STUDIES IN HUMAN ECOLOGY AND ADAPTATION

Seeking a Richer Harvest

The Archaeology of Subsistence Intensification, Innovation, and Change

Edited by

TINA L. THURSTON and CHRISTOPHER T. FISHER

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PREFACE

Since the Enlightenment, research on technological change has served as the foundation upon which an archaeological discipline could be built that is scientific and comparative and able to resist being a tool of nationalist propaganda (e.g., Sherratt 1989). In response to a phase of nationalist archaeology after the 1890s, scholars such as V. Gordon Childe, for example, in his *Man Makes Himself* (1936), brought comparison and materialism back into archaeology. He identified those key innovations that brought what he called the Neolithic and Urban Revolutions, including technologies allowing for an increase in subsistence production such as the domestication of plants and animals, plowing, and irrigation. Following Childe's lead, later in the 20th century there was an explosion in the quantity and quality of theory-building and research along these lines, and it is this outpouring of work that forms the backdrop to the chapters in this volume. During this creative period, Esther Boserup, Julian Steward, Marvin Harris, and Karl Wittfogel, among others, proposed grand theories that aimed to explain the causes and consequences of agricultural intensification, and it is these ideas that are evaluated at length in this volume.

This is an appropriate time to evaluate what we know about agricultural intensification. Archaeologists are busy rethinking intensification, in part because theories developed during the mid to late twentieth century have not always held up well under research scrutiny. Also, we have found reasons to question the global predictions of grand but perhaps overly deterministic and often simplistic causal theories. Archaeologists, and anthropologists more broadly, are engaged in the development of a research epistemology that, while not abandoning theory and comparison, can better accommodate local history and culture and the strongly contingent and variable outcomes of human strategic action. For example, the causal connection Wittfogel and others drew between irrigation systems and the development of centralized political institutions generally has not been found, a topic addressed in some of this book's chapters. What is more commonly found is that irrigation management, even in complex societies with states, often is carried out primarily at the scale of local-level village organizations or irrigation associations governed by leaders whose behavior must be accountable to their local populations, and whose detailed knowledge of local conditions and personalities makes it possible for them to monitor and control the behavior of "rational" but selfish social agents (e.g., O'Connor 1995: 975, 976). Examples of largely local management under conditions of intensive agricultural production, and in which the managerial role of the state is comparatively small, include Bali (e.g., Christie 1992: 16), Ming Dynasty China (Bray 1984: 109), and Tokugawa Japan (Toshio 1991: 488-95, 501-2).

Interestingly, in the latter two cases, Ming China and Tokugawa Japan, some of the most important crops had primarily social and symbolic value, especially, in both cases, cotton. This points to what I see as a limitation in contemporary intensification theory that analyzes primarily the production of food surpluses, and that understands pre-modern complex societies in terms of an economy of surplus production (of food) that is appropriated by a governing elite (e.g., the "Tributary Economy" of Eric Wolf [1982: 79-82]; cf. Harris 1979: 101). We will require a more broadly-conceived theory of agricultural intensification that can incorporate symbolic as well as caloric production. A step in this direction is found in the present volume, when, for example, Feinman, Nicholas, and Haines make the important point that Mesoamerican archaeologists have devoted too much of their attention to the primary food crop, maize. I agree, and would point out that, in addition to their Oaxaca example, some of the most notable phases of agricultural intensification in prehispanic Mesoamerica involved crops suited primarily to the display and negotiation of social standing, such as cotton, dyes, and cacao (chocolate).

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SEEKING A RICHER HARVEST:

An introduction to the archaeology of subsistence intensification, innovation, and change

Tina L. Thurston and Christopher T. Fisher*

INTRODUCTION

Plowed ground smells of earthworms and empires. – Justin Isherwood

In current times, intensification is most often discussed in terms of feeding the world's poor, counteracting globalization, or improving the balance of trade, issues earnestly debated by economists, geographers, development experts, and agricultural soil scientists, chemists, and the like (i.e. Bashaasha et al. 2001, Bebbington 1997, Byerlee et al., 1997, FitzSimmons 1986, Pingali 1989, Smith et al., 1994). When one speaks to current farmers, the voices are more immediate, if sometimes ambivalent (Bennett and Warrington 2003a). Some praise intensification and the coming of the "new" while others damn it, still others point out both successes and failures with the introduction of 'scientific' farming.

For the historically documented past, one finds many illustrations of experimentation with subsistence methods and their relative intensity (Bassett 1988, Jacobs 1996, Koval'chenko and Borodkin 1988, Rhode 1995). Some past processes are described as driven by a need for more food or to supply markets; others as attempts to

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prop up states and empires; usually, there is a substantial distance between the historian's voice and the reality of fields, pastures, and high seas.

In some ways, traditional archaeological approaches to the study of subsistence change have been akin to historic voices – distant, omniscient, and mostly about *outcomes* – or perceived outcomes – this volume seeks to consider the conditions of past farmers, herders, and other producers more directly, taking cues from ethnographers and NGOs, as opposed to historians and demographers, to learn not only about structures and institutions, but also about experience, intention, and process.

With this volume, we attempt a fresh look at an old topic – the intensification of food production – long cited as an important indicator or engine of cultural evolution in the archaeological record. Intensification of subsistence generally refers to productivity increases generated through changes in the methods of agricultural or pastoral production (see discussion Morrison, 1994:115) – a seemingly simple concept that has proved surprisingly difficult to apply. In archaeology, intensification itself is almost always imagined in similar ways: explanations typically focus on "how agriculture intensifies, who benefits, and who (or what) pays the price" (Dove 1997:399), referring to the technologies and features of agricultural systems.

Intensification has been invoked as a both a cause and outcome of state development, population growth, climatic or environmental change, and centralization, and in addition, often forms the basis for explanations centered on the evolution of subsistence systems (R. McC Adams, 1966; Blanton, et al., 1982; Boserup, 1965, 1981; Brumfiel, 1983; Butzer, 1977; Erickson, 1993; Flannery, 1972; Haas, 1982; Kolata, 1996; Parsons, 1991; Parsons et al., 1985; Sanders, 1976; Sanders et al., 1979; Steward, 1949, 1955; Wittfogel, 1957; Wright, 1986).

Given the centrality of intensification to seminal archaeological explanation, and the major shifts in archaeological thought over the past two decades, it is remarkable that more has not been written on the subject in recent years (though there are exceptions – i.e. Hastorf 1983, 1993; Hastorf and Earle 1985, Kirch 1985, 1994; Ladefoged et al. 1995, Leach 1999; Morrison 1994, 1996; Nichols 1987; Stahl 1995; Stone and Downum 1999). Even fewer have attempted to study other processes of subsistence change, such as specialization, diversification, or disintensification.

As some have noted, archaeologists working in a variety of contexts "routinely and incorrectly label virtually any kind of subsistence change...'intensification.' They conflate intensification with more extensive use of some resource rather than employing the term to refer to increased *per capita* labor expenditure for a specific resource or for overall subsistence (Arnold et al 2004:1)." Many consider the conditions of agrarian production and neglect discussion of large-scale marine exploitation, or the complex connections between livestock and cereal strategies (Bencherifa and Johnson 1991, Blowfield and Donaldson 1994, Bourne and Wint 1994) and the multiplicity of mixed processes adopted by farmers to exploit niches and short-term opportunities. Others fail to imagine that conflicting local needs and state demands form a complex matrix of pressures, resulting in a simultaneous combination of strategies (Potter 2001). There is also a tendency to forget that "processes of intensification and innovation that are implicated in change to agricultural systems are, similarly, instances of more general processes of adaptation and transformation which underwrite change in complex systems (Minnegal and Dwyer 2001)" (see also Blanton, this volume).

This lacuna is keenly felt at a time when many contemporary archaeologists have begun to question the utility of the intensification concept (Leach 1999) and re-examine long-held concepts of general cultural change: deep-rooted assumptions regarding the causal primacies of population pressure, elite control, and ecological limiting factors have also come under scrutiny. New renderings of the intensification concept emphasize the role of inequality rather than population pressure, human ingenuity in dealing with climatic or environmental conditions rather than as limiting factors, and the power and agency of non-elites and subaltern groups.

While there are a wide variety of works describing the origins of subsistence systems, and their consequent spread and adoption by foragers, a compendium of both theoretical and case-specific treatments on intensification and other processes of subsistence transformation is lacking. We hope this volume will help fill this gap, and add other voices and perspectives to the discussion.

A BRIEF HISTORY OF SUBSISTENCE INTENSIFICATION STUDIES

"*...small landholders are the most precious part of a state.*" – Thomas Jefferson

"*Agriculture not only gives riches to a nation, but the only riches she can call her own*" – Samuel Johnson

"*Whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would...do more essential service to his country than the whole race of politicians put together.*" – Jonathan Swift

It is not surprising that the views of these famous Enlightenment figures regarding the farmer and the state reflect the preoccupation of classic 20th century processualism with its 'surplus producers' and their 'ruling elites'; both are rooted in a concept of class and power situated firmly in Modernity. It is safe to say that contributors to this volume generally argue against the materialist and ahistorical tenor of such systemic and normative views. Such perspectives originate in the longstanding debate linking demography to intensification that is usually traced to the 19th century economist, Thomas Malthus, whose dismal view of humanity squeezed between population pressure and intensity of production was based on the idea that higher levels of production would lead to higher populations without the resources to support or even feed themselves. For these poor souls, he predicted a downward spiral of disease, famine and warfare (Malthus 1798), mitigated only temporarily by social controls on population and innovations in food-producing technology. These improvements, however, would only lead to higher populations, beginning the cycle of misery once more.

A little more than one hundred and fifty years later, Ester Boserup, a Danish economist, was among the first to intelligently argue against this view, by suggesting that population growth and the resultant population pressure successively acted as 'tipping points' toward increased inputs of labor: prime movers for the adoption of new agricultural technologies or strategies, such as shortening fallow periods, raising productivity, and even constructing features such as terraces and irrigation canals. Such improvement, if continual, could keep human groups a step ahead of starvation. Yet she also saw a downside, envisioning that while yields per unit of land would increase, the labor input necessary was so high that labor efficiency per unit of land would eventually drop. People would be working too hard for the food they were getting, and thus would be unlikely to adopt or continue such strategies under normal conditions.

Boserup's more optimistic view on demography and population (1965, 1970a, 1981) was readily embraced by many New Archaeologists, as part of their avid adoption of ideas from other social science disciplines. One of the first and most influential works in this vein was the volume edited by Brian Spooner, entitled *Population growth: anthropological implications* (1972), with contributions from numerous archaeologists including Adams, Bronson, Carneiro, Sanders, Smith and Young, and Wailes – for all intents and purposes covering every major world area. The volume thus provided a key point of dissemination for Boserupian demographic/labor oriented intensification theory into world archaeology. In the same year, *Annual Reviews* brought out an article which unquestioningly supported these assumptions (Baker and Sanders 1972).

In answer to this, the edited volume entitled *Population Studies in Archaeology and Biological Anthropology: a Symposium* (Swedlund 1975) appeared, a publication of the Society for American Archaeology, in which the Boserupian line was debated by more of the era's greatest names, several of whom wrote vehemently *against* the idea of population driven subsistence shifts (i.e. Blanton 1975, Cowgill 1975b). Dissent from the ever-broadening application of Boserup to the archaeological record was also a key ingredient in Cowgill's (1975a) "On Causes and Consequences of Ancient and Modern Population Changes" – an influential piece still read in many a graduate seminar.

Boserup's work was an especially useful framework for the newly empiricist-inspired studies of the 1970s and 1980s, as it identified archaeologically visible features as evidence of subsistence systems and changes. Throughout the 1970s, those who called themselves New Archaeologists rejected earlier notions that each culture was generally normative in time and space, an assumption that had allowed the previous generation of archaeologists to presume past "mental templates" for accepted behavior and attitudes. New (later 'processual') Archaeologists replaced this with the more measurable, and thus supposedly testable, concept of society as a set of subsystems within a system of culture, which might be recognized archaeologically through material remains – in other words, instead of attempting to model what ancient people were thinking or planning, which was seen as fruitless, they attempted to limit their work to what could be observed materially, conceptualized primarily as external reactions to the environment. As general systems theory and other materially focused concepts were adopted by New Archaeologists, the concept of population pressure, linked to need for a greater food supply, observable through a set of possibly visible and quantifiable "subsistence strategies" fit in well with then-current paradigms.

A flurry of intense interest in such topics followed: *Annual Reviews* surveys of 'demographic methods' in archaeology, a code-name for Boserupian interpretations, were spaced rather closely; in the first, Baker and Sanders (1972) staunchly supported Boserupian principles of subsistence change and intensification with only the slightest of nods to possible alternatives (1972:162). Not long after, Weiss (1976:366) noted that while the Boserupian view of intensification and other subsistence change is pervasive, there were many challenges to such notions with which he agreed. Another review appeared in 1978, authored by previous dissenter Swedlund, in which he argues against the intensification model based on demographics and instead suggests that subsistence pressures occur on a "resource-specific basis" – sometime at levels far below 'carrying capacity' (Swedlund 1978:153) – and that stress may or may not occur when supply and demand for fixed and renewable resources oscillate in different ways. Supply is limited by both the desire and the ability of producers to increase production. He detects a clear difference between the causes and mechanisms of fluctuations in both population and subsistence products (1978:156) and further suggests that decisions to change subsistence methods may be made at various levels: the family or household forming one possibility, with others found among class factions, gender groups, or political parties, depending on the case study and the questions being asked (Swedlund 1978:160).

Hassan (1979), in yet another *Annual Reviews* piece on the same topic, notes arguments both for and against population pressure-driven intensification, pointing out that other causes may lie behind subsistence changes, yet he offers as alternatives mainly the external: "changes in the yield, quality, aggregation, association, seasonal predictability, and spacing of resources as a result of natural or man-made climatic-environmental changes"..."fires, overgrazing, overkill, salinization, erosion, and soil depletion (Hassan 1979:147)" while somewhat cryptically offering "man's [sic] propensity to accept innovations that may better satisfy his needs, lower his subsistence effort, or increase the yield at lower or the same levels of effort (Hassan 1979:147)."

Boserup's then-recent book was described contemporaneously as an important ingredient in many arguments for intensification under conditions of social or natural circumscription (Cowgill 1975a:507), as well as "socio-cultural complexity and accumulations of wealth and power" that follow. Carneiro (1970, 1972), Sanders and Price (1968), and Smith (1972), among many others, relied heavily on the implication that exponential population growth was endemic or at least typical in prehistoric societies of all types, and that it could be assumed when constructing archaeological models. After the late 1970s, despite a record of substantial, if limited, dissent, there was clearly a ubiquitous adoption of Boserup's ideas into the archaeological study of subsistence choices. Remarkably, ten years later, Howell's *Annual Reviews* piece (1986:234) tacitly concedes victory to the Boserupian model, with no references to any opposing views.

The next important influence on archaeological subsistence change theory was the work of ethnographer Robert Netting, which strongly reflected and built upon Boserup's concepts, and also became a model for processual archaeologists, perhaps because many of his arguments are rooted in an assumption of functionalism, which was perceived as well-suited to the difficulties of the incomplete and materially-based archaeological record. Assumptions of a "universal" functionalist set of motives and rationales behind agricultural and pastoral decisions permitted the modeling of past societies based on observations of the present. Netting, a protégé of Julian Steward, reinforced this perspective. His extensive studies of the Kofyar people of Nigeria formed the model for many archaeological hypotheses about intensification, especially through arguments connecting population growth with social change. He typically described social behaviors as adaptations to the problems of farming, highlighting the adaptive advantages of smallholder households in the intensification process.

In addition to its functionalist perspective, Netting's earlier work also mainly focused on external pressures and their effects on farming and ranching: war, disease vectors, and population increase or decrease (Netting 1973) although he also attempted some examination of internal, ideational issues (Netting 1972). He continued throughout his career to argue for economic rationalism as the root of most decision-making among farmers (Netting 1993).

The paradox of Netting's work is that despite what might be seen as flaws by many archaeologists today, he also offered valuable insights that run deeply in many of this volume's contributions: unpacking the notion of inherent links between intensification and degradation (Netting 1993), instead suggesting that degradation occurs in the absence of intense land management, or due to sudden drops in its presence (Fisher, this volume, van der Leeuw 2005), a position which led him to question whether population growth was to blame for many current environmental problems. He also was ahead of his time in suggesting that the concept of inherent "sustainability" among indigenous peoples may be spurious: smallholders may be better adapted to manage intensive farming than "elites" (1993:100), but their management could be substantially flawed. Another important perspective he pioneered was that indigenous corporate management of institutions are not "survivals" of quaint but outmoded institutions, but dynamic, contemporary strategies (Netting 1993:185), and form a vital and successful "indigenous solution" to subsistence problems (1993: 20), directly arguing against the typical notion of top-down imposition of land tenure rights on common people by their rulers. Finally, he reminded his readers that the timeline for the outcome – success or failure – of many observable subsistence decisions is a long one, perhaps best showcased through archaeological frameworks (1993:145).

Another important figure in the agricultural transformation debate is Harold Brookfield, an economic geographer upon whom archaeologists have drawn for decades. Although an early proponent of Boserupian ideas (i.e. Brookfield and Hart 1971), as early as 1972 he recognized the existence of what he termed *social production,* as contrasted with subsistence production, where "inputs may be wildly uneconomic when measured in calorific returns yet wholly reasonable when measured against social returns (Brookfield 1972)." By the 1980s, he had developed further concepts that find utility in current archaeology: agricultural "innovations" defined as strategies that introduce qualitative changes to the production system and can increase the productivity of labor (Brookfield 1984) – departing steeply from Boserup who stated that "higher labour requirements would make cultivators reluctant to innovate (Allen and Ballard 2001:159)." Another important modification was his notion that if a society was forced to deal with environmental constraints on agriculture, that it could well mandate a "more technologically elaborate agricultural system" – a concept missing from Boserup and the focus of many critiques (Allen and Ballard 2002:159). Perhaps most influential was his the concept of *landesque capital* (Brookfield 1984) discussed below and elsewhere in this volume (i.e. Fisher).

Thus, over time, the original Boserup model and its later incarnations were critiqued on several fronts. Even in his consideration of her original publication, Cowgill (1975a) was strongly skeptical of the concept, readily adopted from Boserup, that human groups have trouble internally regulating their own growth, thus leading to overpopulation, noting that if this were so, the planet would have had a billion human residents after only several thousand years. (1975a:508-10). However, he notes that some of the best-known theorists of the era had already substantially bought into the concept. Cowgill rightly noted that in many cases these ideas were implicit, rather than explicit: the authors' data revealed the flaws, but they did not seem to acknowledge this: they 'know' it, but don't 'realize' it, in Cowgill's words (1975a:509). This lack of explicit discussion was one of the insidious pathways through which such critically flawed hypotheses seemed to have been "tested" and supported. The privileging of the importance of external pressures (such as uncontrolled demographic increase) in the processes of social change was one of the prime motivations for both moderate and radical critiques of processual archaeology.

Other critiques went the opposite way: some argued (e.g., Lee 1986, Richerson & Boyd 1998, Turner & Ali 1996, Wood 1998) that Boserup and Malthus were both wrong, but primarily because their visions should be expanded to the degree that they are seen as complementary, representing negative and positive phases of more long-term cycles within the dynamics of population and environment. This view in itself has been critiqued as lacking any consideration of the cultural contexts of both agriculture and population dynamics (i.e. Cowgill 1998). Stone and Downum (1999) argue that Boserup is correct under certain conditions, but not under others. Many might state that a substantially modified Boserupian perspective is now the norm among many ethnographers, geographers, and the like, that takes into account the complex dynamics of agrarian change (Clarke 2001).

Some have rejected Boserup entirely, as reductionist, unilineal, and facile (Brookfield 2001, Hunt 2000, van der Veen 2005), with recent criticism focusing on the proposed "one-way" course of intensification from simple to complex agrotechnologies, the lack of consideration for inputs other than labor, and the 'law' of diminishing returns – the concept that increased labor is essentially fruitless, as it results in diminishing returns for the effort. The concept of landesque capital (Brookfield 1984, Blakie and Brookfield 1987), a type of technology which does not require constant labor inputs, is an important contribution in this area.

Others ask us to move "beyond" Malthus and Boserup entirely (Stone 2001, Brookfield 2001) and unpack the concepts of demography and subsistence strategies, instead urging us to consider more internal engines of choice, related to human experience. Long ago, Cowgill (1974) and others had already recognized that intensification and other subsistence shifts may more logically be tied to "new opportunities" as equally as they are to stress or "threat of hardship" (Cowgill 1974:514). As it happens, one of the most vociferous proponents of this sea change is the early Boserupian Brookfield himself, who, through remarkable self-critique now advocates that important determinants of subsistence change include a producer's management (in contrast to purely technical) skills, their diversification efforts and production investment, and their ability to find new ways of organizing resources – and finally, the livelihood opportunities to which they are exposed (Brookfield 2001). Expanding upon his early idea of 'social production', he argues that "adaptation, innovation, and the seizing of opportunity can take place within a wide range of social, demographic and environmental conditions (Allen and Ballard 2001:159)." This is reflected in recent archaeological critiques that indicate intensification often involves non-food crops or luxury foods, that have social rather than economic meaning (Hayden 2003), or to surplus production for trade (see Leach 1999, Morrison 1994, 1996 for a review).

Boserup herself had great interest in gender issues, proposing that hoe-based intensive farming was a female activity, while plow-based farming was generally male (Boserup 1970b) with implications for more generalized gender roles. The role of women in indigenous agriculture worldwide continues to be avidly studied by ethnographers, economists, development experts and others. In anthropology, the argument that women's decision-making role in agriculture lessens with intensification, perhaps through cooption by male work organization modes and mobility, resulting women's withdrawal into more domestic roles has been made for some time (i.e. Ember 1983, Burton and White 1984). Others contend that this is an oversimplification, and that women's role in intensification is varied, and is determined more by historical context than technology or environment (Stone et al., 1995) and that women, despite their roles in procreation and householding, remain actively engaged in performing and managing intensive agriculture (Cleveland 1985, Cohen 1984). A neglected area of study remains the use of children as a valuable labor pool (Kramer and Boone 2002).

Questions about the gendering of agriculture and subsistence choice have in recent decades become a consideration in archaeological study as well. Some archaeologists have published on the role of women in the development of farming, and the gendering of decision-making and labor inputs involved in subsistence, and have begun to study of the role of gender in intensification and other strategies of change. A few have pursued Boserup's ideas on the impact of changing economic circumstances and subsistence strategies on gender roles and relations such as is seen in recent times (i.e. Galle 1999, Guyer 1991, Prezzano 1997, Rautman 1997, Williams and Bendremer 1997, Watson and Kennedy 1991). Women may have continued to be major contributors to decision-making with the advent of subsistence intensification and change, as they are in current times, and 'intensive gardeners' may have been the "locus where ecological knowledge was learned, controlled, and transferred (van der Veen 2005:159). Small but highly labor-intensive, staple-producing gardens figure importantly in both simple and complex intensification processes (Jones 2005), reflecting the ethnographic observation that in many cases "garden money buys grain (Becker 2000)." The concept of the current worldwide "feminization" of agriculture (i.e. Bencherifa 1990, Besteman 1995, Jha 2004, Pala-Okeyo 1979, 1980) due to the absence of males who migrate for warfare, work, and other opportunities, is mirrored in archaeological inferences about the causes of periodic female assumption of duties in typically male domains (i.e. Arnold 1996).

Thus, over the last decades, the concept of intensification has undergone evolution along several critical threads originating within anthropology, geography, development and elsewhere (see Brookfield 2001:199, Kirch, 1994:15-20, Morrison 1994), yet despite critiques both mild (Lee 1986, Wood 1998) and harsh (Leach 1999, Morrison 1996) for many archaeologists, the entrenched “classic” Boserupian model has remained fairly static. While some current ‘anti-Boserupian’ archaeologists like to believe that these long-popular arguments are essentially dead, this is clearly wishful thinking on the part of her critics. As recently as 2001, Asia Pacific Viewpoints committed an entire two-issue special publication discussing Boserup and post-Boserupian ideas on intensification in Asia, and many archaeologists still consider her ideas an entrenched force to be contended with (Arnold, Walsh and Hollimon 2004, Erickson 1998, Morrison 1996, Stone 1996, van der Veen 2005). Yet others continue to use Boserup quite uncritically in their work (i.e. Sagona 2004).

In the continuing melée, it is easy to forget that Boserup should get her due: she was a revolutionary thinker, whose own work and ideas evolved substantially during her long lifetime (1910-1999), even while those who adopted and used her original concepts did not. She conducted fieldwork around the globe, published prodigiously, and brought social science insight to issues where false and detrimental ideas had been entrenched through inference and implicit acceptance since the 18th century and before. Born and raised in an era when white, western males (including anthropologists) believed that all others were inferior, she brought issues of inequality, gender, race, land tenure, development, and food supply and to the attention of both the academic and non-academic spheres: perhaps her most important contribution. Her current proponents and critics typically acknowledge this fact.

CURRENT MODELS FOR SUBSISTENCE CHOICES

“Happy he who far from business, like the primitive are of mortals, cultivates with his own oxen the fields of his fathers, free from all anxieties of gain” – Horace

“Farming looks mighty easy when your plow is a pencil, and you’re a thousand miles from the corn field” – Dwight D. Eisenhower

Brookfield (1972), a geographer, sparked by shortcomings in the Boserup model and informed by his own research in the Pacific, contributed one of the most detailed intensification definitions, which has been taken as a starting point by critics (see Leach 1999, Morrison 1994). Brookfield’s formal economic definition stated that when

> “Strictly defined, intensification of production describes the addition of inputs up to the economic margin, and is logically linked to the concept of efficiency through consideration of marginal and average productivity obtained by such additional inputs. In regard to land, or to any natural resource complex, intensification must be measured by inputs only of capital, labour and skills against constant land. The primary purpose of intensification is the substitution of these inputs for land, so as

> to gain more production from a given area, use it more frequently, and hence make possible a greater concentration of production (Brookfield, 1972:31)."

Brookfield provides two accompanying caveats that, as argued by Leach (1999), are often ignored in archaeology. The first notes that agricultural technologies with similar labor inputs (i.e. permanent field mounding and simple swiddening) have distinct social implications and, by considering only labor, critical differences in organization and productivity are missed. One analogy drawn from the Americas would be differences in terrace and raised field agriculture: both require similar labor inputs (see Fisher this volume) but, because the output of wetland agriculture is much higher, it potentially yields surplus used to finance power. Distinct theoretical implications are associated with two contemporary techniques. As a solution, Brookfield suggests an additional measure of skill and complexity (Brookfield 1972).

The second caveat provided by Brookfield (1972) suggests that intensification may also cause social and organizational changes not physically apparent but having profound production implications (mirrored in Blakie and Brookfield's definition of *landesque capital*, see discussion below). For prehistory, such transformations are reflected in elite culture predicated on transforming surplus into power. This mirrors recent work that considers the social implications inherent in various agricultural methods. More recently, ethnographers and archaeologists alike have stressed the importance of several other "inputs" – such as knowledge, information, and technology, "inputs" that are completely left out of Boserup's (1965) definition of intensification, the jumping-off point for so many past and recent studies of subsistence change.

Recently there has also been a new mandate for studying the impetus behind intensification beyond mere subsistence production increases. Extreme efforts may be put in to producing small quantities of highly valued but limited-use resources such as religious or prestige-related items. People who are pressed to produce more for elite consumption may be worked to death for meager increases in production. Finally, producers may not realize that their attempts are unlikely to raise yields: we recognize that the object of our studies is not agronomy, but social organization, inequality and power, along with numerous other issues; thus, the study of *failed* or *abandoned* attempts at intensification should be considered to be as important as the documentation of successful ones (Morrison, this volume).

Another important consideration is that different types of intensification produce either short-term or long-term benefits, which can be conceptualized as lying along a continuum where we can place different strategies. Some groups favor one or the other end of the spectrum almost exclusively, while others utilize both short-term and long-term strategies at the same time. Depending on what other conditions arise or vanish, these choices and combinations can change over time.

For example, in some circumstances, cattle production can be intensified fairly quickly and easily, and disintensified just as rapidly when economic opportunities diminish (Bencherifa & Johnson 1990). On the other end of the spectrum, we can refer to the concept of landesque capital developed by Brookfield (1984) and Blakie and Brookfield (1987) to distinguish landscape investment designed for long term gain (see also Kirch, 1994). Landesque capital refers to labor that has been environmentally 'banked 'through the construction of stone walls, terraces, drainage systems, irrigation systems, raised fields or other intensive features. This "built" capital provides benefits for generations – if maintained. Thus, the social capital created by these long-term investments is quite different than what is gained by the rapid and opportunistic intensification that might in some instances be achieved with livestock *or* methods which require constant and high labor inputs, such as manuring.

Some authors make a finer distinction, distinguishing between *innovation* and *intensification* (Bender, 1978; Brookfield, 1984; Blakie and Brookfield, 1987; Kirch, 1994). Both result in higher output, but with innovation this is achieved through increased productivity while techniques of intensification require higher labor costs. Thus, by the law of least effort, intensification is sometimes associated with coercion while innovation is adopted to gain "advantage" (Bender, 1978; Brookfield, 1984; Kirch, 1984 – see also Leach, 1999). However, it is not unusual ethnographically to see local groups self-organize to "gain advantage" in paying taxes or tribute, an indirect coercion, rather than for their own improved life-style or leisure time, leading us to another continuum of strategies.

Kirch (1994) created a "working taxonomy of agricultural change" to distinguish between intensification and innovation in the archaeological record. Intensification is defined, as noted, by more inputs of labor or skill into standard units of land, but two *types* of intensification are identified. The first, *cropping cycle,* is the classic sequence of long to short fallow systems implied by Boserup (1965). This refers to sequences where, for example, a system where half the land is fallow while half is cultivated shifts to a system where only one third is left fallow, thus increasing land under production at any given time. The second category of intensification is that of the above-described landesque capital, meant to include landscape modification serving as infrastructure.

