

Domesticated Landscapes: The Subsistence Ecology of Plant and Animal Domestication

John Edward Terrell,^{1,2} John P. Hart,¹ Sibel Barut,¹ Nicoletta Cellinese,¹ Antonio Curet,¹ Tim Denham,¹ Chapurukha M. Kusimba,¹ Kyle Latinis,¹ Rahul Oka,¹ Joel Palka,¹ Mary E. D. Pohl,¹ Kevin O. Pope,¹ Patrick Ryan Williams,¹ Helen Haines,¹ and John E. Staller^{1,3}

Harvesting different species as foods or raw materials calls for differing skills depending on the species being harvested and the circumstances under which they are being taken. In some situations and for some species, the tactics used are mainly behavioral—that is, people adjust, or adapt, their own actions to fit the behavior and circumstances of the species they are taking. Under other circumstances and for other species, the skills and tactics used may call for greater environmental preparation or manipulation. Therefore, instead of trying to distinguish people today and in the past as either “foragers” or “farmers,” it makes sense to define human subsistence behavior as an interactive matrix of species and harvesting tactics, that is, as a provisions spreadsheet.

KEY WORDS: ecology; landscapes; foraging; farming.

INTRODUCTION

One of the most enduring ideas about prehistory is the belief that things long ago were not only different but that they were also—if we go back far enough in time—the opposite of what they now are. This commonplace thought bolsters

¹Department of Anthropology, The Field Museum, Chicago, Illinois.

²To whom correspondence should be addressed at Department of Anthropology, The Field Museum, 1400 South Lake Shore Drive, Chicago, Illinois 60605; e-mail: terrell@fieldmuseum.org.

³A note on authorship. Writing this paper began with conversations between Hart and Terrell about Aristotle's *natural state model*; after writing a partial first draft, Terrell then invited Barut, Cellinese, Curet, Denham, Kusimba, Latinis, Oka, Palka, Pohl, Pope, and Williams to participate in an e-seminar (via e-mail) to critique this draft, strengthen the thesis being advanced, and contribute short case studies; towards the end of the seminar, Haines and Staller joined as the “discussants” of our penultimate draft prior to journal submission.

the continuing search in archaeology for the origins of things, for discovering the place, time, and reason behind the transformation of ancient ape into *Homo sapiens*, primitive horde into complex society, wild forager into good farmer. Some say that of these quests, looking for the origins of domestication and agriculture is paramount, since “the transition from hunting-and-gathering to agriculture is arguably the most important event in human prehistory, representing a shift from foraging to farming, from food collection to food production, from wild to domestic, that sets the stage for most of the significant subsequent developments in human society” (Price, 2000, p. 1).

Perhaps, but the thought that once upon a time how people lived was so different that nobody then knew about domestication and farming is not the only possible way of thinking about what it was like to be truly prehistoric. As Harris (1996a) commented, there is little doubt that much of the most powerful and insightful work done in archaeology during the twentieth century was dedicated to tracking the origins of plant and animal domestication and charting the impact of husbandry and cultivation on what happened in the past (Richerson *et al.*, 2001). Nevertheless, this mission was and is much debated. When examined carefully, scientists have learned that foraging, long considered to be the opposite of farming, was and is not always as different as commonly thought (e.g., Hynes and Chase, 1982); farming, too, is a loose term that covers a diverse range of human behaviors and relationships with other species (Bailey and Headland, 1991, pp. 265–267; Brosius, 1991, pp. 130–134; Harlan, 1992; Harris, 1996a; Hutterer, 1983, pp. 172–274; Kent, 1992; Posey, 1984; Smith, 2001; Winterhalder, 2001; Winterhalder and Goland, 1997). Nobody questions that modern mechanized agribusiness is different from whatever it was that people once did to earn a living thousands of years (or even just decades) ago. Yet many nowadays agree that foraging and farming may not be as far apart as once thought, and what many people in the past did to put food on the table may have been intermediate between these two seemingly contrary extremes.

We are not convinced, however, that the current willingness in archaeology to grapple directly with the diversity of our species’ subsistence practices now and in the past has gone far enough. While less categorical, today’s ways of thinking about human subsistence strategies still lead to a strongly linear perspective on what many now freely concede is a complex and many-sided issue. Furthermore, the agenda for archaeology suggested by today’s more nuanced ways of talking about subsistence variation seems little changed from the agenda that many scholars followed when the older, more rigidly categorical views were in vogue.⁴ It may

⁴Even the late archaeologist David Rindos, who argued forcefully against “centers of origin” models of domestication and agriculture in his book, *The Origins of Agriculture* (1984, pp. 82–85), wrote about the “growing human control over the physical and biotic environment” during “the history of agricultural systems from their beginnings” as creating “a new niche for plants in the world’s ecology” (1984, pp. 142–143), and saw “the very essence of agriculture” to be a “new system by means of which people related to their immediate environment” (1984, p. 18), “a type of animal–plant relationship”

now seem more challenging to say when people should be called foragers rather than farmers—and it may now seem vital to learn more about how some societies have cultivated “in-between,” or “transitional,” ways of life—but left basically unchanged and unquestioned is the old idea that archaeologists should pin down when and where some of the earth’s ancient inhabitants finally stopped behaving like foragers long enough and successfully enough that the fortunate archaeologist who discovers their remains can label them posthumously as “the world’s first farmers.”

We think this research agenda is outdated not only because many now accept that knowing how to forage may not be categorically different from knowing how to farm. Nor because it is widely acknowledged nowadays that our species has domesticated not only particular species of plants and animals, but also landscapes—a term that we take to mean not only certain places, or types of places such as estuaries, coastal plains, and tropical forests, but also the “species pool,” or range of species inhabiting such places. We consider this agenda to be obsolete also because, as we will argue here,

1. domestication should be measured more by its conduct than by its consequences;
2. any species or place may be called domesticated whenever another species knows how to harvest it; and
3. how human beings domesticate a species varies depending on the species in question, and on how much of that species they want to harvest.

From a conventional perspective, calling a species domesticated usually implies that it has been more or less permanently modified—morphologically or genetically, intentionally or unintentionally—in recognizable ways by human selection and harvesting; from the perspective being proposed here, calling a species domesticated need only imply that there is reason to think that people in one or more places are (or were) repeatedly able to exploit it. Whether the species in question has been significantly modified by human manipulation and harvesting (possibly even to the degree that it has lost the ability to survive on its own) is not a necessary stipulation. Hence finding that a species has been domesticated (as defined here) in one locale need not imply that elsewhere within its geographic range, people were also exploiting it in similar ways, to a similar degree, and for similar reasons. In other words, except perhaps in the case of species that have

that evolved into a highly developed form of symbiosis (1984, pp. 100–101) which “permitted new directions in plant evolution to emerge” (1984, p. 142). “Changes in human behavior and the effect they have on the environment and thus for further domestication underlie the origin of agriculture” (1984, p. 101). “Human interaction with plants introduces a new dimension into the evolution of plants and may ultimately have far-reaching effects upon human subsistence patterns” (1984, p. 138). “Through their dispersal activities, domesticatory humans created a new niche for plants in the world’s ecology” (1984, p. 143).

evolved to become permanently dependent on human intervention for their reproductive success, species in and of themselves are neither inherently “wild” nor “domesticated.”

Given this inclusive understanding of domestication, it is clear to us that species (and places) do not have to be morphologically or genetically altered or distorted in some clearly discernible way before they may be called domesticated. Even if it is true that certain observable alterations in morphology and genetics may sometimes be taken by archaeologists and others as *signs of domestication*, concluding that *only* plants, animals, and places exhibiting plainly detectable signs of use may be labeled “domesticated” risks greatly underestimating the generality and force of domestication in the world around us.⁵

The task we have set ourselves here is fourfold. First, we review why archaeologists and others today still debate the origins of domestication and agriculture even though the diversity of human subsistence practices, ancient and modern, is now recognized and widely acknowledged. Second, we explain why we have concluded that domestication can be measured more effectively by its *performance*—by the skills characterizing it—than by its *consequences*, that is, by the morphological and genetic changes in particular species that these skills may or may not lead to. Third, we offer several brief case studies drawn from around the world illustrating how it is not only species but also landscapes that are domesticated. Finally, we offer the “provisions spreadsheet” as a tool for charting and comparing subsistence practices on different landscapes and at different times.

DEBATING DOMESTICATION

Scholars of an older generation talked about plant and animal domestication and the origins of agriculture as the “Neolithic Revolution.” Nowadays many would agree that our growing dependence on certain plants and animals was a very gradual affair (Price and Gebauer, 1995, p. 7) “clustered so significantly between 10,000 and 5,000 B.C.” (Flannery, 1986c, p. 15). Yet we think the underlying premise has remained largely unchanged. The domestication of plants and animals and the development of agriculture are still seen by many as revolutionary transitions in the history of our species, regardless how fast or slow their pace

⁵Finding an unusual pattern of morphological or genetic variation within a species population may be a sign of intentional (e.g., Cleveland, 2001; Soleri *et al.*, 2000) or unintentional (Rindos, 1984, pp. 138–139, 154–158) human manipulation (selection), but not finding signs of domestication defined in this manner does not necessarily mean that species that appear to be only “wild types” are unimportant in the human diet (e.g., the sago palm, *Metroxylon* spp.); furthermore, there is unfortunately no necessary correlation between how modified morphologically or genetically a species population is and how vital a role it plays in human subsistence (e.g., the tomato, *Lycopersicon esculentum*, which is widely grown, much consumed, and comes in thousands of varieties, yet remains a garnish rather than a staple).

(compare Harris, 1996a, and White, 1959). This premise is debatable for all the reasons that journalists and historians traditionally ask questions.

Who, where, and when. It is still customary to write about certain parts of the globe as “cradles” or “primary centers” of domestication (Denham *et al.*, 2003; Harris, 1996a, pp. 5–7; Pope *et al.*, 2001; Richerson *et al.*, 2001). It may be true that the ancestors of many of today’s most important foods once lived in only a few places on earth, but to focus on only these foods obscures the equally undeniable fact that over many millennia, people have moved thousands of species of plants and animals from place to place around the globe (Rindos, 1984, pp. 281, 284); and as Watson (1995, p. 35) has said, “at present we have only the haziest understanding of how many pristine transitions to agriculture there may have been.” Whether to call the “native soil” of each of these species or varieties a “cradle of domestication” may depend in large measure on how impressed people are with the current economic importance (Ladizinsky, 1998, pp. 51–60) of the plant or animal in question.⁶

What. There is little agreement today on the best constituent definitions of foraging and farming as distinct states or stages of human subsistence life (e.g., Brosius, 1991; Harris, 1989, 1996a; Hayden, 1995; Keeley, 1995; Posey, 1984). Without reasonable agreement on what these words mean (Bailey and Headland, 1991, p. 266), there would seem to be no reliable way to sort people and societies into one or the other of these two categories—or to array them in a sensible way along a continuum between these two seemingly dichotomous end states (Smith, 2001, p. 27).

With this need in mind, Bruce Smith has recommended that domestication itself may be the best diagnostic marker to use to distinguish between the two:

Domestication, I would argue, is the single most important and most dominant feature on this landscape that stretches between hunting–gathering and agriculture. It is important not only because it marks a major threshold in human history, but also because it is a clear and constant vantage point and point of reference . . . [that] towers over the countryside, providing a solid platform from which one can view, in the distance, hunting-and-gathering in one direction and agriculture in the other, and which at the same time is clearly visible across considerable space and time. (Smith, 2001, p. 14)

Commonly acknowledged archaeologically visible signs that a particular kind of plant or animal has been domesticated are, for plants, increasing seed size over time, and for animals, decreasing bone size.

