'Is Humanity Suicidal?' Are There Clues From Rapa Nui?

Ferren MacIntyre
MRI, National University of Ireland, Galway

INTRODUCTION

Bahn and Flenley (1992) suggested that the Rapanui provide a rare example of cultural suicide, in a scenario which had them exploiting their forest ecobase[1] so heavily that they destroyed it, with ensuing resource shortage producing civil war, cannibalism[2], and a 70% reduction of the population. Others have popularized this interpretation (Ponting 1993; Gonick and Outwater 1996; Bush 1997) and despite criticism, Flenley (1998) stands by it, defending each of the aspects which has been questioned, and again suggesting Rapa Nui as an earnest for the world on the basis of the Club of Rome's latest findings (Meadows et al. 1992).

Hunter-Anderson (1998), arguing from the same data used by Bahn and Flenley, suggested that the collapse had little to do with human behavior, but much to do with climatic change, with deforestation starting long before colonization. Her 15 years of work with Micronesians had persuaded her that island societies were well aware of their environmental dependence, and employed many subtle practices to ensure ecological stability. Orliac and Orliac (1998) make many of the same points, speaking of "talented gardeners who maintained a generalized ecosystem ...enriching the ecosystem rather than impoverishing it".

A point little considered is that we know nothing of the ecological and agricultural competence of the original settlers. Tradition suggests an escape from warfare, and endows the immigrants with some heroic attributes, but it seems certain that they arrived without the full panoply of colonization goods which a planned expedition would have carried. What if the '2 canoes' were partying teenagers who saw their village raided and fled? I have argued elsewhere (MacIntyre et al. 1998) that prior to AD 1500 there were 10 to 30 times the number of fish in the ocean that there are today. Escapees could expect to live off the land, without taking much in the way of supplies. What if the founders arrived with only a marginal understanding of how to manage a fragile and isolated ecosystem? What if accident or illness deprived them of their best informed member? What if their past experience was irrelevant, based on a breadfruit-coconut-dog-pig economy, or a mountainous island, or a fringing reef? Such possibilities may make the suicide of Rapanui society more plausible, but they do not address the larger question. Despite our own putative sophistication, our decision-makers may be as blind to, or powerless to prevent, incipient collapse as were the Rapanui of AD 1450.

This debate would be of interest only to Polynesian specialists if did not impinge directly upon a matter of vital concern to humanity. This is E.O. Wilson's (1993) question, "Is humanity suicidal?", which is addressed directly by our interpretation of the Rapanui decline. Thus the answer to the questions raised by the above papers will have repercussions far beyond the disciplines of Polynesian anthropology, palynology and ^{14}C dating.

"IS HUMANITY SUICIDAL?"

E .O. Wilson suggested that there was evidence on both sides of the question. While it is encouraging to find that a respectable argument can be made for 'No', one of the major points he made in our favor was the greening of religion. This suggests that he may be overly optimistic, because powerful organizations like Opus Dei (Hutchison 1997) and Wise Use (Anon. 1990) actively oppose such greening. The driving force behind Wise Use is the supposed 'right' of property owners to use their property for private profit regardless of the consequences to others. With this end in view, Wise Use meetings offer inspirational Sunday breakfasts with topics entitled 'Fighting the Greening of the Pulpit—' (Anon. 1997). In their dealings with green opponents, they are well organized, amoral, and vicious (Day 1989; Bari 1994; Helvar 1997).

To my astonishment as a visiting American, one of my papers (MacIntyre in press) discussing green religion was removed from the wall of my Irish campus hallway at the request of Opus Dei. Similar mediaeval censorship exists in other fundamentalist communities (Catholic, Protestant, Judaic, Muslim, or Marxist) where answers to difficult questions are preempted by dogma.

If the answer to Wilson's question is unequivocal (in either direction), there is no need to worry about it. (Indeed, this is an argument I have heard from the religious: '*Inshallah*', or 'Whatever happens is part of the Divine Plan. The good lord will intervene [to save us, or judge us].' On the other hand, we may already have set in train social, economic, and technological processes which we will not be able to correct in the time available. In either settled case, clues extracted from Rapanui are of no concern. Still, one hopes the answer is 'Not if we take corrective action immediately', in which case it behooves us to pay close attention to Rapa Nui.

MODELING THE RAPANUI POPULATION

Since the popularization of Bahn and Flenley's ideas, it has become fashionable to model the socio-economics of Rapa Nui (Brander and Taylor 1998; Mahon 1998 [Mahon's model seems to suffer a bit from confusion of BP and AD ^{14}C dates]). Predictably, such models tend to be complex. I distrust such complexity, because I know from embarrassing personal experience that my subconscious is capable of selecting coefficients (and justifications for them) which will return my preconceived answer from a complex model. Hence my preference for the approach described in the Appendix, a simple model all of whose structure is open to public inspection. Remember that models prove nothing: their major justification is that a hypothesis unaccompanied by an attempt to show its numerical consequences as a first step in falsification is hand waving.