Innovation, as defined by Kirch, involves increased productivity without increased labor: new tools, planting methods, mulching, water control devices, and erosion control classified as *agronomic – technologic* innovation. *Genetic* innovation, encompassing biological changes in crop assemblages, forms a second, often missed category (but see Kirkby, 1973).

This division between innovation and intensification is useful, but presents its own problems, as it can in fact be argued that landesque capital is also innovation, since after initial construction labor, labor diminishes while returns rise. Must we thus declassify such systems as terraces, raised fields, and canals from the roster of intensive strategies? Not necessarily – one can argue that as long as farmers are aware that their methods remain more productive than other methods, i.e. that ceasing to maintain the system would lead to lower returns – the investment of initial labor is still a part of the system. In addition, while maintaining canal systems and other landesque capital systems may require less labor than building them, maintenance itself may require *more* labor than some extensive forms that might precede such infrastructure (but see Fisher, this volume).

Another factor confounding the concept of dividing intensification and innovation is the adoption of new methods during an availability phase: a group may know of and be familiar with new crops, new tools, and new methods used by neighbors, yet choose not to adopt them. When circumstances, either social, environmental, or both, invite eventual adoption, can we really call this "innovation?" Rather, it provokes the question "why did they wait, postpone, and finally adopt" these already familiar, but unused methods.

If anything, we conclude that there is no constraint to adhere to Boserup's conceptualization of intensification. So much about the theory, as initially set forth, has proved problematic, that the narrow definition of labor as the only intensifying "input" into land may be judged overly rigid. Nor should we seek to decouple intensification from so-called innovation so strongly that we fail to connect them as parts of the suite of strategies available for the management of production.

EXPLANATORY MODELS FOR INTENSIFICATION

> *"Our traditional agriculture was fully self-reliant. The seeds, the manure and the bullock, everything was personal. Only seeds were exchanged by farmers. But the farmer today is totally dependent on the government machinery. It would not be an exaggeration to say that he has become a slave to multinational seeds and fertilizer."* – Vijay, Male. 41, activist/farmer, India (Bennett and Warrington 2003b)

Intensification explanations can be broken down into elements falling along two axes. Each is a continuum defined at the poles by the differing core assumptions inherent to each interpretation. More than one interpretation is often seen when different researchers consider the same case study, which might be viewed as misinterpretation by one or the other. On the other hand, this can represent actual change in agro-economic practice and strategy: cultures can, in reality, move along these continua depending on what conditions are extant, what impetus they have, and what outcomes are sought.

The first continua, characterized as the 'top down' and the 'bottom up' (Chambers, 1980; Scarborough, 1991; Erickson, 1993) encapsulates debate over who, and with what resources, constructed or organized intensification features, innovations, or other planned changes. The more traditional 'top down' approach, following the 'hydraulic hypothesis' (Steward, 1949, 1955; Wittfogel, 1957), suggests that the complexity, large scale, technological sophistication, and massive labor required for intensive agriculture demands coordination, planning, management, and possibly coercion by a centralized entity; most often a state (Kolata, 1991, 1993, 1996; Matheny and Garr, 1983; Sanders et al., 1979; Stanish, 1994). This moves intensive features beyond the purview of kinship group, community, or small polity-based sociopolitical entities with such systems dependant on regional scale mechanisms of socioeconomic integration. In this model, only state level societies are capable of absorbing presupposed high labor, capital, and administrative costs.

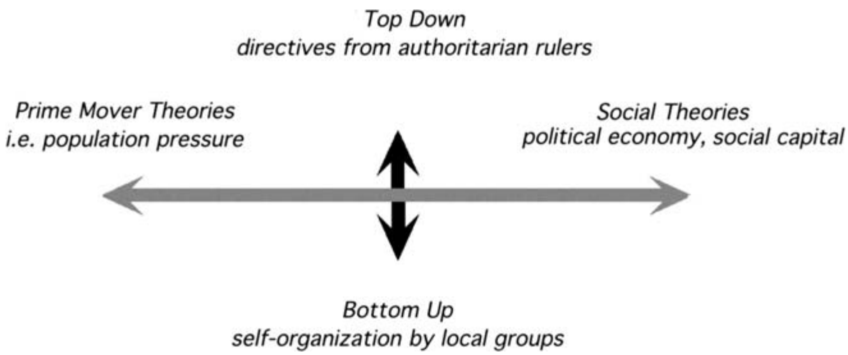

Figure 1. Continua along which intensification explanations can be theorized.

Recent archaeological research has re-examined the 'top down' approach. In several cases, what appear to be state-mandated and planned schemes have turned out to be of local origin, design and maintenance. Some authors have argued, for example, that raised fields and associated settlements appeared before and after the Tiwanaku state's rise and fall, and thus can not have been organized by the state. (Erickson, 1993, 1999; Graffam, 1992). Raised field and canal systems also appear before regional integration in other areas of Latin America (see Denevan 2000; Doolittle, 1990; Sluyter, 1994; Whitmore and Turner 2002). Recently Erickson has proposed a 'top down' alternative arguing that

> "Various sources of evidence strongly indicate that raised field farming was organized, at least initially and probably throughout it's history, at the local level. These pre-Columbian agricultural works are the accumulation of the activities of many generations of farmers producing a totally human made landscape (1993:371)."

To summarize, a 'top down' view sees the scale and complexity of intensive landscapes as requiring planning, coordination, and management accomplished by centralized control. In contrast the 'bottom up' perspective emphasizes an accretionary mode of agricultural system growth (Doolittle, 1984; Scarborough, 1991) based on family and kin organizations providing planning and labor for intensification. In the middle of this continuum lies the probability that the state sometimes exploits and manipulates already extant intensification methods for its own support.

The second axis is composed of explanations promoting different causal mechanisms for intensification adoption. Perspectives explaining intensification by either prime mover (push) or political economy (pull) based mechanisms form the poles of this continuum (Morrison 1996).

In the push-based mode farmers only participate in a labor-intensive mode of subsistence because they are responding to resource imbalance, most often demographic. This 'prime mover' oriented approach makes population pressure (Boserup, 1965, 1981; Sanders et al., 1979; Turner et al., 1977) an evolutionary mechanism seen as a prerequisite for intensification.

As has been noted, for some decades, the literature has critically examined the systemic relationship between population growth and agricultural intensification first proposed by Boserup (1965), and implicit in the prime mover approach (e.g. Blanton, 1975; Cowgill, 1975a, 1975b; Feinman and Nicholas, 1990a, 1990b:104-5, 1992; Feinman et al., 1985; Kowalewski et al., 1980). This growing body of archaeological literature demonstrates that the causal link between demographic stress and agricultural intensification is absent (e.g. Blanton et al., 1981, 1982; Brumfiel, 1976; Feinman et al., 1985; Kowalewski et al., 1989). Part of this rejection is linked to the eventual abandonment of "systems theory" by the social sciences which in archaeology meant that the concept of culture as a set of systems style relationships was discarded (see Zimmerer, 1994, 2000).

'Political economy' explanations form an alternative, modeling intensification as a means of predictable surplus that can be used to facilitate systems of exchange, risk management, craft specialization, and tribute or taxes. This may be observed in both kinship-based societies and in states (Arnold, 1995; Blanton, 1995; Brumfiel and Earl, 1987; D'Altroy and Earle, 1985; Earle 1991; Feinman, 1995; Gilman, 1991; Hayden, 1995; Plog, 1995; Wright, 1984).

The difference between 'prime mover' and 'political economy' perspectives is the emphasis placed on either external or internal mechanisms of evolution. For 'prime movers' expanding populations move causation outside the socio-economic sphere of human control. In contrast, political economy models see intensification resulting from human-driven strategies for agricultural surplus promoted by elites financing power acquisition.

INTENSIFICATION AS PROCESS

> *"Yes, in the first year I thought [chemical fertilizer] was really wonderful. But in the second year the yield began to fall, and in the third year it fell even lower. In the fourth year it was exactly where it was before I started using fertilizer. The money that I spent on buying the fertilizer is a separate matter. Our land was harmed in exactly the same way that a man's body harmed when he drinks liquor. That was the effect the fertilizer had upon my land..."* – Sudesha, Female, 50s, activist/farmer, India (Bennett and Warrington 2003b)

Distinguishing between an intensive form of agriculture and the process of intensification requires distinct archaeological evidence (see Leach's critique of Kirch, 1999:315). The former is accomplished (following Kirch, 1994) by identifying intensive features (landesque capital) permanently modifying the landscape. In contrast, the intensification process is identified by studying changing parameters and increasing investments. Following the process, as best we can, from start to denouement, is the key to answering many important questions. What was the impetus for intensification, for example – increasing the food supply or solving the problem of higher governing costs with a tax increase? Who plans and organizes intensification – central elites, or hard-pressed locals? What is the result of the attempt? Success or failure? Compliance or resistance? Why? Is it possible to tease out combinations of the above strategies and motives? Some geographers have approached agricultural change as a process with some success (i.e. Doolittle 1984, 1988).

Our new concern with both successful and failed attempts at intensification falls into this area of study. While we advocate a new focus on intensification, studies of intensification should, perhaps, also include the study of failed attempts to increase productivity (Morrison, this volume). A number of authors interested in the behavioral ecology of foragers have recently adapted these perspectives to food production strategies (i.e. Russell 1988, Hawkes et al 1982, Keegan 1986), viewing higher returns (more energy) as a Darwinian reproductive advantage. However, many attempts at intensification of both plants and animals have been highly maladaptive, leading to overgrazing, deforestation, and subsequent erosion and degradation - yet these societies did not become extinct - they learned to live in self-created, less optimal conditions. Focusing on the intent of prehistoric people to minimize risk and improve gains is clearly not enough to explain many archaeological sequences. Studying intensification's unplanned consequences and failures sheds a great deal of light on this issue.

CONCLUSIONS

The authors collected here agree that the driving forces behind the wide spectrum of observable subsistence strategies and their subsequent changes through time lie within social groups, and are not externally determined. While climate, population trends, and other external conditions can constitute important factors, human choices, combined with circumstances lying in the economic, political, social, and ideological realms, play important roles.

Reductionist approaches to human subsistence behavior employed by earlier theorists required anthropological archaeologists to discard culture as ancillary. This mechanistic view eliminated or diminished the importance of human actors. This volume attempts to view past people as social agents making decisions on a human level. We collectively urge those working within similar frameworks to consider evidence for past subsistence choices within their sociopolitical and economic contexts, further impacted by the availability of labor, age, gender, skill, and other categories that we acknowledge as vital structuring principles within human societies.

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CLASSIC PERIOD AGRICULTURAL INTENSIFICATION AND DOMESTIC LIFE AT EL PALMILLO, VALLEY OF OAXACA, MEXICO

Gary M. Feinman*, Linda M. Nicholas*, and Helen R. Haines**

INTRODUCTION

The historical relationship between population and agricultural resources is at the core of many key and long-standing anthropological debates (e.g., Boserup 1965; Brookfield 1972; Brown and Podolefsky 1976; Cohen 1977; Grigg 1979; Johnson and Earle 1987; Morrison 1996, with CA comments; Netting 1993; Turner et al. 1977; Turner et al. 1993). In Mesoamerica, the arguments have focused on the distribution and relative importance of land and water as a basis for understanding and accounting for ancient population distributions and sociopolitical developments (e.g., Sanders 1972:112-113; Sanders and Price 1968). These debates have been especially lively in the Valley of Oaxaca, a key demographic and political region situated in the Southern Highlands of Mesoamerica (Palerm and Wolf 1957) (Figure 1). William Sanders and his colleagues, drawing on their investigations in the Basin of Mexico, have asserted that land quality and water resources are the most important factors for explaining prehispanic population distributions (Sanders et al. 1979; Santley 1980:137-138). They apply their model more broadly, arguing the same factors were at play elsewhere, including the Valley of Oaxaca (Sanders and Nichols 1988). In contrast, archaeologists working in the Valley of Oaxaca regard this explanation for settlement distributions, and ultimately social change, as overly narrow. Other factors (politics, economics, ideology) are stressed as equally or, at times, more important in determining settlement size and location (Blanton 1978; Blanton

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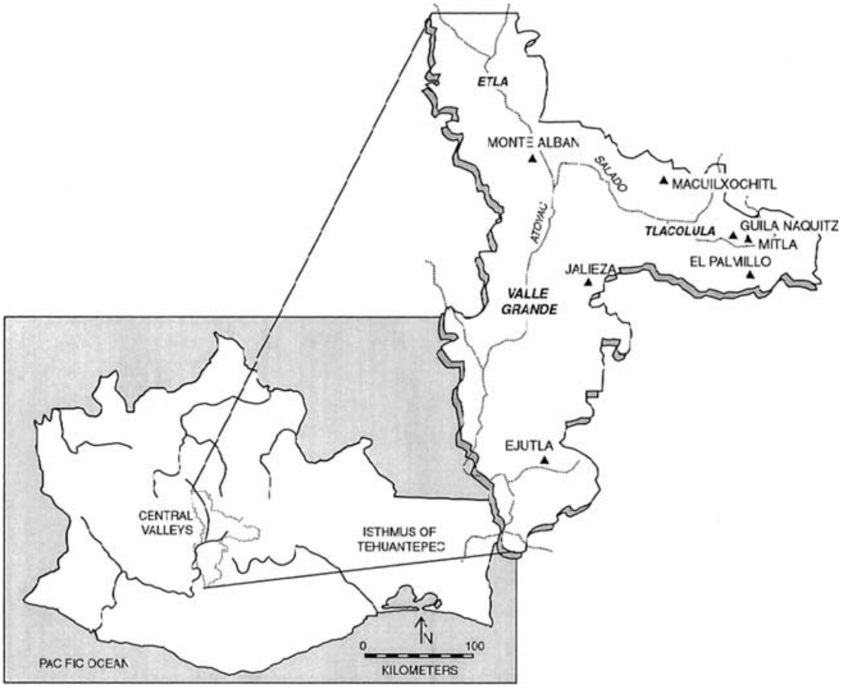

Figure 1. Map of the Valley of Oaxaca showing places mentioned in the text.

et al. 1982, 1993; Feinman et al. 1985; Kowalewski et al. 1989; Nicholas et al. 1986).

During systematic regional surveys of the Valley of Oaxaca and neighboring regions (Blanton et al. 1982; Feinman and Nicholas 1990b, 1996; Kowalewski et al. 1989), pre-hispanic settlements were not found to have been consistently concentrated near the richest valley bottomlands or adjacent to the most dependable and abundant water sources. Rather, ancient sites were dispersed throughout a wide range of ecological zones, including agriculturally marginal areas (Blanton et al. 1982, 1993; Feinman et al. 1985; Feinman and Nicholas 1990a; Kowalewski 1980; Nicholas 1989; Nicholas et al. 1986). Of course, the specific patterns of settlements varied considerably from phase to phase. Such marked diachronic differences in site location and density along with the location of some large sites at significant distances from the region's richest land and most reliable water sources provide empirical justification for questioning whether land and water alone are adequate to retrodict settlement distributions for most settings and times. For ancient Oaxaca, a series of studies (Feinman and Nicholas 1987, 1990a, 1992; Kowalewski 1980; Nicholas 1989; Nicholas et al. 1986) have been undertaken comparing empirically

	Oaxaca	**Mesoamerica**
1500		
1300		
	Monte Albán V	Late Postclassic
1100		
900		
	Monte Albán IV	Early Postclassic
700		
	Monte Albán IIIb	Late Classic
500		
	Monte Albán IIIa	Early Classic
300		
AD 100	Monte Albán II	Terminal Preclassic
BC 100		
	Monte Albán Late I	
300		Late Preclassic
	Monte Albán Early I	
500		
	Rosario	
700		Middle Preclassic
	Guadalupe	
900		
	San José	
1100		Early Preclassic
1300	Tierras Largas	
1500		

Figure 2. Valley of Oaxaca chronology.

derived settlement distributions against the spatial patterns of land and water resources. In response to earlier works that gave priority to land and water resources (e.g., Sanders et al. 1979), these Oaxaca-focused analyses have illustrated that the distribution of land and water cannot provide the explanation for the placement (or size) of archaeological settlements across the landscape (Nicholas 1989).

Of the valley's three arms, Tlacolula is the driest and least agriculturally reliable subvalley for maize agriculture (Kirkby 1973; Nicholas 1989). Yet during regional survey, crews recorded denser populations in this sector of the valley for the Classic period (A.D. 200 – 800; Figure 2) than in several other parts of the region (Kowalewski et al. 1989:208; Nicholas 1989) (Figure 3). Many of the Tlacolula sites are located on ridge summits and hilltops, far from the best farmland in the area. Access to good arable land and accessible water alone cannot explain the settlement density of Tlacolula during the Classic period (or during the subsequent Postclassic period, A.D. 800 – 1521).

In the Formative period (c. 1300 B.C. – A.D. 200), when early villages were first established in the Valley of Oaxaca, the dry eastern Tlacolula subvalley was relatively sparsely settled (Blanton et al. 1993:55-59; Kowalewski et al. 1989:64-64).

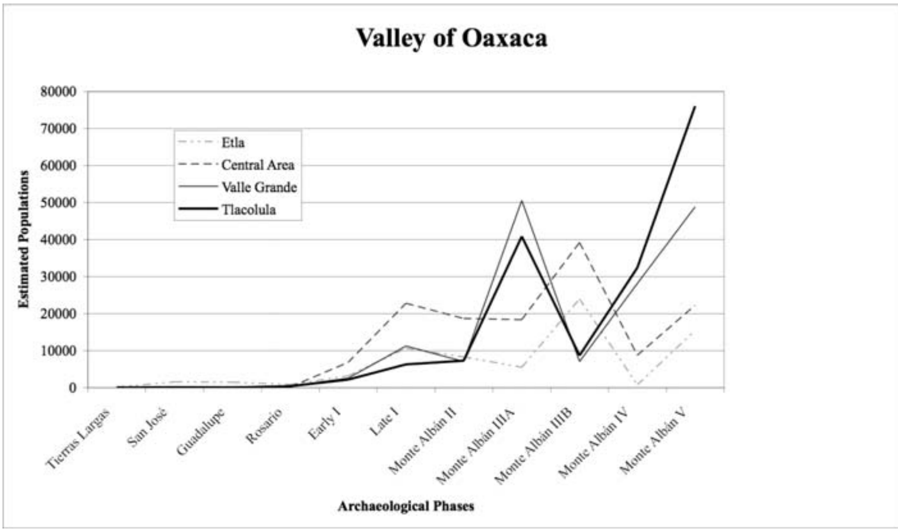

Figure 3. Estimated regional populations in the three arms and central area of the Valley of Oaxaca.

Populations continued to be comparatively depressed in Tlacolula at the time when the early hilltop city of Monte Albán was established around 500 B.C. in the center of the valley. During the centuries following its foundation, new communities were established and grew rapidly in the immediate vicinity of the expanding capital (Blanton et al. 1993:73-74). As a consequence, the population of the Tlacolula arm, especially the eastern portion of that arm, remained sparse compared to the rest of the valley.

By the Classic period, however, the population of Tlacolula increased rapidly, surpassing many other valley sectors (Nicholas 1989:497). By the Postclassic (c. A.D. 800 – 1520), Tlacolula was the most densely occupied subvalley (Kowalewski et al. 1989:312) (see Figure 3). According to 16th century documents, two of the valley's most important Postclassic communities were Macuilxochitl and Mitla, both located in eastern Tlacolula (Asensio 1905 [1580]; Canseco 1905 [1580]). The regional survey confirmed that these two sites also were two of the most extensive Postclassic settlements in the Valley of Oaxaca (Kowalewski et al. 1989:317). If land and water sources in Tlacolula are lacking in comparison to other parts of the valley, then what factors fueled this pattern of growth in the driest part of the valley?

The apparent imbalance between large populations and limited agricultural resources in Tlacolula raises a suite of questions about settlement in the driest part of the valley and how the resident population supported its food requirements. One possible explanation that we (and our colleagues) have previously proposed is the importance of domestic craft production and exchange in sustaining these Tlacolula populations (Blanton et al. 1993; Feinman et al. 2001; Finsten 1983, 1995;

Kowalewski et al. 1989). During the regional surveys, more surface indications of craft activities were recorded in Tlacolula, especially at hilltop terrace sites, than in the other valley arms or subvalleys. Given the distance of these hilltop population centers from productive well-watered land on the valley floor, we have suggested that specialized crafts were produced in order to exchange for foodstuffs. Nevertheless, subsistence dependence is a risky strategy, especially since so many of the large Classic period Tlacolula sites were positioned on ridgetops, indicating that defense may have been an important consideration in their location.

Now, several years removed from the aforementioned debates and with new data at hand, it is time to reconsider the question of Classic period and later populations in Tlacolula. Was production for exchange a key component of domestic strategies in this dry part of the valley? We see two other possible alternatives, one largely methodological, the other interpretive. Methodologically, as we all are aware (Hassan 1981:63-75), it is not a simple matter to derive population estimates from surface settlement pattern findings. The population figures that we estimated for Tlacolula were derived using procedures (Blanton et al. 1982:10-11; Feinman et al. 1985:336) comparable to those followed elsewhere in the region and highland Mesoamerica (Parsons 1971:23; Sanders 1965:50). Nevertheless, is it possible that estimated populations for this eastern arm of the valley were inflated? Much of the Tlacolula population was concentrated in defendable and elevated terrace sites. Were these settlements short-term military redoubts rather than hilltop towns? Although our own interpretations never were in line with such a view, until recently we lacked the empirical basis to assess this alternative.

More significantly, over the past decade or so, new empirical findings from central Mexico (Evans 1990; Parsons and Parsons 1990) have begun to question the overwhelming and universal importance that has been given to maize agriculture in prehispanic Mexico. Is it possible that both the initial attempts to use land and water resources to predict settlement patterns (e.g., Sanders 1972; Sanders and Price 1968) as well as the counterefforts designed to assess such views (e.g., Kowalewski 1980; Nicholas 1989) have given too much weight to maize? As some are coming to suspect for central Mexico (Parsons and Darling 2000a; Parsons and Parsons 1990:6), perhaps the importance of maize as an agricultural staple throughout the Valley of Oaxaca has been overemphasized. Were other kinds of agricultural production and intensification feasibly employed in the dry Tlacolula arm?

A basic assumption of most prior research on all sides of the issue has been that maize agriculture, largely reliant on flat land and available water, formed the foundation of prehispanic subsistence systems for populations throughout highland Mesoamerica (Sanders and Price 1968:9, 87), including the Tlacolula arm of the Valley of Oaxaca (Kirkby 1973; Kowalewski 1980; Nicholas 1989:452). Accordingly, the potential (based on the availability of water and flat land) to intensify maize production in Tlacolula was viewed as limited. Given this focus on maize, the hypothesis that populations in drier parts of the valley may not have relied as heavily on maize or other traditional resources, instead exploiting local xerophytic plants that are known to have economic uses both as food and economic raw materials, has not been satisfactorily assessed.

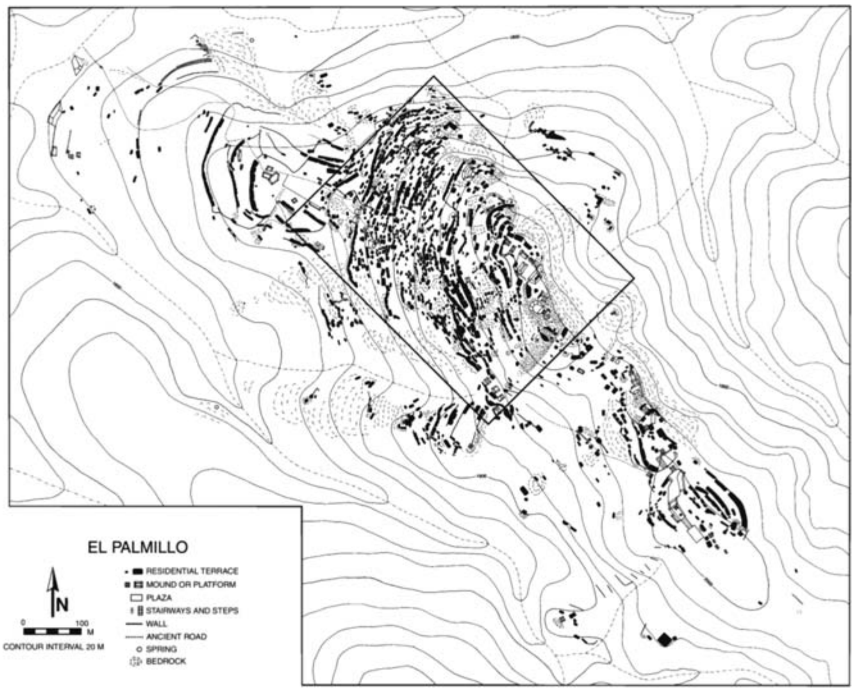

Figure 4. Map of El Palmillo, showing the distribution of terraces on the slopes and monumental architecture on the ridgetop. The area inside the box is enlarged in Figure 5.

In this chapter we draw heavily on recent archaeological and botanical findings from the site of El Palmillo, a large Classic period hilltop terrace settlement in eastern Tlacolula (Figure 4). New data are presented that allow us to inform the series of alternatives that have been advanced above to account for the relatively high prehispanic population density in Tlacolula during the Classic (and by extension the Postclassic) period. To begin, we provide a brief background to the Valley of Oaxaca and our investigations at El Palmillo. Then, in light of the El Palmillo research, we return to the question of population estimates, the previously proposed interpretation of specialized craft production for exchange, and the hypothesis that perhaps much previous research has depended too heavily on maize agriculture at the expense of other resources and their intensification.

THE VALLEY OF OAXACA

Surrounded by the rugged mountains of the Sierra Madre, the Valley of Oaxaca is the largest expanse of flat arable land in the Southern Highlands of Mexico (Kirkby 1973). This Y-shaped valley comprises three smaller subvalleys – the Valle

Grande to the south, Etla to the north, and Tlacolula to the east – that are formed by the drainage basins of the Atoyac and Salado Rivers (see Figure 1). The valley floor is approximately 1500 meters above sea level, so frost is rare and the temperature is mild. These conditions change as one ascends the surrounding slopes that reach heights of 3000 meters above sea level. Rainfall in the valley ranges between 400 to 800 millimeters, but other water sources, especially the Atoyac River and its tributaries, also are present and afford some opportunities for small-scale irrigation.

The terrain in the Valley of Oaxaca can be classified into three broad ecological zones – alluvium, piedmont, and mountain (Kowalewski 1980). Yet it is not solely the geophysical morphology of the landscape but more importantly accessibility to water that determines the potential agricultural productivity of the area (Kirkby 1973; Messer 1978; Nicholas 1989). The Valle Grande, the largest of the three subvalleys, receives slightly more rainfall annually than the others so dry farming (rainfall dependent) is generally more successful in that area. The Valle Grande also contains land that can easily be cultivated through irrigation, drainage works, or by tapping the high watertable (especially in the alluvial zones). The smaller Etla subvalley has the best irrigation potential and therefore the most secure agricultural base. Tlacolula to the east has the most arid and marginal lands (for maize) in the valley, receiving less rainfall than the other two arms. With less irrigation potential, maize farming in much of Tlacolula is often risky (Kirkby 1973; Kowalewski 1980; Nicholas 1989). Generally, as one moves to the east in Tlacolula, the conditions for maize deteriorate.

The moderate climate and abundant natural resources (edible plants and water) made the Valley of Oaxaca an ideal location for human occupation. Several Archaic period (9000 – 2000 B.C.) rockshelters have been found in the eastern part of the valley. Botanical material recovered from excavations at Guilá Naquitz (a small cave site dating to 8750 – 6670 B.C.) document a range of wild indigenous plants that the early inhabitants of the valley utilized for food (Flannery 1986). Residence patterns changed with the shift to agriculture at the end of the Archaic. The first permanent agrarian-based settlements date to the mid-second millennium B.C. (Blanton et al. 1982, 1993; Flannery 1983b; Kowalewski et al. 1989). Settlements are found throughout the valley by the Tierras Largas phase (1400 – 1150 B.C.), yet most of the region's population was concentrated in Etla (Blanton et al. 1993:56; Kowalewski et al. 1989:55). The remaining population was dispersed across the other valley arms, with only one settlement in Tlacolula.

Settlement patterns changed little in the valley until the Late Formative (Monte Albán Early I, 500 – 300 B.C.), when Monte Albán, the new capital, was settled on top of a cluster of high hills in the previously underutilized center of the valley. Situated roughly 400 meters above the valley floor, Monte Albán is the earliest terraced hilltop settlement in the region (Blanton 1978). Monte Albán's population grew quickly, as did the population in nearby areas. Demographic changes occurred at a slower tempo in Tlacolula (Feinman et al. 1985:345).

By the Classic period (A.D. 200-800), however, demographic patterns shifted, so that population densities in Tlacolula became as high or higher than in other parts of the valley (see Figure 3). Many of the largest Classic period centers in the entire region were the terraced hilltop sites located in the Tlacolula subvalley (Feinman and

Nicholas 1990a, 1996; Kowalewski et al. 1989:241). These sites account in large part for the rapid population rise in that part of the valley during the Classic period. Population densities remained high in Tlacolula up to the arrival of the Spanish in the early 1500s (Feinman and Nicholas 1990a; Kowalewski et al. 1989:312).

As noted above, the archaeological findings of dense populations in Tlacolula during the Classic and Postclassic periods, higher than found in other, wetter parts of the valley, are worth considering in more depth. Many of the terrace sites in Tlacolula, which account for much of the estimated population, are located at the edges of the valley, in piedmont locations far from the more productive valley floor. With populations at many of these hilltop sites estimated in the thousands, they frequently exceeded the agricultural potential (based on maize farming) of their immediate sustaining areas. One such Classic period site in the Tlacolula subvalley is El Palmillo.