Unfortunately, from an archaeologist’s point of view, such readily identifiable morphological changes are less common than they ideally should be (Smith, 2001, pp. 16–17), and it can be difficult to document the history of such physical signs successfully (e.g., Staller, 2003; Staller and Thompson, 2002). Furthermore, it is widely agreed that it takes time for morphological changes to become apparent in

⁶In this regard, perhaps it is wise to remember that the word “economic” originally pertained to “household management.”

the archaeological record. Such signs may only begin to show up well after the human practices nurturing them had begun (Pearsall, 1995, p. 159).

How. Thus it is not easy to share Smith's assessment that the presence of domesticates is the best way to differentiate between foraging and farming. Now that it is widely acknowledged that "plants were important in human subsistence prior to the transition to agriculture" and "the shift to dependence on the cultivation of fully domesticated plants [and animals] was a very gradual process" (Price and Gebauer, 1995, p. 7), what distinguishes domesticated plants and animals from their "wild cousins" (Smith, 2001, p. 11), as we have just said, is not always self-evident (Ladizinsky, 1998, pp. 6–8; Pearsall, 1995). We agree instead with Smith's (1995, p. 208) earlier observation that "explanatory frameworks for domestication need to be tailored to the environments, plant and animal species, and developmental sequences of the particular areas under study." We do not agree that domesticates are "above all, a purely human creation" (below) or that "domestication" is a term that only applies to target species that human societies have changed genetically to the degree that "domesticates are no longer viable without continued human protection and care" (Smith, 2001, p. 16; see also Harlan, 1992; Rindos, 1984). Furthermore, even when the plants that people grow in gardens and fields, for instance, are genetically different from uncultivated specimens:

the recognition of domesticates and cultigens can be especially difficult, if not impossible, if the resources are in a semi-domesticated state—that is, tamed or under some form of management more intensive than hunting-and-gathering, and yet before such husbandry practices result in a morphological change in the animals and plants by which their domestic status can be identified. (Zvelebil and Lillie, 2000, p. 59)

Therefore, the thought that domesticates can serve as clear and constant reference points on the human subsistence landscape would seem as problematic as the opposite notion that there really are somewhere "out there in nature" genomic configurations that can be identified as "wild types"—which is a classic example of Aristotelian thinking in the biological sciences.⁷

Why. Smith remarks that societies differing in their reliance on domesticated species "should not be seen simply as reference points on the way to agriculture, as roadside markers of progress, but rather as stable solutions, as end points and destinations worthy of study in and of themselves" (Smith, 2001, p. 24). Nonetheless, many—maybe most—archaeologists may be interested in domestication and agriculture because they see "the transition from hunting-and-gathering to an agricultural way of life . . . as a major turning point in human history" (2001, p. 1). In other words, archaeological interest in subsistence often appears to be linked with ideas about human progress and cultural evolution that are rooted in eighteenth-century social thought (see Stocking, 2001, pp. 17, 265–280). Not all

⁷ As these two definitions from a standard biological dictionary illustrate: "*wild type* —the most frequently observed phenotype, or the one arbitrarily designated as "normal"; *wild-type gene* —the allele commonly found in nature or arbitrarily designated as 'normal'" (King and Stanfield, 1997, p. 363).

archaeologists, however, look favorably on these traditional ideas (Hart and Terrell, 2002).

Therefore, now that archaeologists and other social scientists commonly acknowledge that human subsistence practices around the globe are and were more variable than the labels “foragers” and “farmers” conventionally imply, there is need for conceptual tools for exploring the archaeology of human subsistence that are not tied to old ways of carving up humankind’s diversity, putting the pieces into different boxes labeled “foragers” and “farmers,” and then searching for the time, the place, and the reason some ancient societies shifted from one of these boxes to the other (Smith, 2001, pp. 6–14). Instead of seeing domestication and the development of agriculture as an event, a transition, or a turning point—or perhaps not even as a continuum (Bailey and Headland, 1991, p. 266)—we think archaeologists need to be able to study subsistence skills *without* first having to decide (borrowing words from Smith, 2001),

1. “what exactly distinguishes domesticated plants and animals from their wild cousins, and from entities and interactions that exist in a not-wild, yet not-domesticated realm between wild and domesticated” (2001, p. 11);
2. how “strongly dependent on domesticated species as food sources” (2001, p. 9) people were in the past; and
3. how consciously or willfully prehistoric people intervened “in the life cycle of plants and animals” (2001, p. 6; see Rindos, 1984, p. 143).

Or even without necessarily having to accept that “domesticated species are a prerequisite for, a necessary first step toward, agriculture” (2001, p. 23; see also Rindos, 1984, p. 139). Furthermore we think the answer to the riddle of domestication will not be found if archaeologists only study the relatively few species that have been physically transformed in readily observable ways by human planting, harvesting, or predation over countless human generations. To understand domestication, what must be taken into account is not only the story of particular species, but also the whole range of species—the species pool—from which transformed species have been drawn, for it is not just singular species but landscapes that human beings have been domesticating since the dawn of human time.

DOMESTICATED LANDSCAPES

Although rooted in art rather than in science, there is nothing new about using the word *landscape* in the social and biological sciences, and at the moment, talking about landscapes seems to be enjoying renewed popularity (e.g., Bayliss-Smith and Golson, 1999; Doolittle, 2000; Fisher and Thurston, 1999; Gosden and Head, 1999; Gremillion, 1997; Johnson, 2000; Junker, 1996; Kirch and Hunt, 1997; Urban and Keitt, 2001). Nowadays, for instance, ecologists see broadly focused

“landscape ecology” as firmly based in general ecological and evolutionary theory (e.g., Lomolino and Perault, 2001), and the gathering and analysis of landscape data are likely to be early steps in most habitat conservation planning.

In ecology, there are many ways to design and model landscape studies (Urban and Keitt, 2001), but such investigations can be generally described either as “top-down” or “bottom-up.” In the case of the former, “the relationships of interest are between variables that capture the global properties of a system, e.g. the relationship between the size of a honeybee colony and the number of parasites it contains” (Sumpter and Broomhead, 2001, p. 925). Differential equations are widely used to convey modeling expectations in such cases. Bottom-up modeling starts instead with detailed information about the specific properties and interactions—the “community structure”—of an identifiable species array (or “community matrix”; see Levins, 1975). As Sumpter and Broomhead (2001, p. 925) have said about modeling behavioral interactions between individuals in ecological systems, “by providing insight into the detailed interactions at the local level, bottom-up models allow the validity of the phenomenological assumptions made in global, top-down models to be tested directly.”

While not always explicitly ecological in design and intent, much that has been written about the origins and spread of domestication and agriculture could also be labeled as top-down modeling. Hence Smith’s (2001, p. 6) recent call for “identifying and defining categories of human–plant and human–animal interaction that [can] be considered as the characteristic defining attributes” of human societies might be described as a call for bottom-up modeling instead (see also Winterhalder and Goland, 1997). However labeled, we wholeheartedly agree with Smith that conceptual tools are needed to describe and compare human subsistence practices at different times and places. Before new tools can be developed and put into use, however, archaeologists need to reconsider what it is they are trying to accomplish.

In Harmony With Nature?

According to Smith, what any given society does or did to make a living depends on “the intensity, intentionality, species focus, and total range” of that society’s interventions in the life cycle of plants and animals; “not only the relative level of energy investment but also the casual or inadvertent versus deliberate intent of such actions and the degree to which they are broadly scattered as opposed to focused and sustained, both on particular target species and on particular parcels of land” (Smith 2001, pp. 28–29). This comment resonates closely with Ingold’s (1996) observation that the work people do through activities such as planting, weeding, and so on, does not actually make or produce plants and animals, but only “establishes the environmental conditions for their growth and development.” Hence the difference between foraging and farming “lies in no more than this: the

relative scope of human involvement in establishing the conditions for growth" (Ingold, 1996, p. 21, emphasis in the original).

We think this way of modeling domestication harkens back to the time-honored notion in the social and biological sciences that prior to that day when human beings began to harness the earth, and everyone was merely a hunter-gatherer, our species did not interfere with nature. We lived "in the wild" and "off the land" in balance with the rest of creation. We only reaped; we did not sow.

This established view of preagricultural prehistory has long been championed. Several decades ago, for instance, the cultural evolutionist Leslie White argued that the term *agriculture* is the name used for the "new kind of relationship" that arose when shortages began to disrupt "the old equilibrium of hunting-and-gathering" based on wild foods, and our forebears were forced by circumstance to take greater "cultural control over the lives of plants." White acknowledged that "we have no adequate records of how, when, and where this new type of adjustment became necessary and took place"; it seemed obvious to him, nevertheless, that at certain times and places "the threat of a diminished food supply . . . was met by various measures of cultural control over plant life, which, collectively, we call agriculture" (1959, pp. 284–85). He believed that similar observations can be made also about the origins of animal husbandry (1959, p. 287).

The logic behind this way of thinking about our past as a species is debatable (Harlan, 1992; Rindos, 1984; Winterhalder and Goland, 1997). As White (1959, pp. 283–284) acknowledged:

We know that primitive peoples of modern times, wholly without agriculture, have nevertheless an abundant and accurate knowledge of the flora of their habitats. They know that seeds sprout, that parched plants are revived by rain, that they grow better in some soil than another, etc. No tribe of the modern world, however primitive, is without a vast amount of realistic knowledge and understanding of the nature and behavior of plants in their locality, and we may therefore infer that primitive man, long before the origin of agriculture, possessed like knowledge of his flora. The origin of agriculture was not, therefore, the result of an idea or discovery; the cultivation of plants required no new facts or knowledge.

If so, then White's claim that agriculture was a new kind of relationship that arose in prehistory as a response to growing food shortages might be called a "Lost Eden" hypothesis that overlooks what Charles Darwin taught us. As Ingold (1996, p. 22; emphasis in the original) has said, "both humans and the animals and plants on which they depend for a livelihood must be regarded as fellow participants in the *same* world." What White saw as the old equilibrium of hunting-and-gathering is difficult to reconcile with Darwin's observation that all species—even those "in the wild"—compete with one another for their survival.

Said differently, White's conjecture—and by implication, perhaps also Smith's and Ingold's—that ancient hunter-gatherers lived in harmony with nature fits the conventional wisdom that because ancient foragers were few in numbers, they made few demands that nature could not handle. Because they were also well-attuned to nature, they were able to reap without having to sow. Since they

could reap without sowing, they did not interfere with the normal, or “traditional,” balance of nature.⁸

This familiar argument conforms well to the popular idea that the word *adaptation* means “the good fit of organisms to their environment” (Gould and Lewontin, 1979, p. 592). This way of talking about adaptation, however, can be misleading. As Darwin explained, nature is *not* in stagnant balance. Whether the expression “the struggle for existence” is the best way to describe the give-and-take of nature may be debatable, but Darwin’s message remains clear. Textbooks may say that “organisms are adapted to their environments in that, to survive and reproduce, they must meet their environment’s conditions for existence. Evolutionary adaptation can be defined as conformity between the organism and its environment” (Pianka, 2000, p. 90). But when your survival is at stake, simply conforming to the environment is unlikely to be a wise strategy. In the evolutionary struggles between predators and prey, for instance, neither side can really afford to be passive, for any species that can breach the defenses of another will be strongly favored by natural selection. Or as some have said it more colloquially, “few things promote adaptation faster than the prospect of becoming someone else’s lunch” (Majerus *et al.*, 1996, p. 156; see also Ridley, 1993, pp. 596–601; Van Valen, 1973). Consequently, as John Odling-Smee and his colleagues have observed, it is hardly surprising that—contrary to simple dictionary definitions of *adaptation* —“organisms not only adapt to environments, but in part also construct them” (Odling-Smee *et al.*, 1996, p. 641; see also Terrell, 1986, p. 179).