The easiest explanation for a population crash is that a new feature such as climate change acted as trigger, if not bullet. It is interesting, therefore, that no external influence is needed to

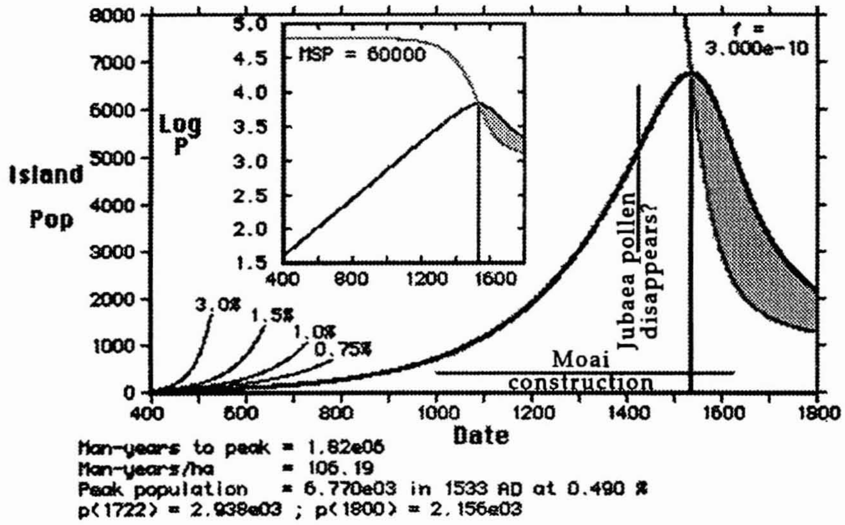

Figure 1. The 'moai' logistic equation for the population of Rapa Nui assuming settlement in AD 400 . The inset re-plots the same data in semilog form, showing a 1000 years of exponential growth. The shaded area is population in excess of the carrying capacity.

model the Rapanui continuum of cultural flowering followed by collapse with a very simple equation, each of whose parameters is easy to understand. To accomplish this, we limit the model to population history only, eschewing attempts to include social, cultural, and economic influences whose numerical coefficients and functional form are guesswork. These effects are implicit in the structure of the model itself.

The sigmoid logistic equation, with a constant carrying capacity or maximum supportable population (MSP) is the classical population model and needs no further justification. To this basis, we add one feature: interactions between people (or competition between tribes) reduces, ever so slightly, the MSP. The history of Rapa Nui follows automatically, as shown in Figure 1.

What we see in Figure 1 is 2 canoes (40 people) arriving in AD 400. The population grows exponentially (straight line in the inset) for a millennium. However, unbeknownst to the Rapanui, 200 years earlier the MSP had begun to droop (upper line in the inset). This decline presumably represents deforestation, although the model does not care about such details. Whatever they are, the seeds of disaster have been sown. The population peak, AD 1400 to 1650, spans the period of most abundant radiocarbon and obsidian-hydration dates (see Appendix for a late-settlement estimate).

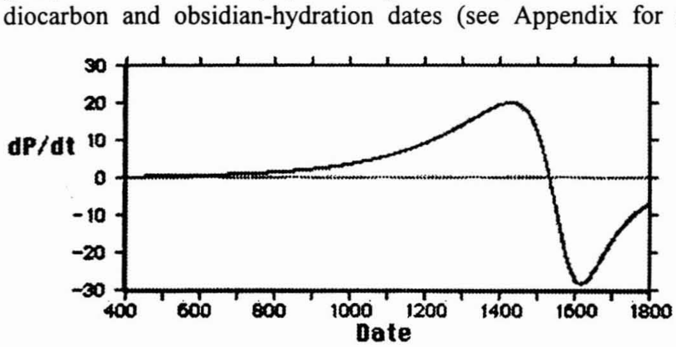

Figure 2. Growth rate (annual excess of births over deaths) for the 'moai' logistic on Rapa Nui. Note the slow take-off and the small absolute value at the minimum.

Population growth begins to slow around AD 1400, which according to some interpretations is the time that palm pollen disappears from the record. Since palms are not known as good canoe material, and I would not move moai on rollers (although palms might make adequate pylons at the quarry), I incline toward Grau's (1998) suggestion that palms were killed for food. 40-year-old palms produce 100 kg of edible nuts per year—but a young palm produces 100 kg of sugary sap plus a palm heart when it is killed: the combination might well have been irresistible, particularly if the tree were in someone else's territory.

Of particular interest is that there is no 'overshoot' in the 'moai' model, as is often assumed. The Rapanui population did not climb past the carrying capacity of the island: rather, the islanders brought the carrying capacity crashing down upon themselves. After ca. AD 1530, when the carrying capacity drops below the actual population, society is in trouble.

The post-16th century descent is probably schematic because the population did not continue its behavior unchanged after the peak of this curve (as the simple-minded model assumes). The equation does not care whether people starve or kill each other, but the population will drop. The decline looks precipitous, but we can obtain more information from other functions of the model. Figure 2 plots the growth rate itself, and raises several questions. The first is whether a small population would be stable during the indicated 500 years of near-zero growth. Many populations in an empty environment grow at 3.5% per year, 7 times the rate here. One suspects that there were oscillations, with losses from accident, forgotten battles, or even emigration: these do not affect conclusions as long as the population ends up near the model figure by, say, AD 1300. The known health problems with a sweet potato diet (Dennett and Connell 1988) may have something to do with this slow growth.

