a dark yellowish-brown (10 YR 4/4) sediment of more than 1 m thickness. This sediment originates from a soil that was eroded upslope in prehistoric times. It is a sandy clay with a compact, moderate to medium prismatic structure. The organic matter that had developed indicates its origin from a soil probably under open shrub land with a thick A-horizon. A very striking characteristic of this soil is the remnants of roots. Many root channels traverse the soil in a vertical direction. They can clearly be identified as root channels of the now extinct endemic palm tree *Jubaea sp.* (Flenley 1993 b; Grau 2001).

The upper layer of the brown sediment with a thickness of about 25 centimeters consists of weak, fine granular structure and does not show the significant palm root structure although it is the same soil. This homogenization of the soil was most likely caused by land use (gardening, digging) between the palm trees.

Above the intensively rooted soil in the profile Cabo

Cumming *1* a layer of 1 cm in thickness consisting of charcoal and volcanic ash covers the palm soil. In this layer we found several carbonized fossil nuts, the fruits of *Jubaea sp.* (Figure 6). These carbonized palm nuts were analyzed by ^{14}C radiocarbon dating. Their calibrated age is AD 1256 – 1299 (Probability: 92.5 %). The charcoal layer was found not only in this profile but also over an area of several hectares in eastern Poike. The thin layers of volcanic material above and below the charcoal layer were probably washed in immediately after the palm forest had been burned. Bite marks in the nuts made by Polynesian rats indicate that the fire reached the nuts while they were still on the soil.

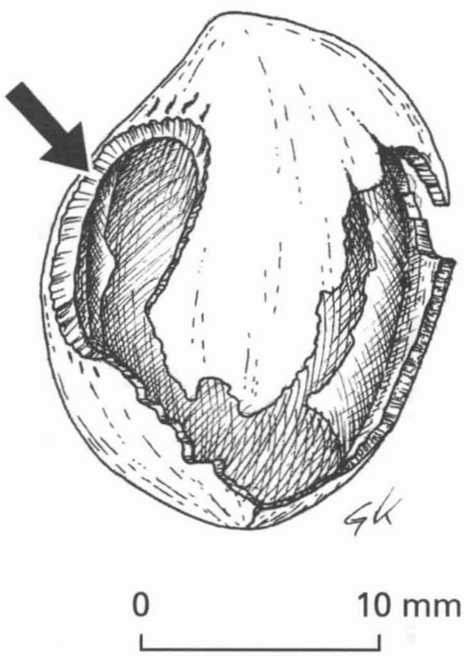

Figure 6. Carbonized nut of *Jubaea* sp. with bite marks of Polynesian rats.

Profile Cabo Cumming 1 also documents the consequences of the woodland clearance: The former palm soil eroded on the more exposed upslope areas and was deposited downslope in concave landforms in many thin horizontal layers. This sediment, with a total thickness of 90 cm, contains more than 160 single layers in this profile with thickness of each individual layer ranging from less than 1 mm to more than 2 mm. At other sites on Poike we found up to 400 layers. Each one or two layers represents one erosion event. Another piece of charcoal in the fine-banded sediment found 64 cm above the main charcoal layer was dated to AD 1348 - 1391 (calibrated age, Probability: 58.2 %). The total age of the fine-layered sediment can therefore be estimated as about 100 years with an average of about 2 erosion (deposition) events per year.

Another profile (Cabo Cumming 2, Figure 7) analyzed in this area of Poike demonstrates the use of land for gardening: A u-shaped pit structure, about 25 cm in diameter and 35 cm in depth, protrudes from the charcoal horizon into the palm soil. Its walls are lined with charcoal and ashes with an enrichment of charcoal on the bottom. The structure is filled by loose sand and contains remnants of burned palm nuts. Also in this profile, the fine-layered sediment covers the palm-rooted soil but does not fill the pit structure. We identified the pit structure as a planting pit that was dug soon after the fire destroyed the palm forest. Wozniak (1999) described garden pits of very similar dimension and shape in lithic-mulched gardens in the northwest section of Rapa Nui. She also emphasized the use of ashes and charcoal as manure in the prehistoric garden culture. The pit structure and the enrichment of ashes, charcoal and carbonized palm nuts in the profile Cabo Cumming 2 suggests that gardening in this area of Poike was carried out very soon after the burning of the palm forest. Organic remnants of the fire were probably used as a mineral-rich manure for the newly cultivated plants.

