Appendix 4: Case Study – Systems model of the population and environment of Easter Island, Rapa Nui

Easter Island (also known as Rapa Nui) is a small island in the middle of a very large ocean. The area of the island is only 166 km^2 (64 mi^2) and it is 2250 km from the nearest other island (Pitcairn Island) and over 3700 km from South America, the nearest continent. You have undoubtedly heard something about this fascinating island related to speculations on what caused the population to crash. In fact, you've probably heard more about this island because of this failure to be sustainable than you've heard about any of the myriad of other islands in the South Pacific.

At one time in the history of this island, the society had fairly sophisticated culture and technology. The cultural history describes a well-developed hierarchy with laws and written script. The evidence of the technology was their ability to move the large stone statues, which the island is most known for, for long distances. They moved carved stone sculptures that weighed up to 82 tons as far as six miles (10 km). The islanders cultivated a large part of the island with multiple crops. Estimates of the maximum population on the island ranged from 7,000 to as high as 20,000. And yet the population and civilization must have crashed. When European boats first recorded their interaction with the island (in the 1700s) the population was only several thousand, and these people were leading a tough life in an impoverished and desolate environment.

You can see from just the outlines of this story why the island's history has always been so intriguing. Now with our interest in sustainable systems, it is important to attempt an understanding. There are parallels between their tiny island and our planet. Once the environment started to decay and subsequent crash of population and society, these islanders had no place to go. Sustainability isn't just about maintaining a mere subsistence life style, it's also about continuing to develop the culture and have a healthy physical existence.

In this case study, we are going to examine the population, agriculture and land use practices that were employed on Easter Island from about 400 AD to about 1700 AD. We are going to analyze the very gradual depletion of the natural capital on Easter Island using a "systems" approach.

References to studies of the fate of Easter Island

A more complete story can be found at the following sources:

- Wikipedia: http://en.wikipedia.org/wiki/Easter_Island
- Discover Magazine: Jared Diamond. "Easter's end." Discover magazine, August 1995. 16(8): 62-69.
- TED talks such as: http://www.ted.com/talks/lang/eng/jared_diamond_on_why_societies_collapse.html
- http://blog.ted.com/2008/10/27/why_do_societies_collapse/
- Diamond, J. (2005). Collapse: How societies choose to fail or succeed. New York, Viking.

Salient features

The story of Easter Island has particular features that make it amenable to examination with a systems approach. First, it is very similar to the systems model for sustainability that we developed in Figure 12 and 13; there are suggestions of growth, harvest, and bad luck. Second, at any time the processes seem to be close to being in balance; it is only by looking at the long term effect of these do we see the impact of a slight over harvest or a previous year of bad luck. Third, the description contains some simple models that could be tied together to get an integrated picture; there is population growth, harvest of trees, soil moisture, agriculture and fishing. These processes are related, but not directly.

Applying the systems tool

We are going to put separate small models together and to examine how these individual processes counter or reinforce each other. This is an oversimplified model in which will only consider three stocks: the number of people, palm trees, and rats.

The number of people is the balance between birth and death rates. As there are more people, there will be more births, i.e. the population growth has a positive feedback component. The number of deaths may depend on many other factors including natural causes, famine, and disease. A simple model diagram for this is given below.

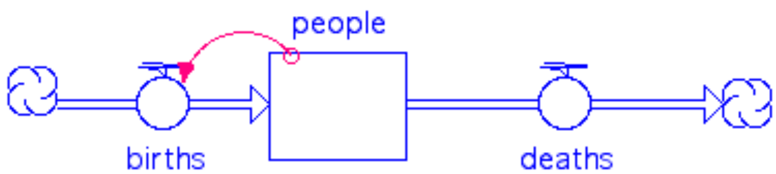

Figure 6-15. Human population sub-model showing positive feedback for births but a constant death rate.

The number of trees is also a balance between the number of palm nuts that germinate and grow, and the cutting down of the trees.

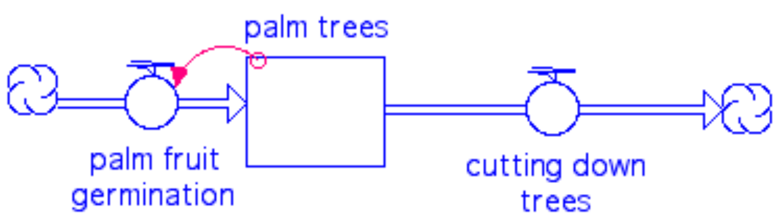

Figure 6-016. Palm tree sub-model also have positive feedback for growth and constant loss.