EL PALMILLO

Located high in the eastern piedmont of the Tlacolula subvalley, El Palmillo did not receive any attention from archaeologists until 1980 when it was visited and mapped as part of the regional survey of the Valley of Oaxaca (Kowalewski et al. 1989:241). The site was revisited in 1997 as part of a program of intensive mapping and terrace-by-terrace surface survey at several hilltop sites in eastern Tlacolula (Feinman and Nicholas 2000a, 2004b). With over 1400 terraces recorded and mapped at the site during the intensive mapping work (see Figure 4), El Palmillo clearly is one of the largest hilltop terraced sites in the entire valley.

Situated between 1760 and 2010 meters, the site occupies the apex and steep slopes of a high piedmont ridge overlooking the modern town of Santiago Matatlán. To the north and east the rocky hill descends sharply, making access to the site from those sides virtually impossible. The southern and southeastern slopes are cut by deep gullies interspersed with steep slopes. The western face is more accessible, although to reach the top requires an arduous climb.

The ridgetop is divided in two halves by a low saddle. The northern hill, the site's highest point, has steeply sloping sides and extensive natural bedrock outcrops. Most of the site's monumental architecture, which often incorporates the natural bedrock, was constructed on this ridge. Terraces are densely packed on the western face descending the northern hilltop. The lower, southern part of the ridge is flatter with fewer outcrops. There is less public architecture to the south, consisting largely of low platforms, and many fewer terraces.

Although access into the core of the site is easiest on the western face, passage is impeded by strings of terraces with high stone retaining walls. In some places as many as 10 terraces shared a single unbroken wall. As much as 2 to 4 meters high in places, these retaining walls form an imposing gauntlet for anyone attempting to reach the site center, even today. Although from the outset our working hypothesis has been that most of the terraces were in fact residential (Feinman et al. 2001, 2002), the high retaining walls also served a defensive function, preventing unrestricted access to the core of the site. Some of the terrace strings near the base of the hill abut steep impassable bedrock on either end. Narrow roads and stairways do run between some of these terraces and up onto the site, so that access could have been monitored in some manner (e.g., Hirth 1982:323).

Based on survey findings (Feinman and Nicholas 2004b), El Palmillo was initially settled during Monte Albán Late I (300 – 200 B.C.), when there was a significant but dispersed settlement of about 4 hectares at the higher reaches of the site, especially on the ridgetop saddle and southern apex. In Monte Albán II (200 B.C. – A.D. 200), settlement shifted to the northern part of the ridge and its descending slopes, and the area of settlement more than doubled.

As noted previously, the Early Classic (Monte Albán IIIa, A.D. 200 – 500) was a time of intense settlement expansion in the eastern part of the Valley of Oaxaca, when many terrace sites were densely settled. El Palmillo reached its greatest extent in the early Classic, extending over 90 hectares and including all habitable areas on both ridgetops and the descending slopes. Most of the 1400 terraces on the site were occupied in Monte Albán IIIa and IIIb/IV (A.D. 200 – 900).

Although occupation at the site continued until the arrival of the Spanish, the settlement was smaller during Monte Albán V (c. A.D. 900 – 1520). Although some settlement remained on the ridgetop, the last prehispanic community was focused on the lower slopes; some of these lower areas continued to be occupied at least until the outset of the colonial period.

How did the residents of El Palmillo sustain themselves in the arid environment of Tlacolula? Two year-round springs and two small seasonal streams are located at the base of the hill, and several smaller springs are dispersed across the site's outcropping bedrock. Yet none of these sources are near large tracts of farmable land. The nearest areas of well-watered farmland are located on the valley floor (Kirkby 1973; Nicholas 1989), several kilometers west of the site. With maize agriculture unreliable (as it is in the vicinity of the site today), did El Palmillo's residents grow other crops or largely receive foodstuffs through exchange? What was the role of specialized craft production? What items (if any) were crafted for trade? Were there resources other than the traditional seed crops (maize) that were important in the diet? What were these plants and their uses? Were economically useful plants present on site in quantities that would indicate prehispanic intensification? In part to address these questions regarding how the residents of Oaxaca's terrace sites supported themselves in seemingly marginal environments, we began excavations in 1999 on a series of El Palmillo terraces.

Because many of the vestigial plant species on site are (or were until recently) considered economically useful (as food or sources of other commodities such as fiber) by the current inhabitants of Matatlán, we completed a botanical survey of El Palmillo (Middleton et al. 2001). To evaluate whether the plant community on site might be a relict of prehispanic gardening (e.g., Bohrer 1991; Folan et al. 1979; Martínez y Ojeda 1996), we also undertook a botanical census of a nearby hill that was similar in elevation, slope, and orientation. This adjacent hill serves as a "control site."

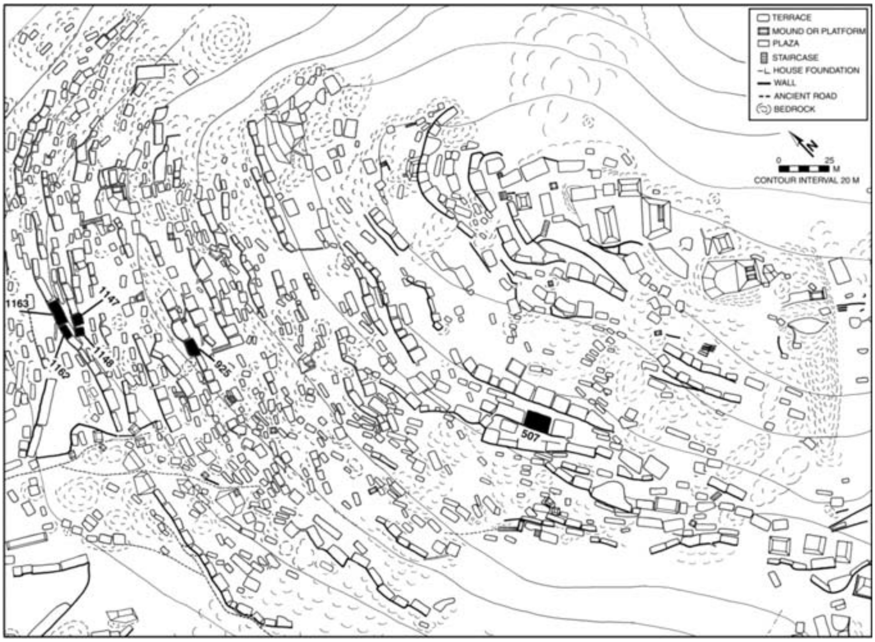

Figure 5. Location of the excavated terraces at El Palmillo.

RESIDENTIAL TERRACE EXCAVATIONS

Because our interests concerned domestic activities and how terrace site residents supported themselves, we chose to begin our excavations near the bottom of the hill, far from the civic-ceremonial structures on the ridgetop. We exposed an area of approximately 500 square meters on four adjacent terraces near the base of the hill in 1999 and 2000, 160 square meters on another terrace approximately 100 meters farther upslope in 2001, and an additional 215 square meters on a single terrace about 100 meters below the site's summit in 2002 (Figure 5). The four lower terraces shared two high stone retaining walls. The two upper terraces also were parts of strings of terraces, although we excavated only one terrace in each string.

Our excavation strategy was to open large contemporaneous surfaces, or "living floors," following natural stratigraphic levels whenever possible. These broad horizontal exposures were excavated in a series of contiguous 2 x 2 meters units gridded across the terraces. All deposits were screened with 1/8 or 1/4 inch mesh (depending on context) to recover by-products and residues of manufacturing and other activities. Soil samples for flotation and for chemical analysis of residues were taken from all floor deposits and from other selected contexts (e.g., Metcalfe and Heath 1990; Widmer 1991). Light fractions were collected to recover plant remains, and heavy fractions were saved for microdebitage analysis.

Figure 6. Residential complex on Terrace 925.

During the excavations, we found that architectural and other domestic features (rooms, patios, oven, burials) occupied virtually all the available flat space on the terraces (Figure 6). Little, if any, of the flat space created behind retaining walls was available for gardens or the cultivation of crops. The basic architectural layout on the terraces was a residential complex consisting of three or four rooms around an open central patio, similar to the plan of residential complexes on several Classic-period terraces excavated by Marcus Winter (1974) at Monte Albán. At El Palmillo, the complexes included a long rectangular room constructed with foundations of flat shaped stones and plastered floors that was situated at the back, upslope (east) edge of the terrace. These rectangular east rooms generally were linked with one or more smaller, square rooms or structures to the south and north, forming arrangements of rooms around a patio that was open to the west (the front, or downslope edge of the terrace). The central patios were plastered, although the plaster was often poorly preserved, indicating they were unroofed and exposed to the elements. The

Figure 7. Crew excavating large oven at El Palmillo.

interment of individuals in household contexts was a common practice among pre-hispanic Mesoamerican people (Feinman and Nicholas 2000b; McAnany 1995; Middleton et al. 1998; Winter 1974). At El Palmillo we recovered the remains of 81 individuals (including males, females, and children) on the six terraces, mostly in the patios, beneath house floors, or in terrace walls. Most of the adult interments and a few of the children were buried with one or more ceramic vessels. A few adults were buried with jade beads, but generally most interments contained few grave goods. Overall, the burial population is composed of young and old, and we have an almost balanced ratio of identifiable males to females. These findings would seem to conform to the expectations for household composition, much like that found for the terraces at Monte Albán (Winter 1974).

A variety of fire installations (especially small hearths and ash pits) were unearthed on the excavated terraces. A small kiln on one of the lower terraces was used to fire ceramics. Although several ash pits on other terraces may just be small refuse dumps, some ash pits had been used to fire small quantities of pottery. On the lower terraces we also uncovered two large ovens that appear to have been utilized to roast maguey (Figure 7). When uncovered, they were filled with dark black ash, charcoal, and fire-cracked rock, and closely resemble ovens used today in Santiago Matatlán for cooking maguey hearts in the process of making mescal (Middleton et al. 2001; see also Flannery and Marcus 1983; Serra Puche et al. 2000), a postcolonial alcoholic beverage. Similar prehistoric agave roasting ovens have been reported in the American Southwest (Fish et al. 1992; Van Buren et al. 1992).

Based on ceramic associations, the excavated terraces at El Palmillo were constructed early in Monte Albán IIIa (c. A.D. 250 – 350). After initial construction, the terraces and the residential structures on them were periodically rebuilt and renovated. Some of these rebuilding episodes involved considerable movement of earth and stone as front terrace walls were raised and tremendous amounts of fill were brought in behind these walls, increasing the area of flattened space on the terraces. The residential complexes often were rebuilt in the same basic configuration but were repositioned just a bit up the slope. At junctures between major episodes of reconstruction, room floors often were replastered. These modifications to the terraces did not occur on an individual basis but rather involved the organization and cooperation of the residents from several adjacent terraces.

The findings from the terrace excavations at El Palmillo are in line with both Winter's (1974) studies at Monte Albán and earlier systematically recorded observations from regional and intensive surveys in the Valley of Oaxaca (Blanton et al. 1982; Feinman and Nicholas 1990b, 1996, 2004; Finsten 1995; Kowalewski et al. 1989). Each of these works points to a heavy residential use of terraces at these hilltop Oaxaca sites. In fact, if the density of residential complexes on the excavated terraces at El Palmillo is representative of other terrace sites in the region, we would propose that, if anything, prior population estimates for most Oaxaca terrace sites are likely to be a bit conservative. These hilltop sites were compact settlements, often with tightly packed and clustered terraces. Although postabandonment farming does not appear to have been a major problem at El Palmillo, it likely was more destructive at other, more accessible terrace sites. Consequently, at certain locales, the number of terraces could have been slightly greater than was estimated during the systematic surface walkovers.

Furthermore, the persistent pattern of terrace rebuilding over centuries at El Palmillo has revealed that these terrace sites were hill towns rather than short-term military redoubts. The presence of women and children in graves would seem to support this interpretation. The deciphered meaning of the Zapotec “hill glyph” as a signifier of place (Batres 1902; Caso 1947; Marcus 1983) also would seem to tie in to the residential character of these elevated terrace communities. Hill glyphs also are present in Mixtec codices from Oaxaca (Furst 1978:254-255). So the recognition that hills may be associated with important residential communities may have a degree of local confirmation. Yet if Classic period settlements, like El Palmillo, had sizable populations that lived at these sites for centuries, we are left to consider how the residents of this dry sector of the valley fulfilled their basic food needs.

SPECIALIZED CRAFT PRODUCTION AND EXCHANGE

More than two decades of research has illustrated that specialized craft production was an important domestic activity in prehispanic Mesoamerica (Balkansky et al. 1997; Charlton et al. 1991; Feinman 1999a; Feinman and Nicholas 1993, 1995; Otis Charlton et al. 1993; see also Costin 1991). As noted previously, the importance of such activities at terraced settlements, especially in drier sections of the Valley of Oaxaca, long has been suspected (Finsten 1983, 1995; Kowalewski et al.

1989). Because many of the items manufactured at these sites were produced in volumes greater than can be accounted for by household or local consumption (Feinman et al. 2001, 2002), it is likely that these goods were produced for exchange (Feinman 1999a; Feinman and Nicholas 1993, 1995, 2000b, 2004a).

Nothing that we have uncovered at El Palmillo leads us to change our preexisting hypothesis that craft production was a key component of the site's economy. An important activity at El Palmillo was the production of chipped stone tools. Using the abundant sources of local chert, the inhabitants of El Palmillo produced a variety of tools, including abraders, generalized bifaces and unifaces, perforators, projectile points, and a variety of scrapers. These formal tools and other finished chert artifacts account for approximately 2% of the total chert assemblage (just under 40,000 pieces from excavated deposits). The low proportion of tools compared to flakes and debris (and the overall ubiquity of chert at the site) would seem to indicate that stone tools were manufactured for exchange, at least to other parts of El Palmillo and more likely also to other sites in the region. Chert (or other suitable) resources for chipped stone tools are not uniformly available in the Valley of Oaxaca (Whalen 1986); therefore, it seems possible, if not likely, that chert tools, cores, and nodules may have been prepared and exported off site.

The distribution of the recovered chert tools and debris was not uniform on the excavated terraces, indicating minor variations in activities among the settlement's residents (Haines et al. 2004). The highest quantity of chert debris was recovered from one of the lower terraces, in locations that appear to have been used as outdoor work areas. This debris included a large amount of production debris (flakes, chips, etc.), some of which had been utilized as expedient tools. In contrast, there was less production debris and so higher proportions of formal tools on the upper terrace. Lithic reduction and tool production for exchange appears to have been more actively engaged in by inhabitants of the lower terraces, while the upper terrace residents used these stone tools in other craft specializations.

An abundant class of chert scraper at the site, scraper or pulping planes (*raspadores*), long have been associated with maguey (*Agave* spp.) and the extraction of fiber from that plant's pulpy leaves (Hester and Heizer 1972; Robles 1994; see also Bernard-Shaw 1990; Fish et al. 1992) (Figure 8). Large ceramic spindle whorls, in the size range typically used to spin maguey fibers (Parsons and Parsons 1990:177; Parsons 1972:61), also are fairly common, especially on the lower terraces. Many of the bone tools recovered during the excavations, including battens, needles, perforators, and spindle whorls, are associated with sewing and weaving. Consequently, it appears that the production of maguey fiber (*ixtle*) and textiles also was important at El Palmillo. Later Aztec accounts list maguey textiles as an important tribute item (Anawalt 1981; Barlow 1949; Berdan 1987); thus during the Postclassic period maguey fiber was manufactured for exchange in Mesoamerica. Given the prehispanic value of textiles, it seems likely that at least some of the textiles produced at El Palmillo were made for the purpose of exchange.

Other items recovered during the excavations at El Palmillo were imported to the site, some from great distances. Excavations on the upper terrace yielded hundreds of obsidian blades and blade fragments as well as several greenstone objects,

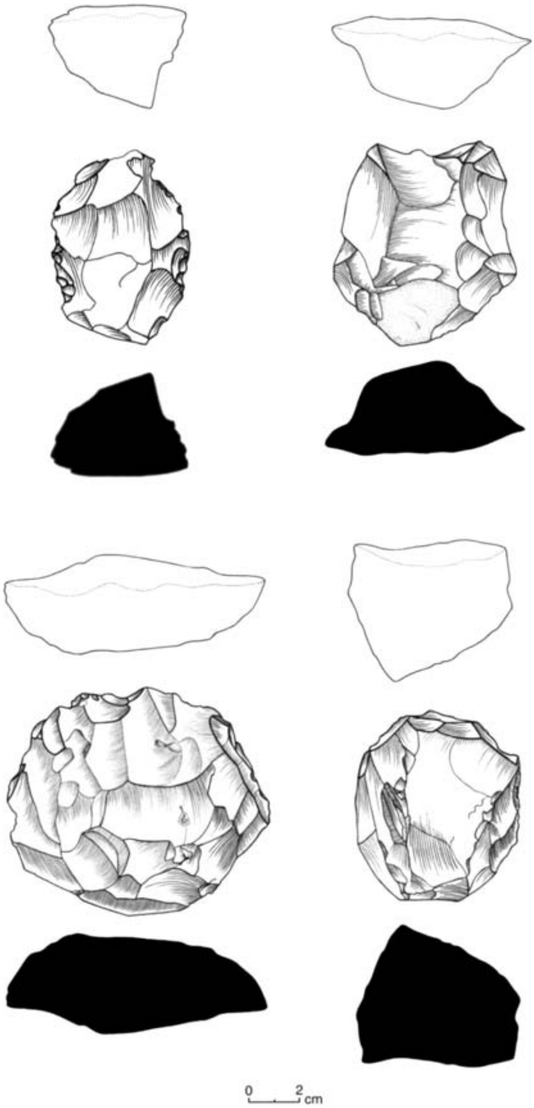

Figure 8. Examples of scraper planes (*raspadores*) from El Palmillo.

from nonlocal sources (there are no known obsidian sources in Oaxaca). Worked marine shell from the Pacific Coast also was brought to the site in small quantities. Goods produced at El Palmillo likely were exchanged for these nonlocal products (and perhaps certain raw materials). Although we cannot document or identify whether or which crops were imported to the site or how much, we suspect that local goods and products were exchanged for edible items produced elsewhere, likely including maize. Yet until we have a better understanding of what local plants, if any, were available, it is difficult to evaluate the overall importance of exchange for subsistence needs.

PLANTS AND INTENSIFICATION AT EL PALMILLO

Maize has traditionally been considered one of the dominant prehispanic cultigens in Mesoamerica (Kirchhoff 1943; Sanders and Price 1968:9; Wolf 1959). Nevertheless, the location of settlements in areas where maize farming could be considered only marginal (or worse) opens questions regarding whether maize was a staple crop for all inhabitants of the Valley of Oaxaca. Rainfall in eastern Tlacolula today is barely sufficient for maize cropping, and crops fail frequently in dry years (Druijven and Kruithof 1992; Kirkby 1973; Kowalewski 1982). According to colonial era accounts (del Paso y Troncoso 1905 [1579-1581]:149-150), maize was seldom consumed in the Tlacolula subvalley near Mitla and Matatlán. Corn was not present in sufficient quantities to support the inhabitants of the area (Horcasitas and George 1955:21). Given the absence of a conjunction between reliable water sources and flat farmland near the base of El Palmillo, it seems doubtful that maize could have been grown in sufficient quantities to support the thousands of occupants that likely inhabited the site during its Classic period apex.

Under semiarid conditions, certain kinds of terracing can provide a more suitable environment where maize and other crops may grow successfully (Donkin 1979; Downum et al. 1985, 1993:81; Fish et al. 1984; Smith and Price 1994). Yet at El Palmillo there was little free, flat space on the terrace surfaces where crops could have been cultivated. It is possible to erect small dams or retaining walls across depressions or gullies (*barrancas)* in the bedrock to create small plots of land (*lama-bordo;* Spores 1969) that take advantage of soil and water run off (e.g., Donkin 1979 Wilken 1987), and several possible *lama-bordos* have been noted near the base of the hill. Yet the available plots and farmable crevices are far too small to have produced crops in the quantities needed to support the population of El Palmillo.

Although most of the flattened space on the terraces was occupied by domestic architecture, plants adapted to rocky terrain could have been fostered and cultivated along the terrace walls and edges. Terrace walls at the site currently support dense xerophytic (drought tolerant) vegetation, particularly during the wet season. Xerophytic plants such as cacti and maguey could easily have been planted on the sloping retaining walls of the residential terraces in the past, providing not only some privacy (Parsons 1936:9) but also reinforcing the walls and preventing erosion (Ortiz de Montellano 1990:97; Patrick 1985; Wilken 1987:105). Most of these sloping and rocky spaces are less amenable to growing seed crops, but they seem to provide little obstacle for cacti and succulents (Cook 1949:25).

The use of xerophytic plants as food, medicine, and sources of fiber has a long history in the Valley of Oaxaca (Flannery 1983a, 1986; Flannery and Spores 1983; King 1986; Smith 1978, 1986). Archaic period (c. 9000 – 2000 B.C.) occupants of the Valley of Oaxaca relied on a variety of xerophytic plants as part of their diet, including seeds from nanche (*Malpighia* sp.) and prickly pear (*Opuntia* sp.), biznaga (*Ferocactus recurvus*), maguey (*Agave* spp.), and susí nuts (*Jatropha* sp.) (Flannery and Spores 1983:22). *Opuntia* spp. remains also are found at later Formative period (c. 1500 – 200 B.C.) villages (Whalen 1981:192).

A botanical study by Martínez y Ojeda (1996) confirmed the presence of many of these same plants on the grounds of the archaeological zone at the long-inhabited site of Yagul (Bernal and Gamio 1974), also in eastern Tlacolula and no more than 20 kilometers from El Palmillo. We also had previously observed that most of these same economically important xerophytic plants were more common at El Palmillo than on the neighboring hills and in the rest of the terrain of Santiago Matatlán. Thus we reasoned that the current plant populations at El Palmillo (and other archaeological sites in the region) may reflect residual or vestigial growth from prehispanic cultivation.

The Botanical Survey

To assess our hypothesis that the present plant community at El Palmillo is a relict of prehispanic activities at the site, we completed botanical surveys of El Palmillo and a nearby "control" hill that was similar in altitude and topography (Middleton et al. 2001). The control hill lacked surface indicators of ancient settlement and thus served to document a native plant community that was markedly less affected by prehispanic human activity. Several local informants assisted with the identification of the principal plant species. Our local informants often were aware of plants that were unique to one hill or the other, although this was checked during the botanical survey. The informants also provided local Spanish and Zapotec names for the plants, as well as local knowledge regarding economic uses. We identified as many plants in the field as possible and collected specimens of both identified and unidentified plants at El Palmillo for later identification and storage at The Field Museum. In Chicago, we were able to make additional plant identifications relying on the collections and resources at the museum (see Table 1 for a list of identified plants at El Palmillo and their economic uses). Several illustrated publications also were especially helpful in this endeavor (García-Mendoza et al. 2004; Martínez y Ojeda 1996, 2004; Pesman 1962; Reyes Santiago et al. 2004; Werling 2001).

The main species at both El Palmillo and the control site include a variety of economically useful plants that are present throughout the immediate area and form the backbone of the local natural floral community (see Martínez y Ojeda 1996). Most are native to the area; remains of many of the plants have been recovered from Archaic period deposits (Smith 1986). Common are *Dodonaea viscosa* (jaras), *Ipomoea murucoides* (pájaro bobo), *Lippia berlandieri* (salvia de castilla), *Lantana camara* (zapotillo), and two species of *Mammillaria* (both commonly called chilillo), all of which have medicinal properties. *Lantana camara* and *Mammillaria spp.* also produce edible fruits, as do *Myrillocactus schenckii* (garambullo), *Stenocereus treleasei* (tunillo), and both species of *Opuntia (pilifera* and *pumila)* found at El Palmillo. Two species of maguey (*Agave karwinskii* and *A. potatorum),* both of which are used for food and fiber, were observed at both locales.

Figure 9. Palmillo plants (*Yucca periculosa*) on the site.

During the botanical survey, we documented several economically useful species that are present only at El Palmillo (and not on the control site) or that are considerably more common at El Palmillo than in the surrounding region (Middleton

Figure 10. Uncultivated maguey plant (*Agave marmorata*) on the site.

et al. 2001). In contrast, there are no economically significant species present on the control hill that were not also observed at El Palmillo. One of the most visible species present only at El Palmillo is *Yucca periculosa* (locally called palmillo). Various species of *Yucca* have been used for fiber and food in both Mexico and the southwestern United States (Anawalt 1981; Ebeling 1986:472-474, 675; Martínez y Ojeda 1996:66; Sheldon 1980) (Figure 9).

The most significant difference between El Palmillo and the control site, however, is in the distribution of maguey (*Agave* spp.) varieties (Figure 10). Of eight different species of maguey recorded at El Palmillo, six species (*Agave angustifolia, A. americana, A. kerchovei, A. macroacantha, A. marmorata,* and *A. rhodacantha)* are not found in the control area (Middleton et al. 2001). Although the remaining two species (*Agave karwinskii* and *A. potatorum)* are present on the control site and throughout the area, they are more common at El Palmillo than elsewhere. All of these varieties were used for food and/or fiber in the past, and most still are today.

Different varieties of maguey often prefer very specific locales and conditions (Gentry 1982). Sánchez López (1989:34) lists eight species of *Agave* for the Tlacolula subvalley. These are the same eight species present at El Palmillo, yet no community in Sánchez López's study had more than three to five species of *Agave*. Patrick (1985:544) reports a similar checkerboard pattern for different *Agave* varieties in contemporary southern Tlaxcala; although local inhabitants recognize as many as a dozen varieties, no more than four or five are found in any one community. Given the range of *Agave* species that still grow at El Palmillo, we suspect that some

Figure 11. Nopal plant (*Opuntia pilifera*) on the site.

of the maguey species at El Palmillo were taken to the site from nearby areas and were fostered or husbanded on site in prehispanic times for their economic and food value; similar practices have been documented in the American Southwest (Bohrer 1991; Hodgson 2001; Hodgson and Slauson 1995; see also Folan et al. 1979)

Based on the marked abundance of *Agave* spp., *Opuntia* sp. (Figure 11), and other economically useful botanical resources that are more prevalent at El Palmillo than elsewhere in the surrounding region, we believe that the site's plant community is a relict of the prehispanic habitation of the hill. At present, we cannot completely rule out that the clustering of economically valuable plant resources on El Palmillo reflects postcontact period use, but that seems highly unlikely. No other hills in the area that also lack modern occupation have this suite or range of economically useful plants. Some of these hills are closer to the modern village or the colonial period hacienda near Matatlán than El Palmillo is. Nothing we have observed leads us to believe that El Palmillo's locale has been used to foster these plants subsequent to its prehispanic abandonment.

Given the economic and dietary usefulness of the identified xerophytic plant community, we propose that these plants were an integral part of the economy and subsistence base of El Palmillo. Below we focus on three economically important xerophytic plants – maguey, yucca, and nopal – that are especially abundant at El Palmillo. With nopal we include a discussion of cochineal. Nopal (*Opuntia pilifera*) is one of the major host plants for the parasitic insect that produces cochineal, a red dye that was very important in Postclassic and colonial Mexico (Anawalt 1981; Baskes 2000; Berdan and Anawalt 1997; Donkin 1977; Hamnett 1971).

Maguey

Maguey (*Agave* spp.) has long been recognized as a highly versatile and economically important plant in highland Mexico, where its use has been well documented ethnohistorically (Beals 1975; Malinowski and de la Fuente 1982; Parsons 1936; Parsons and Parsons 1990) and prehispanically (Anawalt 1981; Callen 1965, 1967; Cook 1949; Ebeling 1986; Evans 1990; Gonçalves de Lima 1956; King 1986; MacNeish 1967; Ortiz de Montellano 1990; Smith 1967, 1986; Smith and Kerr 1968). Maguey, however, generally has not been considered a staple food but rather seen as a marginal dietary supplement that was not intensively used (e.g., Colunga-GarcíaMarín et al. 1993). Yet the Aztec did place important iconographic and cosmological significance on maguey (Martín del Campo 1938; McCafferty and McCafferty 1991; Ortiz de Montellano 1990; Quiñones Keber 1989; Taube 1993).

A sixteenth century account by Francisco Hernández highlights what a significant resource maguey was for the indigenous populations:

> "As a whole it [maguey] can be used as fuel or to fence fields. Its shoots can be used as wood and its leaves as roofing materials, as plates or platters, to make paper, to make cord with which they make shoes, cloth and all kinds of clothes…From the sap…they make wines, honey, vinegar and sugar…From the root, they also make very strong ropes which are useful for many things. The thicker part of the leaves as well as the trunk, cooked underground…are good to eat and taste like cidra (a citruslike fruit) with sugar…This plant, by itself, could easily furnish all that is needed for a simple, frugal life since it is not harmed by storms, the rigors of the weather, nor does it wither in drought. There is nothing which gives a higher return" (Hernández 1959 [1577], vol. 1, pp. 348-349).

More recently Walter Hough was generous in his praise of this plant:

> "When one recognizes the benefits the agave confers on man, there seems good ground for the generalization that without this plant the great population and the civilization of the high plateau of Mexico would have been impossible" (Hough 1908:578).

Maguey's economic utility is enhanced by its long maturation period – between 7 and 25 years. As a consequence, different parts of the plant can be harvested at different times of the plant's lifecycle to produce a wide variety of products. The sap can be processed into a range of liquids and beverages, the flesh can be roasted and eaten, the pulpy leaves can be stripped to produce fibers or mashed into medicinal poultices, and what remains can be burned for fuel.

Maguey sap, or *aguamiel*, is one of the most versatile dietary components of agave (Evans 1990; Hough 1908; Parsons and Darling 2000b; Parsons and Parsons 1990). When fresh, *aguamiel* is a thin, watery liquid with a pleasant sweet/tart flavor that can be drunk raw and in arid areas may serve as a substitute for water (Evans 1990:125). *Aguamiel* is not only refreshing but also nutritious; the sap contains protein, carbohydrates, and a variety of vitamins and minerals including calcium, iron, and vitamin C.