The annual population decrease averaged over the period AD 1550-1722 is also small, with a net excess mortality near 1 person/ week. Washington DC's murder rate is 7 times higher, and no one seems to mind, so the destruction on Rapa Nui was a muted process and may only occasionally have flared into serious fighting. This 'minimalist' interpretation appears to be supported by the skeletal evidence (Owsley 1998).

Figure 3 plots the corrective term which keeps the equation from growing exponentially. Here, it appears to be a good proxy for the reserve carrying capacity of the environment. Malthus (1798) assumed that starvation and misery struck when this function dropped to zero, but there are few clear historical examples, and Amartya Sen was awarded the 1998 Nobel Prize in Economics for showing that shortage of food is not the usual cause of historical famines. In preference to starving, people respond to increasing environmental pressure by adjusting their reproduction not to cross the line. The fast decrease of the MSP in the moai model means that our model population did not have time to detect the approaching limit and was caught unawares.

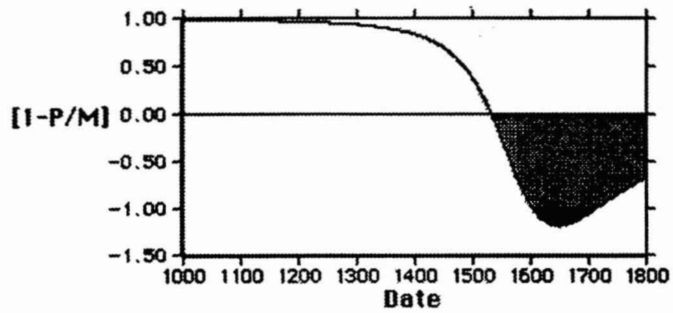

Figure 3. The reserve capacity of the Rapa Nui environment. [1 - p/M] is the term which modifies exponential growth in the logistic equation. This graph suggests that the time of maximum social stress was the minimum of the curve centered near AD 1650 and lasting a century or more. Things had begun to improve when the Dutch arrived in 1722, but the population was still a long way from equilibrium.

The time of maximum social stress on Rapa Nui seems to coincide exactly with a reserve capacity below -1. (This feature was not built into the model, but is, if you will, a discovery made by it.)

Another feature generated by the model is shown in Figure 4, where $M' = dM/dt$ appears to be an acceptable proxy for the rate of ecosystem destruction, expressed in population equivalents. Such graphs are no more reliable than the assumptions underlying the model, but they do offer ways of thinking about the situation which are not obvious in less analytical approaches.

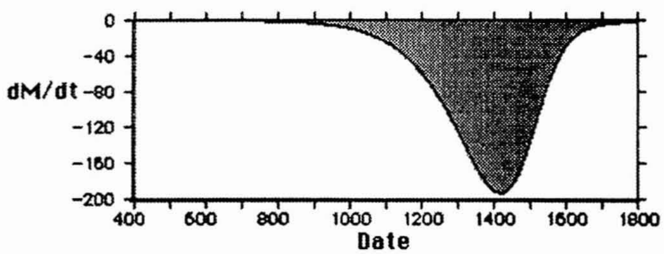

Figure 4. The rate of change of the carrying capacity symbohzed by dM/dt or M', is in this model an exact analog of the rate of environmental degradation.

I originally intended to calculate the man-years required to 'destroy' an acre of Rapa Nui, for comparison with other cultures. Two problems intervened. 1) I found very little reliable comparison data, and 2) the rate, as calculated by the model, varies so much with time that it does not appear meaningful. The computer printing below Figures 1 and Al estimates the total population-years from settlement to the population peak, and the average population-years/ha required to destroy the island. At roughly a man-century per hectare, this is not dramatically different from devastation rates achieved in advanced societies: as one example, the US has lost half of its topsoil in 200 years (Hyams 1952).

It is easy to find destroyed hectares in the model: on the ground it is more difficult, because they are not neat $100m^2$ plots of badlands. One 'lost hectare' in the model may mean that 100 hectares of island have each lost 0.01 of their productive capacity—and who can detect that until it is too late? The degraded forests of China and Korea owe their stunted trees to some 350 years of removal of nutrients in the form of leaf mold, green manure, and ash, extracted as fertilizers for crop land on the plains (Perdue 1987).

SOIL NUTRIENTS

There has been much speculation about the effects of deforestation on Rapa Nui soil. We can certainly expect a decrease in soil moisture with loss of forest cover. We know from experimental forests that nutrient loss to flowing streams increases 3-fold after clear cutting (Likens et al.:1977), but the soil of Rapa Nui is so porous that flowing streams are rare. Harvard's Hubbard Brook Forest—the source of much of our knowledge—grows on granite, a rock much impoverished with respect to trace metals compared to volcanics as fresh as Rapa Nui's. In the absence of detailed studies, it is not clear what form 'soil depletion' might take on Rapa Nui.