Another soil profile below one of the *ahu* demonstrates clearly the construction time of the stone setting. The first stone

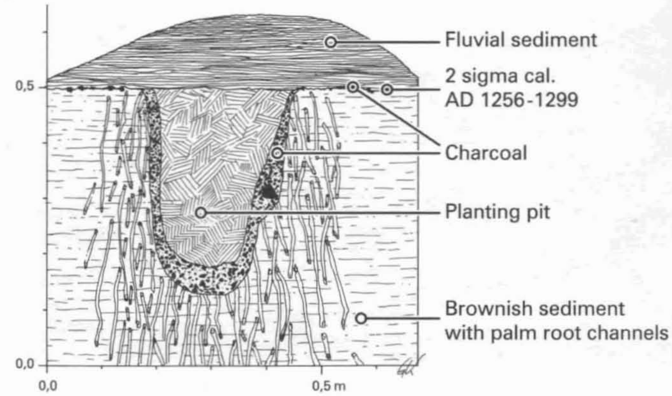

Figure 7. Soil profile, Cabo Cumming 2, Poike peninsula.

layer is set directly above the palm soil and on top of the charcoal layer. The fine-layered sediment wraps up the stones, but it is not located below them. Therefore the *ahu* can be dated to approximately AD 1256-1299.

Stratigraphy and Reconstruction of Land Use and Landscape Changes

The detailed four-dimensional analysis of the soil and sediment sequences leads to a preliminary reconstruction of the prehistoric landscape and land use on eastern Poike, and their changes. A diagonal profile taken near Cabo Cumming (Figure 8) summarizes the evolution of this man-used environment:

Until the middle of the 13^{th} century, woodland with *Jubaea* palm trees dominated, at least on the lower slopes in the east of Poike (Figure 8A). Trees and shrubs profited from organic-rich sediments that were deposited after sheet erosion on the higher elevations, perhaps during late Pleistocene. The high content of organic matter as well as shade and wind protection in the palm forest benefited gardening between the trees. Digging with sticks or basalt spades (Wozniak 1999) probably homogenized the upper horizon of the palm soil. Between AD 1250 and 1300 a dramatic change in this landscape took place. Fire destroyed the palm forest in a large area of eastern Poike (Figure 8B). A natural fire event is improbable as the environment is humid and volcanic activity did not occur in this time as far as we know.

It is very likely that the fire was intentionally lit to clear the land for a more intensive use. It is possible that the fire burnt only the remnants of the woodland such as small trees and shrubs after the majority of palm trees were cut and removed for use, previous to the fire. The opened landscape could now (around AD 1300) be used for the building of settlements, *ahu* and stone tombs (Figure 8C). Agriculture proceeded even on the