Aguamiel can be fermented into a nondistilled, mildly alcoholic beverage called pulque. One liter of this nutritious drink contains roughly 600 calories and supplies important minerals, amino acids, and vitamins (Parsons and Darling 2000b:83). Studies conducted in the 1940s among Otomí villagers revealed that pulque contributed as much as 12% of their total calories (second only to tortillas) and 48% of their total vitamin C (Anderson et al. 1946:888, table 2). Taken in moderation, pulque's nutritional value makes it a reasonable substitute for meat (Gentry 1982:11).

A fermented beverage (most likely pulque) was consumed in Oaxaca in the sixteenth century (del Paso y Troncoso 1905 [1580]:145), and the Postclassic consumption of pulque is documented in the Codex Vindobonensis (a Mixtec document from Oaxaca) (Furst 1978:201-203). Similar images also are present in the Codex Nuttall (Nutall 1975:plate 82). The drink could have been an important dietary staple for earlier prehispanic people as well (Evans 1986:305; Martín del Campo 1938). In Oaxaca today, pulque has largely been replaced by mescal, which is produced by distillation that was introduced by the Spanish, although small-scale pulque production is still practiced in some Oaxacan villages, including Matatlán.

Aguamiel also can be boiled down into a sugar that can be formed into cakes for easy portability; these cakes are highly caloric and can be stored for long periods of time (Evans 1990:126-127; Parsons and Darling 2000b:83). The heart and leaves can be roasted and eaten. The highly nutritious flesh contains roughly 350 calories and 4.5 grams of protein per 100 grams (about a 3.5 ounce serving) (Fish et al. 1985:112).

At El Palmillo, several classes of evidence point to the importance of maguey as a food source. Two large ovens similar to present-day maguey ovens in Matatlán (Feinman et al. 2001) were excavated on the lower terraces. Soil sampled from the El Palmillo ovens is compositionally similar to soil collected from ovens in Matatlán (Middleton et al. 2001; see also Serra Puche et al. 2000). In addition, coarse fibers that are magueylike were found adhering to sooted stones and ceramics from the El Palmillo ovens. We suspect these ovens were used for roasting maguey hearts for consumption.

The artifact assemblages from the excavated terraces at El Palmillo contain a range of tools almost identical in form to tools used today for processing maguey into food and fiber. To collect maguey sap, a hollow cavity is cut into the heart of the plant. The sap flows from the fleshy leaves into the cavity and is collected daily. The cavity must be scraped several times a day to remove the thin crust of oxidized tissue that regularly forms and will stop the flow of sap if not removed. Today, sharpened metal disks are used to scrap the interiors, but in the past obsidian, basalt, or chert scrapers similar to those discovered at El Palmillo were probably used (Alvarez Palma et al. 1998:23-26; Evans 1990:121-122).

But as Hernández noted so many years ago, maguey provides more than just food. The most important economic product from maguey is fiber (*ixtle*) (Figure 12), which has been used since prehispanic times in Oaxaca (King 1986) and elsewhere in highland Mesoamerica (Smith and Kerr 1968) to make ropes, nets, baskets, mats, and sandals. By the time the Spanish arrived, spinning and weaving maguey fibers into cloth had become very important household activities across the highlands (Anawalt 1981; Brumfiel 1991a, 1991b; Durán 1994 [1581]; Gibson 1964; Hicks

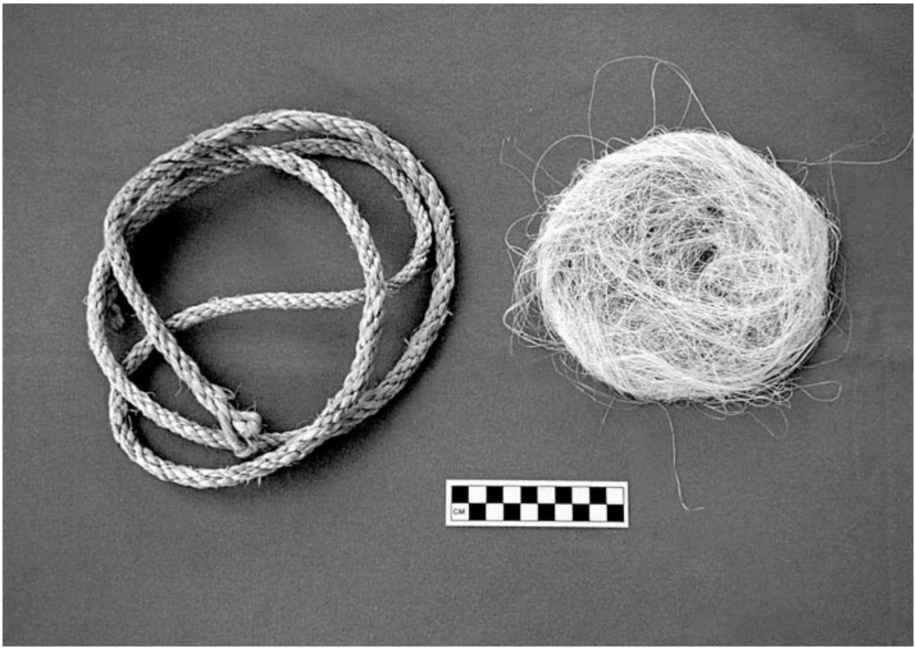

Figure 12. Modern rope made from maguey fiber and a bundle of *ixtle* fibers.

1994; Nichols et al. 2000; Sahagún 1961 [c. 1570]). Maguey fibers, once extracted from the heavy pulpy leaves, are light and easily transportable, and it is likely that a portion of the raw fibers produced also were traded in an unfinished form (Berdan 1987:248). Although maguey fiber has continued to be an important economic good into historic times in highland Mexico (Beals 1975; Cordry and Cordry 1940; Kelly 1944:106; Palma Cruz 2000; Parsons 1936; Patrick 1985), today in Oaxaca and elsewhere in Mexico *ixtle* largely has been replaced by synthetic fibers (Johnson 1977; Palma Cruz 2000:101).

Two types of fiber can be extracted from maguey, *penca asada fina* (fine fiber made from the inner leaves of the plant) and *penca grande* (coarse fiber made from the heavier outer leaves). These fibers can be spun into thread and then woven into textiles. Maguey leaves (*pencas)* can produce between 60 and 88 grams of fiber (Parsons and Parsons 1990:157, table 13). Based on an average of 75 grams of fiber per leaf, and 20-30 leaves per plant, roughly 2000 grams of dried fiber can be extracted from a single agave plant (Parsons and Darling 2000b:84). This would be enough fiber to produce approximately 10 square meters of cloth, fulfilling the maguey clothing needs for one person for about three years (Parsons and Darling 2000b:85).

The range of tools recovered at El Palmillo indicate that the inhabitants of the site were actively engaged in both fiber and textile production, seemingly also in domestic contexts. Extraction of the fibers is a labor-intensive process that requires the leaves to be sheared from the plant, and then either roasted or placed in a rotting pit to allow the flesh to soften; the fibers are then extracted by washing and scraping the leaves (Parsons and Parson 1990). We recovered many obsidian blades and other cutting tools on the excavated terraces, which could have been used to cut the leaves free of the plant (Evans 1990; Nichols et al. 2000). The scraper planes (*raspadores*) could have been used to remove fibers from maguey leaves.

Ceramic spindle whorls used to spin fibers into thread were recovered from all the excavated terraces at El Palmillo (Feinman et al. 2002) (Figure 13). Different types, or grades, of thread can be produced based on the size and weight of the spindle whorl and the dimension of the central hole (Evans 1990; Nichols et al. 2000; Parsons and Parsons 1990; Parsons 1972, 1975). According to Parsons and Parsons (1990:328-330) mid-weight whorls (between 11—23 grams) can be used to spin the fine *penca asada fina* fibers into a fine thread; heavier and larger whorls (above 23 grams) are unsuited for the finer fibers and instead were most likely used to spin thread from the heavier *penca grande*, resulting in a heavier, coarser thread. Spindle whorls recovered at El Palmillo included sizes suitable for spinning both fine and coarse threads. Bone awls, needles, and battens used in weaving also were recovered from both the upper and lower terrace areas at El Palmillo (Feinman et al. 2002).

The preponderance of *Agave* spp. at El Palmillo and the range of ceramic, stone, and bone tools used for processing this xerophytic plant point to an active fiber and textile industry at El Palmillo. In addition several stone bark beaters recovered during the excavations may have been employed to make maguey fiber paper (Gon-

Figure 13. Ceramic spindle whorls from El Palmillo.

çalves de Lima 1956:195). The residents of the excavated terraces at El Palmillo likely produced goods from maguey fiber for exchange to other parts of the site, to other sites in the vicinity, and possibly beyond. Yet maguey was more than just an economic raw material providing fiber that could be worked into a large range of products; maguey stalks also served as a combustible for fires and the hearts and leaves provided important sources of nutrition, from protein-rich liquids to storable solid foods.

Yucca

El Palmillo derives its name from the large stands of *Yucca periculosa* plants that dot the hill (with the densest clusters at the site's apex). These plants are more conspicuous at El Palmillo by their absence at the control site and in the rest of Matatlán's terrain (Middleton et al. 2001). Palmillos also are present at other archaeological sites in the region (Yagul [Martínez y Ojeda 1996] and the Mitla Fortress), but do not appear to be as abundant at those sites as at El Palmillo.

Although there are fewer references to yucca than maguey in early documents and other reports, yucca has a long history of exploitation in parts of highland Mexico, especially in central and north-central regions (Sheldon 1980), and the southwestern United States (Bell and Castetter 1941; Ebeling 1986). Some Mexican species of yucca provide edible fruits and flowers (Martínez y Ojeda 1996:66; Sheldon 1980:386), and at least one species is a source for a fermented liquor (Ebeling 1986:675). Native Americans in the southwestern United States also processed the fruits and seeds into dried products that could be stored over the winter (Ebeling 1986:472-474). Given the abundance of *Yucca periculosa* at El Palmillo, it likely was at least a minor dietary component for the site's residents.

Most references to prehispanic uses of yucca concern the plant's fibers. Weaving yucca fibers was an important industry, and textiles made from yucca were widely used among the Aztecs to make mantles (*tilmatli*), women's skirts (*cueitl*), cord (*mecatl*), and cord jackets (*mecaxicolli*) (Anawalt 1981:27, 33, 45). Yucca fibers also could be woven tightly to produce fine cloaks or fashioned into loose, net-like constructions (Berdan 1987:245; Sahagún 1961 [c. 1570], Book 10:75). In the precontact southwestern United States yucca fibers were woven into rope, cord, baskets, mats, cloth, and sandals (Ebeling 1986:472-474). Yucca fibers are still used today in north-central Mexico to make a range of products, but especially cordage that serves a range of uses (Sheldon 1980:383-385).

Today in Oaxaca "palm" fronds are woven into mats (*petates*) (Beals 1975, 1979); brooms, baskets, and other utilitarian objects woven from palm or palmlike plants are found in the markets of Matatlán today. Most of the production today takes place in several towns in eastern Tlacolula (Cook 1983). Weaving *petates* from palm during the colonial period also is reported in historical records of the area (Schmieder 1930; Taylor 1972:103). In their modern market studies of Oaxaca, neither Beals (1975, 1979) nor Cook (1983) explicitly identifies the species of the palm used, so it is unclear whether goods were made only from imported palms (family Arecaceae) that are not native to the Valley of Oaxaca or from yucca, which to the untrained eye looks superficially similar to palm. At least some prehispanic *petates* were likely made from yucca.

There is no direct archaeological evidence for yucca at El Palmillo, but the documented use of this species in highland Mexico subsequent to contact provides a circumstantial case for yucca exploitation. Bone awls and stone tools resembling those used by the modern inhabitants of palm-weaving villages (Cook 1983; see also Osborne 1965) have been encountered in some quantity at El Palmillo. Although we do not know what fiber they were worked on, the abundance of yucca at El Palmillo today in conjunction with a set of tools that may have been used to process the plant provide some support for yucca weaving at El Palmillo during the Classic period.

Nopal and Cochineal

Opuntia pilifera (nopal), which is far more frequent at El Palmillo than in the surrounding hills, has a variety of economic uses; virtually all parts of the plant (fruit, juice, flesh, and sap) can be consumed in some form (Meyer and McLaughlin 1981; Russell and Felker 1987). According to Oviedo y Valdés (1526, cited in Donkin 1977:11), the edible fruits (tuna) resemble "large figs," and early accounts refer to them as "higuera de las Indias" (Indian figs). These fruits can be processed into a type of preserve (*miel, melcocha, queso de tuna)* by allowing the juices to evaporate; alternately the juices can be extracted and allowed to ferment to make an alcoholic beverage that the Aztecs called *nochoctli* (Donkin 1977:12).

Nopal flesh also can be prepared in a variety of ways for both consumption and economic purposes. Joints from the plants can be cooked with chiles (*Capsicum* spp.) (Donkin 1977:12), or the pad can be peeled and eaten. Today in Matatlán the pads are a key dry-season food, especially for village inhabitants of lesser means. Sap from nopal (*zumo)* can be drunk when water is scarce or mixed with other substances as a salve for burns (Donkin 1977:12). Historic documents record the Spanish applying poultices of pulped nopal to broken bones (Donkin 1977:12). *Opuntia* spp. also are the host plants for an economically important insect that produces the vibrant red dye, cochineal.

Cochineal was highly prized by both the Spanish (Donkins 1977; Evans 1990; Gibson 1964:354; Lee 1947-1948) and the Aztecs (Durán 1994 [1581]; Evans 1990). The dye is produced from the dried bodies of the female scale insect, *Dactylopius coccus* Costa (Baranyovits 1978:88; Lee 1947-1948:450). The desiccated remains closely resemble small seeds or grains (Baranyovits 1978; Lee 1947-1948), which led to the colloquial term *grana* (grain) being used to describe the raw dye. The name cochineal is a derivation of the Spanish term for the dye "*grana cochinilla*" (*coccinus* in Latin meaning "scarlet in color") (Brunello 1973:84). The Aztecs referred to the nopal plant as *nopal nocheztli*, "the cactus which produces the blood fruit," and to the raw dye simply as *nocheztli* (Baranyovits 1978:87; Lee 1947-1948:452).

Once these tiny insects are harvested from the plants and dried, they retain less than 70 percent of their original body weight, or an average of 10.74 milligrams each (Baranyovits 1978:89). It can take as many as 70,000 insects to produce one pound of cochineal dye (Lee 1947-1948:451). In prehispanic times, cochineal was processed into flat cakes (*nocheztlaxcalli*); illustrations in the Codex Florentine reveal the production and display of cakes for sale (Sahagún 1963 [c. 1570], Book 11:239, plate 804). Cochineal in this form, however, is inconvenient for trading over long distances (Donkin (1977). Spanish merchants preferred the dried "granular" form of the dye (Baranyovits 1978; Donkin 1977; Lee 1947-1948), although this may have had more to do with verifying that the dye had not been adulterated than with ease of transport.

To maintain their monopoly over the cochineal market, the Spanish encouraged the misconception that the dye was botanical in origin (Baranyovits 1978:88; Lee 1947-1948:451). Yet although the dye is not botanical, it is plant dependent. *Dactylopius coccus* are host plant specialists that feed solely on plants of the genus *Opuntia* (Cactaceae) (Baranyovits 1978). Two of the common host plants, *Opuntia pilifera* (nopal) and *O. pumila* (cardo) are found at El Palmillo, and nopal is especially abundant on site.

Historic accounts document the careful tending of *Dactylopius coccus* colonies to protect them from their many predators. While not arduous, cochineal production was labor intensive, so that most of its production was carried out at the domestic scale by peasant farmers (Baskes 2000:10; Donkin 1977:13). To maximize cochineal production, prehispanic cochineal farmers or *nopaleros* (Humboldt 1811, vol. 3:77-78) collected and transplanted the insects manually to different pads or nopal plants. To increase their colonies, *nopaleros* would often plant additional cactuses, forming orchards or nopalaries (Donkin 1977:17).

Cochineal had many uses among prehispanic populations, the most well documented of which is for dying textiles. In the Codex Vindobonensis, 12 deities are depicted drinking pulque, nine of which are dressed in red (Anawalt 1981:134; Furst 1978:201-203). Prehispanic scribes used cochineal for painting codices (Donkin 1977:20), and artisans used it to color wood, stone, and ceramics (Franco Brizuela 1977; Lee 1947-1948:453).

The dye was popular with native women who used it as a cosmetic (Donkin 1977:20; Lee 1947-1948:453). Spanish physicians in the sixteenth century used a mixture of ground cochineal and vinegar to treat wounds, clean teeth, and as a cure for head, heart, and stomach ailments (Donkin 1977:21; Lee 1947-1948:472). It also was highly prized in Europe as a bright, color-fast, red dye for fabrics (Baranyovits 1978:87). Cochineal is superior to dyes found in the Old World and was the preferred red dye until the late nineteenth century when it was largely replaced by easier to obtain synthetic dyes (Baranyovits 1978). Yet it was still easy to obtain in the markets in Tlacolula and Oaxaca into the 1930s (Parsons 1936:45), and small-scale production continues today in a few villages.

By 1572 cochineal production in Oaxaca was important enough to the Spanish export economy to warrant the establishment of a separate weighing and registration office in the valley (Lee 1947-1948: note 116). Cochineal was Mexico's second most valuable export commodity (after silver) for much of the colonial period (Baskes 2000:9. For Oaxaca, however, it was the region's most important economic product by the mid-eighteenth century (Hamnett 1971:59: Taylor 1972:14), when as many as one-third of the province's households were involved in some aspects of its production (Baskes 2000:12). As much as 40% of the cochineal was produced in the central valleys, including the district that encompassed Matatlán (Baskes 2000:17). Colonial documents include mention of several peasant cochineal producers from Matatlán (Baskes 2000:84; Taylor 1972:65).

Although Oaxaca was a major supplier of cochineal both historically (Baskes 2000; Donkin 1977; Gibson 1964:354; Lee 1947-1948; Taylor 1972) and prehispanically (Durán 1994 [1581]:182, 204), direct archaeological indicators for cochineal use are not well identified. The earliest evidence of *Dactylopius* as a source of dye comes from Peruvian textiles (Fester 1943; Yacovleff and Muelle 1934). Cochineal's history and its first use in Mexico is still debated. Although Rodríguez et al. (2001:76) propose that the insect originated in South America and was transported to southern Mexico by sea no earlier than 1450 B.C., others suggest the insect is indigenous to southern Mexico (Baskes 2000:9).

At present, Classic period cochineal production at El Palmillo can only be inferred from the dense concentrations of its host plant, *Opuntia pilifera* (nopal), on site. There is no question that cochineal was important in Oaxaca in the Postclassic period; this red dye was one of the major tribute items exacted from Oaxaca by the Aztec (Berdan and Anawalt 1997:108; Schmieder 1930:19). Its role in Classic period Oaxaca is less clear. Although we have found bright red pigment on figurines and urns at El Palmillo and other Classic period and earlier sites in Oaxaca, we have not yet established if cochineal was the source of this red dye (but see Franco Brizuela 1997). Yet arguments for a Classic period cochineal industry at El Palmillo are strengthened by the archaeologically documented presence of the spinning and weaving of maguey and other fibers (Feinman et al. 2001, 2002), materials on which the dye would have been applied. Given its later importance in Postclassic and colonial Oaxaca, cochineal likely was a key economic good at El Palmillo during the Classic period.

CONCLUSIONS

Based on our research at El Palmillo, we offer new perspectives on the relationship between population and agrarian resources in the dry eastern Tlacolula arm of the Valley of Oaxaca. In this study, multiple lines of evidence have been interwoven to illustrate that the Classic period inhabitants of the site relied economically on a complex of xerophytic plants that served subsistence needs as well as raw materials for specialized production and exchange. While this agricultural strategy may largely have entailed the fostering and dispersal of locally available plant resources, it also likely involved the relocation and concentration of valued plant varieties that were not initially available on the site itself.

Recently, studies focused on the arid highlands of central Mexico, particularly during late prehispanic Aztec times, have identified maguey as a critical food and economic resource (e.g., Evans 1990). Our study not only extends the seeming importance of these drought-resistant resources south to the Valley of Oaxaca, but it stretches archaeological evidence for a lifeway focused on these resources back to the earlier Classic period. We also have outlined some of the key plants that may have supplemented maguey, at least in ancient Oaxaca.

More significantly, the role or maguey, yucca, nopal, and associated plants provides a key vantage for understanding Classic period Oaxaca, as it helps us see how such large populations were supported on lands that were rather marginal for maize. Our findings have done nothing to alter our view that land and water still cannot be used to retrodict a region's prehispanic population distribution in the manner that Sanders and his colleagues asserted. Yet at the same time, we see that considerations of the relationships between people and agricultural resources must be envisioned more recursively (Feinman 1999b; Fisher et al. 1999; Lees 1992) than most, if not all, scholars tended to think or model decades ago. Labor strategies, the suite of available technologies and resources, as well the opportunities for exchange all have important effects on "agricultural potential."

Although this research has provided some clues regarding how the inhabitants of terraced hilltop sites (such as El Palmillo) in dry Tlacolula managed to feed and support themselves in a marginal environment for maize, it also raises some new questions. For example, since maguey and other xerophytic plants have been exploited in Oaxaca as early as the Archaic period and through intensification were capable of providing a significant resource base for later, larger populations, then why was this subvalley not more densely settled prior to the Classic period? At the same time, we still do not know what led to the early Classic period demographic spurt in Tlacolula. It is important to remember that this growth did not occur in a context in which other parts of the valley were overpopulated or entirely filled in, spurring people to move into drier, less "desirable" areas (Feinman et al. 1985; Nicholas et al. 1986). One possibility is that population growth in Tlacolula and the intensification of xerophytic plants for food and economic raw materials were partly spurred by new exchange opportunities as all arms of the valley were consolidated under the hegemony of centrally situated Monte Albán. Such an interpretation dovetails with the ample indicators of craft activities found at Oaxaca terrace sites, especially at those in drier sectors of the region.

In sum, the intensification of xerophytic plant communities now appears to have been a central aspect of the prehispanic highland Mesoamerican economy. If our interpretation of this intensification regime is borne out, then an interdependence with maize-producing communities and active networks of exchange to move goods across the region also likely were key parts of this ancient economic puzzle.

Table 1. List of common identified plants at El Palmillo.

Scientific Name	Family Name	Common Names	Economic Uses
Acacia farnesiana (L.) Willd.	Fabaceae	huizache de cerro (S.)	
Agave americana Linnaeus	Agavaceae **	maguey de pulque (S.)	pulque, mescal
Agave angustifolia Haw.	Agavaceae	espadín (S.)	preferred species for mescal
Agave karwinskii Zucc.	Agavaceae	lechugilla (S.)	mescal, fiber possible but not preferred
Agave kerchovei Lem.	Agavaceae	maguey de coyote (S.)	ixtle amarillo, not eaten due to bitter flavor

Agave macroacantha Zucc.	Agavaceae	javaline (S.)	mescal
Agave marmorata Roezl	Agavaceae	dob yet (Z.)	mescal, pulque
Agave potatorum Zucc.	Agavaceae	tobalá (S.)	mescal, quijote is mixed with masa to make tortillas
Agave rhodacantha Trel.	Agavaceae	dob bao (Z.)	mescal
Arbutus sp. Linnaeus	Ericaceae	madroña (S.)	edible fruit
Arctostaphylos sp. Adans.	Ericaceae	manzanita (S.)	fruit, tea for cough, treat-ment of kidney stones
Asclepias sp. Linnaeus	Asclepiadaceae	hierba de lagartija, pluma de gallina (S.)	
Azrtecaster pyramidatus Rob. and Greenm.	Asteraceae	romero de campo (S.)	brooms
Bursera galeottiana Engl.	Burseraceae	copal rojo (S.)	incense, glue
Bursera glabrifolia (H.B.K.) Engl.	Burseraceae	copal blanco (S.)	incense (preferred), fruit medicine for diabetes
Byrsonima crassifolia (Linnaeus) Kunth	Malpighiaceae	nanche (S.)	edible fruit
Cnidoscolus urens (Linnaeus) Arth.	Euphorbiaceae	mala mujer (S.)	medicine (circulation, mild pain killer)
Croton ciliato-glanduliferus Ortega	Euphorbiaceae	agua de pollo (S.)	sap is dangerous to eyes
Dodonaea viscosa Jacq.	Sapindaceae	jaras, jarilla (S.)	medicine
Euphorbia cotinifolia Linnaeus	Euphorbaceae	palo sordo (S.)	
Eysenhardtia polystachya (Ortega) Sarg.	Fabaceae	cuatle (S.)	medicine (kidney stones), cures leather
Ferocactus recurvus (Miller) Borg.	Cactaceae	biznaga (S.)	medicine (cuts, rashes), sweets
Fouquieria splendens Engelm.	Fouquieriaceae	ocotillo (Z.)	
Gonolobus sp. Decne.	Asclepiadaceae	hoja santa de campo (S.)	medicine for skin problems
Gossypium sp. Linnaeus	Malvaceae	algodón de campo (S.)	clothing, forage
Hechtia podantha Mez.	Bromeliaceae	lechuguilla (S.)	fiber
Hibiscus tenorii Fryxell	Malvaceae	flor de chilillo (S.)	ornamental flower
Ipomoea murucoides Roem. & Schult.	Convolvulaceae	pájaro bobo (S.)	medicine (variety uses), sap for clearing surface of water
Jatropha oaxacana J.Jiménez Ram. & R. Torres	Euphorbiaceae	nuez de campo (S.) susí (Z.)	medicine (rashes), edible nut
Lantana camara Linnaeus	Verbenaceae	zapotillo (S.)	fruit, medicine (granadillas), tea
Larrea tridentata (DC) Colville	Zygophyllaceae	batidor (S.)	
Lippia berlandieri Schauer	Verbenaceae	salvia de castilla, orejita de ratón (S.)	medicine for muscle/ear ache
Malpighia galeottiana A. Juss.	Malpighiaceae	nanche silvestre (S.)	edible fruit
Mammillaria collinsii (Britton & Rose) Orcutt	Cactaceae	chilillo (S.)	fruit, medicine (cuts, rashes)
Mammillaria karwinskiana Martius	Cactaceae	chilillo (S.)	fruit, medicine (cuts, rashes)
Mentzelia hispida Willd.	Loasaceae	pegajosa (S.)	medicine for bone pain
Mimosa aculeaticarpa Ort.	Fabaceae	uña de gato (S.)	
Myrtillocactus schenckii (J.A. Pur-pus) Britton & Rose	Cactaceae	garambullo (S.)	edible fruit
Opuntia pilifera F.A.C. Weber	Cactaceae	nopal (S.)	edible fruit
Opuntia pumila Rose	Cactaceae	cardo (S.)	edible fruit
Pellaea sp. Linnaeus	Pteridophyta	hierba de susto (S.)	medicine (anxiety)
Plumeria rubra Linnaeus	Apocynaceae	flor de mayo (S.)	ornamental flower

Prosopis laevigata (Willd.) M.C. Johnst.	Fabaceae	mesquita (S.)	fire wood
Pseudosmodingium multifolium Rose	Anacardiaceae	pirul de cerro (S.)	
Ptelea trifoliata Linnaeus	Rutaceae	arbol de zorillo (S.)	
Quercus sp. Linnaeus	Fagaceae	encine (S.) yega yu (Z.)	medicine (loose teeth)
Quercus sp. Linnaeus	Fagaceae	encino (S.) bla ta zi (Z.)	cures leather
Randia echinocarpa Moc. & Sessé ex DC.	Rubiaceae	durazno de campo (S.)	edible fruit
Salvia hispanica Linnaeus	Lamiaceae	flor de elote (S.)	seeds
Senecio praecox (Cav.) D.C.	Asteraceae	arbol de ixtle (S.)	medicine (broken bones)
Senna atomaria (L.) Irwin & Barneby	Fabaceae	chinchillo	
Senna pallida (Vahl.) Irwin & Barneby	Fabaceae	hierba de peine (S.)	paint
Senna polyantha (Moc. & Sessé ex. Colla.) Irwin & Barneby	Fabaceae	guaje de chivo (S.)	
Solanum sp. Linnaeus	Solanaceae	hierba loca (S.)	medicine (rashes)
Stenocereus marginatus (DC.) A. Berger & Buxb.	Cactaceae	organo (S.)	edible fruit
Stenocereus pruinosus (Otto) Buxb.	Cactaceae	pitayo (S.)	edible fruit
Stenocereus treleasei (Vaupel) Backeb.	Cactaceae	tunillo (S.)	edible fruit
Tecoma stans (L.) Juss. ex. Kunth	Bignoniaeceae	hierba de chichi (S.)	medicine (children’s fevers)
Wigandia caracasana H.B.K.	Hydrophyllaceae	hoja de san pablo (Z.)	seasoning in barbocoa
Yucca periculosa Baker	Agavaceae	palmillo (S.)	fiber, edible flower
Zanthoxylum limoncello Plachan & Oerstead	Rutaceae	limón de campo (S.)	

* S = Spanish, Z = Zapotec.
** The family name Agavaceae is accepted in Mexico and appears in the literature. North American herbariums prefer a more traditional nomenclature, which classifies the genus *Agave* under the family Amaryllidaceae.

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THE WET OR THE DRY?:

Agricultural intensification in the Maya Lowlands

Jeffrey L. Baker*

Understanding how food is obtained or how it is produced and how it moves from producer to consumer is essential to understanding how a society functions. Archaeologists in general, and Mayanists in particular, have been poor at understanding how agricultural systems function within complex societies, or how and why agricultural systems change. Utilizing data from the Maya Lowlands, this paper will first examine historical models of Maya agricultural systems and contrast these models with ethnographic data on twentieth century Maya farmers. This paper will then discuss the nature of the archaeological record at the site of Blue Creek in northwestern Belize (Figure 1). The initial examination of the agricultural economy at Blue Creek will focus upon the system as it might have existed in the Late Classic (Table 1). This will be followed by a discussion of the evidence for agricultural practices in the millennium and a half prior to the Late Classic. The shortcomings of the agricultural data will then be used to discuss attempts by archaeologists to understand the intensification process.