The usual fertilizer contains nitrogen, potassium, and phosphate. Volcanic rock should be sufficiently rich in potassium for this not to be limiting. Islands characteristically receive a steady input of both nitrogen and phosphate in marine aerosol: breaking bubbles selectively eject the sea-surface microlayer into the atmosphere. The microlayer is rich in surfactants, many of which contain nitrogen, and its phosphate to sodium ratio may be 1000 times that of seawater (Maclntyre 1979). Exotic mechanisms aside, the usual recycling of nutrients to islands is by seabirds. Rapa Nui would have had initial supplies of nitrate and phosphate to see agriculture through several easy centuries. Only after extinction of birds would a problem arise, but this problem is distinct from deforestation per se.

A ROLE FOR CLIMATE VARIABILITY

There is no dearth of examples of mindless deforestation in human history. Sumer, Assyria, Egypt, China, Knossos, Myceanae, Classical Greece and Rome, Venice, and others all destroyed a vital component of their ecological support base by clear cutting forests (Perlin 1991). The cedar-less mountains of Lebanon, the barren hills of Attica, the white karst of the Dalmatian Alps, the baked slopes of Italy and the Iberian peninsula, the rolling farms of England, the grasslands of Denmark, and the soil-less mountains of Western Norway, were deliberately deforested, primarily to build warships. But Western civilization has no monopoly on ecostupidity[1]: comparable destructive behavior by small-scale societies is attested by examples in Lewis (1992).

Rapa Nui, because of its small size and isolation, was always biologically impoverished (MacArthur and Wilson 1967) and particularly vulnerable to ecological abuse. The 'Pleistocene' extinctions described by Martin (1967) have not fully not run their course, and are on the increase today. The damage wreaked by Polynesians on the larger and more resilient islands of Hawai'i and New Zealand does not encourage one to believe that the Rapanui treated their biota any better.

Nevertheless, one should not overlook the possibility that climate variability (for instance) contributed the final straw to Rapanui collapse. I write looking at an e-mail page of current 'anecdotal ENSO impacts' collected by the US National Academy of Science's decade-to-century climate-fluctuation group (Lowell Smith, personal communication.) which suggests how easily climatic variability of the El Niño/ Southern Oscillation can stress a population already at an environmental limit. Events of the sort which might have affected Rapa Nui include: 10 Galapagos sea lions where 100s were expected, rain in the Galapagos causing vegetation to overgrow seabird nesting sites, Peruvian fishmeal production down 80%, drought in Hawai'i affecting forest-product production, poor sugar harvest in Cuba, forest fires in Mexico and South East Asia, undernourished bait fish in California waters, absence of pinnipeds and cetaceans from Eastern Pacific water over 200m depth, famine and widespread child malnutrition in Mindanao.... While some of these may be contradictory (drought and flood don't occur together), they indicate the possible results of relatively small decadal climatic fluctuations. Under conditions like these a marginally supportable population last year may become far too many in the following year.

Unfortunately, like many regions affected by ENSO, Rapa Nui lies outside the Tropical Ocean and Global Atmosphere observational grid which covered 2 warm ENSO phases (1986-1987 and 1991-1992) and one cold phase (1987-1988). Partly as a result, Easter Island does not appear in the index of the state-of-the art volume (Climate Research Committee 1995). Still, considerable progress has been made in understanding the consequences of ENSO (TOGA Panel 1996), and the next research programs are in the planning stage (GOALS Panel 1998). A compelling case can be made for integrating a Rapa Nui observational station into the GOALS (Global Ocean-Atmosphere-Land System) component of CLIVAR (Climate Variability and Predictability Program).

Conclusions and Recommendations

Attempts to model elements of Rapanui history suffer from the usual problems of models: simple models are suspect for their failure to separate important effects; complex models are suspect because they require data which we simply do not have, and there is little reason to believe that their explicit numerical functions represent reality any better than the implicit relations of simpler models. Still as long as we refuse to believe our creations, they can sometimes suggest what needs to be looked at in more detail.

Perhaps the most valuable contribution of a simple analytic model is its ability to generate additional functions (*M'*, [1-p/*M*}]) which can be interpreted as real processes. I was not expecting this. However, these are really useful only if they are found to influence phenomena other than the population itself.

The '*moai*' logistic was found by a search for a function which would produce the right behavior. Its interpretation as an expression of competition is ad hoc and after the fact: the functional relationship is correct, but the implied meaning of 'competition' is open to debate. Nevertheless, it seems remarkable that such a simple function should work so well. As discussed in the Appendix, each year the MSP is diminished by the factor $(1\text{-}3\text{x}10^{-10}p^2)$. This would be easy to explain if, for instance, the Rapanui tore up the landscape by playing football in a round robin contest: the number of games (and the devastation) increases as the square of the number of teams. Since they did not play football (as far as we know), some more plausible explanation is required. I do not know what it might be.

A similar function, linear in p, is perfectly understandable and gives similar results, but the population decline is not nearly as sharp. The problem may be that I am forcing one function to represent behavior both before and after the crisis, even though we know that Rapanui society changed dramatically in this period. If no one objects too strenuously to this model perhaps I will attempt one with 'before' and 'after' functions.