The third strand in our model will be the rat population. People brought rodents to the island. These rats play a key role in this problem. People eat the rats and the rats eat the palm fruit, decreasing the tree population. Their population is just like the others, there is positive feedback for rat births and several factors controlling death.

Now we are going to connect these three stocks and flows models with factors that affect either the birth or death rates. The following list details these interactions.

1. Rats have a positive effect on people births because this is a source of food for people. The birth rate of people will increase with more rats (and the birth rate will decrease if rats are low).

2. Rats have a negative effect on human death. The death rate of people will increase if rats are too low.

3. People have a positive effect on the harvesting of trees. More people cut down more trees because they need them for fishing and to cultivate land for crops.

4. Rats have a negative effect on the rate of palm fruit germination. The number of rats decreases the percentage of new palm seeds that germinate successfully because the rats chew on the seeds.

5. Palm trees have a positive effect on rat births, because the rats eat the palm fruit.

We could add more detail to this model, but even with only these five interactions this turns out to be a very interesting and instructive model. Looking at the model diagram, below, you can see that there are many positive feedbacks and only a few negative feedbacks.

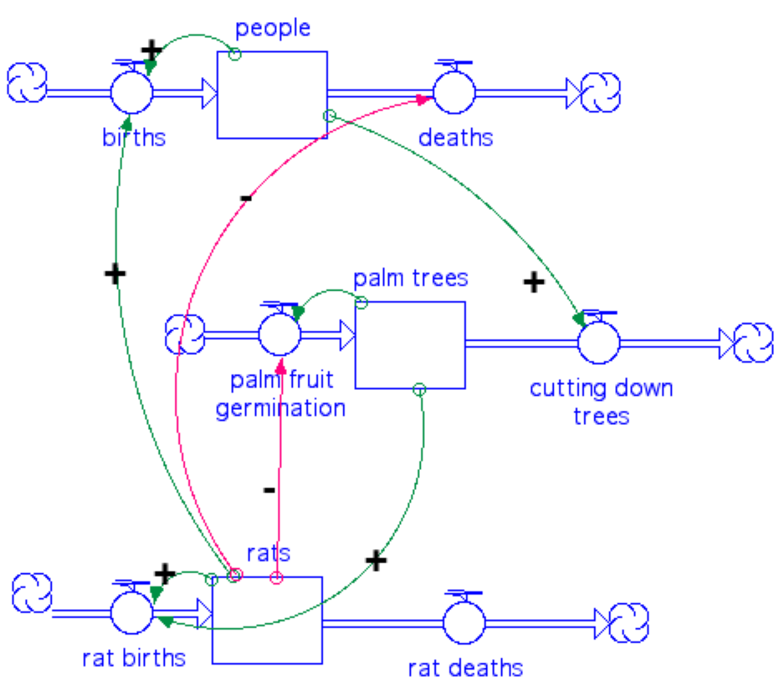

Figure 6-17. The rat submodel interacts with both humans and trees.

According to the historical record, as the human population grew, people cut more and more trees. They needed these trees for making boats for fishing and they needed more and more land for cultivation. Over harvesting trees, just on its own would have been a problem for them, but this was exacerbated by the fact that they also ate rats, and rats depended on the trees for food. As the human population continued to grow, they cut enough trees such that they ran out of trees to use for fishing. Simultaneously, with fewer trees they not only couldn't fish effectively but the other food source, rats, declined.

The model built here only represents a few of the interactions that have been described. By putting these into a systems diagram, we can explore the possible behaviors of the individual populations and their effect on each other. It is possible that the population could have also reached a balance. There is nothing inherent in the structure of these relationships that makes it crash. However, the balance comes about because all of the relatively rapid rates of all the processes are cancelling each other out, but a minor imbalance in the rates can lead to abrupt changes in the whole system.

Some narratives of Easter Island decline blame the population for their resource use strategies. For example in the book "Collapse" (2005), Jared Diamond wonders what the person who cut down the last palm tree was thinking. Even this simple model shows that there were multiple factors in play and the path toward a downward spiral of trees could have been set in motion when there were still many trees. This should be a cautionary tale for working with real and complex systems, i.e. the controls may have delays and multiple factors that make them very difficult for a person in the ecosystem and society to observe. It's not just a matter of taking the right action for the moment, but also being able to understand the more complex interactions and consequences of our actions.