HISTORICAL PERSPECTIVES ON MAYA AGRICULTURE

For most of this century, Mayanists have relied upon the direct historical approach for determining the agricultural practices of the pre-hispanic Maya. It was argued that since modern farmers practiced a long-fallow swidden system, and that was the only system observed historically, then the pre-hispanic Maya must have utilized a similar system (e.g. Sanders 1962, 1963). It was often suggested that the

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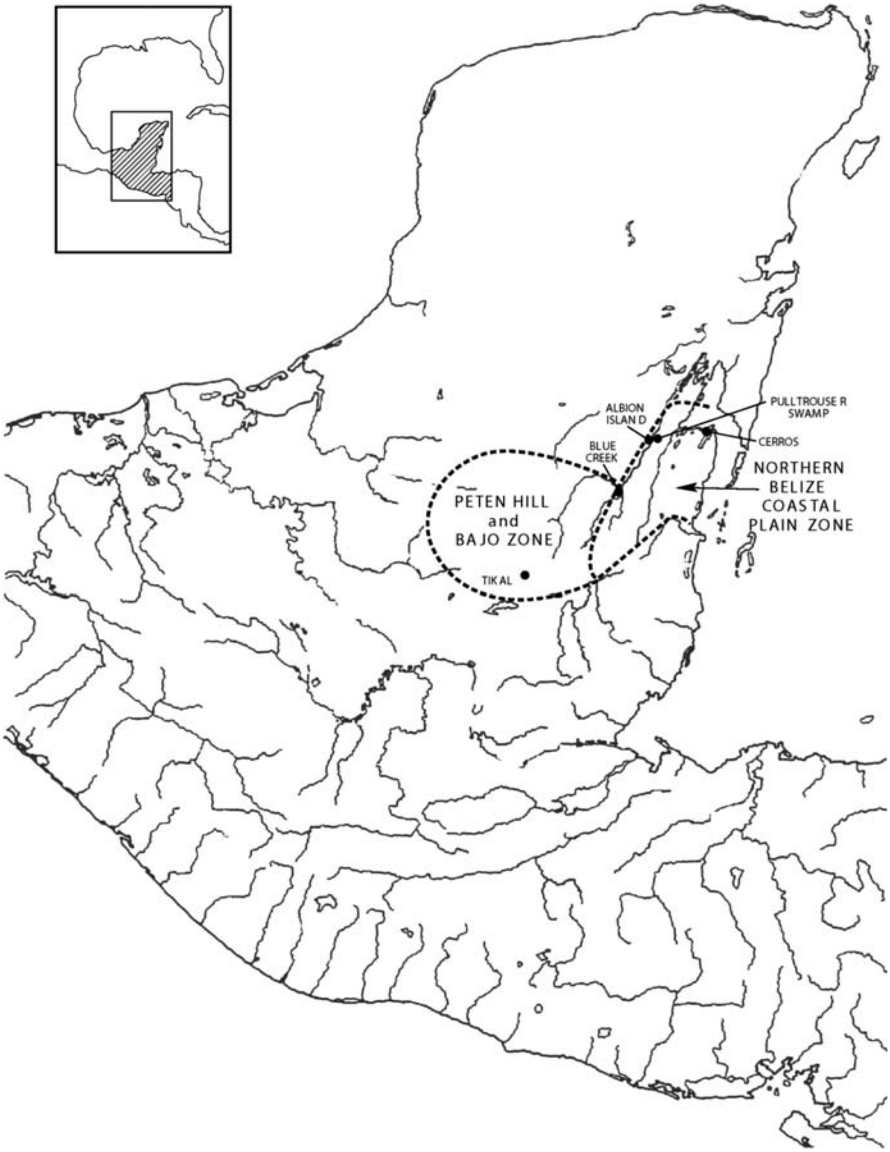

Figure 1. Map of the Maya Lowlands showing selected geographic features mentioned in the text.

limitations of the tropical environment required fallow periods in excess of ten years (Linton 1962: 38; Roys 1972: 39; Thompson 1954: 85).

Ethnographic descriptions of twentieth century farmers do not fit this swidden model. In most of the ethnographic accounts, farmers are utilizing a short-to-medium fallow system (Table 2), while historical accounts were somewhat ambiguous on the nature of the agricultural system[1] (McAnany 1995: 65-68). Lundell (1937: 12) notes that, “In addition to milpas some Maya have a *semi-permanent and a permanent plot* for other crops. The first located in or near the milpa, the latter in enclosures around the hut” [emphasis added]. While some of the crops found in the permanent and semi-permanent plots were tree crops, others like cotton and tobacco, are annual crops that can be fairly demanding of the soil (Table 3).

Table 1. Prehispanic chronology of the Southern Maya Lowlands.

PostClassic	930 CE – 1500 CE
Terminal Classic	830 CE – 930 CE
Late Classic	600 CE – 830 CE
Early Classic	250 CE – 600 CE
Late Preclassic	250 BCE – 250 CE
Middle Preclassic	1000 BCE – 250 BCE

Table 2. Crop fallow cycles among 20th century Maya farmers.

Reference	Crop Length (Years)	Fallow Period (Years)	Crop:Fallow Cycle
Cowgill (1961)	2	5-12	1:2.5-1:6
Steggerda (1941)	2-3	10	1:5 – 1:3
Atran (1993)	2	4-7	1:2 – 1:3.5
Reina (1967)	2-3	6	1:2 – 1:3
Carter (1969)	1-2	2-6	1:2 – 1:6
Wilk (1991)	1	15	1:15

Table 3. Crops Grown in Permanent and Semi-Permanent Plots (from Lundell 1933).

Semi-Permanent Plots	Permanent Plots (Kitchen Gardens)
Plantain Banana Cacao Papaya Yucca	Cacao Chayote Tomato Peppers Beans Mamay Cotton Tobacco

In addition to the discrepancy between the observed and theorized fallow cycles, the swidden thesis also presented a simplified view of the agricultural system, a perspective which viewed the various seasonal and perennial wetlands as unutilized ecological zones. Admittedly most of the early ethnographic descriptions focused upon the Maya living in northern Yucatan, a part of the Peninsula where wetlands are scarce rather than those Maya living in the southern lowlands where wetlands are plentiful. The failure to acknowledge the ecological variability tat exists across the Yucatan Peninsula is a characteristic of the swidden thesis and most subsequent models.

In the 1960s, archaeological surveys began to uncover evidence for population densities well in excess of the carrying capacity of swidden agriculture (Rice and Culbert 1990), leading researchers to question the nature of the Maya agricultural system (Bronson 1966, Harris 1972, Wilken 1971). The most significant discovery was made in 1968, when raised fields were discovered along the Rio Candelaria (Siemens and Puleston 1972). The finding of numerous additional raised field areas in northern Belize (Siemens 1982) stimulated the development of a new model, the so-called "New Orthodoxy" which assumed that the Maya relied heavily upon intensive agriculture, while continuing to utilize an upland swidden system (Turner 1993). Puleston (1977a: 457) argued that intensive wetland cultivation allowed the Maya to circumvent the "need for 5 – 10 year fallows." In other words, upland areas had to be cultivated in a swidden system.

In spite of this viewpoint, several researchers were arguing for intensive, upland agricultural practices (Netting 1977, Sanders 1979, Turner 1974, Wilken 1971). Of particular note is Hellmuth's exploration of ethnohistorical data that described contact and early colonial period Maya living in the Peten as cultivating the same plot of land for up to 20 years (Hellmuth 1977: 436). At this same time, other researchers began to note the ecological variability found within the Maya Lowlands (Sanders 1977, Turner 1978).

These arguments appear to have had minimal impact at the time. The continued references to an upland swidden system found in the literature (e.g. Demarest 1992, Fedick 1989, Ford 1986, Hammond 1992, Jacob 1996, Lucero 1999, Marcus 1983, Pohl 1990a, Willey 1989)[2] emphasizes the deeply held biases western society has against the tropics (e.g. Pohl 1990b: 417), a bias that is not limited to archaeologists (e.g. Goodland and Irwin 1975, Lovejoy and Salati 1983).

While the New Orthodoxy was the dominant model at the end of the 1970s (and continues to exert a strong influence today), a second viewpoint was developing in the 1980s. This "Alternative Orthodoxy" views the use of perennial wetlands as being restricted to the Preclassic, with rising sea levels at the end of the Preclassic forcing the Maya to abandon wetland fields (Bloom et al. 1983, Pohl et al. 1990). The seasonal wetlands in the Peten were used rarely, if at all, in this model (Pope and for Dahlin 1989, Fedick and Ford 1990). In the Alternative Orthodoxy, upland areas provided the major subsistence source, but were only utilized in a short-to-medium fallow swidden system.

While the role of wetlands in the Maya agricultural system was a matter of controversy at the end of the 1980s, the nearly universal consensus was that upland areas were cultivated in a swidden system (see Pope and Dahlin [1989: 102] for a dissenting opinion). In the words of one writer "'Upland agriculture' is swidden agriculture" (Pohl 1990a: 7).

Both the New Orthodoxy and the Alternative Orthodoxy continued two characteristics of the swidden thesis, an oversimplification of the ecological variability present in the Maya Lowlands and an underestimation of the complexity of the modern agrarian system. In recent years writers have again begun to acknowledge the ecological diversity present within the lowlands (Dunning and Beach 1994, Fedick

Table 4. Comparison of ethnographic data with the alternative and New Orthodoxy models.

Ecological Zone	Ethnographic Data	New Orthodoxy	Alternative Orthodoxy
Uplands (Coastal Plain)	Medium fallow with 5-10 years fallow	Medium fallow with 5-10 years fallow	Swidden
Perennial Wetlands (Coastal Plain)	Not Used	Raised Fields 2-3 crops per year	Not used
Uplands (Bravo Hills)	Short to medium fallow 5-12 years fallow	Medium fallow with 5-10 years fallow	Medium fallow
Seasonal Wetlands (Bravo Hills)	Flood Recessional System Annual Cultivation(?)	Raised fields 2-3 crops per year	Rarely used

Table 5. Amount of land used by 20th century Maya farmers.

Source	Area Cultivated per Year (in ha)	Length of Fallow	Total Area (in ha) Used in Agricultural Cycle
Cowgill 1961	3.4 – 5.0	5 – 12 years	23.8 – 35.0
Steggerda 1941	4.58	10 years	24.08 – 47.52
Kempton (cited in Cowgill 1961)	1.7 – 3.4	8 – 18 years	8.5 – 68.0
Atran 1993	1.28 – 3.6	4 – 7 years	6.4 – 32.4
Reina 1967	2.14 – 3.21	6 years	17.12 – 25.68
Wilk 1991	2.15 – 3.14	15+ years	32.25 – 66.5
Carter 1969	2.8	2 – 6 years (ave: 3.4 yrs)	28-56

Table 6. Housemound-land ratio in the Late Classic Maya Lowlands. (Unless otherwise noted, data from Rice and Culbert 1990).

Site Name	Land (in ha) per Housemound
Seibal	.69
Tikal (central 120 squ. Km)	.89
Tikal (rural)	2.56
Becan (rural)	1.25
Macanche-Salpeten Basin	1.47
Petenxil-Quexil Basin	2.56
Yaxha-Sacnab	1.69
Belize Valley	.84
Belize Valley (Fedick 1996: 121)	1.61
Uaxactun	3.12
Nohmul	8.33

1996). Accompanying the renewed recognition of the ecological variability has come an acknowledgement that the upland agricultural practices also were highly intensive (e.g. Chase and Chase 1998, Fedick 1996, Hughbanks 1998, Neff 1998, Robin 1998, Turner and Sanders 1992).

ETHNOGRAPHIC ACCOUNTS

How do these archaeological models compare with the ethnographic record? Based upon descriptions from the 1950s and 1960s, we can depict the modern agricultural system in the following manner: within the Belizean coastal plain, the main crop was grown in upland areas in a short to medium fallow swidden system. A supplemental crop, grown in the dry season, was planted along the margins of lakes, rivers and wetlands in a flood recessional system (Wright et al. 1959). Within the Peten, a similar pattern was present. The main crop was grown in upland areas, utilizing a short to medium fallow cycle (cropping periods varied from one to three years with fallow periods generally lasting five to eight years). In addition, farmers utilized two supplemental crops: the Yaxkin, which was planted in upland areas toward the end of the rainy season, and the San Jose, which was planted in seasonal wetlands during the dry season (Cowgill 1961, Reina 1967).

In comparing the Alternative Orthodoxy and the New Orthodoxy with the ethnographic data (Table 4), it is clear that, in these models, the upland agricultural system is no more intensive than the modern system, and, in some views, less intensive. Yet, the Late Classic population may have been ten times greater than the modern population (Rice and Culbert 1990), while the pre-hispanic economic system also seems to have been more vibrant than the economic system of the 1950s and 1960s.

Comparing the land available per household in the Late Classic with the land available per family in the 1960s provides additional evidence that the Late Classic agricultural practices had to be more intensive than the modern system. Modern farmers usually cultivate in excess of two hectares (Cowgill 1961; Fedick 1996: 114), with an additional four or five plots of land in various stages of fallow. Between cultivated and fallow land, each family uses around 20 to 30 hectares of land (Table 5). It should be noted that this figure does not include land occupied by houses and land used for kitchen gardens. In the Late Classic period, each rural household had access to 1 to 2.5 hectares of land (Table 6). The difference between the Late Classic data and the modern data is even greater than it appears in these tables. The ethnographic figure is for cultivated land only, excluding kitchen gardens, while the figures for the Late Classic are for total land, including houses, kitchen gardens, land occupied by roads, trails and plazas as well as other types of uncultivable land.

In the modern economy, the most important crop is grown in upland areas. While the Alternative Orthodoxy has adopted a similar viewpoint, the New Orthodoxy reduces upland areas to supplemental zones. The under-utilization of upland areas that is characteristic of the New Orthodoxy seems unlikely in light of both the ethnographic data and the nearly ubiquitous presence of house mounds throughout upland areas. This viewpoint is a continuation of assumptions within the swidden thesis that upland areas can only be cultivated in a swidden system. It is unlikely that most Late Classic farmers could have used swidden methods when they had access to less than three hectares of land.

There are significant differences between both models and the modern system when it comes to wetlands. While the New Orthodoxy proposes that both seasonal and perennial wetlands were utilized in an identical manner, ethnographically, this is not the case. Seasonal wetlands are used in a flood recessional system, while perennial wetlands are not used at all. Does this support the argument made by Pohl and others (1990, 1996) that perennial wetlands can not be utilized today because the water table is too high? As Puleston's (1977b) experimental raised field demonstrated, re-excavation of the ditches is capable of converting the perennial wetlands into cultivable land today.

That seasonal wetlands are utilized today, while perennial wetlands are not, is an indication that extensive modification is not necessary for their utilization. There is no reason to expect to find raised fields in seasonal wetlands simply because their presence has been documented in perennial wetlands. It is clear from the ethnographic evidence that the utilization of seasonal wetlands has been more frequent than those years "when rainfall patters were just right" (Pope and Dahlin 1989: 102). As Ursula Cowgill notes "the bajo [seasonal wetland] is able to supply sufficient water for plant needs in *most* years" (Cowgill 1961: 15, emphasis added).

Both the New Orthodoxy and the Alternative Orthodoxy are based upon a limited set of archaeological data. Ethnographic data and any additional archaeological data are forced to fit the models created from a highly limited amount of data. Both models also opt for a description of the agricultural system as being dominated by either wetlands or uplands, when the ethnographic data notes that these types of agriculture are complementary to each other (Cowgill 1961; Wilk 1991).

THE AGROECOLOGY OF BLUE CREEK

Blue Creek is a medium sized center that was occupied from the Middle Preclassic until the end of the Late Classic. Although initial work at the site focused upon the monumental architecture (Guderjan 1995), increasing attention has been focused upon the rural areas outside of the site, where several agricultural features have been found (Baker 2003, Guderjan 2002). It is from this rural area that the inhabitants of the urban core would have drawn their food. The area that the urban core of Blue Creek relied upon for its food (the sustaining area) would have been limited by two factors: 1) limitations on the distance that food could be imported in a preindustrial setting. 2) The size and location of the sustaining areas of neighboring polities. Research in the Old World has suggested that preindustrial overland transport of food was generally limited to a distance of 25 km (Chao 1986; Morley 1996). It is unlikely, however, that Blue Creek's sustaining area extended out to a distance of 25 km. Guderjan (2002) has argued that Blue Creek controlled an area of approximately 150 km^2, or an area extending out approximately 7 km from the urban core of Blue Creek. For the purposes of this paper, this area will be considered the Blue Creek sustaining area (Figure 2).

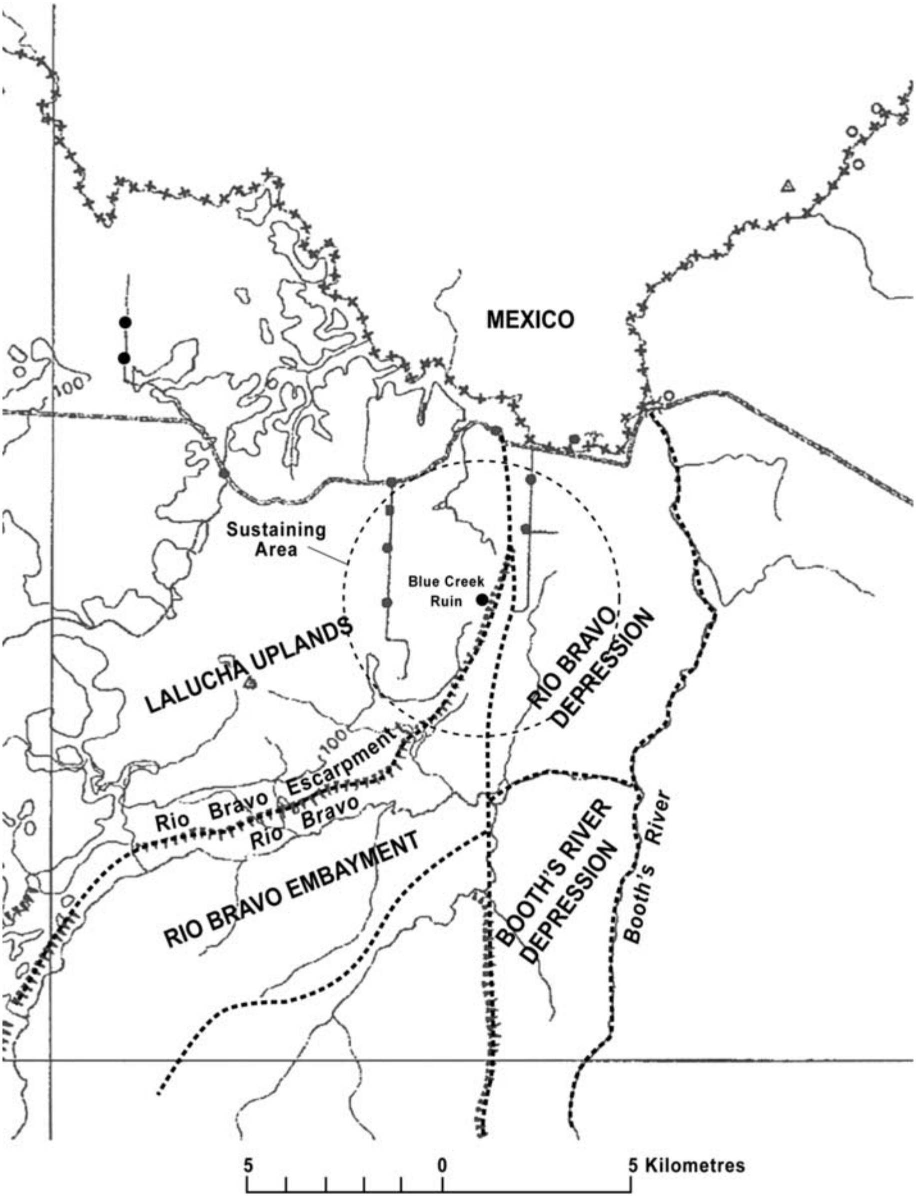

Figure 2. Map of ecological zones in the vicinity of Blue Creek.

The site of Blue Creek sits upon a large escarpment, the Rio Bravo Escarpment, that varies from 50 meters to over 150 meters in height (Figure 3). The Escarpment marks the boundary between two of the major physiographic regions within the

Figure 3. Photograph of the Rio Bravo Escarpment.

Maya Lowlands, the northern Belizean coastal plain and the Peten hill-and-bajo region (Lundell 1937, Dunning and Beach 1994, Turner 1978). The portion of the Peten physiographic province within Belize is referred to as the Bravo Hills (King et al. 1992), a term that will be used here to avoid confusion with the modern political unit of the Peten in Guatemala.

Like most of the Maya Lowlands, the Blue Creek area is underlain by limestone bedrock, with karstic processes dominating the landscape. The karst topography is most apparent in the Peten hill-and-bajo region, where rolling hills are found interspersed with depressions, referred to locally as bajos, that may flood during the rainy season (Figure 4). Most of the habitation, both ancient and modern, is confined to the rolling hills, with bajos being avoided because of their frequent flooding. Elevations within the Bravo Hills range from 100 m above mean sea level (amsl) to slightly over 250 m amsl.

The northern Belizean Coastal Plain is relatively flat, with few natural elevations exceeding 20 m amsl (Figure 5). Several major rivers, and a number of smaller rivers and streams flow across the coastal plain toward the Caribbean. Throughout the coastal plain there are a wide variety of wetlands, varying in size and their hydrologic cycle depending upon their elevation, connections to major rivers and distance from the coast.

Both the Bravo Hills and the Coastal Plain can be subdivided into a series of ecological zones (Baker 2003; Brokaw and Mallory 1993). The area of the Bravo Hills within the Blue Creek sustaining area falls within Brokaw and Mallory's Lalucha Uplands. The part of the coastal plain of concern to use here lies entirely within

Figure 4. Photograph of the Bravo Hills.

the Rio Bravo Depression, a large, north-south trending depresssion (Baker 2003). Both of these ecological zones, as well as the Escarpment, can be further subdivided into a series of ecological niches that would have provided different opportunities and problems for the pre-hispanic farmer.

Prior to 1960, the Rio Bravo Depression was dominated by a series of wetlands and meandering drainages, with patches of dry land scattered throughout the Depression (Figure 6). Three types of dry land were present within the Depression: Bravo outliers, fluvial islands and the escarpment shelf. Bravo outliers are steep hills that are outliers of the Bravo Hills and formed as a result of karstic processes. Although the modern inhabitants of the area do not use the outliers for habitation, the outliers investigated contain the remains of prehispanic habitation (Lichtenstein 2000). It is possible that the sides of the Bravo outliers might have been terraced, although the current level of data on these features does not allow us to confirm or disprove this statement. In all likelihood, the residents of the Bravo outliers would have cultivated kitchen gardens on the top of the hills.

The fluvial islands are low-lying, gently sloping ridges that were created by fluvial processes. The known fluvial islands contain high densities of house mounds, with the habitations forming a series of discrete communities (Clagett 1997, Lichtenstein 2000, Popson and Baker 1999). In terms of agricultural production, it is likely that the residences on the fluvial islands were surrounded by gardens and orchards. The sides of the islands do not have the steep slopes that are associated with the Bravo outliers, rendering terracing unnecessary. It is likely that other types of dry land plots were cultivated on the fluvial islands, although no physical trace of these plots remains. It is probable that the edges of the fluvial islands were cultivated in a flood recessional system.

The final type of dry land found within the Rio Bravo Depression is the escarpment shelf. This is a strip of flat land extending out from the base of the escarpment

Figure 5. Photograph of the Belizean coastal plain.

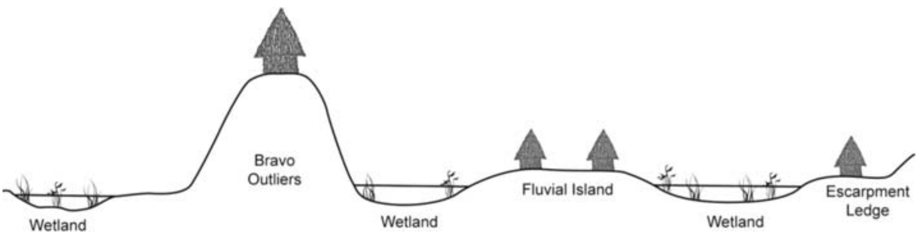

Figure 6. Generalized profile of ecological niches within the Rio Bravo Depression.

that varies in width from a few meters to approximately 500 meters. Like the fluvial islands, the escarpment shelf contains a very high density of pre-hispanic house mounds. The shelf may have been cultivated in a manner similar to the fluvial islands. There are, however, two significant differences between the fluvial islands and the escarpment shelf. The first difference is the presence of a number of springs located along the base of the escarpment. These springs would have provided a reliable water source for households throughout much of the dry season. The second difference between the fluvial islands and the escarpment shelf is the escarpment itself. Some of the rainwater falling on the escarpment would reach the escarpment shelf as runoff. Because of this runoff, agriculture on the escarpment shelf would have been slightly more secure during the dry season than on the other areas of dry land within the Rio Bravo Depression.

The final type of ecological niche found in the Rio Bravo Depression is the numerous wetlands. Referring to the wetlands within the Depression as a single ecological niche is misleading. At the present time, it is impossible to subdivide the wetlands into a series of distinct niches because of the landscape modifications that have occurred over the last 40 years. Research elsewhere in northwestern Belize has, however, provided evidence for a variety of different wetland types, with some wetlands being dominated by palms, some by woody species, and others by grasses and sedges. Raised fields have been found in wetlands dominated by all three types of vegetation (Baker 2003).

The wetlands in the Blue Creek sustaining area contain the remains of at least five raised field complexes, including three immediately surrounding the Chan Cahal complex (Figures 7 and 8). The rasied field complexes show a great deal of variability in the size, shape and orientation of individual platforms. It is possible that this variability could be related to the presumed differential hydrology of the wetlands (Smith 1983). Fields that are linear in shape may be associated with a slightly higher water table when compared with wetlands containing fields that are quadrangular in shape. This variable hydrology was important for farmers, and probably impacted the frequencies with which raised field complexes were cultivated. We cannot assume that every complex of fields was cultivated at the same frequency (cf. Siemens and Puleston 1972: 234). It might have been possible to cultivate some fields two or three times a year, while other fields may only have produced a single crop each year. Not only could the variable hydrology effect the frequency with which different complexes were cultivated, but it also could effect the frequency with which different parts of the same complex were cultivated (Erickson 1999; Fisher et al. 1999).

Work at Blue Creek also has uncovered evidence that some raised fields were constructed in two distinct phases. The earlier phase is characterized by fairly small ditches, less than half a meter deep, with the later phase of construction being associated with deeper and wider ditches (Figure 9). The deeper ditches may have been dug in response to climatic variability. In the Lake Titicaca Basin, modern farmers increased the size of ditches in response to dry years (Erickson 1993). The bigger ditches were necessary to reach the water table during dry years, allowing farmers to utilize splash irrigation. A similar phenomenon could have been the stimulus for Blue Creek farmers to increase the size of their ditches.

There are a number of wetlands and lagoons in the Rio Bravo Depression that do not appear to have been used for agriculture. It does not, however, mean that these areas went unutilized as farming was not the only source of food and fibers for the Maya. One settlement on a fluvial island contained the remains of several substantial middens of apple snails (*Pomaceae* sp.) (Lichtenstein 2000), the source of which may have been these unmodified wetlands. The wetlands and lagoons also

Figure 7. Photograph of a raised field complex near Blue Creek. Note the equilateral shape of these fields in comparison with the linear shape of fields shown in Figure 8.

could have been a source of a variety of other wild resources such as birds, reptiles, insects, reeds, grasses and sedges.

The escarpment is the next ecological zone to be examined here. Given its steep slope and shallow soils, the escarpment may not seem to have significantly influenced the agrarian economy of Blue Creek, but recent research has provided evidence that indicates the escarpment may have played an important role in the agricultural economy of Blue Creek. There are six niches within the escarpment (Figure 10): the lower slopes of the escarpment, escarpment ledges, the middle slopes of the escarpment, the top of the escarpment, the backside of the escarpment and *rejolladas* or dry sinkholes.

The lower escarpment consists of those portions of the escarpment within 30 m of the base of the escarpment. A number of residential terraces have been identified on the lower slopes of the escarpment. Are these residential terraces an indicator that the escarpment was cultivated? Not necessarily, ethnographic data indicates a more complex relationship between the location of the house and the location of the agricultural field. Factors like access to drinking water (Stone 1991), avoiding insects (Tozzer 1907) or maximizing the best soils (Tindituuza 1971) may be more important to the farmer than reducing travel time to the agricultural field. The relative importance of these factors will vary depending upon the agricultural intensity (Baker 1995; Stone 1996). The farmers at Blue Creek who built their residence on the lower slopes of the escarpment may have been trying to locate their houses in close proximity to the springs at the base of the escarpment, or they may have been trying

Figure 8. Photograph of a raised field complex near Blue Creek. Compare the linear shape of these fields with the equilateral shape of fields shown in Figure 7.

to maximize their agricultural land within the Depression. By placing their houses on the escarpment, farmers would have increased the agricultural land within the Depression. It should be noted that the known residential terraces are all located immediately adjacent to raised field complexes, and in locations where the escarpment shelf is extremely narrow. The entire escarpment has not, however, been surveyed.

The limited number of excavations into the residential terraces on the lower slopes suggests that occupation of the lower slopes may have occurred relatively late in the history of Blue Creek. There is no Preclassic occupation, a very limited presence in the Early Classic, and more extensive occupation in the Late Classic (Lichtenstein 2000). These residential terraces could be an indicator of the extreme land pressure that was facing the Blue Creek Maya at the time.