Knowledge Is Power

The thought that it is a wise strategy to construct as well as adapt to one’s environment should not necessarily be taken to mean that one must always know that what is being done will improve one’s chances of survival, or that everything done with this practical aim in mind works successfully. David Rindos argued forcefully in his book, *The Origins of Agriculture* (Rindos, 1984), that foresight (he himself somewhat confusingly favored the word “intention”) must have had little to do with domestication and the development of agriculture for two major reasons. First, as someone who saw himself as a staunch evolutionist, Rindos judged that “unconscious selection was to Darwin the preeminent force behind the domestication of plants and animals” (1984, p. 11); therefore, explanations giving people too much credit for what happened should be viewed with suspicion. Second, since archaeologists basically do not have direct ways of discovering people’s intentions in the past, it would be unscientific to base inferences about causation on assumptions about human motives and insight that are unverifiable (1984, p. 86; see also 1984, pp. 97–99, 154–166, 258).

⁸For example, see Rindos (1984, pp. 157, 279–280); Flannery (1986c, pp. 16–17); for discussion, see Winterhalder and Smith (2000, pp. 56–57).

In a broad sense, Rindos was undeniably correct that people could not have foreseen that their efforts at making a living might lead one day to such developments as modern hybrid corn (maize) and mechanized dairy farms. It is far more plausible that it was the cumulative effect of individual actions and subsistence choices over many generations—and not long-range planning or clairvoyance—that led to modern irrigated rice paddies, industrial poultry farming, and the like. But on similarly logical grounds, it can also be argued that trying to account for currently popular subsistence practices such as these “after the fact” as the demonstrable consequences of major transitions in our ancient human past risks committing the well-known “fallacy of false cause” (*non causa pro causa*).

Rindos (1984, pp. 97–98) defended his conclusion that “intentionality cannot be considered causative in the development of agriculture” by adding that he did not deny “that people, like other animals, act,” and that neither people nor other animals “would choose a difficult or inefficient mode of subsistence over easier options open to them.” In other words, he did not deny that choice and deliberate action, however motivated, governed domestication and agriculture. His contention then was basically that archaeological explanations must not attribute to people “knowledge that they could not have had” (1984, p. 98)—a conclusion that is a far cry from insisting that only “unconscious selection” governs evolution.⁹

Therefore, seen even from Rindos’ perspective, the keystone of action—and of survival in our less than perfect world—is knowing what might be done at any given moment to survive, and knowing, too, how to do what you finally decide to do. Or as the old saying goes, knowledge is power. If so, and if it is true that hunter-gatherers have and have always had abundant and accurate knowledge of the flora and fauna of the places they inhabit, and that, as White (1959, p. 284) agreed, the “origin of agriculture was not, therefore, the result of an idea or discovery,” then knowing how to hunt and gather is not be so different from knowing how to plant and cultivate. Knowledge of what works effectively in accomplishing all four of these subsistence tasks is power, that is, such knowledge is a way of “controlling,” or “harnessing,” the earth. Put simply, therefore, the “planned intervention in and control over nature” (Ingold 1996, p. 22) that many conventionally associate with the idea of domestication is inherent to foraging as well as farming.

We suspect that the intrinsic commonalities of foraging and farming would be easier to see if the language normally used to describe people as hunter-gatherers or agriculturists went beyond such words as “control” and “intervention,” and included also words such as “understand” and “predict.” Then it might be more

⁹ Although he described the question “why humans began to establish coevolutionary relationships with plants” as “a question without meaning,” Rindos did not rule out “consciousness” altogether, and wrote about what some would call our human cognitive skills as “symbiotic relationships,” “behavioral patterns,” “dispersal relationships,” and the like (e.g., Rindos, 1984, p. 142); at times he acknowledged also that changes in “incidental domesticates” under human use, for instance, could generate “feedbacks that ultimately change the values humans place on the plants on which they feed” (1984, p. 158).

obvious than it evidently now may be that any knowledgeable fly-rod fisherman or Inuit seal hunter has domesticated his or her surroundings—here, trout streams or Arctic shorelines—at least as skillfully as a farmer domesticates the Indiana landscape by turning the sod and planting corn and soy beans (compare Doolittle, 2000, pp. 5–6).

EXAMPLES

To understand and evaluate the historical significance of plant and animal domestication, we think it is wise to step back from archaeology's accustomed ways of debating the issues involved to see human subsistence practices in a broader ecological and evolutionary perspective. Like the nouns "domestication" and "domesticate," the verb "to domesticate" comes from the Latin *domus* ("house"). Dictionaries say this verb means "cause to feel at home; naturalize" (*New Shorter Oxford English Dictionary on Historical Principles*, 3rd ed, revised, 1993). From an ecological and evolutionary perspective, not only species but also habitats and entire landscapes can be called domesticated when the creatures inhabiting them know how to make their living there. The following briefly detailed case studies illustrate how misleading it can be to discount or ignore that neither species nor places must "look domesticated" before they can be significant dimensions of the human diet, and that the true range, or "mix," of species and subsistence skills that people use and have used to make a living around the world cannot be easily pigeonholed into categories as minimal as "foraging" and "farming."

Human Subsistence in the Lowlands of Greater Near Oceania

Whether called "vegeculture" (Hather, 1996), "arboriculture" (Kirch, 1989; Lepofsky, 1992; Yen, 1974), or perhaps both, traditional subsistence practices in many parts of Greater Near Oceania in the Southwest Pacific are difficult to understand if foraging and farming are seen as separate and distinct ways of putting food on the table. In this part of the world that includes both eastern Indonesia and western Melanesia (Terrell, 2002), the word "agriculture" normally connotes subsistence systems based on shifting cultivation (also known as "swiddening" or "slash-and-burn cultivation"), the construction of terraces and permanent field boundaries, and a number of techniques of water control (Weisler, 1999, p. 647). As Therin and colleagues have said, until recently many experts thought that agriculture began in Oceania only a few thousand years ago with the introduction of domesticates and other foreign "Neolithic" traits (notably pigs and pottery-making) from Southeast Asia; today it looks like many, maybe most, of the major food crops cultivated in Oceania are native to Greater Near Oceania, not Asia (Therin *et al.*, 1999, pp. 438–439).

Whatever the real story, seeing agriculture as more or less synonymous with domesticated species and formal cultivation practices overlooks a good part of what people do in this part of the world to make a living. Subsistence practices in Greater Near Oceania are so diverse that it is hard to know how to generalize about them. It seems likely, nonetheless, that agroforestry is everywhere an important set of subsistence practices (Latinis, 2000). The term “agroforestry” refers to predominantly arboreal-based economies in which manipulating and maintaining forest ecosystems and forest resources—including birds, reptiles, amphibians, insects, mammals, roots, grasses, leaves, and a wide range of medicinal plants—are central. While other subsistence practices—for example, maritime-strand economies, intensive highland root-cropping economies, and the like—were probably also locally important in the past just as they are today, it now seems undeniable that agroforestry has long played a dominant subsistence role throughout Greater Near Oceania.

Having said this, it is important to say also that much remains to be documented about agroforestry practices in the Pacific. The harvesting of edible starch from the inner pith of sago palms has received the most scholarly attention (Barrau, 1959; Ellen, 1978, 1979, 1988; Hughes, 1970; Ohtsuka, 1977, 1985; Rauwedink, 1986; Rhoads, 1982; Ruddle *et al.*, 1978; Schuiling *et al.*, 1993; Stanton and Flach, 1980; Wallace, 1869), although the use of other tree resources is now receiving closer attention (Cristanty *et al.*, 1986; Kirch, 1989; Lepofsky, 1992; Yen, 1974). Most researchers, however, continue to see the use of trees in human subsistence as only a minor component of other more typically “agricultural” systems rather than as a major human subsistence focus in their own right. To date, less than a handful of ecological and anthropological studies specifically looking at agroforestry have been carried out in Greater Near Oceania (Klappa, 1999; Latinis, 1999).

It is known, nevertheless, that a variety of forest habitats (lowland, strand, mangrove, riparian, swamp, upland, etc.) are exploited, and most people utilize resources from not just one but several of these habitats. People are also quite aware of the ecological and successional properties of forests, and they use their known properties to manipulate and manage a variety of forest ecosystems suitable for human needs. Quite often, too, forest biodiversity is not only maintained but may also be increased, in part to foster conditions favorable to species of insects, reptiles, birds, and mammals also taken and eaten. Palm starch, pandanus fruits (*Pandanus* spp.), coconut (*Cocos nucifera*), banana (*Musa* spp.), a large repertoire of fruit- and nut-bearing trees (e.g., *Artocarpus* spp., *Canarium* spp., *Terminalia catappa*, etc.), and certain kinds of root crops usually provide the major starch, protein, and fat components of local meals. A variety of tree leaves and other plant leaves as well as bamboos (*Bambusa* spp.) also contribute significantly to the diet. Furthermore, forests provide construction materials, fuel, medicines, and trade commodities.

Unfortunately for those who like neatly defined categories, it is also the case that gardening and swidden fields are important in Greater Near Oceania. Yet here again, what “gardening” means and how gardens fit into the overall subsistence picture are difficult to typify. In Maluku, for example, cutting down trees in the forest and clearing the ground for garden plots are seen as part of forest management, and strange as it may seem, much of the produce grown in these small gardens is often not eaten except when other foods are scarce, or is sold as market commodities (Latinis, 1999).

Prehistory of “Agriculture” in the Highlands of New Guinea

Claims for early Holocene agriculture in New Guinea have been made on the basis of archaeological finds at Kuk Swamp in the Wahgi Valley, Papua New Guinea (Phase 1 at ca. 10,190 cal B.P.; Golson, 1977; Golson and Hughes, 1980). Similarly interpreted mid Holocene evidence has been documented at Kuk and other wetland sites in the interior of New Guinea (Phase 2 at ca. 6950–6450 cal B.P.; e.g., Golson, 1982; Harris and Hughes, 1978). From ca. 4500 cal B.P. onwards (Phase 3), ditch networks of clearer significance, namely those used to demarcate and drain cultivated plots, were dug along wetland margins within several, large intermontane valleys. The wetland archaeological remains are almost certainly the surviving elements of much broader subsistence practices that included the clearance and use of valley slopes and, presumably, the use of uncleared forest at higher and lower altitudes.

These later ditch networks, which became increasingly regular in design and are comparable to modern cultivation systems, were undoubtedly constructed to enhance drainage for agriculture. The significance of the early archaeological remains associated with Phases 1 and 2 remains uncertain and has fostered the greatest controversy (Harris, 1996b; Spriggs, 1996). From ongoing research at Kuk by Denham and his colleagues (Denham *et al.*, 2003), however, several lines of evidence associated with early Holocene subsistence practices at Kuk are becoming clearer.

First, the archaeological remains from early to mid Holocene contexts (Phases 1 and 2), which predate the digging of formal ditch networks, have long been considered difficult to interpret (Golson, 1977, 1991). Part of these difficulties arises from attempting to make the archaeological evidence conform to preexisting notions of “agriculture.” In contrast to previous interpretations of this evidence, it seems more plausible that the earlier archaeological remains represent former cultivation of the wetland margin without the construction of large-scale drainage channels. These remains represent former plots in which plants were grown, as opposed to fields on an artificially drained wetland margin. Rather than subsequently eroding an argument for a dependence on cultivation from the early Holocene in the Highlands, this reappraisal refocuses debate away from equivocal and uncertain archaeological remains towards more compelling lines of evidence.

