

## Chapter 1: Introduction

Human-induced environmental change is an issue of international concern. The effects of large-scale changes such as deforestation and global warming are topics of media headlines (Goudie 1986). Environmental change resulting from human activities, however, is not unique to the modern era (Jacobsen and Firor 1993). Archaeological data demonstrate that people have been modifying their surroundings for thousands of years. The interactions between people and their environment range from relatively benign to the extreme of landscape degradation and extinction. The more significant anthropogenic changes to the environment are better documented from prehistoric contexts around the world because they are more easily recognized in the archaeological record (Dewar 1984; Kohler 1992; Lamb *et al.* 1991; MacPhee and Burney 1991; Steadman 1995; Van Andel *et al.* 1990). These studies document, among other things, how human actions have affected prey abundances. Very few investigations, however, have examined the repercussions of these changing faunal abundances on human subsistence (see Linares 1976 for an exception).

Research in Polynesia has also tended to examine paleoenvironmental change resulting from human colonization and the post-colonization adaptive changes in human subsistence as two separate events (see Kirch and Hunt 1997 for exceptions). These two aspects of change, however, are intimately linked to one another. Thus, in this dissertation, my approach is to examine both as part of a dynamic system.

### Faunal Depletion in Polynesia

The extirpation or extinction of native species after human colonization is a common theme across Polynesia (Cassels 1984; Kirch 1984; Olson and James 1984; Steadman

1989, 1995). Prior to the arrival of humans, the terrestrial vertebrate fauna of Polynesia consisted mainly of birds and a few reptiles. Although marine mammals were found in some areas, the only terrestrial mammals that were able to colonize the region were bats. With the arrival of humans, native vertebrates were subjected to both massive habitat alterations and introduced predators. Among the new predators were dogs and rats, who preyed on smaller native animals, as well as on the eggs and nestlings of birds (Fleming 1969). Humans, however, were the most significant new predator on Polynesian islands. The abundance of bird and marine turtle remains in many early Polynesian archaeological middens attests to the efficiency with which humans exploited these resources (Dye and Steadman 1990; Kirch 1973; Kirch *et al.* 1992; Kirch and Yen 1982).

Polynesian faunas were also indirectly affected by humans through environmental changes that occurred as people modified and destroyed habitats through deforestation and fire (Christensen and Kirch 1981, 1986; Kirch 1982, 1983; Kirch *et al.* 1992; McGlone 1983). Forest clearing not only reduced critical habitat, but the resultant erosion also led to increased sedimentation into waterways and along shorelines, and in some cases, caused the infilling of bays (Athens and Ward 1993; Kirch 1985; Kirch and Kelly 1975; Spriggs 1986). Sedimentation into these bodies of water, in turn, altered the distributions of resident marine and estuarine species (Allen 1992; Best 1984; Green 1976).

The effects of predation and habitat alteration on the native fauna varied. In some cases, the range of a species was drastically reduced, becoming restricted to areas that allowed only limited access by humans (Cassels 1984; Olson & James 1982). In other cases, human predation appears to have reduced the average size of molluscan

populations through the consistent harvesting of larger individuals (Green 1976; Kirch and Yen 1982; Kirch *et al.* 1992; Poulsen 1968).

The most dramatic effect of human impact on native faunas, however, was extinction, the magnitude of which is best known for birds (Olson and James 1982, 1984; Steadman 1989, 1995, 1997; Steadman *et al.* 1990). Based on the number of new species identified from prehistoric contexts that were extinct by the time of Western contact, Steadman (1989, 1995) estimates that over half of the bird species of Polynesia were lost after human colonization. Typically, the birds that became extinct were large, flightless, and/or ground-nesting species that were highly susceptible to both predation and environmental change (Cassels 1984).

The high extinction rate of island species is due to a combination of the high level of endemism, the small population size on islands relative to mainland populations, and the lack of experience with predators (Fosberg 1963). Since many species were endemic to a particular island or an archipelago, once their population size began to decline as a result of human presence, there was little chance of replacement from “mainland” sources (MacArthur and Wilson 1964). In addition, prior to Polynesian colonization, native species had few predators with which to contend. Indeed, these species are often described as “naive” because of their lack of experience with or knowledge of predators (Diamond 1989:232). With predation pressure low, many bird species evolved traits such as flightlessness that would later make them vulnerable to introduced predators.