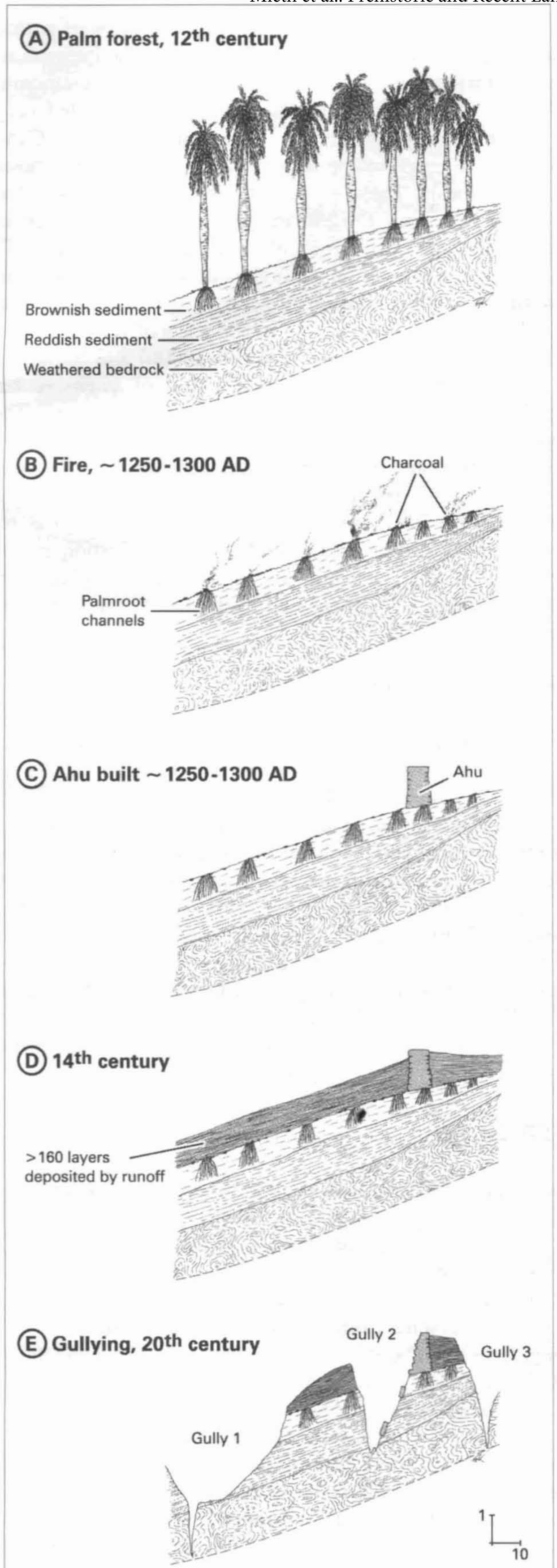

Figure 8: Evolution and reconstruction of landscape and land use on eastern Poike (10x super elevation in scale).

lower elevations of Poike as indicated by the profile Cabo Cumming 2. More intensive, however, was probably agricultural land use on the upper slopes. The fine-banded sediment that was found in wide areas on the eastern side of Poike as also is described by Bahn and Flenley (1992:177). This can only be the result of erosion on arable land. Rainfalls caused sheet erosion of the cultivated soil that was then washed down, trapped and deposited downslope in single layers, very probably in a grassland landscape around the settlements and *ahu* (Figure 8 D). *Ahu* and other stone settings were slowly buried by these sediments. Charcoal, obsidian artifacts and larger coral fragments in the sediment are further evidence of land use in higher elevations. Single erosion events occurred relatively frequently, in some areas 2-4 events per year. No gullying occurred at this time. Evolution and dimension of the agriculturally-enabled erosion indicate that there was some kind of "control" on soil erosion by the people using the land. But the land use techniques and erosion control in this area still remain unknown, as the assumptions for agriculture on Poike were different from the other farmland areas on Rapa Nui. Due to the lack of loose rocks and stones on the landscape surface of Poike, stone mulching, an important strategy elsewhere on the island, was probably absent here.

After about AD 1400, arable land use in eastern Poike probably ceased and grassland protected the surface from soil erosion. Possibly also the dwellings were abandoned at this time. Was the increasing amount of sediment that buried houses and *ahu* step by step the reason for giving up the settlements?

The next dramatic change in Poike´s environmental history was initiated at the end of the 19th to the beginning of the 20th century when intensive sheep grazing took over. The grassland now was trampled by high numbers of animals and burned annually by the European sheep farmers (Ramírez 2001). The Poike peninsula is still intensively grazed today by cattle; the number is about 500 (Chavez, personal communication 2002). Overgrazing partly destroyed the vegetation and thus enabled the development of gullies. Rainwater could accumulate on the pathways of sheep and cattle and overland flow carved gullies. Still today many tracks of the cattle on the upper grassland of Poike can be identified as initial paths of runoff concentration (Figure 4). Near the coast, the soil has been removed completely by regressing sheet erosion. Following the sheet erosion, gullies with a maximum depth of 4 meters cut into the volcanic bedrock (Figure 8 E). Lateral erosion will destroy the remnants of the *ahu* within a short time. Probably many archaeological structures near the coast have already eroded and washed down into the sea.

Recent attempts to stop or prevent this erosion process failed. *Eucalyptus* forest that was planted did not stop erosion by overland flow. Also, other attempts of soil protection were not successful. Bottoms of oil-cans were installed in erosion rills to prevent overland flow and the erosion and transportation of soil particles (Figure 9). Transported sediments soon filled the upside areas of these "miniature-dams", allowing water to pass unhindered and intensifying gully erosion below with even higher energy as the sediment load was reduced. The ongoing intensive land use on Poike by cattle grazing will favor the erosion process and the consequent loss of the archaeological sites, mainly near the eastern and southern coastal cliffs of Poike.