Second, human modification of the tropical montane forests in New Guinea is of great antiquity (Hope and Golson, 1995). The suggestion that “waisted” stone blades were used for forest clearance and manipulation since the time of first settlement in New Guinea (Groube, 1989) is potentially corroborated by evidence of Pleistocene clearance of lower montane rainforests (Haberle, 1994; Hope and Golson, 1995). However in the early Holocene, rates of forest clearance within midaltitude intermontane valleys running across the Highland spine of New Guinea increased (after Haberle *et al.*, 1991). The accelerated rates of forest clearance determined through palynology are corroborated by increased rates of erosion on the valley slopes and deposition along some wetland margins (Hughes *et al.*, 1991). The increased rates of forest clearance may initially have been intended to create a mosaic of different habitats, plots, or patches for plant cultivation and exploitation, which had the cumulative and unforeseen results of yielding extensive grasslands that are subsequently maintained by periodic burning.

Third, many of the major staples of Pacific agriculture have now been documented from Pleistocene and early Holocene contexts in Melanesia (Barton and White, 1993; Haberle, 1995; Loy *et al.*, 1992). Some of these plants were formerly considered to be foreign introductions to the region, e.g., taro (*Colocasia esculenta*); a yam (*Dioscorea* sp.), and Eumusa bananas (*Musa* spp.). Independently of these prehistoric finds, Lebot (1999) has argued that there is biomolecular evidence for domestication in Melanesia of most of the major Pacific staples including taro, bananas, the greater yam (*Dioscorea alata*), giant taro (*Alocasia macrorrhiza*), breadfruit (*Artocarpus altilis*), and sugarcane (*Saccharum officinarum*). Thus, and in contrast to previous portrayals of early agriculture in the interior of New Guinea as being depauperate in suitable high caloric sources, a whole range of staples were potentially available for human manipulation in the highlands as well as in the lowlands. Ongoing research at Kuk is beginning to provide direct evidence of the former human use of these staples in the form of stone tool residues (Fullagar *et al.*, 2002) and phytoliths in sediments (Lentfer, 2002). The Holocene record of staples dovetails with earlier work on seeds at Kuk which identified a range of plants, some of which are used as vegetables today (Powell, 1982). Thus there is now greater understanding of the broad range of plants available for human use from the early Holocene.

Although these lines of evidence are still being clarified, a picture is emerging of widespread human alteration of the midaltitude valleys of New Guinea from the early to mid Holocene. In some cases, the forests were almost completely replaced by grassland. Within this highly anthropogenic environment, people were cultivating areas of wetland margin, and probably the valley slopes for which the evidence has not been preserved. At that time, the plants being grown and used were not marginal species, but some of the major staples of contemporary Melanesian subsistence. Given the problems of expressing contemporary Melanesian practices in terms of the traditional farming–foraging dualism (Roscoe, 2002), it is not surprising that the categories to articulate these prehistoric subsistence practices

are ambiguous. The three lines of evidence reviewed here suggest practices akin to agriculture—in terms of both their effects on the landscape and the dependence of people upon them for their subsistence—had emerged in the intermontane valleys of New Guinea by the early-to-mid Holocene.

Forager Vs. Farmer in Ancient Mesoamerica

The conventional archaeological view of the transition from Archaic Period mobile forager to village farmer has been one of over 5000 years of gradually increasing dependence on domesticated plants culminating in the emergence of settled village farmers in the Early Formative period ca. 1500–1000 B.C. (e.g., Flannery *et al.*, 1967; MacNeish, 1964; Mangelsdorf *et al.*, 1964). In particular, the appearance of sedentary village farming communities based on maize agriculture is considered one of the hallmarks of Mesoamerican culture. Nevertheless, several inconsistencies in the “Formative village farmer” versus “Archaic mobile forager” dichotomy have emerged in recent years. Stable carbon isotope analyses of human bone from several Mesoamerican sites indicate that maize, which has a distinct isotopic signature, was a relatively minor component of the Early to Middle Formative diet in some areas such as the Pacific watershed of Chiapas, Mexico, and northern Belize (Blake *et al.*, 1992; Tykot *et al.*, 1996). Although it is possible that some other cultivated crop, perhaps manioc, was the staple and that we have not yet detected its presence, these findings at least call into question the preeminence then of crops usually seen as “cultivated.” There is abundant evidence that hunting-and-gathering was a significant subsistence activity in the Early and Middle Formative villages, and it now seems plausible that in some regions and time periods, it was as significant or more so than farming.

If Formative “farmers” actually spent much of their time hunting, fishing, and collecting, what were their predecessors doing? One of the bone isotope studies from Lowland Chiapas noted above (Blake *et al.*, 1992) also included two Late Archaic skeletons, which unexpectedly had carbon isotope signatures indicative of higher maize consumption than later Formative people. These Archaic period skeletons were excavated from coastal shell mounds in Chiapas, long thought to be the vestiges of hunter-gatherer societies, not farming communities. More recently, studies in lowland Belize (Pohl *et al.*, 1996) and coastal Tabasco, Mexico (Pope *et al.*, 2001), have produced evidence of extensive Archaic Period land clearing, and maize and manioc cultivation. The temporal and spatial scale of this land clearing appears inconsistent with the designation “mobile foragers.”

The idea of maize as a Mesoamerican subsistence staple needs reevaluation. Evidence for an early central role for root crops in the diet is emerging (Piperno and Pearsall, 1998), and manioc is now documented spreading northward to Panama by ca. 5800 cal B.C. (Piperno *et al.*, 2000), Tabasco, Mexico, by ca. 4600 cal B.C. (Pope *et al.*, 2001), and northern Belize by ca. cal 3400 B.C. (Pohl *et al.*, 1996).

Evidence for the intensive use of uncultivated plants should likewise be revisited. Beans other than cultivated *Phaseolus* appeared in the diet of residents of the Pacific watershed of Chiapas (Blake *et al.*, 1992), Tamaulipas in northeast Mexico (Kaplan and MacNeish, 1960), and Guilá Naquitz in Oaxaca, Mexico (Kaplan, 1986; Kaplan and Lynch, 1999). At Guilá Naquitz, common bean (*Phaseolus vulgaris*) was in use by 7500 B.P., well before its use in cultivated fields (Kaplan and Lynch, 1999). Similarly, Archaic period residents of caves of Tehuacán, Puebla, Mexico, and Tamaulipas, focused heavily on foxtail millet (*Setaria geniculata*). In Tamaulipas, selection for larger grain size has been observed, and residents continued to harvest millet long after the introduction of maize (Callen, 1967).

The conclusion to be drawn from this brief survey of Mesoamerican subsistence is that the old concept of a simple linear transition from Archaic forager to Formative farmer is outmoded. People in this region used a mix of subsistence skills in time and space. Both Archaic and Formative peoples used certain plants intensively; some of the uncultivated plants were staples.

Africa

Africa continues to be described by journalists, visitors, and scientists as a vast continent with wild places still largely untouched by humankind. Few scholars today doubt the claim that Africa was the birthplace of our species, or that it was our only home until about a million years ago. Unfortunately, however, Africa's more recent contributions and role in modern history remain poorly known even by many academics, including many anthropologists. It is not surprising, therefore, that few people know about traditional African ways of managing this continent's many species of useful plants.

For example, the seeds of over 60 species of uncultivated grasses are commonly harvested in Africa, and there is a long history of intimate relationships between people and certain trees and tubers. The baobab (*Adansonia* sp.), the oil palm (*Elaeis guineensis*), and the *karate*, or *shea* (the butter tree, *Butyrospermum* sp.) are a few examples. Karate grows in many parts of the Sahel in West Africa. The edible oil extracted from the fruit of this tree is important to the diet of savanna peoples, where this species enjoys a nearly sacred status.

Many African plant species including Abyssinian oats (*Avena abyssinica*), Guinea millet (*Brachiaria deflexa*), African rice (*Oryza glaberrima*), and *safu* plums (*Pachylobus edulis*) (Harlan, 1989) are not intentionally grown, but when they do come up in fields or gardens, people are careful to protect them so that they can eventually be harvested, nonetheless. For example, Abyssinian oats grow as a weed in emmer and barley fields, and Ethiopian cultivators make no effort to get rid of it. As a consequence, *A. abyssinica* has evolved into two varieties, a nonshattering variety and semishattering one. The nonshattering form is reaped along with the emmer and barley; the semishattering ones are sometimes collected,

but when it is, some seed is left in the fields to propagate for next season. Since *A. abyssinica* is less dependent on human intervention, it serves as a food to fall back on when other species fail (Harlan, 1989).

Many archaeologists have noted a relationship between old village sites and the baobab, a tree whose wide distribution on the continent is thought to be largely the result of human propagation (Wickens, 1982). In fact, wherever one comes across *Adansonia*, one is likely to find an abandoned village. This is not surprising, because the Swahili of East Africa, for example, have 18 uses for this tree (Kusimba, 1993). Young baobab rely on humans for survival, humans turn to mature *Adansonia* for sustenance. The bark is used for fiber, while its leaves and roots are used as medicinal herbs. Its fruit is eaten and used as shampoo. While young, *Adansonia* are sometimes hollowed out, so that as they mature the opening deepens, becoming a cistern, trapping rainwater for dry season use.

These few examples show how we cannot fully understand and appreciate the long history of intimate relationships between people and selected trees and seeds in Africa using current ways of thinking about and modeling domestication.

Lacandon Maya of Chiapas and Guatemala

The Lacandon Maya of the lowland rainforests of Chiapas, Mexico, and Peten, Guatemala, provide another compelling case for examining the human socialization of the landscape without using socioeconomic typologies (e.g., "hunting-and-gathering bands," "horticultural villages," and so on). Over the last 150 years, the Lacandon have been alternately portrayed by explorers and anthropologists as either hunting-and-gathering bands, small permanent agricultural communities, or a semisedentary farming society (see Boremanse, 1998, p. 15; Vos, 1988; Palka, 1998; Sapper, 1891; Tozzer, 1907, p. 37). These varying descriptions of Lacandon society were not merely tracing culture change through time, nor were they the product of imperfect data. Lacandon subsistence and adaptive strategies differed between groups, and they changed within a group or family depending on social, economic, and environmental circumstances. All ethnographic sources are in agreement, however, that both cultivated and gathered resources have been important to the Lacandon (Baer and Merrifield, 1971; Duby and Blom, 1962; McGee, 1990, pp. 34–43; Nations and Nigh, 1980; Perera and Bruce, 1982; Soustelle, 1970, p. 24).

Today the Lacandon largely live in residential clusters, and they make their living from wages, peddling crafts, selling lumber, agriculture, and gathering. Traditionally, they cultivated a large number of plants of various origins in their corn plots, gardens, and fallow fields, such as sugar cane, manioc, mangos, and mahogany trees (see McGee, 1990, pp. 34–43; Palka, 1997, 1998; Tozzer, 1907, pp. 51–55). Although maize is still a major staple, a large portion of what they eat or use comes from the forest. They hunt deer, parrots, curassows (a large pheasant-like

bird), monkeys, and peccaries, to name a few of their favorite game animals, and they search for mameys (a large nutritious red tree fruit), palms, nuts, seeds, roots, and other plants for food and medicine. Fishing in the many lakes and rivers is also routine. Additionally, honey from wild bees in the forest is also prized and gathered frequently for their tables and for making a meade-like drink (*balche*) for ceremonial occasions. The forest is also a critical resource area exploited between harvests or when planted crops fail, and as a source of ritual foods.

Until they were pressured into living in residential clusters, many Lacandon traditionally lived in semipermanent nuclear family residences that were frequently relocated as part of the search for new crop land or on the death of a relative, and also to avoid contact with others. New clearings for crops and domestic structures were easily made wherever they went, and they relied on hunting, gathering, and trade for subsistence before the new harvest was in.