As in the rest of Polynesia, the arrival of humans in New Zealand marked the beginning of tremendous changes for both plants and animals. Deforestation and increased erosion, and the introduction of predators led to significant habitat reduction and numerous extinctions (Anderson 1997; Anderson and McGlone 1992; Atkinson and

Cameron 1993). By the historic period, many taxa were found only on offshore islands or remote areas of New Zealand that were relatively predator-free. In addition, over thirty species of birds became extinct, of which the vast majority were ground-nesting and/or flightless (Anderson and McGlone 1992; Cassels 1984).

Two taxa that were particularly common in early archaeological middens were moas and seals. Moas are the best known casualty of the arrival of humans in New Zealand (Anderson 1984, 1989a, 1989b; Trotter and McCulloch 1984; Worthy 1990). Endemic to New Zealand, moas became extinct some 300 to 500 years after Polynesian colonization. As large, flightless, ground-nesting birds, moas epitomize the kind of birds that are most vulnerable to extinction (Cassels 1984). Although habitat alteration was surely a factor, the abundance of moa remains in early period middens suggests that human predation was also a major contributor to moa extinction (Anderson 1984, 1989b; McCulloch and Trotter 1984). While the role of prehistoric human predation in faunal extinctions is still being debated in other areas of the world, moas also provide one of the very few solid cases of prehistoric extinction that can be attributed, at least in part, to human predation (Anderson 1989a, 1989b, Cassels 1984; Grayson 1984a).

Like moas, seal remains are abundant in New Zealand's archaeological middens. There are four pinniped species that can be found along the coast. The most common both prehistorically and today is the New Zealand fur seal (*Arctocephalus forsteri*), the only pinniped species to have had breeding colonies on New Zealand shores. Smith (1985) found that fur seal distributions had constricted significantly during prehistory. They were once found throughout coastal New Zealand, but by European contact they were confined to the South Island's remote south and west coasts.

The impact of the depletion of native vertebrates on human subsistence is likely to have differed significantly between tropical Polynesia and New Zealand because of the kinds of available alternative resources. In the tropical regions of Polynesia, a wide variety of resources were available to human populations. Many islands had extensive reef systems, that, although impacted by humans, remained a rich source of fish and shellfish. Most importantly, the colonists of tropical Polynesia were able to rely on domesticated animals (pigs, dogs, and chickens) and a suite of horticultural crops (e.g., taro, yams, sweet potatoes, breadfruit) that they brought with them from their homeland. Polynesian islands contained few edible plants; thus, domesticated plants were particularly important to Polynesian subsistence.

New Zealand differs markedly from any other archipelago colonized by the Polynesians. Located at temperate latitudes, the environments of New Zealand ranged from coastal forests to alpine fjords. In this new environment, the traditional Polynesian subsistence pattern was transformed mainly because a range of resources that were important components of subsistence were no longer available. For example, New Zealand marine environments, as in most temperate regions, are relatively poor in fish resources compared to tropical reef systems. The most significant change, however, was the loss of many of the important tropical root and tree crops that were at their geographic limits in this temperate region (Anderson and McGlone 1992). Although a few of the crops could be cultivated seasonally in northern New Zealand, they could not be grown at all in the southern third of the country (Figure 1.1). In addition, only one of the Polynesian domesticates, the dog, became established in New Zealand. As a result, the subsistence economy in the south was based on foraging, including fishing, shellfish harvesting, and the hunting of marine mammals, moas and other birds. With fewer

alternative resources available in New Zealand as compared with most of Polynesia, the loss of 'wild' fauna, such as moas and seals, is likely to have had far more significant consequences for Maori foragers.

### **Explanations of Prehistoric Subsistence Change in New Zealand**

The changes in subsistence resulting from faunal depletion in New Zealand were first described by the 19th century scholar, Julius von Haast. Haast (1874) noted that archaeologically, the conspicuous remains of moas in early midden deposits were often overlain with deposits that were dominated by fish and shellfish. To explain this pattern, Haast (1872, 1874) proposed a two phase chronology for New Zealand that paralleled chronologies developed for Europe. He argued that an earlier Paleolithic peoples with crude tools who hunted the moa to extinction just as prehistoric European ancestors had done with the mammoths. These "Moa-Hunters" were later replaced by or subsumed under another migration of people, the Neolithic Maori, whom Haast characterized as 'shellfish eaters' (Haast 1874:98). In essence, moa and shellfish were simply traits used to distinguish the Moa Hunters from the Maori.