It would contribute greatly to our understanding if we could persuade a pedologist to take a look at contemporary Rapa Nui soil and compare it with the rocks from which it has weathered. This might obviate a lot of speculation about soil degradation.

Considering the Orliac and Orliac (1998:note 4) complaint that "Flenley's data [on which the Rapanui-collapse hypothesis rests] are very difficult, if not impossible, to interpret", the most needed research is that suggested by Flenley himself (1998): "...re-investigation using modern techniques of radiocarbon dating which may avoid the errors". (NB: No one is criticizing the existing work. The problems are primarily those of obtaining representative samples, and of obtaining reliable data from small amounts of carbon. With hindsight and new techniques, it is easier to suggest how this might be improved.)

The "modern techniques" are more expensive. They might not be justified if Rapa Nui were only one more Pacific island. But if the historical behavior of the Rapanui can illuminate Wilson's question, there is scarcely any project more important to the human race.

Appendix

The Arithmetic of the Model

Verhulst's (1845) sigmoid 'logistic' equation is the prototype population equation. In the incremental form best suited to numerical computations it is

$$p_{n+1} = p_n + kp_n\, [1\text{-}p_n / M\}\Delta t,$$

with p_n = the population in year n, k the growth rate over time period $\Delta\ t$, and M the maximum supportable population, or carrying capacity. Integral and incremental form give slightly different results, but many forms of M do not integrate to known functions, those that do are often so strange that one loses all contact with underlying mechanisms, and for a process as discrete and intermittent as human reproduction, the incremental form seems preferable in any case. Computers are so fast these days that integrating for a millennium to obtain the population of a single year is effectively instantaneous.

If the term in brackets were 1 ($M = \infty$), the logistic would integrate to exponential growth; the bracketed term ensures that growth slows as the carrying capacity is approached.

Applied to fruit flies, the logistic works well with M = constant (Pearl 1924). Perennially popular for human populations, (Pearl and Reed 1930; Pearl et al. 1940; Maddox 1994) this is inadequate because we exert more control over our environment than flies can (Fremlin 1964,1972). Malthus (1798) hypothesized that M should increase linearly with time (the 'malthusian' logistic, with $M = (a + bt)$, and the US population is superbly fitted by the 'technagog' variant (MacIntyre, unpublished ms.) (the name means 'led by techniques' and refers to the apparent inevitability of something being done simply because we have learned how to do it), with $M = K\exp(2t)$, where 2 is the technological growth rate at which we expand the environment's ability to support us. Other functional forms of M are appropriate for other situations.

The form of M which we call the 'moai' model is:

$M_{n+1} = M_n(1\text{-}fp^2)$, with (in our special case) $f = 3\text{x}10^{-10}$.

If the term in p were linear, it would indicate that every added person diminished the original carrying capacity (perhaps by something as subtle as compacting soil by walking on it all his life). The implication of the quadratic term p^2 is that it is interactions between people (or competitive between tribes?) which irreversibly diminishes the carrying capacity. The mechanism of damage is not described, but at least in some cases on Rapa Nui took the final form of species extinction of useful plants.

Unfortunately for my original intention of using this model to choose between alternative histories, even the settlement date is unknown. Irwin (1992) is happy with AD 400 followed by intermittent contact through the Pitcairn Islands until these were abandoned at some later time. He also suggests 2-way contact from Rapa Nui to South America. Both of these ideas seem to require a more populous early history for Rapa Nui than the slow-growth model makes likely. With the birdman motif appearing in Hawai'i (Lee 1992) and coastal Peru (Heyerdahl 1998), it seems increasingly unlikely to have been invented in Rapa Nui: this implies 16th-century contact at a time when logic suggests the Rapanui had lost the ability to build sea-going canoes. A puzzle.

A settlement date of AD 800 has been suggested, and Figure A1 shows what happens when we adjust the growth rate to accommodate an AD 800 landing. The population can grow slightly faster, the peak is slightly higher (both of which may be more realistic), and the excess deaths reach a maximum of 80 /year, and population peak (as in Figure A2) is narrower, extending from AD 1468 to AD 1560. But even this simple model is too flexible to guide our hypotheses, for it can reject neither date.

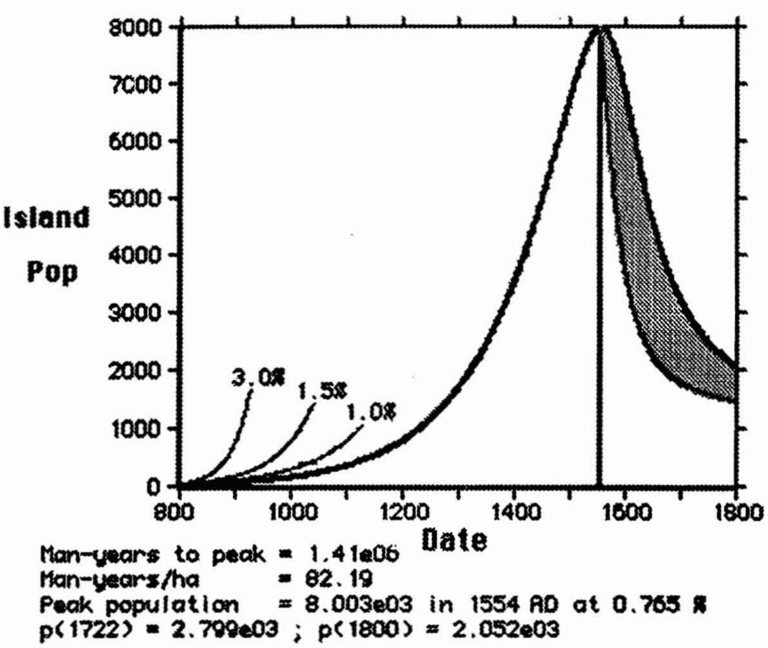

Figure A1. As Figure 1, with settlement beginning in 800 AD (Hunter-Anderson 1988).