The second ecological niche found on the escarpment is the escarpment ledge. The escarpment ledge is not continuous, but instead consists of a series of natural terraces scattered around the escarpment. Invariably, these ledges are the location of prehispanic housemounds, usually large, elite compounds. The flat surface of the ledges may have been cultivated, although the soil on at least one escarpment ledge is extremely shallow to non-existent. Ledges that do contain thicker deposits of sediment would have benefited from rainwater running off of the upper slopes of the escarpment. The elevation of the escarpment ledges would have placed the residences well above even the highest floodwaters in the Rio Bravo Depression.

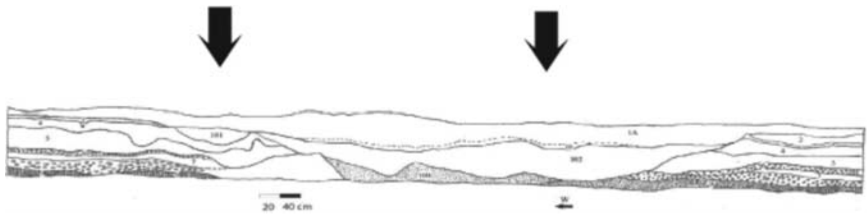

Figure 9. Construction phases of raised fields at Blue Creek.

Farmers living on the ledges also would have had easy access to the abundant resources found in the Rio Bravo Depression.

The middle of the escarpment includes those portions of the escarpment not included in any of the other ecological niches. There is currently no evidence for the use of the middle slopes of the escarpment, although it is possible that future survey may change this assessment. It is, however, possible that the middle slopes of the escarpment were the location of forest reserves.

The top of the escarpment is the location of the civic-ceremonial core of Blue Creek, as well as a series of residential courtyards. These residential courtyards are found in the immediate vicinity of the civic-ceremonial center as well as at other locations along the top of the escarpment. On the slopes immediately adjacent to the civic-ceremonial center, there are the remains of some dry field terraces, possibly the location of kitchen gardens associated with the adjacent elite residences.

One of the more important niches within the escarpment is the rejolladas. These dry sinkholes serve as sediment traps and also retain moisture better than other lands. For these reasons, rejolladas are highly prized agricultural lands in the northern Yucatan (Kepecs and Boucher 1996). Farmers with rejolladas on their ejido parcels are able to cultivate two crops a year from these features (Kepecs and Boucher 1996: 77). In early Colonial sources, rejolladas were elite controlled features that were used for growing fruit, including cacao (Farriss 1984: 180). In the Petexbatun region of Guatemala, rejolladas are used for dry season farming by recent Kekchi immigrants (Dunning 1996: 65). Three rejolladas are found immediately adjacent to the Blue Creek civic-ceremonial core. These sinkholes may explain why settlement was originally established at this particular location.

The backslope of the escarpment also was an important area for agricultural purposes. Throughout northwestern Belize, the highest concentration of check dams, terraces and other water control features is found in this location (Hughbanks 1998), although it should be noted that similar features are found elsewhere in northwestern Belize (Scarborough et al. 1995). Several possible explanations exist to explain this concentration of terraces and check dams on the backslope of the escarpment.

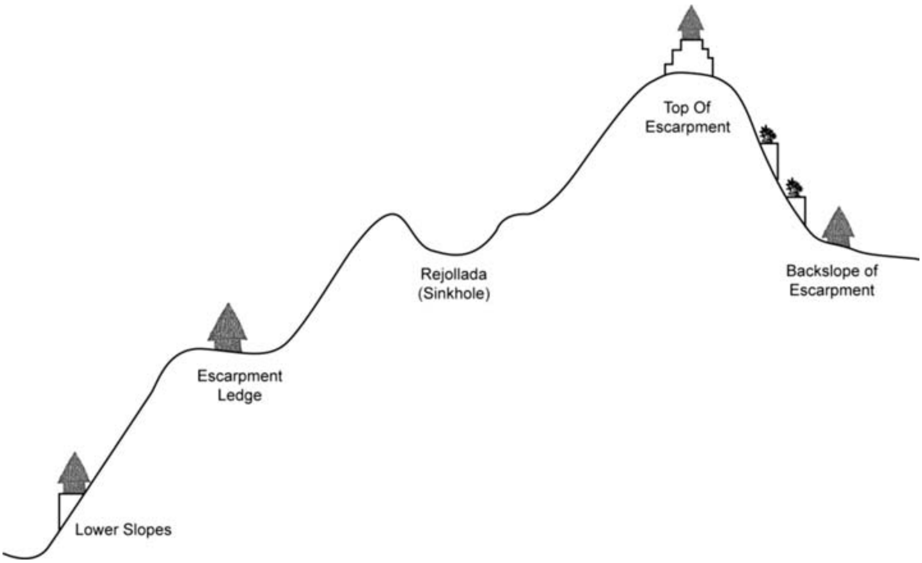

Figure 10. Generalized profile of ecological niches within the Escarpment.

Wright and others (1959: 196) noted that the Rio Bravo escarpment has a minor orographic effect on weather systems moving in from the Caribbean, creating a zone of slightly higher rainfall around the escarpment. This zone may have been particularly important for growing a second upland crop, e.g. the Yaxkin crop, with the construction of check dams and terraces an attempt to help conserve moisture during the dry season. The backside of the escarpment also has the highest population density in northwestern Belize (Dunning et al. 2003), which could be a factor in the high density of water control features found on the backside of the escarpment.

The final ecological zone within the Blue Creek area is the Lalucha Uplands (Figure 11). This area is characterized by rolling hills, with interspersed flat lands and seasonal wetlands. On the tops of the hills, prehispanic habitations are found. Occasionally the sides of the hills will contain terraces, quite possibly the location of the occupants' kitchen gardens. The residences on the hilltops tend to be larger than those found in the flat lands. Excavation provides evidence that the structures on top of the hills were usually occupied by the wealthier members of the community (Hanratty and Driver 1997, Lichtenstein 2000).

The flat lands are relatively well-drained zones which contain the remains of smaller structures. At Blue Creek, these areas are currently deforested and used for modern, mechanical agriculture. Elsewhere in northwestern Belize, this ecological niche is characterized by two different vegetation associations: mesic upland forest and cohune ridge forest (Brokaw and Mallory 1993). Both vegetation types are associated with some of the best agricultural soils in northern Belize (Brokaw and Mallory 1993; King et al. 1992). Elsewhere in northwestern Belize, linear rock alignments, presumably the remnants of field walls, are present in the flat lands (Kunen

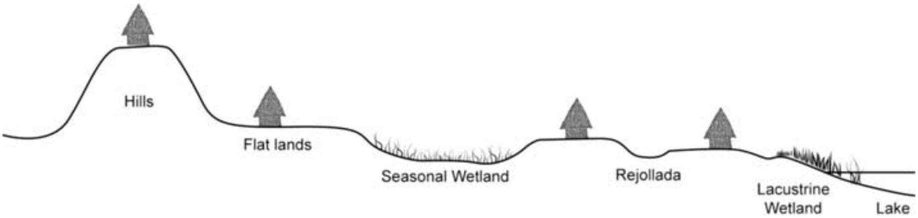

Figure 11. Generalized profile of ecological niches within the Lalucha Uplands.

2001). While there is no evidence for the utilization of the flat lands in the Blue Creek area, this does not mean that the flat lands were unutilized or utilized in a swidden system. Neither ditching nor terracing would be necessary in this ecological niche. The absence of field walls in the Blue Creek area also can not be taken as an indication that the flat lands at Blue Creek were not utilized intensively. Stone is not the only material that can be used to mark boundaries. Roads, trails and a variety of plants, including most trees and agave can mark the boundary of an agricultural field (Stone 1994). These items would not leave a discernible archaeological trace. It also would be wrong to assume that boundary markers are only associated with intensive agriculture, or that they are always associated with intensive agriculture (Stone 1994).

Farmers will not invest labor in permanent constructions if they are not needed. Their absence should not be taken as evidence that the agriculture being practiced in areas without permanent constructions was any less intensive than areas with permanent constructions (Farrington 1985). Rather than building terraces or walls or digging ditches, farmers may invest their labor in weeding, applying mulches, or manipulating the soil.

Another group of ecological niches present within the Lalucha Uplands are the seasonal wetlands. There is a great deal of variation in the seasonal swamps found in the Lalucha Uplands, with at least seven different vegetation associations being known to occur in these features (Baker 2003, Kunen et al. 2000, Lundell 1937). There is currently no evidence for the utilization of seasonal wetlands in the Blue Creek region, but these areas have not been thoroughly investigated yet. Modern farmers in the Peten use most of the vegetation associations found in seasonal wetlands for agricultural purposes without any modifications (Atran 1993; Cowgill 1961; Reina 1967). Similar to the flat lands, it may not have been necessary for the prehispanic farmer to modify these features in order to use them. In some areas, however, the risk involved in agricultural activities could have been reduced by digging drainage ditches. It is worth noting that one family has recently dug a drainage ditch in a seasonal wetland in the Peten (Culbert, personal communication 2000).

Two other ecological niches exist in the Lalucha Uplands, but both occupy relatively small areas. These niches are rejolladas and lacustrine wetlands. The rejolladas would have played a role similar to the rejolladas found on the escarpment, although they occur with much less frequency in the Lalucha Uplands. Lacustrine wetlands are a relatively narrow band of seasonally flooded land that occur along the edges of aguadas and lakes. This is potentially an important zone for dry season agriculture, with the land being used for flood recessional agriculture. There is currently no evidence for landscape modifications in lacustrine wetlands in northwestern Belize, or similar ecological niches elsewhere in the Maya Lowlands. As noted above for other ecological niches, the farmers may simply have felt that the labor investment necessary to modify these areas would not have produced a suitable return.

Similar to the South Pacific (Kirch 1993) and southern India (Morrison 1996), the agricultural system of the Maya can only be understood by paying attention to *both* the wet *and* the dry. Modern farmers do not limit their activities to one zone or the other, but cultivate both. When farmers intensify their agricultural practices, there is an increased utilization of *both wetland and upland plots* (Wilk 1991).

THE AGRICULTURAL ECONOMY OF BLUE CREEK

The agricultural economy of the Late Classic Maya at Blue Creek would have been highly diverse. Within the coastal plain, farmers were cultivating raised fields within the wetlands. While everyone would agree that this was an intensive system, the exact frequency with which the fields were cultivated is still a matter of debate. The Maya residing on the floodplain were living on the islands of dry land within the otherwise swampy floodplain. Adjacent to the house mounds, the farmers would have been cultivating kitchen gardens. These gardens would have consisted of tree crops, vegetables, as well as a few staple crops such as maize. Other dry fields may have been scattered around the floodplain. All of the plots, (kitchen gardens, raised fields, and other dry fields) would have been tended very carefully, weeds would have been pulled, and mulched. Household waste and vegetable matter collected from the edges of walkways, in the interior of wetlands and from the escarpment would have been mulched to use as a fertilizer on the fields. While houses were located near the base of the escarpment and some portions of the escarpment clearly played a role in the agricultural economy, significant portions of the escarpment may have been reserved as a source of wood and other wild resources.

Within the Bravo Hills, farmers would have been cultivating kitchen gardens adjacent to their house mounds. Other small plots of land would have been located around the upland areas. Particularly favorable areas, such as the backside of the escarpment, may have been cultivated more frequently. The seasonal wetlands within the Bravo Hills also were utilized on a regular basis. To what extent and how is unknown.

The system as described above would not have been uniform. Given the evidence for substantial status differences at Blue Creek (Guderjan 1995), it is probable that a few individuals would have had access to more land than the average farmer. These people would have had several options available to them: 1) they could have cultivated their land in a swidden system, allowing the extra land to be fallowed. 2) The land could have been used for cash cropping of items such as cacao or cotton. 3) The land could have been rented out to other farmers.

The large, elite run estate was probably a limited proportion of the Late Classic subsistence economy at Blue Creek. As argued elsewhere (Baker 1998), it is unlikely that an intensive, paleotechnic agrarian economy would have been based upon the presence of large, elite or state run estates. In the preindustrial era, the large, landed estate was more a sign of an owner's social standing than a major economic force (Morley 1996: 112; Nutini 1995: 196). While the goal of the estate may have been economic self-sufficiency, the ability of the large, agrarian estate to produce a surplus would have been limited by the inefficiency of slave or wage labor in a pre-industrial setting (Bradley 1991: 73-74; Chao 1986: 132-59; Netting 1993: 227-8).

AGRICULTURAL CHANGE AND AGRICULTURAL INTENSIFICATION

For the purposes of this paper, agricultural intensification will be divided into two components: agricultural change or how the system changed and agricultural intensification, or why the system changed. This distinction is important because we can not understand why a system changed until we understand how the system changed. In the case of the pre-hispanic Maya, what was the system like prior to the Late Classic?

Two raised field complexes have been investigated in northwestern Belize, one at Blue Creek and a second complex at Sierra de Agua. Excavations at these two sites have only provided evidence for a Late Classic utilization of fields (Baker 2003)[3]. This situation seems to be representative of wetland agriculture throughout the Maya Lowlands. In spite of several claims for a Middle Preclassic date for raised fields in the Maya Lowlands (Pohl et al. 1990; Puleston 1978), there is no clear evidence for the construction of raised fields this early. Raised fields at Cerros and Pulltrouser Swamp in northern Belize appear to date to the Late Preclassic (Berry and McAnany 2000, Scarborough 1986, Turner and Harrison 1982).

A similar pattern exists in regard to terraces, check dams and other types of water control features. In northwestern Belize, a few terraces provide evidence for construction during the Early Classic, but most terraces were not constructed until the Late Classic (Hughbanks 1998). This is representative of the situation throughout most of the Maya Lowlands (Chase and Chase 1998; Turner 1983), with evidence for the Preclassic construction of terraces only coming from the site of Nakbe in the Peten (Hansen et al. 2000). The vast majority of terraces in the Maya Lowlands appear to have been constructed in the Late Classic Period.

Based upon current evidence, the two major types of agricultural features found in northwestern Belize date predominantly to the Late Classic, with a very small number of agricultural features showing some evidence for construction in the Early Classic. In northwestern Belize, there is no evidence for the construction of agricultural features in the Preclassic.

Can we make any statements about the Preclassic and Early Classic Maya agricultural systems based upon indirect evidence? Two types of evidence will be discussed here: 1) changes in the household:land ratio (h:l ratio) over time, and 2) changes in the pollen percentages in sediment cores extracted from lacustrian sediments. The h:l ratio for the central Peten lakes region shows a gradual decline from the Middle Preclassic to the Early Classic (Table 7) (Rice and Rice 1990)[4]. A much more dramatic decline in the h:l ratio is observed between the Early Classic and the

Table 7. Hectares per household in the Peten Lakes Region (Data from Rice and Rice 1990).

Temporal Period	Hectares per Household
Terminal Classic	11.76
Late Classic	2.05
Early Classic	8.13
Late Preclassic	9.71
Middle Preclassic	10.52

Late Classic. When compared with the ethnographic data (refer to Table 6), even the earliest settlement data demonstrates that the land available in the Middle Preclassic was less than half that utilized by farmers during the 20th century. The informationthat can be garnered from the settlement data is, however, limited. It does not allow us to determine whether there was an actual increase in the cultivated area, (e.g. by expansion of agricultural practices into previously unused soil types), or to determine what the frequency of cultivation was.

Pollen cores also do not provide clear cut information on agrarian change. Most of the pollen cores from the Maya Lowlands show a similar pattern, with a dramatic drop in arboreal pollen around 2500 BCE (Cowgill et al. 1966; Pohl et al. 1996). The arboreal pollen remains quite low until ca 1500 CE when the arboreal pollen finally rebounds and slowly recovers to modern levels (Pohl et al. 1996). For the 4000 year period in which arboreal pollen is quite low, there is little significant change in the pollen, yet the archaeological data indicates significant changes in the agricultural practices during the Classic Period. These changes are not reflected in the pollen cores.

Do the pollen cores suggest that the third millennium BCE populations were cultivating the Maya Lowlands more intensively than their modern counterparts? The deforestation present in the pollen cores would seem to support this conclusion, but another possibility is present. The dominant arboreal pollen in the sediment cores comes from Moraceae trees, in particular *Brosimum alicastrum* (white ramon) and *Chlorophora tinctura* (red ramon) (Leyden 1987). In both modern and colonial times, the leaves of the ramon tree have been valued as a source of feed for horses (Hellmuth 1977: 434). When farmers cleared trees for their swidden plots, they preserved the trees as a source of fodder for their horses, not for the nuts as Puleston (1978) suggested. The absence of horses in pre-hispanic times would not have provided farmers with the same stimulus for preserving the ramon trees. The complete absence of evidence for the use of the ramon tree by pre-hispanic populations suggests that farmers were not preserving this tree prior to 1500 CE (Turner and Miksicek 1984). A significant difference between the pollen records, ca. 2000 BCE and the modern pollen may be due to differential treatment of the ramon tree and not to significantly different agricultural practices. The early evidence for deforestation may not indicate a substantial difference between the modern fallow cycle and the fallow cycle ca. 2000 BCE, but instead may be evidence of the differential treatment of a limited number of tree species.

Until the Late Classic, when there is a virtual explosion in the construction of agricultural features, there is little that can be said about changes in the agricultural system. The Late Classic is the most thoroughly investigated era, yet, we have a poor understanding of how the system functioned at that time. The evidence for agricultural practices in earlier times periods remains sketchy. It is difficult to discuss the underlying causes for agricultural change, when how the system actually changed is, at best, poorly understood.

ARCHAEOLOGY AND AGRICULTURAL INTENSIFICATION

As argued above, the data set present in the Maya Lowlands limits our ability to discuss the intensification process. This situation is not unique to the Maya Lowlands. Other areas of the world face a similar problem in which archaeologists can make a fairly descent portrayal of the agricultural system at its peak, but data from earlier time periods is often limited to the occasional canal or terrace and to pollen records (e.g. Basin of Mexico [Sanders et al. 1979], south Pacific [Kirch 1993]). For archaeologists to make a significant contribution to the discussion of agricultural intensification, there are several problems we must overcome.

Dating of agricultural features can be extremely problematic. Rarely do we find sealed, well-dated contexts within agricultural features. Terraces may be reconstructed several times during their life, with new material being incorporated each time, or the initial construction could involve the use of fill from middens that date to earlier time periods.

Raised fields also can create dating problems. In their initial construction, the excavation of the ditches removes earlier sediments and places these sediments on the top of platforms, where they now overlie later sediments. During their use, sediment from the planting surface of raised fields is continually being eroded into the ditches. As part of the routine maintenance activities, the ditches are cleaned out, with the fill in the bottom of the ditch being placed on top of the fields, further mixing the sediment on the planting surface. Following abandonment, the edge of fields will slump into the ditches. This material may consist of sediments and ceramics that not only pre-date abandonment, but also could pre-date construction of the fields, making it difficult to date the abandonment of the fields.

Another approach to dating agricultural features has been to utilize the associated settlement. If the associated settlement covers a thousand years or more, to what part of this occupation do the agricultural features date (cf. Erickson 1993). It is sometimes thought that the features will correlate with peak populations (e.g. Sanders et al. 1979). This process uses the population estimate to date the agricultural features, rather than dating the agricultural features independent of the population estimates. If we are to understand the relationship between agricultural features and population, the agricultural features/practices need to be dated independently of the population estimates.

The pollen preserved in lake sediments also is used to reconstruct changes in agricultural practices (Kirch 1993; Leech 1999). For the Maya, it is clear that there were significant changes in the agricultural practices during the Classic Period. Yet, these changes are not reflected in the pollen records. Conversely, given the previous example of ramon in the Maya Lowlands, it might be possible for there to be significant changes in the pollen data, without there being any significant change in agricultural practices. Using pollen data, can we identify and differentiate between different fallow lengths? There is currently profound disagreement on what sort of changes should be seen in pollen records associated with different types of agricultural practices (e.g. Leech 1999).

Population is an important and often overlooked aspect of agricultural change. In spite of Boserup's obvious correlation between these two variables, a recent critique of Boserup's model ignored the population issue (Leech 1999)[5]. If we are to understand the relationship between agricultural change and population change, not only do we need to have good control over changes in the agricultural practices, but we also need to be able to discuss changes in population size and distribution.

Although archaeologists have used and abused Boserup's model, our ability to make a substantial contribution to the population-agriculture debate has been limited by our inability to come to terms with the limitations of the archaeological data. For archaeologists to make a significant contribution to the discussion of intensification, we must improve our methods for understanding agriculture. Ultimately, we need to determine if it is possible to gather information that will provide us with data on fallow cycles, or less likely, annual labor expenditures.

CONCLUSIONS

Maya archaeologists have relied heavily upon a stereotyped image of the agricultural practices of the modern Maya. This stereotype has been used to reinforce models created from a limited amount of archaeological data. The limited amount of land available to the average household during the Late Classic Period is an indication of the intensive nature of the pre-hispanic agricultural practices. Like most intensive farmers, the Maya would have utilized a variety of ecological niches, even focusing upon minor variations in topography or climate. As the example of Blue Creek shows, some the ecological niches are highly distinct while the variation between other niches is subtle. The escarpment shelf is similar to the fluvial islands, but houses located on the shelf would have had direct access to a variety of springs, while fields located on the shelf would have benefited from rainwater runoff flowing down the escarpment. Similarly, fields located on the backside of the escarpment would have benefited from the slightly higher levels of rainfall present in this location. These minor ecological differences influenced not only the agricultural practices present in an area, but the density of occupation found in the various niches.

Evidence for changes in agricultural practices at Blue Creek is relatively minimal prior to the Early Classic, when the first agricultural features are constructed. The Late Classic sees an explosion in the number of agricultural features constructed and used. Yet, permanent agricultural constructions were associated with a small percent of agricultural fields.

In examining and interpreting archaeological data, we need to be aware of the biases we bring to the table. Because of the fragmentary nature of the archaeological record, we have to rely upon assumptions in interpreting the data. Many of the assumptions can be tested with ethnographic and historic data. In the case of the Maya, most models of the pre-hispanic agricultural system are not supported in all, or part, by the modern ethnographic data. While the ethnographic data is capable of helping us understand the pre-hispanic system, we cannot blindly force the pre-hispanic data into a modern ethnographic model. To gain a more accurate picture of the pre-hispanic system, we must account for the considerable differences between the modern era and the pre-hispanic era. Not only do we need to be aware of what soils they cultivate today, but we also need to be aware of methods that would allow pre-hispanic farmers to cultivate todays unutilized soils.

Farmers will change their priority over time. Local ecological variation also may play an important role in agricultural decision making strategies. Areas of slightly higher rainfall may be highly prized resources.

In the absence of agricultural features such as terraces, canals and raised fields, it can be extremely difficult to determine what type of agricultural practices were present, and how intensive these practices were. Pollen diagrams may not reflect changes in agricultural practices, while settlement data by itself, only provides a limited amount of information concerning agricultural practices. If, we as archaeologists are to make a substantive contribution to the intensification problem, then we must be aware of the limitations of our data set and work to overcome those limitations. This can be done through both improved excavation methods and cross-cultural comparisons.

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[1] The historical research of Hellmuth (1977) presents unambiguous evidence for intensive agriculture in the early colonial period, but this evidence was not available to archaeologists such as Morley and Thompson.

[2] Both Fedick (1996) and Pohl (Pohl et al. 1996) have reversed their stance in recent years, and are now discussing an intensive upland system. This reversal is part of a “second revolution” in ideas about Maya agriculture that may prove to be farther reaching than the revolution associated with the rejection of the swidden thesis (Harrison 1990).

[3] Recent excavations at Blue Creek have uncovered evidence that a few fields were constructed in the Early Classic (Lohse 2004).

[4] At the time of writing, the Blue Creek settlement data was being analyzed, and was not available for calculating the household-land ratio.

[5] Not only did Leech ignore the population question, but most of the commentators on her article also ignored the population question. Of 9 writers, only two (Brookfield and Kirch) made any mention of population data. The article by Leech was a critique of other researchers’ attempts to apply Boserup’s (1965) model to the south Pacific.

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AGRICULTURAL INTENSIFICATION IN THE LAKE PÁTZCUARO BASIN:

Landesque capital as statecraft

Christopher T. Fisher[*]

INTRODUCTION

Intensification of agricultural production figures prominently in theories for the origins of complexity, state building, and environmental change. Recent literature has focused on identifying exactly what intensification is, what causes people to increase inputs of labor, cultivation frequency, and productivity, and how intensification can be identified archaeologically (see Kirch 1994; Leach 1999; Morrison 1994, 1996, contribution in this volume). These treatments of intensification have important implications for the way that the concept has been used in Mesoamerica.

Here I reexamine the trajectory of intensification as commonly applied to Mesoamerica, using data from the Lake Pátzcuro Basin, Mexico. I argue that; 1, There is no compelling reason to assume that agriculture is initiated with slash and burn farming (see discussion in Brookfield 2001); 2, agricultural techniques commonly assumed to be labor intensive (raised fields, terracing) may not require as much labor as commonly assumed; 3, if, following recent work by Morrison (1996) intensification is a process (i.e: you intensify from something), it follows from points 1 & 2 that for Mesoamerica we have not yet demonstrated that there was intensive agriculture in the classic sense. To clarify, I am not saying that Mesoamerica lacked agricultural intensification, just that the process has not yet been demonstrated – which is a striking proposition given the long-standing theoretical importance of Mesoamerican case studies to theories of social complexity, state formation, etc. Given this it may be necessary to re-tool our expectations of what intensification

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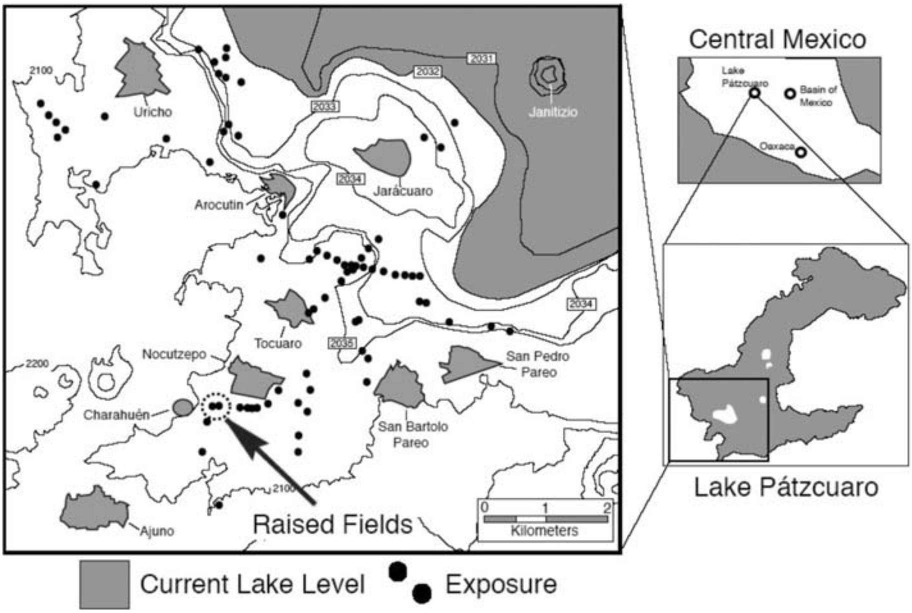

Figure 1. Location of the study area. Modern villages are shown in black. Exposure locations are shown as black circles.

may have been like in Mesoamerica, the mechanisms that initiated it, and the need for better models – especially landesque capital forms of production.

One important example is that of the Prehispanic Tarascan Empire centered in the Lake Pátzcuaro Basin, Mexico (Figure 1), where agricultural intensification formed a key component of statecraft (Pollard 1993), specifically, the engineering of lakeshore lands into raised field systems that could mitigate dynamic lake levels, and the construction of terrace landscapes that both repaired Classic period land degradation (A.D. 300-800) while increasing productivity. Both are key factors in the formation of the Tarascan State (Fisher et al. 2003; Fisher 2005).

AGRICULTURAL INTENSIFICATION: DEFINITIONS

Intensification of production is a process through which inputs of labor toward a given unit of land are increased resulting in higher productivity (see discussion in the introduction to this volume). It is generally assumed that the degree of productivity increase is limited by intrinsic parameters of a given land unit and technology. Eventually a ceiling is reached where the value of additional labor will exceed the possible surplus generated (law of diminishing returns). A guiding tenet of this view of intensification is that labor and skills can be measured against constant land – a problematic assumption at best (see discussion in Brookfield, 1972, 1984, 2001; Morrison 1994).

Innovation is achieved when productivity is increased by some mechanism associated with lower labor costs (see discussion in the introduction to this volume, also Kirch 1994:15-20). Landesque capital systems fall in a 'nether world' between innovation and intensification (see discussion below) since they require varying amounts of labor through time but always with increased yields.

Trajectories of Intensification

Harold Brookfield, writing about modern farmers, recently asserted that the Boserup scheme's supposed stepwise transition between least intensive and most intensive forms of land-use has tended to impose a deterministic template on a diverse set of actual histories" (2001:199). This statement also holds true for archaeology where the 'Boserup template' conditions much thinking on the trajectory of agricultural intensification (see discussion in Brookfield 2001; Leach 1999; Morrison 1994, 1996, contribution in this volume; Stone 1999).

Following Boserup (1965, 1981) population pressure creates a food deficit, met with changes in crop frequency seen as intensification. In the common evolutionary scheme, adapted from Boserup, the degree of intensification can be correlated with the labor requirements thought to be necessary to perform each successive type of agrotechnology, eventually leading to increasingly intensive technologies such as terrace, raised or drained fields, and complex irrigation systems.

