Your ECOLOGICAL *footprint*

The Footprint of the *Moai*

An ecological footprint can be used to assess the use of environmental goods and services that are associated with any human activity. The footprint of the *moai* on Easter Island quantifies how this religious and political institution affected the island's environment.

Measuring the footprint of a statue begins with asking what it takes to produce and transport a huge piece of stone weighing as much as 80 metric tons over rough terrain with nothing but human muscle power (Figure 1). The answer is a lot of energy! But in this case it wasn't fossil fuel energy, but the food energy consumed by the people who carved, moved, and erected the statues. Most of the food came from the land, so the footprint of the *moai* can be measured by the area of productive agricultural land that was used to support the human labor that carved, transported, and erected the statues. Let's look at the transportation part in more detail.

The statues were carved from a volcanic tuff in a quarry in the Rano Raraku crater, and they were transported to various sites on the island. A typical statue stands 4 meters tall and weights about 12.5 metric tons, although many statues are much smaller or larger. There are many theories about how the statues were moved from the quarry to their coastal sites. Archaeologist Jo Anne van Tilburg and her colleagues used a combination of archaeological and anthropological information about Polynesian culture and modern computer techniques to reconstruct a likely explanation. They suggest that most statues were moved with a system of wooden rollers. Palms and other tree species provided the wood for the track roller system. Various other plants were harvested to provide the cords and ropes used to lash and haul the statues. One concerted pull would have moved the statue about five meters. This pulling activity was followed by pauses to move the rollers, tighten the lashes, and so on.

Given the arduous and time-consuming nature of the task, van Tilburg and her colleagues asked how the islanders would choose a path from the quarry to the site where a statue was to be erected. They picked a likely typical transport path from the Rano Raraku quarry to a site on the eastern coast, a distance of about 10 kilometers. They used a three-dimensional computer map of the island's terrain to simulate the time and effort associated with alternative routes. The islanders probably picked a route that minimized total energy expenditure. Computer simulations suggested that the optimal route was the shortest one (10.1 km) because even though it required the most people (seventy), it took the shortest amount of time (about five days) and thus used the least energy.

The islanders lived in large extended families of forty-five to fifty people. Virtually every member provided some form of productive labor to the island economy. About eight males of appropriate age and strength per extended family would have been available to participate in the *moai* transport. Thus the seventy males who worked on the transport were supported by nearly nine extended families (between 391 and 435 people) who would have had to join forces to provide food for the workers as they hauled the statue over the 10 km path.

How much food was required? The average man who helped transport the *moai* required about 2,880 kcals of food energy per day. Of that, 500 to 600 kcals of protein would have been required to maintain muscle and other body tissue expended in the work task. Archeological data indicate the protein came primarily from rats, fish, and to a lesser extent chickens. The remaining 2,200 kcals were carbohydrates supplied by two staple island crops: 1,000 grams of sweet potato and about 500 grams of banana.

FIGURE 1 ***Raising*** **Moai** *Archaeologists reenacting the transportation and raising of a* moai *statue.*

The seventy men moving the *moai* would have collectively required about 201,600 kcals per day. The average sweet potato yield was 7,200,000–14,820,000 kcals per hectare (3,000,000–6,000,000 kcals per acre), while banana cultivation yielded 6,916,000–13,832,000 kcals per hectare (2,800,000–5,600,000 calories per acre). Thus between 0.6 and 1.2 hectares (1.5–3.0 acres) of cultivated sweet potatoes and 0.65–1.3 hectares (1.6–3.2 acres) of cultivated bananas would have been required to support the workers. But cultivation on the island typically involved a fallow period in which a plot of land cultivated in one year would remain uncultivated the next year to allow soil fertility to recover. As a result, the total number of hectares required to produce a continuous crop would have to be roughly doubled to between 1.2 and 2.4 hectares (3–6 acres).

But the footprint of the *moai* did not stop there. The chief who had commissioned the transport task also needed a reserve supply of stored food to trade for the animal protein. In addition, the chief needed food of all types to host various social and ritual obligations inevitably associated with the project. Thus the chief required food to hire the carvers, feed the workers and their support network (extended families), trade for protein-rich foods, and "feed the gods" as well. Van Tilburg estimates that the total footprint of the *moai* transport task was about 20 hectares (50 acres) of productive land.

STUDENT LEARNING OUTCOME

- Students will be able to describe how it was possible to move massive statues long distances without the assistance of large animals or machines.