Although many aspects of Haast's chronology have been abandoned, New Zealand prehistory has continued to be dichotomized into an early moa-hunting peoples and the later Maori (Davidson 1984). Subsistence studies, in particular, have examined subsistence in terms of two periods of time: moa-hunting and post-moa subsistence (Anderson 1982, 1983). In this view, "big-game" hunting of moas and seals was prominent during early times; after these resources were depleted, the focus shifted to fish, small birds, and shellfish (Anderson 1982, Anderson and Smith 1996c, 1996d). Research on this apparently sudden shift from moa hunting to post-moa subsistence

patterns has been at a relatively large scale and generally descriptive because many subsistence studies has focused on reconstructing diet through the use of meat weights.

The emphasis on using meat weights to reconstruct diet can be traced to Wilfred Shawcross. As a means to document the level of energy capture, Shawcross (1972) converted bone counts to meat weight measurements in his analysis of faunal data from the North Island archaeological sites. Counts of bones were inappropriate for determining the relative contribution of each taxon because the unit of measurement for the amount of energy capture was the individual. The caloric returns per individual varied across taxa. Larger animals like moas and seals obviously provided much more in the way of energetic returns per individual than small taxa such as fish or shellfish. To correct for these differences in returns, the minimum number of individuals (MNI) per taxon was multiplied by the expected returns of that taxon, in terms of meat weight, to obtain the energy gains represented by that taxon, and eventually for the assemblage as a whole. Once the energy gains for the assemblage were reconstructed, the number of people supported at the site could then be estimated.

Shawcross' goal (1972) in the use of meat weights was to understand subsistence in terms of the laws of thermodynamics or energy capture. The more energy captured, the greater the carrying capacity at the site, and ultimately, the more elaborate the public works or material culture could be. The use of meat weights continues to be used in subsistence studies in New Zealand; however, the theoretical underpinnings that were the impetus for its use have largely been abandoned. Instead, meat weights are simply used to reconstruct population size and the relative contribution of particular taxa to the diet (e.g., Anderson and Smith 1996c).

In addition to the emphasis on diet reconstruction, detailed analyses of subsistence change in southern New Zealand have been constrained by the small samples of faunal material recovered and the low number of well-stratified deposits. Often a site may only consist of two or three strata, making it difficult to examine dietary change over time within that site. In such situations, the entire assemblage from a site is usually treated as a single unit or datum point that represents a period such as “late Archaic” or “early Classic”. The data points from different sites are then compared regionally (Anderson 1982). However, because the data are aggregated by site, much of the variability in the data is lost. Thus, changes in subsistence can only be described broadly, such as the shift from moas and seals to fish and shellfish. While these types of analyses have described the overall pattern of subsistence change in New Zealand, questions about the mechanisms and timing of that change remain unanswered.

In this dissertation, I attempt to provide a more detailed understanding of how prehistoric human subsistence changed in southern New Zealand as human foragers altered their environment and depleted their resource base. To accomplish this, I use a theoretical perspective that is designed to study temporal change, and measure the expected changes within one well-stratified, well-dated site.

Foraging theory models are similar to the ecological models used by Shawcross (1972) in that both examine changes in terms of energy capture. However, as will be discussed in Chapter 2, foraging theory models derived from evolutionary ecology were developed specifically to provide explanations about subsistence behavior in relation to evolutionary fitness (Stephens and Krebs 1986). Thus, the goal is not the reconstruction of diet, but its explanation in terms of evolutionary success.

These models were designed for application in an ecological time frame. Recent studies have shown that these models can also be applied to archaeological contexts to understand subsistence change over a larger time scale (e.g., Broughton 1999; Simms 1987). The value of these models for the New Zealand situation is that they can be used to generate predictions about changes in subsistence that are linked with declines in faunal abundances, particularly those that are due to human foraging.

In addition to taking a different theoretical approach, this study will attempt to gain a more fine-grained assessment of subsistence change in southern New Zealand by examining variability in diet within a shorter time frame. Studying changes in faunal data from different strata within a site can better track how resource use changes as the abundances of important taxa decline. As discussed above, this approach requires a large sample of faunal material from a well-stratified site. The well-dated, deeply stratified sequence at the Shag River Mouth site provides an opportunity to examine subsistence change at a single locality. With over 30 radiocarbon dates taken from eleven strata of deposition, and a faunal assemblage of over 25,000 specimens, the Shag Mouth site is perfectly suited for such an analysis.