Therefore, the Lacandon Maya both were and are difficult to classify using conventional anthropological labels. They are neither strictly agriculturists, nor hunter-gatherers; they are neither always sedentary, nor always mobile. Using the spreadsheet approach suggested in this paper (below), it would be obvious instead that their subsistence strategies and lifeways are based on a wide range of materials and foodstuffs reflecting how the Lacandon have domesticated the landscapes where they reside.

Managing Traditional Subsistence Knowledge in the Peruvian Andes

The Andes is a region of high biodiversity where people have traditionally managed many kinds of plant ecotypes—also called “landraces,” “cultivars,” or “peasant varieties”—that are evidently adapted to the widely varying local climatic conditions, soil types, pests and diseases, and the like.

The Amuesha of Peru are an Arawak-speaking people who number about 5000 and who live mostly in the Palcazu River Valley on the eastern side of the central Peruvian Andes (Wise, 1976). In spite of European conquests, missionization, colonization, modernization, and most recently, guerrilla warfare, the Amuesha still follow their traditional subsistence practices of slash-and-burn cultivation, fishing, gathering, and some hunting (Barclay, 1985).

Botanical surveys among the Amuesha have found more than 125 plant species under cultivation. Their main food, however, is cassava (*Manihot esculenta*), of which there are hundreds of locally recognized varieties (Salick *et al.*, 1997). The particular varieties under cultivation in any one field are changed frequently, and people trade different varieties with one another to see how well novel varieties will succeed in their own fields (Salick, 1989; Thurston, 1992).

On an elementary level, it seems obvious that by planting so many different varieties of cassava, the Amuesha are good pragmatists, since nurturing biological diversity can be a fine way to assure that even if some botanical varieties yield

poorly or fail altogether, other varieties should be able to take up the slack. However, the Amuesha say that before the beginning of this world, cassava plants were people and that when this world ends, these plants will be people once more (Salick *et al.*, 1997; Smith, 1977). It is a shaman's duty to keep these people alive.

Because of this responsibility, a shaman must learn and remember a great store of information about each variety of cassava under his care—its traditional origins, who has cultivated it in the past, and what are the proper rituals for planting, cooking, and eating it. Since women are the principal gardeners, they are also the custodians of the cassava “people,” and they, too, must know the correct myths, songs, names, and rituals for the “individuals” they are caring for.

Therefore, what is characteristic about how the Amuesha cultivate cassava is that what they are selectively favoring is this plant's overall genetic and morphological diversity on the Andean landscape rather than only one or a small handful of readily observable traits, or characteristics, such as size, texture, or taste. In a region such as the Andes, where growing conditions are so variable and changing, this traditional emphasis may be very wise and adaptive. But this case study illustrates that even when it may be appropriate to say that it is not just the landscape but also a particular species that is “under domestication,” this subsistence focus may have as much to do with social values as with economic rationality and optimization.

Harvesting the Landscape During the Wari Period at Cerro Baúl, Peru

Archaeologists once assumed that during the development of the first expansive state in the highlands of Peru, known as Wari (A.D. 600–1000), subsistence was mostly based on the cultivation of maize and potatoes and the herding of camelids, and that settlements were located near the cultivation ecotone between the uplands (*suní*) and valley lands (*quichwa*) (Hastorf, 1993, p. 60). However, research today is uncovering complex patterns of Wari resource exploitation that extended beyond the traditional wild vs. tame dichotomy.

At Cerro Baúl, an administrative center on the southern frontier of the Wari polity, the llama (*Lama glama*), a camelid traditionally domesticated in the Andes, predominates in archaeological assemblages. But the most ubiquitous plant remains found in prehistoric households at this site are seeds of the molle tree (*Schinus molle*). Every dwelling so far excavated in one affluent residential sector, for example, has at least one subterranean storage facility 1–2 m³ in size filled with molle seeds. No other plant has been found in Wari contexts at Cerro Baúl in dedicated storage pits such as these.

S. molle is an extremely drought resistant plant that grows uncultivated in the valley bottoms around Cerro Baúl today. At the present time, its light-purple-rounded fruits are used in the production of *chicha*, an alcoholic beverage that was widely produced in the prehistoric Andes from many different vegetal sources,

including maize. It also serves as a preservative and pest control. During the Wari occupation, *S. molle* processing appears to have been undertaken on an extensive scale, and this fruit may have then been a major ingredient in *chicha* production.

While there is no evidence that the morphology of this tree was modified in some way as a consequence of this intensive level of prehistoric exploitation, vast irrigation projects undertaken at this time transformed the upper sierra (see Williams, 1997, 2002) and substantially altered the morphology of the local landscape, including habitats where *S. molle* grew. While its commonness in valley bottoms probably declined because of reduced river flows, new favorable habitats may have opened up along the irrigation canals. Since this plant was evidently such a valued commodity, it is also possible that *S. molle* was even encouraged to grow along these artificial waterways. In other words, human-induced alterations of the landscape undertaken to cultivate such conventionally recognized domesticates as maize may have also dramatically altered human interactions with this so-called “wild” tree.

The animals exploited by the Wari at Cerro Baúl tell a similar story. In addition to such conventionally recognized domesticated species as *L. glama*, *L. pacos*, and *Cavia porcellus* (*cuy*), the Andean deer called the *turuka* (*Hippocamelus antisensis*) was also harvested. Since the *turuka* is rarely found at elevations below 4000 masl, and the Wari colony at Cerro Baúl was located at only 2500 masl, some sort of resource extraction from the higher Andean *puna* some 50 km away is implicated. Furthermore, a wide variety of marine fauna ranging from shellfish (esp. *Choromytilus chorus*, *Protothaca thaca*, and *Oliva peruviana*) to shark has been recovered in excavations within elite residences at this mountaintop city. Since the sea is over 100 km away, these affluent households were evidently able to tap into a catchment area that was hundreds of kilometers in diameter, either directly themselves, or perhaps through relationships with people elsewhere who had firsthand knowledge of how to harvest these more distant resources.

This brief survey of subsistence activities at Cerro Baúl hints at the range of resources and harvesting strategies used by the Wari to meet their subsistence needs. The impact that this settlement had on the local Andean landscape during the last half of the 1st millennium A.D. was not limited to the fields they cultivated, nor to the corrals where they penned their animals. Neither was their involvement with other species confined to such traditionally identified domesticates as the llama and *Zea mays*.

An Expanded Role for Domesticated Animals in the New World

In the 1960s, Higgs and Jarman (1969, 1972) started questioning the wisdom of looking at only the small number of species that eventually dominated the Holocene economies of the ancient Middle East to study prehistoric animal domestication; they questioned, too, the wisdom of using only morphological change to

decide whether the animal bones found at archaeological sites came from animals that were “wild” or “domesticated.” They proposed that husbandry had not been a purely Holocene phenomenon; citing faunal evidence for economic specializations at sites over a wide geographical area, they argued that husbandry had been practiced in the Pleistocene, as well. For example, they noted the heavy reliance on red deer and pig during the Pleistocene all over Europe south of the Baltic Sea. They showed how old specializations or modes of human–animal interaction had persisted into the Holocene even after animals such as ovicaprines and cattle came to dominate economies in the Middle East. Additionally, they stressed that domestication does not always have to leave observable traces. Few would question the close relationship between humans and some elephants, for example, yet even today there are no physical differences between captive and free-roaming elephants (*Elephas maximus*) (Higgs and Jarman, 1972, p. 8).

Higgs and Jarman (1972) believed that the New World would prove particularly helpful in revising our approaches to domestication. Mounting information since the 1960s has borne out their prediction. For example, New World techniques of taming animals in households or training them to specific locales through feeding have now been documented ethnohistorically and ethnographically. Other recorded methods of husbandry include management through periodic roundups and enhancement of plant food resources through burning (see Bourke, 1892; MacNutt, 1912, pp. 259–269; Pohl, 1981, 1985, 1990; Pohl and Feldman, 1982).

Archaeologists have often had difficulty tracing human landscape modification, but paleoecological methods are being developed that are altering the situation dramatically (Piperno and Pearsall, 1998). Landscape burning can now be detected in paleoecological cores through the presence of charcoal and changes in vegetation, and burning is now recognized as a distinctive and widespread signature of human modification of the landscape beginning as early as the early Holocene in Panama (Piperno and Pearsall, 1998). Burning favors the growth of edible disturbance vegetation such as sunflower (*Helianthus annuus* L.) and amaranth (*Amaranthus* spp.), and also creates conditions favorable to game animals such as white tail (*Odocoileus virginianus*).

Archaeologists can get other hints about prehistoric management practices from evidence for people moving animals out of their usual habitats. For example, people of Ceramic period cultures in the West Indian Archipelago enhanced their food supplies after 250 B.C. by importing “wild” animals (see below). Evidence for the importation of animals may well mean that similar practices of husbandry were also in place in their source localities. The widespread distribution of some imported rodents in the West Indies, in particular, suggests that their care and feeding were well-understood.

Scientific methods can now help archaeologists detect evidence for the regular feeding of animals, and such animals can thus be identified as domesticated even in places where they are native. For example, carbon isotope studies of faunal remains from a large ceremonial midden next to a Late Classic period (ca. A.D. 850)

Maya pyramid at Lagartero (Chiapas, Mexico) have established that some of the white-tailed deer excavated there had unusually high levels of maize consumption consistent with their being fattened for sacrificial rites (White *et al.*, 2004). In the future, phytolith and starch grain analyses of residues on animal teeth have the potential to provide yet other useful information on prehistoric animal feeding practices.

Archaeologists accustomed to the economic uses that they see as dominating Middle Eastern exploitation of animals have generally failed to appreciate fully enough the intensive ritual use of animals and animal products in the New World. For example, Mogollon-Anasazi people in the American Southwest bred the turkey (*Meleagris gallopavo*) primarily for feathers for textiles and ceremonial uses and only secondarily for food beginning in the Mogollon pre-Pottery phase 500–300 B.C. (Breitburg, 1993). After A.D. 1000, captive macaws and parrots imported from southern Mexico, as well as captive local turkeys, were managed in large numbers for feathers and for sacrifices in northern Mexico and in the southwestern United States (Creel and McKusick, 1994; Di Peso, 1974).

Archaeologists have traditionally distinguished Old and New World subsistence economies by the fact that fewer animals underwent domestication in the New World. Only the guinea pig, turkey, and camelids are commonly cited as present in the prehistoric repertoire of indigenous New World animal domesticates. As Higgs and Jarman predicted, this impression overlooks the significant and growing evidence for intensive animal use in the New World.

The Caribbean

There is good archaeological evidence from the Greater Antilles for the domestication of island landscapes beginning in the Archaic Period and the first days of human settlement. Archaic people in the Caribbean are usually described nowadays by archaeologists as having been seasonal hunter/fisher/gatherer folk, or more simply as foragers whose survival depended on fishing, hunting, and gathering. However, the presence of avocado (*Persea americana*) and yellow sapote (*Pouteria salicifolia*) at the archaeological site of Cueva de la Marí a Cruz in Puerto Rico brings into question the simplicity of this labeling, for it is likely that these species had been deliberately introduced from the continent (Newsom, 1993; Petersen, 1997; Rouse and Alegría, 1990, p. 23). Furthermore, the environmental needs of these species today can be taken to infer that islanders then were already practicing some kind of arboriculture, a subsistence practice that Caribbeanists usually associate with later “horticultural” groups (Newsom, 1993). Similarly, Veloz Maggiolo (1991, 1993) has reported high incidences of *guayiga* or *zamia* (*Zamia debilis*) in late Archaic assemblages in Hispaniola, again

suggesting the manipulation and cultivation of these wild resources during this period.