The various time derivatives which seem useful are:

$$p' = dp/dt = kp[1\text{-}p/M]$$

$$[1\text{-}p/M]' = d[1\text{-}p/M]/\,dt = [pM' - Mp']\,/M^2$$

$$p'' = d^2p/dt^2 = k\{p'[1\text{-}p/M] + p[1\text{-}p/M]'\}$$

$$= k\{p' + M^2[p^2M' \text{-}2Mpp']\}$$

with M' shown in Figure 4 and p'' in Figure A2. $M(t)$ in the moai logistic is not analytic, so its derivatives are not functions and we calculate them incrementally.

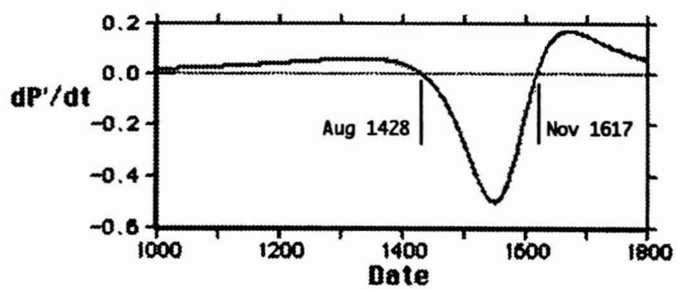

Figure A2. The 2nd derivative ('acceleration) of population with time allows exact determination of the model peak width (defined as time between inflection points). What such features of models lack in terms of comparability to the real world, they make up for by expanding the universe of discourse.

M_0 represents the initial carrying capacity of Rapa Nui, and needs some justification. It is twice the maximum suggested population obtained by multiplying the number of known house foundations (3244, Van Tilburg 1994:67) (not necessarily contemporaneous) by 9 members per family (by no means a universal). Routledge's informants told her that half the island could grow sweet potatoes and bananas, making possible an MSP as large as 52,000. Métraux used Tahitian density to suggest a maximum historical occupancy of 3000 to 4000 (Métraux 1940), although the rolling contours and fertile soil of Rapa Nui allow a larger density than the steep slopes of tropical Polynesia. Tropical 'Uvea, 1/3 the size of extra-tropical Rapa Nui, supports 10,000 people on a coral atoll with less favorable soil and a lower fraction of usable land (Sand 1993). The 'Polynesian average' (presumably for arable land) was 2 people per acre (Van Tilburg 1994:159) or 5 per hectare, and Easter Island, with 17,100 (Henry 1994) might have supported 85,500, or 60,000 with 70% efficient use of the land. More realistically, 60,000 might represent an ideal which could be reached only with recycling soil conservation, biodiversity monitoring and preservation, and similar concepts which we do not yet apply ourselves. It was never the actual population, and its single significant digit marks it as a free parameter, adjusted to make the model yield the 'right' result.

The moai model does not care about early oscillations as long as the population ends up near the curve about AD 1300 when the MSP begins to drop. (modeling population oscillation calls for a positive term in M(t) to allow for forest regeneration during periods of low environmental pressure, but our hypothesis and its parameters already run far ahead of the data.)

The tiny interaction parameter (3×10^{-10}) seems insignificant until one runs the equation. According to Figure 1, it took 650 years for interaction to become visible, but by 1100 years (AD 1500) the rate of change was catastrophic. The switch from a low-effort abundant environment (La Pérouse 1797), perhaps already influenced by the romanticism of Rousseau, estimated 3 day's work per year for food production) to an impoverished subsistence economy occurred within a single lifetime.

The second time derivative of the population, *p*", is interesting because it locates precisely the limits of the population peak which we estimated to lie between AD 1400 and 1650. As shown in Figure A2, we could, if desired, place these at August of AD 1428 and November of AD 1617.

I, and Howland (1961) before me, have tried to publish modified logistics in professional demographic journals, only to be told rather pointedly that such simplistic ideas are long out of fashion, and that one must use serious equations if one wants to be taken seriously. The problems with the serious equation—Lotka's multistate cohort-component projection (Sharpe and Lotka 1911) —are two. First, it is an integral equation with the unknown on both sides of the equal sign, and thus solvable only by extraordinary acrobatics, so that the average scientist loses all intuitive contact and must treat its results as ex cathedra pronouncements. Second, it requires data which change so rapidly that the results are valid for less than a decade (Monro 1993).