The primacy of swidden agriculture in prehistory, implicit in the Boserup template, has been challenged (see Leach, Morrison 1994, this volume). Early evidence for swidden most often comes from changes in vegetation gleaned from lake-core pollen data, which as argued by Leach for the Pacific, is far from conclusive. Burning, paths, settlements, and most pervasively climate, can all account for vegetation shifts often attributed to early or initial agriculture. As an alternative Leach 1999 (see also Morrison 1994, 1996, contribution this volume) argue for multiple pathways and starting points. Just like modern farmers (see discussion in Brookfield 2001) prehistoric land-use would involve a variety of simultaneous strategies of varying intensity. Thus initial land-use may involve intensive and extensive agrotechnologies implemented to take advantage of variations in fertility, soils, topography, and location at many scales.

For Pátzcuaro is it possible that large-scale agriculture was initiated with raised field farming? Is the presence of maize pollen enough to infer a subsistence dependence? Most importantly, is there evidence that the intensity of agro-technologies increased through time?

What Is Required for Intensive Features?

In the Americas intensification most often takes the form of landesque capital – a concept developed by Brookfield (1984, see also Brookfield 2001; Blakie and Brookfield 1987, Kirch 1994; and the introduction to this volume) to identify landscape manipulation that serves as production infrastructure. Though landesque capital is commonly considered to be a form of agricultural intensification, Kirch (1994:19) actually classifies landesque capital as a distinct form of intensification, apart from fallow or other systems; it actually allows land mangers to beat the ‘diminishing returns’ syndrome. Though initial labor investment in stone walls, terraces, drainage systems, irrigation systems, raised fields or other infrastructure features may be beyond household labor, subsequent costs associated with maintenance are lower.

For example, Erickson (1993, 1999, 2000), Graffam (1992) for raised field farming and Denevan (2000:300) for terracing, have demonstrated that much less labor is needed than commonly assumed for initial construction and that output, even in the first year, significantly exceeds shifting cultivation. In many respects this turns the traditional intensification cycle on its head. Through landesque capital farmers actually achieve long-term productivity gains with reduced labor requirements. Additionally the systems of which these features are a part are most often constructed piece-meal, over many generations (accretionary landscapes – i.e. Doolittle 1984). Thus the question can be asked, are landesque capital systems necessarily agricultural intensification? Is expansion of landesque capital processual intensification?

If we return to the traditional definition of intensification, especially problematic is the need to measure labor inputs against a constant, most often land (see Morrison 1994). But, since land area is constantly in flux, how can this measurement actually be achieved? One possible outcome of landscape manipulation, especially associated with primary complex societies, is land degradation – seen most often in the prehistoric record as soil erosion (see discussion in Butzer 1996, Fisher et al. 2003, Redman 1999). Indeed, degradation is often cyclical in nature, with periods of both long-term stability (on the order of centuries), followed by periods of intense degradation (see discussion in Fisher et al. 2003; Redman 1999).

A fundamental property of landesque capital landscapes involves the consequences of abandonment - both intentional and unintentional. Landesque capital landscapes depend on constant inputs of labor for stability with degradation often resulting from a failure to repair and maintain agro-infrastructure. Thus

> “The peril is that such systems require abundance of labor, not only for their establishment but also for their maintenance. If some of that labor is withdrawn, as by an increase in off-farm employment opportunities, or by emigration, or by the demands made on male labor generated by the state for corvée work, or for war, the consequences can be disastrous. The created system itself if one of high sensitivity, although it is resilient as long as the necessary inputs for its maintenance are available (Blakie and Brookfield, 1987:33).”

As an example, colonialism caused the abandonment of many engineered environments, especially terrace systems (see Blakie and Brookfield, 1987: chapter 6). For the Americas Harden (1991), Zimmerer (1991, 1993, 2000), Kirkby (1973), Spores (1969) and Fisher et al. (2003) tie terrace abandonment to degradation (see discussion in Denevan 2000; Whitmore and Turner 2001). Of interest is the example given by Spores (1969) of Lama Bordo terracing in the Mixteca Alta, Oaxaca. These concave features are designed to catch colluvium caused by intentional up-slope disturbance. The resulting planting surface is highly fertile, especially if inputs of colluvium are continued. Thus landscape instability in one portion of the catchment promotes sustainable land-use in another.

This means that landesque capital systems can both trigger degradation, through abandonment, and in turn promote intensive-style land management, through the need to stabilize and create productive landscapes. In some contexts this makes degradation a possible intensification trigger.

For the Lake Pátzcuaro Basin intensification took the form of raised field and terrace systems that emerge in the context of increasing social complexity associated with a low population density (Fisher, 1999). Can we consider these features intensive in the Boserupian sense? Is it possible that the creation of terrace landscapes, for Pátzcuaro in the Early to Middle Postclassic, was a response to earlier degradation?

Process

Distinguishing between an intensive form of agriculture and the process of intensification requires distinct archaeological evidence (see Leach's critique of Kirch, 1999:315). The former is accomplished (following Kirch, 1994) by identifying intensive features (landesque capital) permanently modifying the landscape. In contrast, the intensification process is indicated by changing parameters showing increased labor investment. For Futuna, as an example, Kirch (1994) demonstrated a shift from swidden to pondfield agriculture requiring higher labor inputs (though see Leach's criticism of the primacy of swidden agriculture for the Pacific, 1999).

INTENSIFICATION IN THE LAKE PÁTZCUARO BASIN

At the time of European Conquest, the Lake Pátzcuaro Basin (Figure 1) was the geo-political core of the Tarascan Empire which controlled much of the western highlands of Mexico (see Pollard 1993). The Lake Basin was home to a large urban population, has a long history of occupation, and a heavily engineered environment.

In 1983 Gorenstein and Pollard published a seminal analysis of precontact Tarascan socio-political and subsistence networks within the Lake Pátzcuaro Basin based on early Colonial documents and modern land-use and crop yields. One striking conclusion from this work was that in the last century before Conquest, up to 44% of the maize needed to support the large, Pátzcuaro Basin population was imported – even with 31% of the arable land area permanently irrigated (1983:108). More recent population estimates based on archaeological survey (Pollard 1995) would boost population numbers by roughly 15-20% (see Fisher 2000, 2005; Fisher et al. 2003) further exacerbating the 'maize deficit'.

There is much anecdotal evidence that agricultural intensification, including wetland irrigation ('seedbeds' – several places in the Relación de Michoacán, Craine and Reindorp 1970; wells and ditches – Palerm and Wolf 1957:112, and others), and terraces (see Donkin 1979:56-57; Whitmore and Turner 2001:142, 147), were common features of the Prehispanic Lake Basin landscape. But until recently there has been a lack of direct archaeological evidence.

This paper draws on a recent program of landscape research undertaken in the southwest portion of the Lake Pátzcuaro Basin that coupled geoarchaeological (Fisher 2000) and settlement pattern research (Pollard 1995) to explore the relationship between demography, land degradation, and the development of social complexity, enabled by a major lake regression (see Fisher 2000, 2005, ND; Fisher et al. 1999, 2003; Pollard 1995). By examining deposition on newly exposed lake-bottom, the source, timing, and duration of past episodes of erosion could be identified. Importantly, for the first time in this region, intensive agricultural features were identified in the form of wetland agricultural features (see Fisher et al. 1999) raised fields/*chinampas*) and large tracts of abandoned Prehispanic agricultural terraces (see Fisher 2000; Fisher et al. 2003). The following discussion summarizes the relevant findings from this study while more specific information can be found in Fisher 2000, Fisher et al. 2003, Pollard 1995, 1996a, 2000.

Physical Background

Lake Pátzcuaro is a shallow, highland lake on the Central Mexican Altiplano (Chacon, 1993). The Lake Pátzcuaro Basin shares many characteristics with the more familiar Basin of Mexico (elevation, vegetation, monsoonal climate) though there are some important differences. At only 928 km^2 the Lake Pátzcuaro Basin is smaller than the Basin of Mexico (7,000 km^2) and receives almost twice as much rainfall: 900-1250 mm/year Pátzcuaro, 450-1000 mm/year Basin of Mexico (Pollard, 1993; West, 1948).

Extensive paleoenvironmental research has been undertaken within the Lake Pátzcuaro Basin elucidating connections between humans, climate, and land degradation (see Fisher et al. 2003; O'Hara et al. 1993; Redman 1999; Whitmore and Turner, 2001:232-233). Lake Pátzcuaro is an 'amplifier' lake with climatic flux causing shifts in lake level as great as 10-13 meters in the last decade (Chacon, 1993; Pollard, 1993; O'Hara, 1993). Recent research has focused on a variety of lake cores recovered from the Mexican Highlands suggesting reduced rainfall for the Pátzcuaro Basin between A.D. 700-1100 resulting in similarly low lake levels (Gorenstein and Pollard 1983; O'Hara, 1993). This would have resulted in a regression episode estimated to have been between 10-13 meters below the level of the lake at the time of European contact.

Cultural and Landscape History

Much of the following section is summarized from recent archeological and geoarchaeological investigation within the Pátzcuaro Basin (see Fisher 2000, 2005; Fisher et al. 2003; Pollard 1993, 1995, 1996a, b, 2000a, b, c; Pollard et al. 2001; Pollard and Cahue-Manrique 1999). Table 1 provides a phase summary of lake level, population, and area occupied (see summary in Fisher et al. 2003).

Evidence for the initial occupation of the Lake Pátzcuaro Basin comes indirectly through the presence of maize pollen in lacustrine cores dated to sometime between 1690 - 940 B.C. (Bradbury 2000; Hutchinson 1956; Watts 1982). During the Late Preclassic period (<A.D.350) small village societies are known from the adjacent

Cuitzeo (Chadwick 1971) and Zacapu (Michelet 1992; Michelet 1989) Lake Basins. Recent, on-going excavations at the site of Erongaricuaro have revealed a Preclassic settlement on the piedmont suggesting a more intensive occupation of the region at this time (Pollard 2002). The Preclassic period corresponds to a major episode of environmental disturbance that was thought to be the result of agricultural adoption (O'Hara et al. 1993 : Unit II, 3600-2800 B.P.). No evidence for this was found by Fisher et al. (2003) with Israde et al. (2005) arguing that this may be the result of a major tectonic event. More work is needed to unravel the causality of this early event.

Period (A.D.)	**Hispanic (1520-1650)**	**Postclassic (1520-900/1000)**			**Classic (900/1000-350**	
	Early	Late	Middle	Early	Epiclassic	Middle
Phases	Early	Tariacuri	Urichu	Urichu	Lupe	Loma Alta
Unit	5	4	3	3	2-3	1-2
Lake Level	2040	<2033	<2033	>2035-<2033	>2035	>2035
Pop.	1560-3560	13,087-7155	7806-4087-	1706-925	1018-581	393-543
Sett. Area (ha)	200	851.25	472.5	107.5	52.52	20
Persons/km²	64	334-182	199-104-	43-23	26-14	14-10
Erosion	4	2	2	2	4-5	5

Table 1. Summary of trends by archaeological phase for the Lake Pátzcuaro study area. Phases come from Pollard (1995), lithostratigraphic units come from Fisher (2000), lake level is reported in meters above sea level (m asl), population estimates are based on full pattern settlement survey (Pollard 1995) and were calculated by Fisher (2000). Adapted from Fisher et al. 2003, Table 1.

Measured Age	Calibrated Age	A.D. Intercept	C13/C14 Ratio	Lab No.	Remarks
*2360± 40	BC 520-380	BC400	-24.5	Beta-161015	Charred Material
1020± 40	990-1030	1010	-9.5	Beta-164513	**Zea mays**
1170 ± 40	1170-970	780-980/885	-24.5	Beta-102811	Charred Material
1260 ± 40	1275-1070	675-880/775	-24.7	Beta-102807	Charred Material
1330 ± 40	1300-1170	650-780/680	-22	Beta-102805	Charred Material
1360 ± 40	1315-1230	635-720/665	-23.9	Beta-102808	Charred Material
1480 ± 40	1415-1300	535-650/605	-25.4	Beta-102813	Charred Material
1500 ± 40	1435-1320	465-475/590	-22.4	Beta-102806	Charred Material
1550 ± 50	1535-1320	415-630/540	-18.9	Beta-102810	Charred Material
1890 ± 40	1895-1715	55-235/120	-26	Beta-102812	Charred Material

Table 2. Radiocarbon information for the Lake Pátzcuaro landscape study. All dates are accelerator MS determinations and calibrated using CALIB (http://depts.washington.edu/Qil/calib/). Adapted from Fisher et al. 2003, Figure 1b.

For the Central Highlands, the Classic Period (A.D. 400-900) marks a shift in socio-political organization characterized by increasing extra-regional economic ties. Large, well planned ceremonial centers appear, such as Tres Cerritos in the Cuitzeo Lake Basin, Tingambato, located just southwest of the Pátzcuaro Basin, Guadalupe in the Zacapu Basin, and several centers greater than forty hectares in size within the Pátzcuaro Basin. These settlements contain ball courts, mound groups with sunken plazas, and group tombs with exotic items. Evidence of increasing social complexity comes from Pollard's excavations at Urichu including a large group tomb containing multiple individuals associated with sumptuary items dated to the Epiclassic. This corresponds to a major episode of soil erosion and associated landscape disturbance (see Fisher et al. 2003).

The early/middle Postclassic (A.D. 900-1350) marks a shift in socio-political organization for the region partly due to a breakdown of Classic period exchange networks and a re-organization of the Central Mexican Highlands. For Pátzcuaro, the early Urichu Phase (A.D. 900-1100) saw the growth or expansion of major defensible upland centers while much of the lakeshore is abandoned. This trend ends in the latter portion of the middle Postclassic (A.D. 1100-1350) with an explosion in the number, location, and size of settlements.

The middle and late Urichu period (A.D. 1100-1350) marks the beginnings of centralization, social stratification, and economic integration leading to the formation of the Tarascan State in the Late Postclassic (A.D. 1350-1525). Sites appear in less defensible locations and new upland areas are colonized. Large centers grow dramatically in size and complexity with new zones of monumental construction becoming true urban centers.

This trend intensifies during the Tariacuri Phase (A.D. 1350-1525) with the integration of the basin while the region served as the geopolitical core of the Tarascan State with centralized economic, settlement, and political systems. By the end of the Tariacuri Phase the landscape had become a mosaic of residential and agricultural terraces even in the capital, Tzintzuntzan. This increasing Tarascan settlement and associated environmental modification stabilized the landscape resulting in some of the lowest rates of soil erosion identified within the Lake Basin (Fisher et al. 2003 – see Butzer 1993, O'Hara et al. 1993 for an alternative viewpoint).

During the early Hispanic period (A.D. 1520-1650), the indigenous population was more than halved as a consequence of European introduced disease, labor conscription, starvation, and emigration. These changes were rapid and dramatic, and by the 1530s large herds of pigs, episodes of native starvation, and abandoned landscapes are

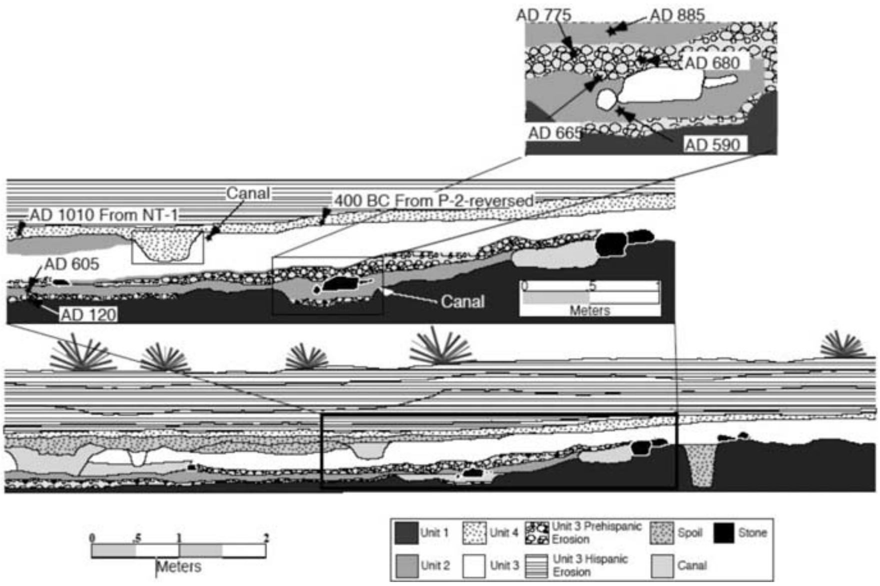

Figure 2. North wall of Nocutzepo trenches 2-3 showing the location of AMS determinations, canals and associated agricultural horizons, and the lithostratigraphic units used in this study.

reported (Warren 1984, 1985). Between A.D. 1580-1650 the basin was centralized (*Congregaciones*) into the modern pattern of settlement along the lakeshore drawing the remaining population from many Prehispanic hamlets, villages, and centers and leaving a largely abandoned landscape. The abandonment of pre-conquest landscapes resulted in an environmental catastrophe with severe and pervasive land degradation that is largely responsible for the abased modern landscape.

Prehispanic Tarascan Raised Fields: Intensification for Early Surplus

In 1996 two paleoenvironmental trenches near the modern village of Nocutzepo (Figure 1) yielded evidence for canals and associated agricultural horizons (‘seedbeds’ or *chinampas*). The features are dated by nine AMS dates forming a tight spread between AD 120 - and AD 1010 (Table 2). Figure 2 shows the basic sequence of deposition, location of AMS determinations, and the location of the raised field features found in 1996.

Five lithostratigraphic units characterize deposition in the region beginning with a pre-Holocene diatomite tuff dated to the late Pleistocene (see Bradbury 2000), and covered by the first of three marsh soils (Unit I). Beginning sometime after A.D. 120 episodes of landscape instability, documented by colluviam on the lakebed (Unit II), coupled with stability marked by marsh formation (Unit III) occur, lasting until A.D. 800.

One canal dating to this period was discovered (see Fisher 2000, Fisher et al. 1999). This feature was excavated into the marsh sediments of unit I, filled with colluviam from Unit II, and then capped with Unit III sediments before A.D. 590 (1500 ± 40 b.p. Beta-102811). This canal appears during the Middle Classic Loma Alta phase when the population of the Lake Basin was low during the development of the first ceremonial centers in the region (Fisher 2005, Fisher et al. 1999, 2003). Thus the earliest agricultural intensification currently known for the Basin occurs in the absence of population or other stresses, and without ‘top down’ control (Fisher et al. 1999:648).

The Prehispanic portion of the sequence is then capped with a third marsh soil (Unit IV) and buried under Hispanic period rythmites of eroded upland sediment (Unit V). In a second episode of raised field construction two later canals, roughly three meters apart, were excavated into the clay rich soil (Unit III) and filled with the final marsh episode (IV). Between these two features is an organic rich zone that is either an agricultural soil or zone of spoil from the adjacent canals. These features occur sometime between A.D. 885 and A.D 1010, during a period of increasing social complexity, but when the population of the Lake Basin is still relatively low. Thus the second episode of intensification may support some aspects of ‘top down’ management models, but not stress-based perspectives for causality (Fisher et al. 1999).

These two separate episodes of canal construction are related to fluctuations in lake level rather than socio-political, or demographic change. The period when the first canal is abandoned correlates with the beginning of a drying trend in the central highlands of Mexico (see Metcalfe et al. 2000) that significantly lowered lake levels.

Given the distribution of Prehispanic settlements on newly exposed lakebed (see summary in Fisher et al. 2003) this low stand, culminating sometime in the Middle Postclassic, would have lowered lake levels to around 2033 m asl – or roughly the current level of Lake Pátzcuaro. Similarly the construction and abandonment of the second set of fields may mark the start of the lake transgression in the Middle Postclassic period that culminated with the high lake level documented at the time of European contact (early A.D. 1520's)(Gorenstein and Pollard 1983; O'Hara 1993).

Given the fluctuating nature of past Pátzcuaro lake levels (Fisher 2000; Fisher et al. 2003; O'Hara et al. 1993) I argue that, like the Titicaca Basin (see Erickson 1999, 2000), Tarascan wetland farming was adapted to significant environmental dynamism. As the lake rose and fell, ditches and canal systems were alternatively abandoned, colonized, or irrigated depending on the base water level. In this fashion field systems on the lake margin successively served as raised, drained, or irrigated fields depending on landscape position, environmental condition, and socio-political necessity.

This may be why the Nocutzepo fields lack permanent infrastructure features such as stone lined channels, etc. Farmers may have wanted to minimize labor investment since incrementally each year areas of raised fields would have needed re-tooling depending on landscape position. Though this record of canal construction and reconstruction cannot be taken as processual agricultural development following

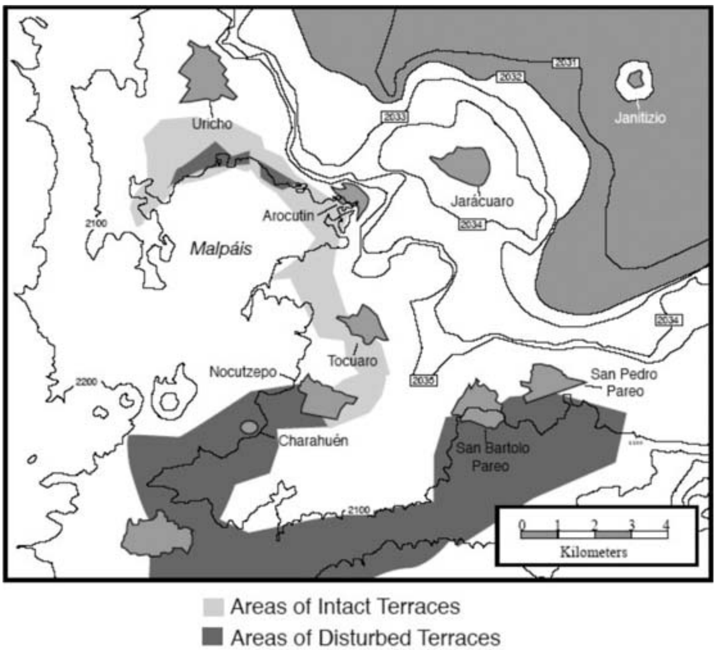

Figure 3. Location of intact and disturbed prehispanic terraces within the study area.

Morrison (1994, 1996, contribution in this volume), it nonetheless represents continual labor investment for significant agricultural surplus.

Terraces

During 1996 landscape research (Fisher 2000; Fisher et al. 2003) and settlement pattern surveys conducted by Pollard (1995, 1996a), significant tracts of terrace landscapes could be discerned within the study area, shown as Figure 3. Away from settlements, most terraces would be classified as sloping-field (Donkin 1979:8; Rojas-Rabiela 1988:119; Whitmore and Turner 2002: 136-145) or bench type terraces (Donkin 1979:32; Rojas-Rabiela 1988:119; Whitmore and Turner 2002:145-154), though cross-channel (Donkin 1979:32; Rojas-Rabiela 1988; 120; Whitmore and Turner 2002; 155-161) and other types probably existed. Most of these features were badly disturbed/eroded through abandonment, modern land-use, and grazing, with a few notable exceptions (Figure 4).

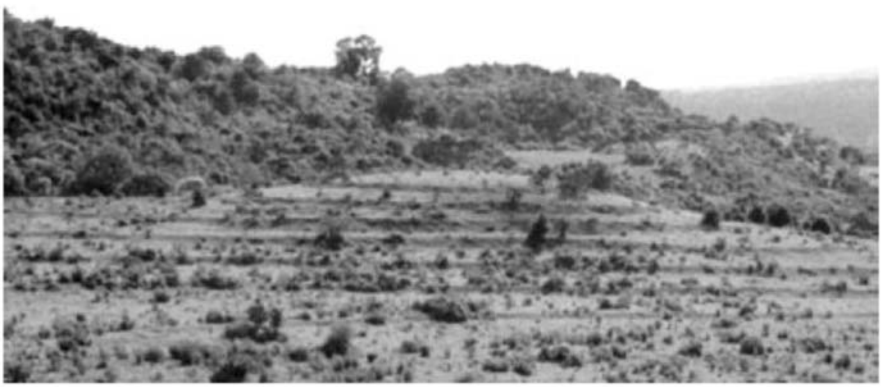

Figure 4. Photograph of intact bench terraces near the Prehispanic settlement of Urichu. These features are carved directly into uplifted diatomite known locally as *uirás*. In some respects they are similar to *tepetate* terraces from the Basin of Mexico (see Williams 1972).

Construction ranged from rubble/rock retaining walls that were probably not faced to simple planting platforms that had been cut directly into cemented sediments/bedrock. Many of the latter type occur on uplifted diatomite found at the lake margin and known locally as *uirás* (see Fisher 2000; Fisher et al. 2003). Outside of the study area within the Lake Basin more substantial sloping-field terraces with cut and faced stone can be found, most notably around Ucasanastacua between Tzintzuntzan and Ihautzio on the slopes of Cerro Tariacuri. Many of these terraces are still farmed today.

Around and within settlements terraces are more substantial with cut/faced stone, rubble platforms, and significant architecture. The more robust construction of these features allowed a higher survival rate.

The majority of these features occur around Late Postclassic settlements, and contain traces of Postclassic ceramics (Table 1; Urichu-Tariacuri phases), providing a proxy means of dating construction. This corresponds to the period of maximum population growth and occupation for the Prehispanic sequence when the Lake Basin was the core of the Tarascan Empire (see summary in Fisher et al. 2003). The construction of terraced landscapes also follows severe Classic period erosion that removed much of the soil mantle from many locations within the study area (Fisher et al. 2003). Beginning sometime during the Late Classic period this soil erosion is greatly reduced and remains low until the time of European Conquest for the Basin (early A.D. 1520's) – one direct consequence of terrace construction.

For the Lake Pátzcuaro Basin, the Postclassic period is associated with increasing urbanism, social complexity, and dramatic population growth – all of which presages the formation of the Tarascan State (circa A.D. 1350), and later Empire. By whatever means terrace construction was accomplished, either 'top down', 'bottom up', or some element of both, (see the introduction to this volume) this process would have significantly increased agricultural production while at the same time consolidating/repairing landscapes damaged during the Classic period. Though this process is initiated before the rapid 'population boom' of the Late Postclassic (Tariacuri phase), expanding terrace landscapes would have required increasing amounts of labor. Terrace systems would have been one reason (among many) to encourage immigration and high birth rates for increased labor demands.

CONCLUSION

Returning to the discussion of intensification presented in the introduction to this paper, several implications from the record of Tarascan landscape modification can be outlined. First, the earliest archaeological evidence that we currently have for any kind of agriculture is in the Preclassic (post A.D 120), with the construction of the first set of canals/fields. This precedes the first reported maize pollen by ~1500-800 years – which is inferred by depth and assumed accumulation rates of sediment but not directly dated (see Bradbury 2000). In other regions of Mesoamerica early agriculture appears in wetland or estuary contexts (Pohl 2002). In the absence of concrete data we cannot say conclusively what form agricultural adoption took for Lake Pátzcuaro, but there is no reason to assume a-priori that it would have occurred on the slopes surrounding the Lake rather than in a wetland context, as has been suggest by O'Hara et al. (1993).

It seems likely, that early farmers would have engaged in a diverse set of agricultural strategies like their modern counterparts and, given the low labor costs to high yields of raised field farming, that wetland agricultural fields would have been an important production component. This would mean, given current lake level models for the Early Preclassic that this agriculture may have occurred lower, close to the current level of the lake (2033 m asl). Further research targeting this area should yield fields in these localities if this is correct.

Next, if we think of intensification as a process of increasing inputs, in this case labor, there is little difference in the form and function of the two episodes of raised field building discussed in this paper. Both would require similar inputs of labor using relatively the same technology. But, through time, following the successional scheme of raised field building outlined above, increasing areas of Pátzcuaro wetlands would have been transformed in an accretionary sense. Like the Lake Titicaca Basin (Erickson 1999, 2000), each generation would benefit from previous landscape modification – even if those fields had been inundated. In this sense this is certainly intensification as a long-term process, except here farmers bank on the landscape capital of previous generations, which allows them to produce predictable surplus in the face of constant environmental change. Here, the environment was adapted to buffer risk from a nature that was outside the control of humans.

It seems likely that this argument holds for the terraced landscapes that covered much of the Lake Basin at the time of European contact as well. Thus these two Prehispanic agricultural technologies are certainly intensification – though not in the classic ‘Boserupian’ sense. Likewise, though terrace construction was initiated for a variety of reasons during the Postclassic period, a strong consideration must have been the need to repair past environmental damage to provide predictable, productive landscapes for the increasingly complex polities of the Lake Basin prior to state formation. This sequence of events is similar to the Maya region (see Dunning et al. 2002) and Europe (Redman 1999; Runnels 2000; van Andel et al. 1990; van der Leeuw et al. 1998) where terrace construction follows major periods of land degradation.

Finally these conclusions have ramifications for the way that past agriculture is modeled in the Lake Pátzcuaro Basin. In 1983 there was no data concerning the form and function of Tarascan agriculture, and in its stead Gorenstein and Pollard used modern intensive farming as an analogy for past practice. Because landscapes are amalgams of past natural and human induced change, modern environments are often poor analogies for those of the past. Given the high degree of landscape change that has occurred in the Lake Basin just since European conquest (see Fisher et al. 2003), we must recognize how different each successive socio-landscape was throughout the Prehispanic period.

It now seems that the degree of environmental modification was significantly more profound than previously recognized. Given the above it is necessary to reconsider Models of Tarascan subsistence to accommodate succesional wetland field systems, extensive terrace landscapes, and the socio-landscape strategies adopted by Lake Pátzcuaro land managers to cope with Classic period land degradation.