The marked increase in the amount of charcoal found in a sediment core dating to about 5300 B.P. or the early part of the Archaic Period in Puerto Rico (Burney *et al.*, 1994) hints that some kind of deforestation or manipulation of some of the resources was also being practiced back then. While it is still uncertain whether this increase was the result of cultivation or some hunting practice (such as landscape burning), this evidence suggests that soon after their arrival, settlers were having a direct impact on the landscape—in other words, they were already domesticating island landscapes in quite tangible ways. As the ecologist Lindenmayer and his colleagues recently noted, a considerable body of ecological theory and a growing number of empirical studies indicate that major changes in the distribution and abundance of organisms can occur in response to human-induced landscape change, particularly if there is loss of habitat and fragmentation of the ground cover (Lindenmayer *et al.*, 2002, p. 1).

Around 300 B.C., the Greater Antilles saw the arrival of people from South America who used subsistence strategies similar to those used by what Steward (1948) called the “Tropical Forest Tribes.” The evidence at hand suggests that these settlers locally introduced a wide range of botanical resources to the islands including manioc, yams, and a variety of tubers, maize, chili peppers, some kinds of beans, tobacco, and medicinal plants. Although many researchers classify these settlers as agriculturists, it now seems more likely that even if these newcomers were horticulturalists, their diet still depended heavily on “wild” animals and plants. On the basis of certain kinds of artifacts and of archaeobotanical data, Newsom (1993) has suggested that people then put food on their table, using a variety of strategies including forest gardening, home gardening, vegiculture, and arboriculture, as well as intensive forms of cultivation. While evidence for this inference is limited, both archaeological and ethnohistoric documentation dating to the fifteenth century A.D. and later supports the soundness of this claim at least for late prehistoric times.

We do know that by later prehistoric times, the islanders were getting animal protein from a number of species acquired by a variety of methods. While some species were hunted or fished, others were trapped and tended. Further, in several instances new species were introduced from other islands or the South American continent. Of the introduced species, perhaps the main noninsular animal consumed was the guinea pig. This animal is thought to have been first managed in the Andes, and its attested archaeological presence in Puerto Rico and Hispaniola suggests that guinea pigs were introduced by people as part of the process of domesticating the landscape. The chronicles also mention that rodents were hunted using dogs and fire. In Puerto Rico, the most common untamed rodent (*Isolobodon portorricensis*) seems to have been originally introduced from Hispaniola by prehistoric people. Reptiles such as crocodiles, sea turtles, and iguanas were hunted widely. Birds were

also hunted in multiple ways with traps, nets, and the bow-and-arrow probably being the most common techniques. Spanish chronicles mention the use of decoys and disguises on Cuba to trap larger herons in mangrove areas. Fish were another important resource that were exploited in multiple ways. The historic documents suggest that while some fishing techniques were present in most islands, others seemed to be more localized. The use of harpoons, fish hooks, nets, and traps seem to have been widespread (Mercado, 1990). On Cuba, evidence exists for the use of *remora* fish (*Remora remora*) to trap sea turtles and other larger fish (Las Casas, 1951, p. 513; Mártir de Anglería, 1964, pp. 137, 631). Also for Cuba, documents mention the use of corrals near the shore to trap fishes between tides (Las Casas, 1951, p. 311). Finally, the use of poison for fishing is also mentioned for this island (Mercado, 1990).

In summary, archaeological evidence shows that people have been domesticating the landscapes of the Caribbean islands since the first days of human settlement in the region through deforestation, the introduction of exotic species of animals and plants, and the harvesting of a variety of island resources using different methods and devices. How extensively people altered their island landscapes, however, may not have been uniform throughout the region, and enough evidence is at hand to say that people then used harvesting strategies that varied from place to place, and also over time.

DISCUSSION

These examples illustrate some of the known diversity of human subsistence practices, now and in the past. They show how challenging it can be to put human societies into just two boxes labeled foragers or farmers, for regardless how they are labeled, it is evident that people use a variety of strategies to harvest resources from the world around them. It is obvious, too, that some of the skills employed call for more planning and manipulation than others. Yet this diversity of means does not obscure the commonality of ends also evidenced by these case studies.¹⁰ Whatever the set of harvesting skills used, knowing about the world around you and about what needs to be done to make use of it in particular places and at particular times gives people some control over their world and therefore over their destiny.

From this perspective, we think many kinds of animals—not just *Homo sapiens*—know how to use the landscape intensively and how to create a milieu that suits their needs (Odling-Smee *et al.*, 1996; Rindos, 1984, pp. 101–127). One well-known example is the leaf-cutter ant which makes part of its living farming fungus in underground chambers using little pieces of leaf hunted down

¹⁰Or *adaptive strategies*; see Boone and Smith (1998), Krebs and Davies (1997), Levins (1968), and Smith and Winterhalder (1992, pp. 34–38, 54–55).

aboveground and carried home to be used as nutritious mulch (Hölldobler and Wilson, 1990, pp. 596–608; Wilson, 1986). It would be hard to find a finer instance of an animal other than ourselves involved in creating the right environmental conditions favoring the growth and development of a preferred food. These ants may be farmers by default or genetics rather than by training and experience (Flannery, 1986c, pp. 14–15), but by more than one definition of farming as a way of life, they are farmers nonetheless. Here again, however, labeling even these creatures in this way would be misleading. As Hölldobler and Wilson (1990, p. 599) report,

the main properties of the leafcutter-fungus symbiosis can be stated as follows. Adult ants are fundamentally nectar feeders, predators, and scavengers. Their entire digestive system . . . is geared to this dietary commitment. They are ill suited to be herbivores. The fungus, in exchange for protection and cultivation, digests the cellulose and other plant products normally inaccessible to leafcutters and shares part of the assimilable metabolic products with them.

It should be added that the symbiotic fungi grown by these ants have evidently lost the ability to produce sporophores (fruiting structures) and are dependent on their hosts for transport—unlike other fungi, they do not rely on wind-borne spores to transfer themselves from place to place. Furthermore, although these underground ant gardens are monocultures dominated by a single fungus species maintained by a variety of techniques, microorganisms are also present and it is suspected that these, too, may be involved in the symbiosis between ant and plant.¹¹

However described, while foraging aboveground to farm below ground, these ants have a decided effect on almost all forms of fresh vegetation covering the landscapes they “attack” to bring home bits of leaf¹²—which from a human point of view makes them one of the most important insect pests in the New World (Wilson, 1986, p. 6). Seen from the other side of the fence, however, what people often view as economically devastating insect behavior has evolved in the ecosystems of the New World tropics and warm temperate zones to the point where it supplants to a major degree the environmental role in ecosystems elsewhere played by herbivorous mammal species (which are comparatively scarce in this part of the world):

They prune the vegetation, stimulate new plant growth, break down vegetable material rapidly, and turn and enrich the soil. In the tropical moist forests [they] are major deep excavators of soil and stimulators of root growth. If leafcutters were to be extirpated, a profound readjustment of the structure of forests and grasslands would result, including the extinction of at least a few species of plants and animals. (Hölldobler and Wilson, 1990, p. 597)

Thus once again, it may be that the behavioral skills needed in this case to accomplish these feats of landscape management are genetically ordained or

¹¹ Acknowledging, of course, that since fungi do not have chlorophyll, scientifically they are neither plants nor animals but are another kind of organism altogether, and so perhaps what these ants do with this life form should be labeled neither farming nor husbandry.

¹² And sometimes the nylon tents of field ecologists, too (Bruce Patterson, personal communication 2002).

programmed, but there is little doubt that these small creatures domesticate landscapes in their own particular way in the New World.

The late plant geneticist Jack R. Harlan may not have been the first to write about landscapes as we have been doing here, but he was certainly one of the most renowned scholars to talk about “domesticated landscapes.”¹³ Resonances of what we are proposing can be found throughout his classic book *Crops & Man* (Harlan, 1992). There he describes domesticated landscapes, however, as areas “intimately known and spiritually safe” where one feels so at home that “the landscape can be thought of as being brought into the household” (1992, pp. 63, 64). We want this notion to do more work than this, for Harlan’s use of the coupled words “domesticated landscape” implies that a house need not be a home—that like a botanist’s glass greenhouse, a landscape can be a *domus* filled only with wild crops (1992, p. 23).

In Harlan’s estimation, for instance, prehistoric Australians were able to domesticate the Australian landscape without domesticating the plants and other animals living beside them. “The consensus, I believe, is that domestication involves genetic changes that adapt the plant or animal to the *domus*, and full domestication results in populations that cannot survive without the aid of man. . . . And yet, some 30–45,000 yr of landscape domestication in Australia has not resulted in domesticated plants” (1992, p. 64; 1995, pp. 30–31). We think the several ethnographic and archaeological examples just given suggest to the contrary that

1. while human beings may not have to change or genetically transform a species to subsist on it;
2. domesticating (that is, knowing how to harvest) a species, sooner or later—as Darwin taught us—may change it, intentionally or not;
3. and what our species does to domesticate (harvest) a species depends at least in part on the species in question and on how much of that species we want to harvest;
4. therefore, to learn how landscapes are domesticated, we need to know both what species are being harvested there, and also what is being done to harvest them;
5. furthermore, as environmentalists and evolutionary ecologists insist, our impact on the earth has not been limited to changing the genetic composition of the species that we harvest; we also move species from place to place, weed out those we do not want, push others to extinction (often

¹³It can be argued that at least some of the elements of the concept of “domesticated landscapes” can be traced back thousands of years to the Sanskrit word *jāṅgal* (from where we get the English word “jungle”). By the fourth century B.C., this word had come to mean either “nonirrigated land” or “wasteland,” i.e., land with which people had formed no abiding relationship. In the later Prakrit languages, *jāṅgal* as a noun meaning “wasteland” is less common than the adjectival form *jāṅgali* meaning “untamable” or “uncontrollable.” In India, these words only began to mean “wild” in an Aristotelian sense in the last few centuries, primarily during British rule (Dhavalikar, 1996).

without even intending to do so), and in yet other ways alter the species composition of the places that we choose to call home;

6. hence we domesticate landscapes much like leaf-cutter ants do; by our activities, we shape not only the physical appearance of our surroundings, but also what other species live in our neighborhood—and further, we may try to dictate what our neighbors must look like and what they must be able to do to be welcomed.

Consequently, the knowledge that domesticates a landscape is not merely knowledge about a place, pure and simple—it is not simply knowledge that leads to a sense of being “at home” there. The kind of knowledge that we are pointing to is knowledge about a landscape for a reason, so to speak—in this instance, knowledge about how to put food on the table (or the proverbial roof over one’s head, since the resources taken from a place can be more than food and water).

Therefore, while Harlan wrote about domesticated landscapes, his usage of this expression falls short of what we are proposing here. After thousands years of human use, the Australian landscape may have looked wild enough to him (1992, pp. 10, 23; but see also Harlan, 1995, pp. 30–31), but this is not the way it looks to Australian archaeologists today (Allen, 1997; Gosden and Head, 1999). As Hynes and Chase (1982, p. 38) wrote a number of years ago about the First Australians: “Their knowledge and manipulation of plants is neither simple nor ‘pre-agricultural,’ and can only be understood by detailed study of the particular cultural and biological systems within which they operate. . . . Most important, some plant communities may have been not merely modified but created by Aboriginal cultural activity.”