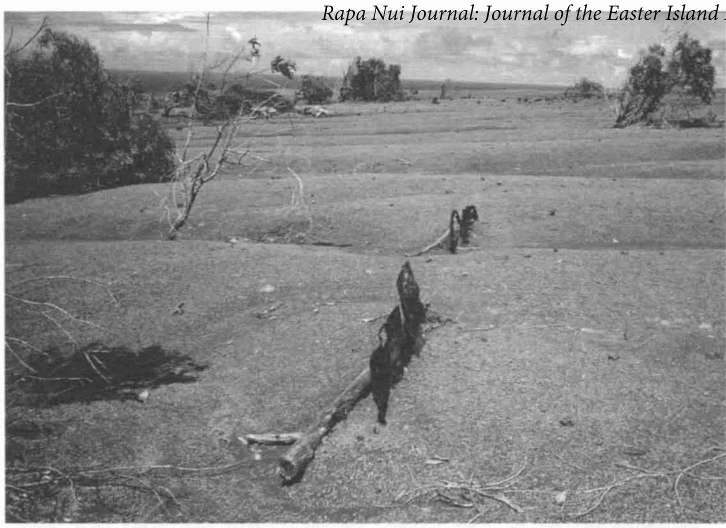

Figure 9. Bottoms of used oil cans as an inefficient soil protection mechanism.

Discussion and Conclusions

The results of our investigations on Poike may lead to a new open-minded discussion about the prehistoric land use, its presumptions and conditions on the Poike peninsula. Poike was surely not an uninhabited, unused and lonely place. Today many archaeological sites such as *ahu*, tombs, and other stone settings, as well as obsidian artifacts and transported coral fragments on the soil surface and in the sediments, are evidence of prehistoric settlements. Settlements and larger ceremonial complexes are correlated with intensive farmland use as Stevenson et al. (2002) mention for other locations on Rapa Nui. We found testimony of agricultural land use on Poike in the described soil profiles. The conditions for plant cultivation on Poike were surely not bad; on the contrary, they might have been good: The area on top of the high cliffs resulted from the higher rainfall beginning at the 200 m elevation. In the concave landforms above the coastline, the first settlers found fertile soils. These were the results of late Pleistocene deposition processes and soil development during the Holocene under woodland. This soil had a compact structure. Water would even not drain very quickly in this ancient soil as many authors assume. Looking at the recent soil conditions that resulted from loss of old topsoils with their A- and compact B-horizons, which then was followed by exposure, weathering, erosion, and sedimentation of the C-horizons with their crack systems, enforced the quick infiltration of rain water. Palm forest on top of the cliffs of eastern Poike provided climatic protection for the cultural plants and for the soil itself. Until AD 1250 the farmland use on Poike in an area with possibly only few dwellings can be described as "sustainable". Palm forest clearance and burning between AD 1250 and 1300 correlates with the phases of forest clearance analyzed by Flenley (2001) and with the interior upland intensification of agricultural production and building of dwellings as proposed by Stevenson et al. (2002) for other parts of the island. In this way, the pressure on agricultural production, on more surplus of food production for the growing population, and the rapid enlargement of the ancient stone culture also reached the remote Poike peninsula. Possibly the intensification of arable land-use correlated with a change from diverse plant cultivations to a dominance of sweet potato production (Yen 1988, Stevenson et al. 2002). The intensification of land use went hand in hand with a growing ceremonial significance of eastern Poike. The stone settings located very close above the extended charcoal band in the area of Cabo Cumming, a remnant of the ancient palm forest are testimony for this hypothesis. These stone settings can likewise be dated very clearly between AD 1250 and AD 1300, with the latest in the early 14th century. Intensification of agriculture in the 14th century, more inland and on the higher slopes of the Poike peninsula, fits the chronicle estimations of agricultural intensification in the southern and northern inland parts of Rapa Nui proposed by Martinsson-Wallin and Wallin (2000) and Stevenson et al. (2002). We hypothesize that a kind of intensive but "controlled" form of agriculture lasted about 100 years. The techniques of agricultural land use on Poike might differ from dryland cultivation, stone protection structures, and stone mulching methods described by Stevenson et al. (2002) and Wozniak (1999, 2001). From this point more research is required. We will conduct further studies on this question and on the question of why farmland use in this area of Poike completely ceased probably at the end of the 14th to the beginning of the 15th century AD.

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