In contrast, a modified logistic is sometimes capable of subsuming all of the variables of Lotka's approach into a few parameters. Why this should be is one of life's mysteries, but it works impeccably for 350 years of US Census data, spanning the transition from a mix of rapid immigration and reproduction in the 1600s, through the opening and closing of the frontier, past wars domestic and foreign, depressions, baby booms, and the demographic transition. (Many social changes and historical events do show up—but only as noise in a greatly expanded plot of the first derivative.) If my 1969 model holds up for the year 2000 Census, I will try once again to publish it, for, simplistic or not, it will by then have predicted the US population for 40 years. It is exactly on target as of early 1999.

Naturally, agreement of one modified logistic with one population does not mean that another modified logistic will work for another population. But it does show that (if one stumbles onto the appropriate function for *M*), a simple equation will work for centuries during which social mores undergo major changes. Whether the 'moai' logistic is as good for Rapa Nui as the 'technagog' logistic is for the US is an open question, but at least it gives us a straw man to aim at.

FOOTNOTES

[1]These may be neologisms. In any case, I use them to mean: *ecobase* n. The environmental ecosystem supporting human life, including but not limited to: removal of atmospheric toxins and particulates by plants and rainfall; purification of water by evaporation, stream flow, and underground bacteria; maintenance of biodiversity in pests by their wild population; and all self-regenerating subsystems that we make use of.
ecostupidity n. Any behavior which puts our ecobase at risk, including, but not limited to: overpopulation, species extinction, subservience of ecological concerns to economic dogma such as 'free trade'.

[2]Recently we went through a period when it was politically incorrect to accuse other cultures of cannibalism. However, since my own antecedents bit the throats out of enemies in battle "a sweeter bite I never tasted" and ate bureaucrats—a sheriff, "sodden and suppit in broo" is historically attested in Edinburgh—I have no problem accepting cannibalism on Rapa Nui.

REFERENCES

Anonymous. 1990. *Wise Use Memo.* Center for the Defense of Free Enterprise, Bellevue WA.

Anonymous. 1997. An Internet announcement of the fly-in meeting of the Rhode Island Chapter of Wise Use, 7-9 June 1997, at which there were 50 panels and 100 speakers.

Bahn, P. G. and J. Flenley. 1992. *Easter Island, Earth Island.* Thames and Hudson, London.

Bari, J. 1994. *Timber Wars.* Common Courage Press, Monroe, NE.

Brander, J. A. and M. S. Taylor. 1998. The simple economics of Easter Island: A Ricardo-Malthus model of renewable resource use. *Amer. Econom. Rev.* 88(l): 19-138.

Bush, M. B. 1997. *Ecology of a Changing Planet.* Prentice Hall, NJ.

Climate Research Committee. 1995. *Natural Climate Variability on Decade-to-Century Time Scales.* National Academy Press, Washington DC.

Day, David. 1989. *The Environmental Wars.* Ballantine Books, NY.

Dennett, Glenn and John Connell. 1988. Acculturation and health in the highlands of Papua New Guinea. *Current Anthropology* 29: 273-299.

Flenley, J. 1998. New data and new thoughts about Rapa Nui. *Easter Island in Pacific Context.* C. M. Stevenson, G. Lee, and F. J. Morin, eds. Easter Island Foundation, Los Osos CA: 125-128.

Fremlin, J. H. 1964. How many people can the world support? *New Scientist* 415:285-287.

Fremlin, J. H. 1972. *Be Fruitful and Multiply: Life at the Limits of Population.* Hart Daves, London.

GOALS Panel. 1998. A *Scientific Strategy for US Participation in the GOALS (Global Ocean-Atmosphere-Land System) Component of the CLIVAR (Climate Variability and Predictability) Program.* National Academy Press, Washington DC.

Gonick, L. and A. Outwater. 1996. *The Cartoon Guide to the Environment.* Harper Collins, New York.

Grau, J. 1998. The *Jubaea* palm, key to the transportation of moai on Easter Island. *Easter Island in Pacific Context.* C. M. Stevenson, G. Lee, and F. J. Morin, eds. Easter Island Foundation, Los Osos CA:120-128.

Helvar, David. 1997. *The War Against the Greens.* Sierra Club Books, San Francisco.

Henry, L. L.1994. The area of Rapa Nui. *Rapa Nui J.* 8:70-73.

Heyerdahl, Thor. 1998 The common occurrence of the Birdman cult and the double-bladed *Ao* paddle on Easter Island and in prehistoric Tucume. *Easter Island in Pacific Context.* C. M. Stevenson, G. Lee, and F. J. Morin, eds. Easter Island Foundation, Los Osos CA:178-184.

Howland, W. E. 1961. Letter. *Science* 133: 939, and personal communication.

Hunter-Anderson, Rosalind. 1998. Human vs. climatic impacts, or, did the Rapanui really cut down all those trees? *Easter Island in Pacific Context* C. M. Stevenson, G. Lee, and F. J. Morin, eds. Easter Island Foundation, Los Osos CA:85-99.

Hutchison, Robert. 1997. *Their Kingdom Come: Inside the Secret World of Opus Dei.* Corgi, London.

Hyams, Edward. 1952. *Soil and Civilization.* Harper Colophon Books, NY, 1963.