There may still be, as Harlan wrote, a consensus in the sciences that full domestication results in populations that cannot survive without the aid of man, but such a definition of *domestication* is too restrictive. There are even pathogens that meet this qualified definition—for example, the virus that causes human acquired immune deficiency syndrome (AIDS). We doubt that many would be content to call such deadly pathogens “fully domesticated species” (Smith, 2001, pp. 13, 15–16). And such a restrictive definition, as Harlan himself insisted, slights the reality that domestication is an evolutionary process, and hence there are “all degrees of plant and animal association with man” (Harlan, 1992, p. 64). In sum, the harvesting done by any species is likely to lead over time to morphological and genetic changes in the species being harvested or preyed upon, in the species doing the harvesting, and in the species composition of the landscapes they all inhabit (Pearsall, 1995, p. 192; Rindos, 1984).

Therefore, instead of continuing to talk and argue about “wild *versus* domesticated species” or about “degrees of domestication” and the supposed continuum, or middle ground, between foraging and farming, we think what is needed is a more helpful and rigorous way to describe and compare human subsistence

resource breadth							
	R ₁	R ₂	R ₃	R ₄	R ₅	...	R _n
S _e			X	X			
S _e ∞S _b	X						
S _b ∞S _e					X		
S _b		X					

Fig. 1. A model provisions spreadsheet showing the varying skills (S_i) used by a hypothetical community to harvest specific resources (R_n) from the landscape around it.

practices without first having to label them (Stiner, 2001). We call one such analytical concept the “provisions spreadsheet” (Fig. 1).

THE PROVISIONS SPREADSHEET

Sketched briefly, the basic model we are proposing for the charting and comparison of human subsistence practices has these principle elements:

- 1. *goal*: provisioning of food, shelter; and raw materials;
- 2. *observations to be made*: the *occurrence* (presence/absence), *number of individuals*, or *amount* of each species harvested for food or shelter;
- 3. *primary variables*: *yield*, *accessibility*, and *reliability* or *yield stability* (Cleveland 2001, p. 252) of each available species; and
- 4. *secondary variables*: *skills* used to achieve the specified goal (behaviors to change or adapt to the yield, accessibility, and reliability of available species populations).

Where the primary variables are

- 1. The specific *yield* provided by each resource being harvested, perhaps measured either in terms of *calories* and *profitability* (energy gain/time) when what is at stake is survival, and when not, then perhaps in locally specific terms of *social value* (measured possibly in locally defined “portions” or *units per person*).
- 2. The specific *accessibility* of each resource harvested, both *temporal* (e.g., its availability from season to season) and *spatial* or *geographic* (possibly

assessed as the time and effort needed to find and harvest a specific resource).

3. The *reliability*, or *yield stability*, of each resource harvested—how likely it is that each will live up to expectations over time. In evolutionary ecology, this variable is often described as “risk,” and models exploring alternative risk management strategies are predicated on the assumption that the suite of resources harvested ought to be a mix of more or less reliable foods that optimizes the likelihood of survival during times of scarcity (Flannery, 1986c, pp. 4, 14, 16–17; Piperno and Pearsall, 1998, pp. 239–241; Winterhalder, 1990, 1997; Winterhalder *et al.*, 1999).

The case studies given earlier showed how harvesting or exploiting different species as foods or raw materials generally requires differing tactics depending on the particular species being taken. In some instances, the skills used are predominantly *behavioral* (S_b)—those doing the harvesting adapt what they are doing to fit (to capture or take) the *target resource* (R_n) being harvested—and our allusions to fly-rod fishing and Inuit seal hunting come to mind. In such instances, the people involved are normally called foragers, hunters, or gatherers of the resources being taken. For other species, however, the tactics used may call for greater preparation and *environmental manipulation* (S_e). In such instances, those doing the harvesting are more clearly changing rather than adapting to the yield, accessibility, and reliability of species they are taking (and often the landscape where they are taken), and convention says that they should be called farmers or cultivators of one description or another. Instead of phrasing what is being done in this black-or-white fashion, however, we think it makes more sense to acknowledge that any harvesting strategy that people use is likely to be a “mixed” strategy that may be expressed abstractly as a relation of some kind ($S_b \propto S_e$) involving both behavioral skills (S_b) and environmental manipulations (S_e ; see Fig. 1).

By thus changing and adapting to the yield, accessibility, and reliability of a species to domesticate it—to harvest it effectively—human beings become part of the selective context of local populations of that species. If genetic variation within these local populations is sufficient, and their reproductive cycles are fast enough, more or less significant changes may occur that become manifest as changes in morphology, behavior, or both. Evolution of this sort may occur in plants, for example, when human beings become their primary dispersal agent (Rindos, 1984, pp. 142, 54–155).

The fitness of local species populations may increase over time through their interactions with people even when no immediate genetic or behavioral changes occur if human beings aid them in their reproductive success—for example, by planting these species in new places (e.g., the sago palm, *Metroxylon* spp.). Harvesting and habitat destruction by people can also lead to local population extinctions if the reproductive cycles of the species involved are long, or when local populations

lack sufficient genetic variation within them to balance human exploitation (which is what some say happened to mastodons and other large mammals once prehistoric people reached the New World during the late Pleistocene).¹⁴ Alternatively, human interactions with local species populations can also be a component of stabilizing selection that results in no evolutionary change in reproductive fitness (Hart, 1999).

We think it should not be forgotten, however, that local populations being made use of by people are also components of the selective environment affecting the survival and characteristics of the people using them. Consequently, the tactics used by people are likely to change, too. Such “evolution by consequences” (Skinner, 1981) may improve the fitness of the human communities involved if the yield, accessibility, or reliability of a resource increases relative to the amount of time and energy expended by the people involved (Rindos, 1984). Hence, as the evolutionary give-and-take between people and their resources goes on, the mix or array of behavioral (S_b) and environmental (S_e) tactics is likely to vary over time as alterations in human behavior are selectively reinforced by what is happening to the resources being harvested.

In Fig. 1, the array of resources ($R_1, R_2, \dots R_n$) indicates the *resource breadth* of a hypothetical human community (i.e., it represents the actual array of the species they exploit as resources). This array can be thought of as a snapshot or picture of how this model community is domesticating its world, its domesticated landscape (Fig. 3(b)). Note, however, that no assumption is made that the species tabulated are all interacting directly with one another even though they may all be elements of the same local ecosystem. The species represented are only ones that the community is actively using, not the complete array of species occurring locally on the landscape (Fig. 3(c)).

Just as the set of relations ($S_b \propto S_e$) shown on a provisions spreadsheet summarizes a community's actions at a given time, so too, a chronologically ordered sequence of such spreadsheets would be a database for exploring human–landscape interactions over time and space. The history of these interactions might be expressed, for instance, as a subtraction matrix showing patterned local change over time; or as a topology for exploring points of continuity or discontinuity between people living at different times and places.

Some may object that it would be difficult to construct these spreadsheets given only archaeologically recovered evidence (for an abbreviated ethnographic example, see Fig. 2). It is clear that some species are more likely to leave traces in the archaeological record than others, and that concerns about the efficiencies of archaeological recovery techniques, sampling design, and the like are genuine. Furthermore, archaeologists recognize that inferences about what people in the

¹⁴The continued survival of the fox in the British Isles, for example, solely depends on human intervention. There would probably be no foxes there today if it were not for the upper-class British sport of fox hunting (see Carr, 1976).

past did to provision their households are exactly that—inferences (or hypotheses) about human behavior and subsistence skills—and not directly observable phenomena (see, for example, the many analyses of subsistence data given in Flannery, 1986d). As far as we can see, however, constructing an archaeologically grounded provisions spreadsheet as an interpretative step in the process of turning surviving material evidence into human history should be no more challenging—and may be more understandable—than many of the steps that archaeologists conventionally take to try to establish the character of subsistence activities in the past. In fact, the major difference between the tables of species conventionally published in archaeological site reports and a provisions spreadsheet is the added stipulation that one must try to gauge the likely harvesting skills ($S_b \propto S_e$) that were used in the past at the site in question to harvest the species evidenced.

We think one of the major advantages of systematically constructing these spreadsheets is that taking this step should make it easier to examine what happened in the past when, for instance, people added new resources to the array they had been accustomed to harvesting (Hart, 1999). Building these spreadsheets to document patterns of subsistence variation over time and space may also be a convincing way

Fig. 2. A simplified provisions spreadsheet for subsistence items used in Central Maluku, Indonesia (also known as “The Spice Islands”; for detailed discussion, see Latinis, 1999). This table illustrates how harvesting different species usually requires differing tactics depending on the particular species being taken. An “X” indicates the main class of strategies used to take the particular species listed; check marks (✓) indicate variant strategies used commonly enough to warrant inclusion. It should be noted that different individuals or families even in the same community may use a somewhat different mix of strategies to take the species listed.

S_b : For some species, the skills used are predominantly *behavioral* (S_b), i.e., those doing the harvesting adapt what they are doing to fit (to capture or take) the *target resource* (R_n) being taken. For Central Maluku, hunting feral pigs and phalangers in mature forests, collecting shellfish or fishing, and collecting leaves for stews and medicines are good examples.

$S_b \propto S_e$: For other species, the behavioral tactics people use may call for minimal or casual preparations (i.e., *environmental manipulations*, S_e) beforehand to make these particular species easier to find and take when they are needed. For example, while traveling through the forest, people in Central Maluku may move plants to more favorable locations, weed out their competitors, or take steps to assure that they are properly shaded or alternatively exposed to open sunlight.

$S_e \propto S_b$: Some species are easier to find and more reliably taken if people beforehand have worked to regulate their growing conditions more extensively than they might otherwise need to do. For example, people may cut down large trees to open up the forest canopy to improve the growing conditions for certain forest-floor species, and in Central Maluku, select species may then also be planted, removed, weeded, or mulched without repeating the activities involved often or regularly enough that convention dictates we should call such cleared forest areas “gardens.”

S_e : For yet other species, the tactics used may call for planned and repeated environmental manipulation (S_e) beforehand. In these instances, people are clearly changing rather than adapting to the yield, accessibility, and reliability of species they are taking (and often the landscape where they are taken), and convention says they should be called “farmers” or “cultivators” of one description or another. For Central Maluku, products in well maintained gardens (e.g., tomatoes), wet-rice paddies, and plantations (e.g., a cashew or citrus plantation) are good examples. Various fruit and nut trees in well-ordered and maintained house gardens may also fit this category.

of tracking how adaptable and resilient human communities have actually been in the face of such change.