In sum, this analysis differs from previous research in that it uses foraging theory to generate expectations about subsistence change resulting from the decline in the abundance of important resources such as moas and seals. In particular, these predictions examine changes in the number and types of resources that are used, the habitats exploited, and the treatment of individual prey items. The expectations are tested using the large dataset from the well-stratified and well-dated Shag River Mouth site.

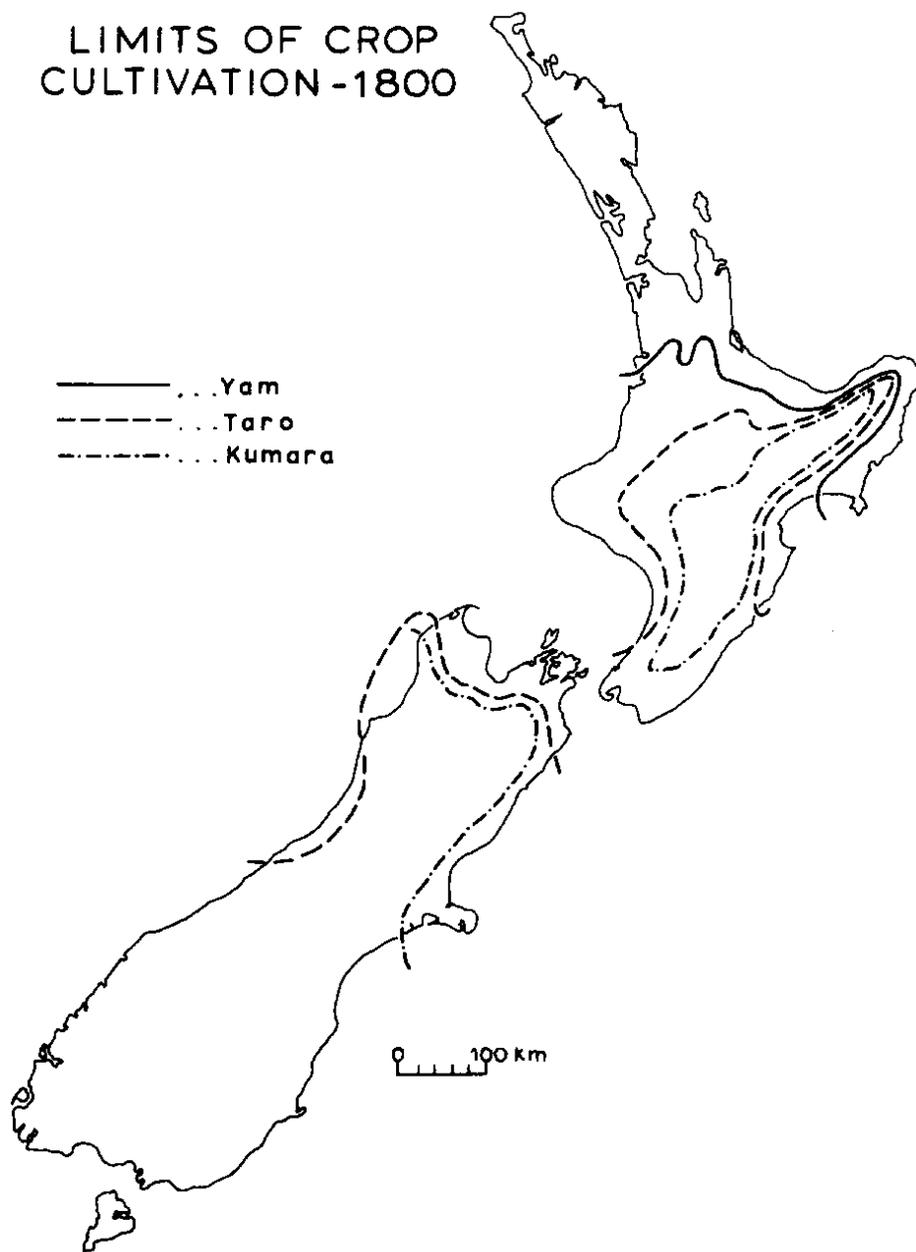


Figure 1.1. The limits of root crop cultivation in New Zealand (from Anderson 1977).