Irwin, Geoffrey. 1992. *The Prehistoric Exploration and Colonization of the Pacific.* Cambridge University Press, Cambridge.

La Pérouse, J. F. de. 1797. A *Voyage Around the World Performed in the Years 1785*-1788. Johnson, London, 1:71.

Lee, Georgia. 1992. *The Rock Art of Easter Island. Symbols of Power, Prayers to the Gods.* Arqueologia Monumenta 17. UCLA.

Lewis, M. W. 1992. *Green Delusions: An Environmental Critique of Radical Environmentalism.* Duke University Press, Durham, NC.

Likens, G. E., F. H. Bortnann, R. S. Pierce, J. S. Eaton and N. M. Johnson. 1977. *Biogeochemsitry of a Forested Environment.* Springer-Verlag, New York.

MacArthur, R. H. and E. O. Wilson. 1967. *The theory of island biogeography.* Princeton University Press.

Maclntyre, Ferren. 1979. Chemical fractionation and sea-surface microlayer processes. *The Sea: Ideas and Observations on Progress in the Study of the Sea,* E. D. Goldberg, ed. 5: 245-299.

Maclntyre, Ferren. (in press). The Three Tasks: YHWH's answer to environmental critics? Paper presented at the 4th Interdisciplinary Environmental Association meeting, Washington DC, 7-10 July 1998.

Maclntyre, F.; T. Noji, and K. W. Estep. 1998. Shifts in marine biomass and the provisioning of voyages before 1500. *Easter Island in Pacific Context* C. M. Stevenson, G. Lee, and F. J. Morin eds. Easter Island Foundation, Los Osos CA:107-112.

Maclntyre, F. (in preparation). The logistic curve and the Census count of 2000. To be submitted to *Science* in AD 2000, after the Census.

Maddox, J. 1994. Population stability within reach? *Nature* 370: 583-584.

Mahon, Ian. 1998. Easter Island: The economics of population dynamics and sustainable development in Pacific context. *Easter Island in Pacific Context.* C. M. Stevenson, G. Lee, and F. J. Morin, eds. Easter Island Foundation, Los Osos CA.:110-119.

Malthus, T. 1798. *An Essay on the Principle of Population, As It Affects the Future Improvement of Society.*

Martin, Paul S. 1967 Pleistocene Overkill, *Pleistocene Extinctions: The Search for a Cause.* P. S. Martin and F. M. Wright, Jr., eds. Yale University Press, New Haven:75-130.

Meadows, D. D. L. Meadows and J. Randers. 1992. *Beyond the Limits.* Earthscan, London.

Métraux, A. 1940. Ethnography of Easter Island. *Bishop Museum Bull.* 160. Honolulu, 1971.

Monro, J. M. 1993. World population forecasts. *Nature* 363:215-216.

Orliac, Catherine and Michael Orliac. 1998. The disappearance of Easter Island's forest: Over-exploitation or climatic catastrophe? *Easter Island in Pacific Context.* C. M. Stevenson, G. Lee, and F. J. Morin eds. Easter Island Foundation, Los Osos, CA:129-134.

Owsley, D. 1998. Skeletal pathology of Easter islanders. (Abstract), *Easter Island in Pacific Context.* C. M. Stevenson, G. Lee, and F. J. Morin eds. Easter Island Foundation, Los Osos CA.:401.

Pearl, R. 1924. *Studies in Human Biology.* Wilkins, Baltimore.

Pearl, R. and L. J. Reed. 1930. The logistic curve and the Census count of 1930. *Science* 72:399-401.

Pearl, R., L. J. Reed and J. F. Kish. 1940. The logistic curve and the Census count of *1940. Science* 92: 486-488.

Perdue, Peter. 1987. *Exhausting the Earth: State and Peasant in Hunan 1500-1850.* Harvard University Press, Cambridge MA:35,247.

Perlin, J. 1991. A *Forest Journey.* Harvard University Press, Cambridge, MA.

Ponting, Clive. 1993. *A Green History of the World: The Environment and the Collapse of Great Civilizations.* Penguin, London.

Sand, C. 1993. A preliminary study of the impact of the Tongan maritime chiefdom on the late prehistoric society of 'Uvea, Western Polynesia. *The Evolution and Organization of Prehistoric Society in Polynesia.* M.W. Graves and R. C. Green, eds. Auckland: New Zealand Archaeological Association Monograph 19:43-51.

Sharpe, F. R. and A. J. Lotka. 1911. A problem in age-distribution. *Philosophical Magazine* 21:435-438.

TOGA Panel. 1996. *Learning to Predict Climate Variations Associated with El Niño and the Southern Oscillation.* National Academy Press, Washington DC.

Van Tilburg, Jo Anne. 1994. *Easter Island: Archaeology, Ecology and Culture.* British Museum Press.

Verhulst, P. F. 1845. Recherches mathematiques sur la loi d'accroissement de la population. *Nouv. Mem. Acad. Roy. Soc. Belle-lettr. Bruxelles* 18:1-38.

Wilson, E. O. 1993. Is humanity suicidal? *Bio Systems* 31:235-242.