Whether it makes sense to identify at least some of the species arrayed on a provisions spreadsheet in themselves as “domesticated” (Fig. 3(a)) is a moot

Resource breadth (R₁ ... R_n)

Keladi Hutan - <i>Alocasia</i> spp.	✕	➤		
Kedondong - <i>Spondias pinnata</i>		➤	✕	➤
Kecapi - <i>Sandoricum koetjape</i>			➤	✕
Kangkong - <i>Ipomoea aquatica</i> , <i>I. reptans</i>			➤	✕
Jackfruit - <i>Artocarpus integrifolia</i> , <i>Artocarpus heterophylla</i>			➤	✕
Hanua - <i>Macaranga</i> sp.(?)		➤	➤	
Guava - <i>Psidium guajava</i>		➤	✕	➤
Gomu, Ai Masi - <i>Artocarpus</i> spp. ("wild" breadfruit?)	➤	✕		
Ginger - <i>Zingiber officinale</i> , <i>Zingiber</i> spp.	➤	➤	✕	➤
Genemu, Melinjau, Melinjo - <i>Gnetum gnemon</i>	➤	✕	➤	
Ferns - <i>Cyathea</i> spp., <i>Thelypteris</i> spp., <i>Stenochlaena</i> spp., <i>Diplazium esculentum</i>	✕	➤		
Eggplant - <i>Solanum melongena</i>				✕
Durian - <i>Durio zibethinus</i>	➤	➤	➤	✕
Corn - <i>Zea mays</i>				✕
Coconut - <i>Cocos nucifera</i>	➤	➤	➤	✕
Cocoa - <i>Theobroma cacao</i>			➤	✕
Citrus - <i>Citrus</i> spp.		➤	➤	✕
Chili - <i>Capsicum</i> spp.		➤	➤	✕
Cempedak - <i>Artocarpus champeden</i>			➤	✕
Cassava - <i>Manihot esculenta</i>			➤	✕
Cashew - <i>Anacardium occidentale</i>			➤	✕
Candlenut - <i>Aleurites moluccana</i>	➤	✕	➤	
Cabbage - <i>Brassica</i> sp.			➤	✕
Breadfruit - <i>Artocarpus altilis</i>		✕	➤	➤
Beans (long/string) - <i>Vigna unguiculata</i>			➤	✕
Banana - <i>Musa</i> spp.		➤	➤	✕
Bamboo - <i>Bambusa</i> spp., others (e.g., <i>Dendrocalamus</i> spp.)	➤	➤	✕	➤
Avocado - <i>Persea americana</i>			➤	✕

$S^b \propto S^o$

$S^b \propto S^e$

$S^b \propto S^h$

S^e

Ti - <i>Cordyline terminalis</i>	×	✓	✓	✓
Taro - <i>Colocasia esculenta</i>		✓	×	×
Tamarind - <i>Tamarindus indica</i>		✓	×	✓
Sweet Potato - <i>Ipomoea batatas</i>		✓	✓	×
Sugarpalm - <i>Arenga pinnata</i>		✓	×	✓
Sugarcane - <i>Saccharum officinarum</i>		✓	×	×
Starfruit - <i>Averrhoa carambola</i>			✓	×
Soursop - <i>Annona muricata</i>			✓	×
Sago - <i>Metroxylon sagu</i>	✓	×	✓	✓
Rice - <i>Oryza sativa</i>				×
Rambutan - <i>Nephelium lappaceum</i>		✓	×	✓
Pumpkin - <i>Cucurbita</i> spp.				×
Potato - <i>Solanum tuberosum</i>				×
Pineapple - <i>Ananas comosus</i>			✓	×
Petai, Pate - <i>Parkia speciosa</i>	✓	×	✓	
Peanut - <i>Arachis hypogaea</i>				×
Papaya - <i>Carica papaya</i>			✓	×
Pandanus - <i>Pandanus</i> spp.	×	✓	✓	
Pacific almond, Ketapang - <i>Terminalia catappa</i>	×	✓		
Onion - <i>Allium</i> spp.			✓	×
Nipa - <i>Nypa fruticans</i>	×	✓		
Nenari, Ngali, Lale - <i>Canarium</i> spp.	×	✓		
Mangosteen - <i>Garcinia mangostana</i>		✓	×	✓
Mango - <i>Mangifera</i> spp.		✓	×	✓
Malay apple - <i>Syzygium malaccense</i>			×	✓
Lontar - <i>Borassus flabellifer</i>		✓	×	✓
Langsat - <i>Bouea macrophylla</i>			×	✓
Kenari - <i>Canarium indicum</i>		✓	×	✓
Keladi Hutan - <i>Cyrtosperma</i> spp.	×	✓		
Keladi Hutan - <i>Colocasia</i> spp.	✓	×	✓	

Fig. 2. (Continued)

A variety of reptiles	×			
Turtles (meat and eggs) - <i>Testudines</i> spp.	×			
Snakes - <i>Serpentes</i> spp., mostly python (<i>Python reticulatus</i>)	×			
Shellfish - a variety of mollusks, crataceans, bivalves, and gastropods	×			
Sea cucumbers - <i>Holothurioidea</i> spp.	×			
Prawns and shrimp - <i>Dendrobranchiata</i> sp., <i>Pleocyemata</i> sp.	×	➤		
Pig - <i>Sus scrofa</i> , <i>Sus</i> spp., <i>Babryrousa babyrussa</i>	➤	×	×	➤
Octopus - <i>Octopus</i> spp.	×			
Lizards (meat and eggs) - <i>Lacertilia</i> spp., mostly monitor lizards (<i>Varanus</i> sp.)	×			
Kuskus - <i>Phalanger orientalis</i> , <i>Spilocuscus maculatus</i>	×	➤		
Grubs (sago and other wood grubs-mostly from large beetle species) - <i>Coleoptera</i> spp.	×	➤	➤	➤
Goat (mostly Muslim coastal villages) - <i>Capra</i> sp.			➤	×
Fish	×	➤	➤	➤
Dog - <i>Canis domesticus</i>				×
Deer - <i>Cervus timorensis</i>	×			
Crabs - <i>Brachyura</i> spp.	×			
Cow (mostly transmigrant Javanese villages and coastal Muslim villages) - <i>Bos javanicus</i>				×
Civet - <i>Viverra tangalunga</i> , <i>Paradoxurus hermaphroditus</i>	×			
Chicken (mostly eggs) - <i>Gallus gallus</i>			➤	×
Cassowary - <i>Casuarius casuarius</i>	×			
Wild birds (meat, eggs, and nests) - <i>Aves</i> spp.	×	➤		
Beetles (<i>Coleoptera</i> spp.) and other insects	×			
Bats - <i>Chiroptera</i> spp.	×			
Yam - <i>Dioscorea</i> spp.	➤	➤	×	×
Various kinds of fungus - e.g., <i>Auricularia</i> sp., <i>Lentinus</i> sp.	×	➤		
Tomi Tomi - <i>Flacourtia inermis</i>	➤	×		
Tomato - <i>Lycopersicon lycopersicum</i> , <i>Lycopersicon esculentum</i>				×

Fig. 2. (Continued)

question. It is clear that plants, animals, and people may evolve together as a consequence of the kinds of sustained interactions expressed by these spreadsheets. To the degree that these interactions have influenced human behavior enough to make people the dominant force behind the continued survival of local plant or

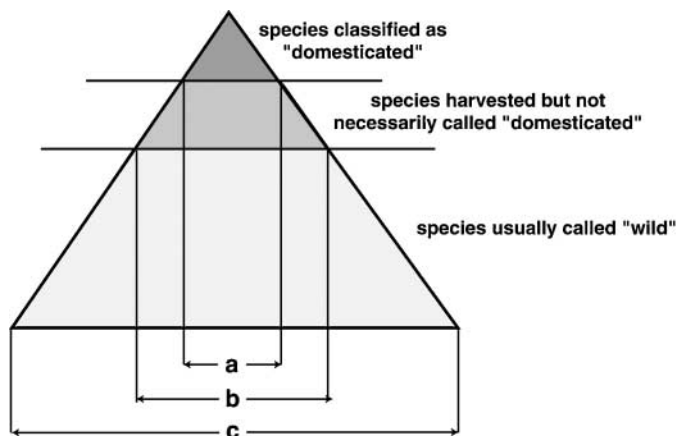


Fig. 3. The “Landscape Pyramid”: (a) the range of species (or species populations) usually classified as “domesticated” on the evidence of their morphological or genetic peculiarities; (b) the total range of species actually harvested from the landscape, i.e., the “domesticated landscape”; and (c) the total range of species occurring on the landscape.

animal populations, it might make equal sense to say that any species found on a provisions spreadsheet time after time attests to the success with which that species has “domesticated” (shaped) the behavior of the people involved (Harlan, 1995, p. 240; Rindos, 1984, pp. 262–263). Consider the case of *Zea mays*. Starting in the early Holocene as a geographically restricted species in Mexico, maize has successfully spread worldwide through its interactions with people, and it has been able to do so because people take pains to create living conditions for this crop that are favorable to its survival. People do virtually anything they possibly can to help *Zea mays* triumph over pests and competitors; they have expanded this plant’s geographic range by helping it boost its genetic fitness in marginal environments; they have developed processing techniques that boost its nutritional value as a staple food; and where and when people fail at such tasks, famine and death may be the price they have to pay. Our species’ success and that of *Zea mays* are often so intertwined that deciding exactly who domesticated whom might be beside the point. However, being instrumental in the survival of another species is not an element of the definition of *domestication* that we have been using here. When all is said and done, we are the species harvesting *Zea mays*, not the other way around. From this perspective, therefore, *all of the species* on a provisions spreadsheet may be called “domesticated species,” not just some of them. The morphological (and genetic) changes sometimes seen in plants and animals that are a consequence of their human use can be taken by archaeologists as manifest clues to what we have been doing to other species, intentionally or unintentionally, but as Eric Higgs used to say (according to Mary Pohl), focusing research only

on such visibly transformed species is like looking down the wrong end of a telescope.

CONCLUSIONS

Over the years, the story of domestication and agriculture has been chronicled in different ways and for differing purposes. Whether seen as a revolution or an evolution, the history being recounted has usually had one consistent feature. The underlying theme has been *replacement*. The story of agriculture has been about how human beings have learned to control Mother Nature's wild, impulsive ways by replacing them with our own orderly, efficient, and thus more trustworthy ways of going about being fed, housed, and properly looked after. Similarly, the story told about domestication has often been about how human beings have learned to replace the lean and allusive varieties favored by nature with more fruitful and abundant creations of our own design. We have argued here, however, that this kind of story is only one possible way of writing the history of agriculture and domestication. However appealing this standard account may be (e.g., Diamond, 2002), it is reasonable to wonder whether sticking only to the theme of replacement undermines our chances of answering the very questions writing that history is meant to address.

Certainly the notion that to be *controlled*, Mother Nature must first be *changed* or *transformed* is not only debatable, but has often been debated. It may be true that ecologists nowadays are uncomfortable with a simplistic ecosystems view that when disrupted, nature tries to return to a previously balanced state (O'Neill, 2001). Certainly seeing nature as a well-oiled machine—specifically, as a complex system of connected parts (or subsystems) with distinct feedback loops—may be a view that underestimates what many now see as nature's inherent disorder and evolutionary flux. Even so, one would be hard-pressed to deny that people (and undoubtedly other creatures, too) can learn from watching nature's ways, and are capable of then putting this knowledge to work to put food on the table. As the old saying goes, knowledge is power—one way of controlling nature is understanding how nature works.

What the oft-designated "hunter-gatherers" of Australia (Harlan, 1992, pp. 20–23; Ladizinsky, 1998, pp. 2–4) or the Amazon (Posey, 1984; Stearman, 1991) have been doing to domesticate their landscapes is different from what sharecroppers have done in Arkansas, or wheat farmers do in Kansas. Yet the goal of putting food on the table in each case is not so different. And Harlan (1992, p. 46) was right when he wrote that "every model proposed so far for agricultural origins or plant domestication has generated evidence against it"—an observation that carried him to the conclusion that there is no explanation for the origins of domestication and agriculture with universal or even wide application, and which then encouraged him to offer his well-known "no-model model" that "people do similar things for entirely different reasons and they find very different solutions to

the same problems.” We agree with this sentiment, but disagree with the premise that questions consistently yielding unsatisfying answers are still questions worth asking, nonetheless.

Stated perhaps too abruptly, concluding that the final answer to the “origin of domestication and agriculture” question is that no single model will work (Harlan, 1992, p. 47; see also Flannery, 1986a, pp. 19–28; 1986d, pp. 4, 9, 16; Pearsall, 1995, p. 192) leads us to regard this persistent question as a nonquestion. Therefore, as an alternative, we have turned to the twin concepts of the domesticated landscape and the provisions spreadsheet. With these notional tools in mind, we think the focus of research on the evolution of human subsistence behavior changes. What becomes challenging is not deciding how people should be classified—as foragers or as farmers—but instead, how successfully archaeologists can use what they have found to discover what people in the past were doing to put a family together, food on the table, and a roof over their head.

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