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CHINAMPA CULTIVATION IN THE BASIN OF MEXICO:

Observations on the evolution of form and function

Charles D. Frederick*

INTRODUCTION

Chinampa agriculture is one of the best known, yet least studied forms of intensive agriculture in Latin America. Despite the voluminous literature concerning this productive means of cultivation (e.g. Rojas 1983, 1985; Jimenez-Osorino et al., 1990) archaeological investigations of *chinampa* agriculture are virtually nonexistent. A few researchers have examined *chinampas* directly (most notably Avila 1991; 1992; Parsons et al., 1982; 1985), but their emphasis was generally on settlement, rather than the fields themselves (e.g. Parsons et al., 1982; 1985; Javier 1996; Corona 1996). Other than Avila's precocious work, large scale studies of *chinampa*s (as opposed to *chinampa* settlements) do not exist. The richness of the written record concerning *chinampa* agriculture has probably restrained field inquiry to some extent. However, as I intend to show, existing studies rarely exploit the fertile ground that lies between the written accounts and the archaeological realities. The history of *chinampa* agriculture is largely unknown, and awaits focussed and detailed study. Although we think we understand how these fields were constructed and maintained and what plants were grown on them, archaeological evidence of these attributes is minimal. The data summarized in this paper indicate that *chinampa* construction was considerably more variable than is traditionally recognized. Furthermore, the claims extending *chinampa* agriculture into the period before the Postclassic are currently unsupported by direct field evidence. In essence, my point is that we know precious little about the prehistory of *chinampa* agriculture.

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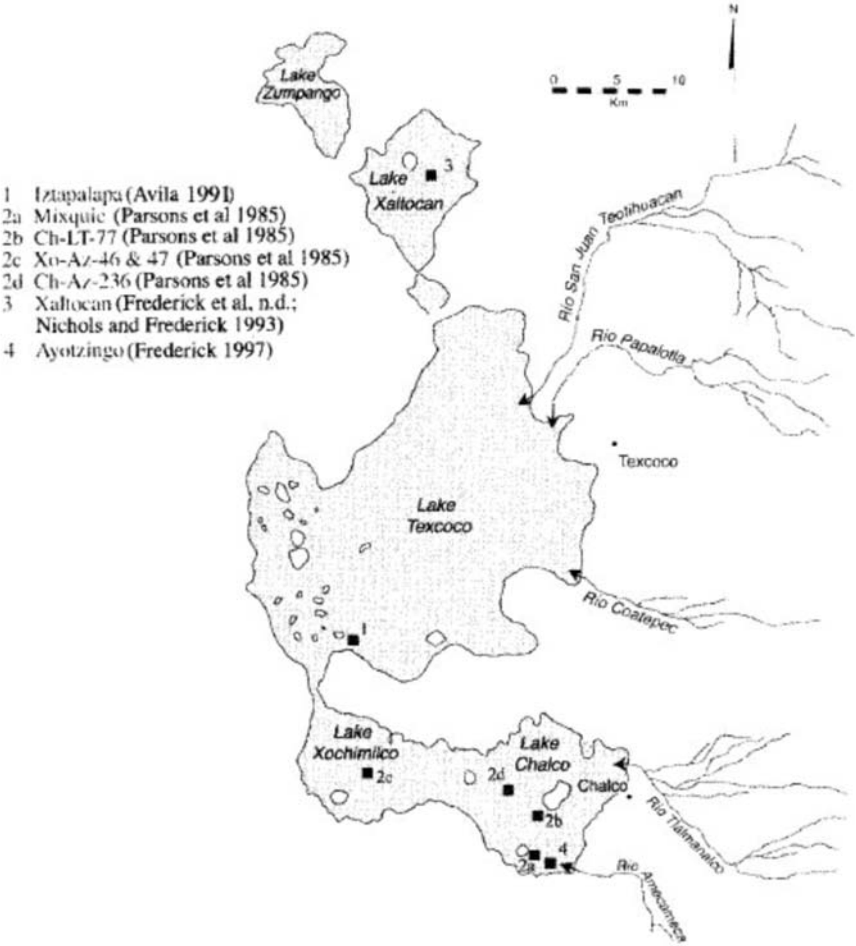


Figure 1. Map of the Basin of Mexico lakes illustrating the locations of fields mentioned in the text.

EXISTING FIELD STUDIES OF *CHINAMPAS*

The four studies of *chinampas* (two of which examine multiple features) present in the literature at the moment are 1) Avila 1991; Avila 1992; 2) Parsons et al., 1982; Parsons et al., 1985; 3) Frederick et al., n.d.; Nichols and Frederick 1993; Brumfiel and Frederick 1992; and 4) Frederick 1997. These studies are summarized briefly on Table 1. Figure 1 illustrates the locations of the studied fields. I am

Table 1. Summary of excavated chinampas in the Basin of Mexico.

Locality	Source	Number of Fields Studied in Detail	Number of Fields Examined	Age	Dating	Methods of Study
Iztapalapa	Avila 1991, 1992	none	Multiple	LA, M	ceramic	mineral, particle size, macrobotanical, microfossil (ostracode, sponge, gastropod) soluble salts, elemental analysis (Na)
Chalco-Xochimilco	Parsons et al., 1982; Parsons et al , 1985	1 (Mixquic)	5 localities: Mixquic Ch-LT-77, Op-A Ch-Az-46, Op-A Ch-Az-236, Op-A* Xo-Az-47, Op-A Xo-Az-47, Op-C	LA LA or LT LA (III-IV) LA, M LA (IV, modern) LA (III-IV)	ceramic, radiocarbon	elemental analysis (Ca, Mg, K) , pH,
Xaltocan	Frederick et al n.d.; Nichols and Frederick 1993; Brumfiel and Frederick 1992	1	3 total	probably EA (II)	ceramic, radiocarbon,	microfossil (diatom, pollen), macrobotanical, particle size, pH, CEC, soluble salts,
Ayotzingo	Frederick 1997	1	2	T, EA, LA	radiocarbon, ceramic	microfossil (diatom, pollen) macrobotanical, particle size, LOI, magnetic susceptibility

* denotes possible field

M = modern; LA=Late Aztec; EA = Early Aztec; LT = Late Toltec; numbers after EA and LA denote ceramic types (e.g. Aztec I, II, III, IV).

purposefully excluding the so-called *"chinampas"* at Teotihuacan (i.e. Quintero and Sánchez 1991) and restricting this discussion to fields clearly constructed in the major lakes of the Basin of Mexico. The analytical methods employed by these four studies are diverse, and there is some overlap. Most of the studies include documentation of the stratigraphy, radiocarbon dating, and analysis of archaeological inclusions (primarily lithics and ceramics). Environmental analyses (biological, pedological, and sedimentological studies) recur, although most studies do not have the same suite of analyses. Environmental archaeological methods include mineralogical examination, granulometry, organic matter content, pH, cation exchange capacity, magnetic susceptibility, soluble salts, elemental analysis, and analysis of biological inclusions (pollen, macrobotanical remains, gastropods, ostracodes, sponges, and diatoms).

The interpretations of these methods are also variable. All of these studies have documented the stratigraphy of *chinampas*, but critical interpretation of the strata and their implications for construction and development are often lacking. For instance, Avila's (1992; 1991) pioneering study of *chinampas* in Iztapalapa integrates a wide range of environmental evidence, but does not use these data to their maximum advantage. This is the only criticism I can level at his work because it is a laudable effort, especially seeing that it was performed in a salvage context. Parsons et al., (1982; 1985) take an alternative approach to *chinampa* examination in their study of a field near Mixquic. They use elemental analysis and literal interpretation of the stratigraphy in order to deduce the construction method, use, and possible cause of abandonment, Avila's study is exemplary for the breadth of investigation and insight, and Parsons' for its critical interpretation.

With our advantage of over 15 years of hindsight, however, it is clear that these studies lack an integrated approach and a research design that identifies critical issues and data gaps. Using the excellent basis Avila and Parsons have given us, we can plan studies that include the missing elements.

The inspiration for this paper comes from my work in the Basin of Mexico during the last several years, where I have encountered *chinampas*, once purposefully and once inadvertantly. These encounters gave me the opportunity to examine the deposits closely and critically. I compared my observations with the descriptions in the literature. During this process I saw with amazement how rare field studies of *chinampus* actually are. I noted that the commonly accepted and recited description of field construction is rarely applicable to documented and/or excavated features. In this paper I attempt to summarize the existing studies and then use this information to chart a direction for future efforts. Although there is a wide range of attributes I could discuss, I have chosen to focus upon three: methods of construction, antiquity of *chinampa* origins, and variation in field morphology through time.

METHODS OF CONSTRUCTION—INTERNAL STRUCTURE

In principal, we should be able to deduce the methods of *chinampa* construction from a detailed analysis of the deposits. The geometry, arrangement, and composition of the deposits provide explicit clues regarding how the field was constructed, what materials were used, and where they came from. In essence, the *chinampa* deposits are the artifact of *chinampa* construction, and the stratigraphy shows how they were made and used. This point is graphically illustrated by a literal interpretation of historic descriptions of *chinampa* construction methods (below).

Historic Accounts

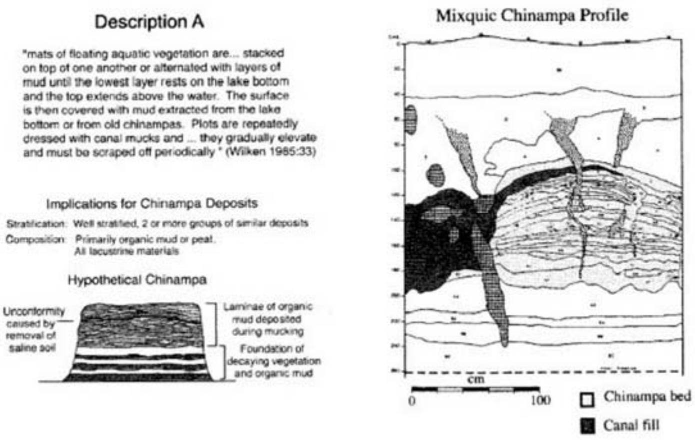
The historic literature includes a number of descriptions of *chinampa* construction. Perhaps the most fundamental is derived from the nahuatl roots of the word *chinampa*: *chinánitl* means "an enclosed bed surrounded by cane or stakes" or "net of branches"; *pan* means "on or above the surface" (Moriarty 1968:467; Gómez-Pompa 1978). Popper (1995:54-55) suggests that the name *chinampa* was not a widely used term for a raised field until the late sixteenth century. Unfortunately the deconstruction of the name provides few solid clues to the means by which such fields were constructed. More detailed descriptions, however, are available.

The following is the most commonly recited description of *chinampa* construction. (I will refer to this as *Description A*.)

> The first step in *chinampa* construction was to locate a *timiento'* (foundation) in the lake. This was done from a canoe by sounding the depth of the lake until a shallow area was found. A rectangle was then marked out above the '*cimiento*' with reed stakes. With the *cimiento* thus prepared, *cesped* was cut and brought to the site. *Cesped* is a dense bed of vegetation or mat of aquatic plants essentially *lirio* (waterlily) and tule, which grew in the large swampy areas of the lake in masses "so thick that a man walking over them would not sink". Rectangular pieces of *cesped* (about 10 m^2, although Armillas put the figure at 500 m^2) were cut with large knives, and pushed and pulled by canoes to the *cimiento* where they were piled one on top of another until they formed a solid bed. On top of this vegetation was piled mud from the lake bottom, and earth taken from old *chinam-*

> *pas* that had grown too high, until the surface of the *chinampa* was approximately *30* cm above the water. This stage finished, the chinamperos would plant seedlings of *ahuejotes* (water willows) all around the edge of the *chinampa* at intervals of four or five meters. Ahuejotes grow rapidly and straight upwards without branching out a great deal, which would shade the *chinampa* surface. The *ahuejotes* served to prevent the sides from eroding, as well as to fix the *chinampa* firmly to the lake bottom. Aquatic plants in the past were, and presently are, collected in canoes and brought to the *chinampa* where they are left in a corner to dry or chopped up with a machete and turned into the soil green. Mud from the lake bottom is also used as a fertilizer. Previously the organically rich mud was spread over the entire *chinampa* prior to sowing, encouraging the *chinampas* to increase in height until the distance from lake level to *chinampa* surface prevented water reaching the plant roots. Soil was then taken from the old *chinampa* for use in the construction of new ones (Outerbridge 1987:79-80).

From this description, we would expect to observe specific stratigraphic features in a cross-section of a *chinampa* field, as illustrated in Figure 2a. *Chinampas* constructed according to this method should possess the following elements: 1) a basal peat or interbedded peat and organic rich mud (as some versions of this model call for the interlayering of *cesped* and mud); 2) a zone of more mineralic material, possibly organic rich sediment, consisting of lake mud and/or soil from the tops of other *chinampas;* and 3) an upper zone of thin bedded mud or organic rich mud which is deposited during preparation for planting. Furthermore, if soil was stripped from the *chinampa* during use, it should be apparent in the stratigraphy as one or more prominent unconformities within the third (uppermost) deposits.

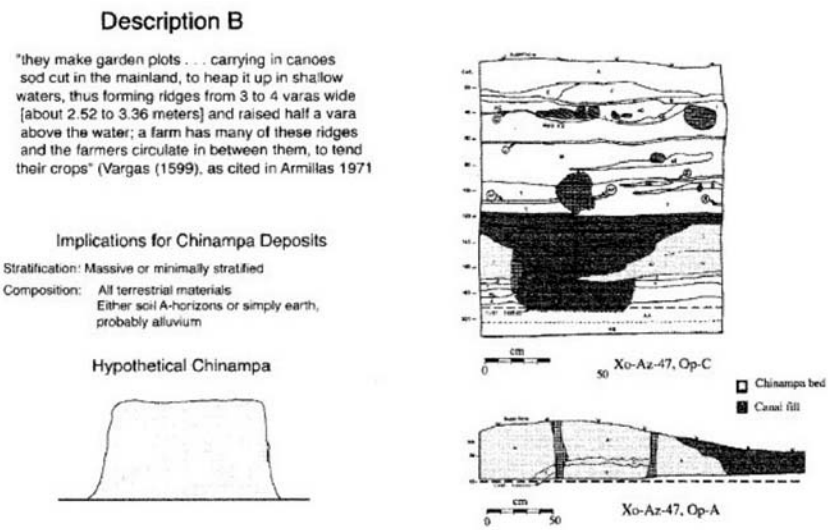


Figures 2a and 2b. 2a: Hypothetical *chinampa* resulting from use of construction technique in Description A. 2b: Example of a *chinampa* exhibiting Type 3 internal structure which appears to have been constructed in a fashion similar to Description A. Profile from the Mixquic *chinampa* of Parsons et al., 1985.

There are other historic accounts, such as the one below that I will refer to as *Description B*:

> "they make garden plots . . . carrying in canoes sod cut in the mainland, to heap it up in shallow waters, thus forming ridges from ***3*** to 4 varas wide [about 2.52 to 3.36 meters] and raised half a vara above the water; a farm has many of these ridges and the farmers circulate in between them, to tend their crops" (Vargas (1599), as cited in Armillas 1971:653).

If this is interpreted literally as sod (emphasis on the verb "cut") it implies the use of turf. This may also simply refer to the borrowing of earth and the deposition of it alone to form a *chinampa*. If the word "sod" is used literally and refers to "the upper stratum of the soil that is filled with the roots of grass and other herbs; turf' (Webster's Third New International Dictionary, unabridged, 1986) then these deposits can be expected to be organic rich soil A-horizons, derived from alluvial or volcanic soils. These materials will be distinctly different from the lake bed deposits upon which they rest. They may also exhibit formal stacking as occurs with some turf structures, although I consider this to be unlikely. If we assume that Description B is sufficiently detailed to describe the construction process, and that "sod" as a generic reference to earth, then *chinampas* constructed in this way should be massive internally (if the same sediment source is used), or they may exhibit minor stratigraphic variation if more than one source was used. The geometry of the latter would give an idea of the nature of deposition (such as basket loads or layers); the composition would indicate the sediment source (see Figure 3a). Again, the sediment of the *chinampa* should be distinctly different from the underlying lacustrine deposits.

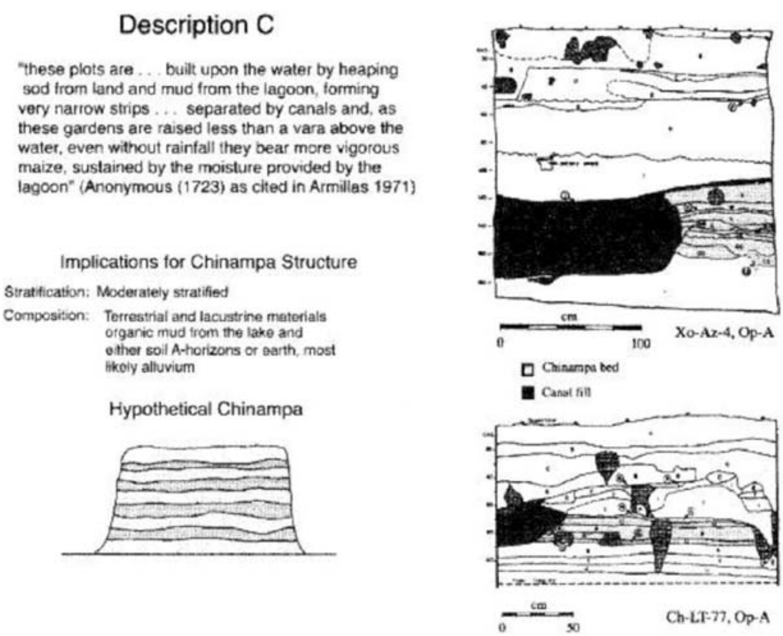


Figures 3a and 3b. 3a: Hypothetical *chinampa* resulting from use of construction technique in Description B. 3b: Profiles of Type 1 *chinampas* that may be consistent with construction methods similar to Description B. Profiles are from excavations at Xo-Az-47 (Operations A and C; Parsons et al., 1985**).**

A variation on the theme of Description B is the following (I will call this *Description C*):

> "these plots are...built upon the water by heaping sod from land and mud from the lagoon, forming very narrow strips...separated by canals and, as these gardens are raised less than a vara above the water, even without rainfall they bear more vigorous maize, sustained by the moisture provided by the lagoon" (Anonymous (1723) as cited in Armillas 1971:653).

As above, the interpretation of "sod" is critical, but the other important issue is the interlayering of lacustrine muck and terrestrial earth/sod to form a *chinampa*. This again implies significant internal variation in the deposits comprising the *chinampa* that should be apparent upon examination (see Figure 4a). Neither of the last two accounts mentions the use of *mucking* (the excavation of mud from canals and placement upon the *chinampa* surface as fertilizer) in the maintenance of *chinampa* fertility. This may be an oversight or a reflection of practice.



Figures 4a and 4b. 4a: Hypothetical *chinampa* resulting from use of construction technique in Description C . 4b: Profiles of *chinampas* exhibiting Type 2 internal structure (from Parsons et al., 1985). These fields may have been constructed using methods similar to Description C, but clear linkage of these fields with this description requires more detailed sediment descriptions than are presently available.

It should also be noted that one of these accounts provides for some excavation of the ditch/canal between the fields, whereas the others do not. In all cases the historic descriptions indicate that the canals are primarily artifacts of construction, rather than excavation or purposefully cut drainage features.

Discussion

From these examples (and this is not an exhaustive set of descriptions or possible construction methods) it is apparent that the historic accounts hold considerable promise as a source of information with which to compare archaeological profiles. I have purposely avoided detailed descriptions of modern practices (although Description A (Outerbridge 1987) undoubtedly includes reference to some modern practices) in order to examine the range of practices involved in Prehispanic or Early Colonial *chinampa* cultivation. Integration of similar information for modern cultivation would clearly provide clues useful in identifying more recent horticultural practices in field exposures of Colonial and modern *chinampa*s.

It is clear that built *chinampas* will have at least two group of deposits: 1) those that reflect the initial construction (what Parsons et al., 1985) referred to as the foundation, and 2) a series of deposits that reflect the maintenance and use of the field once it was constructed. Much of the previous section focussed upon construction methods, but similar attention can be devoted to evidence of field use. If cultivation was not very robust, then it is clear that highly stratified use-related deposits should be present. However, if cultivation involved turning the soil frequently, then the deposits should be very mixed (a process referred to as haploidization). It is not clear from the literature which of these extremes best reflects prehispanic *chinampa* cultivation. Prehispanic farmers possessed a variety of tools used for cultivation, which ranged from a simple, fire hardened stick similar to a long handled dibble (the *uitzocotli* or "palo o bastón de plantador"), to shovel or spade-like implements such as the *uictli uxoquen* or "coa con mango zoomorfo" which had shovel like blades and L-shaped handles decorated with animal carvings (see Rojas Rabiela 1985:210-224 for an extensive discussion of such implements). The most common implement appears to have been the "coa de hoja" or *uictli* which resembled a large spatula or flat bladed spade that came to a triangular point. Hence, it is clear that there were sufficient tools for complete turning of the soil if it was desired, so it is not necessarily safe to assume that haploidization did not occur.

Before proceding, I should also point out that *chinampa* construction conceivably could span the ditching to mounding continuum, with some fields in the lake margins created by ditching alone (with perhaps total removal of the resulting spoil) to a variety of construction techniques such as those already described in deeper water areas. Hence, there is no reason to assume that the techniques mentioned above are a complete list of all possible construction methods.

EXCAVATED *CHINAMPAS:* THE REALITY

Although some early literature suggests that *chinampas* may have been formed by ditching alone, all of the *chinampas* that have been examined to date appear to be raised beds. Examination of the profiles of previously studied features suggests that actual *chinampas* exhibit a wide range of internal variation that can be best described as a cline from internally massive to highly stratified. For the sake of this discussion I have identified 3 classes of chinampa based upon their internal structure: 1) totally massive, imported sediment; 2) multiple deposits of varying thickness; imported sediment or spoil from excavation of the canal/ditches; 3) very complex, highly stratified deposits.

Type 1 *Chinampas*

The first form is perhaps the most perplexing in regards to use and cultivation. These features are massive or minimally stratified (<3 strata comprising the *chinampa* platform), and are often composed of new, exotic or imported sediment (see Figure 3b for examples that fit this general type of *chinampa*).

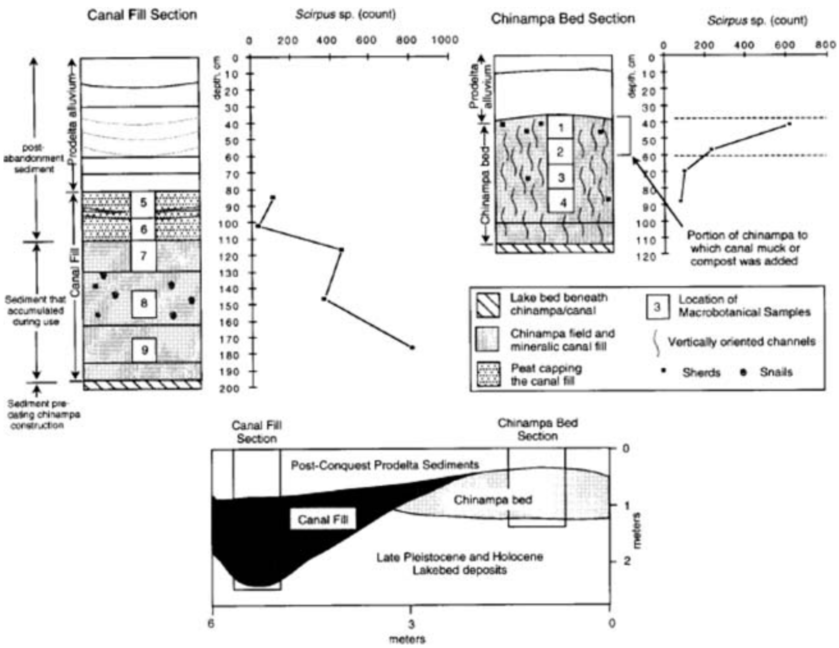


Figure 5. Trends in bulrush (*Scirpus* sp.) from the Ayotzingo *chinampa* and canal (Frederick 1997; unpublished data). Bulrush would have been growing in the canal when the *chinampa* was first constructed, and the concentration of bulrush seeds at the top of the *chinampa* field is best explained by either mucking (dredging of mud from the canal and placing it on the ridge) or addition of compost containing Bulrush.

Fields exhibiting this character are the Ayotzingo *chinampa* (Frederick 1997), Ch-Az-47,Op-A, and Xo-Az-47,Op-C excavated by Parsons et al., (1982; 1985), some of the fields at Iztapalapa excavated by Avila (1991), and the fields uncovered at Xaltocan (Frederick et al., n.d.; Brumfiel and Frederick 1992; Nichols and Frederick 1993). The massive character of the deposits implies one of two things: 1) rapid construction from a homogeneous sediment source; or 2) secondary alteration or pedoturbation of the deposits by use or post-abandonment processes. The existence of this kind of field implies that either they were not mucked, or that they have been rigorously cultivated and that this activity destroyed any stratigraphic evidence of mucking. It is also possible that the fertility of such fields was maintained through the addition of compost alone.

In the case of the Ayotzingo field, the results of the macrobotanical analyses provide some information relevant to this point. The most ubiquitious seeds found in the bottom of the canal fill are *Scirpus* or Bulrush. The same are the dominant seeds in the top of the *chinampa* ridge, which implies that either the field was mucked with mud from the bottom of the canal, or that a compost containing Bulrush was added to the ridge crest (see Figure 5).

Type 2 *Chinampas*

These *chinampas* exhibit internal structure intermediate between type 1 and 3 features, and are composed of multiple thin beds of sediment, but none of them are particularly organic-rich (see Figure 4b). Features in this category include Ch-LT-77,Op-A, Xo-Az-46 Op-A excavated by Parsons et al., (1982; 1985). A brief examination of the profiles will underscore the differences between these features and type 3 *chinampa*s.

Type 3 *Chinampas*

The last of these conforms with the classical model of *chinampa* cultivation as cited in the historic documents (Description A, above). Interestingly enough, only one of the features documented so far exhibits this structure, namely the Mixquic *chinampa* described and studied by Parsons et al., (1985; 1982; See Figure 2b). In essence these fields consist of two attributes: 1) a basal series of strata that form to the foundation of the *chinampa,* and that consist of peat and organic rich mud; and 2) a series of thin bedded deposits similar in composition to the adjacent canal fill deposits (presumably organic rich mud). The existence of *chinampas* with this morphology indicates that the assumption that *coa* cultivation is not a rigorous means of disturbing the soil is true in some instances, otherwise this form of *chinampa* would not exist. However, features exhibiting this form of internal structure may have been used for an entirely different purpose or cultivated in a different fashion. It is perplexing why more *chinampas* do not conform with this model. The rarity of this kind of feature underscores the fact that our impressions of how *chinampas* were made need to break free of the confines of the written records. We must start from the ground up, literally, by examining features, rather than beginning with assumptions.

Canals/Ditches

Many of the fields documented so far provide evidence of excavation of the ditch between the canals. In most cases this can be demonstrated by excavation of the canal beneath the lacustrine surface upon which the field was constructed. This is most graphically illustrated by the Iztapalapa, Xaltocan and Ayotzingo fields, and fields excavated at the following sites by Parsons et al., (1982; 1985): Xo-Az-46 Op-A, Xo-Az-47, Op-C. In most cases, the amount of excavation into the preexisting substrate is less than the amount of earth added to form the *chinampa,* and in many cases, just 10-20 cm. Other fields, such as the Mixquic *chinampa,* provide no evidence of canal excavation. This suggests that in some instances canals may have initially been formed by building up the ridges between them, rather than purposefully digging them out.

Hence the field evidence indicates that canals may have been formed as an artifact of construction, or as an artifact of excavation and construction.

Discussion

A literal interpretation of the historic accounts appears to support the existence of all of the features described above. Type 1 and 2 fields best fit Description B, whereas Type 3 fields clearly originate from practices similar to Description A. No fields perfectly matching Description C are present, although one could argue that some of the fields examined by Parsons et al., (1982; 1985) may fit this description. It is difficult to be certain with only basic field descriptions. Of all the fields documented thus far, only one (Xaltocan) may fit Wilken's (1985:42) description of a *chinampa* platform created by excavation of canals.

Overall, there is a surprising degree of variability in *chinampa* structure and this variability reflects differences in construction and cultivation methods. Factors influencing construction include: 1) availability of technical information, 2) availability of materials, 3) political control of construction, and 4) individual initiative, to name but a few. Even if construction was rigidly enforced, the actions of individuals and the availability of material could account for some of this variability. The existing field evidence, however, suggests that varying degrees of central control were involved in the creation of *chinampa* settlements in the Basin of Mexico.

Previous researchers have used the plan form organization of *chinampa* landscapes as a means to infer the degree of central organization involved in their construction. Most *chinampa* settlements exhibit remarkably regular spatial organization (e.g. see map in Coe 1964:93) and this has been inferred to represent centralized organization of their construction. Other settlements (e.g. Mixquic, and Xaltocan; see Sanders et al., 1979:277-281; and Frederick et al., n.d. for illustrations) exhibit more irregular networks that appear to have been developed in the absence of a centralized authority. However, some *chinampa* communities are highly variable in plan form and do not appear to have been constructed with a master plan in mind. If this inference regarding construction is valid, it is logical to expect a wide range of variability in *chinampa* structure.

Furthermore, given the wide range of plants cultivated on *chinampa*s, it is reasonable to expect some variation in the upper deposits which will reflect the existence of specialized cultivation techniques. However, at this time, it is not clear what the internal structure of the "typical" prehispanic *chinampa* (if such a thing exists) may be.

METHODS OF CONSTRUCTION

Morphology

For some time, two principal *chinampa* morphological variants have been recognized: small, narrow ridges with canals of equal or slightly smaller widths, and much wider fields separated by narrow ditches. With the exception of Avila's study, all of the *chinampas* in the archaeological literature are small (2-4 m wide) ridges, and have canals that are about the same width as the *chinampa* ridges or slightly narrower. These features, therefore, are approximately half water and half land. Avila (1991; 1992), however, documented a shift in *chinampa* morphology from narrow (mode of 3 m) to much wider (mode of 12 m) *chinampas* that appears to have occurred in the period since the Conquest (see Figure 6). This change in morphology led to a four-fold increase in *chinampa* area. The agricultural landscape changed from one with a land to water ratio of between 3: 1 to 1 : 1, to one that is vastly more biased in favor of land, with ratios around 10: 1 to 28: 1. A similar shift has been noted in historical records by Rojas (1984) and Popper (1995).

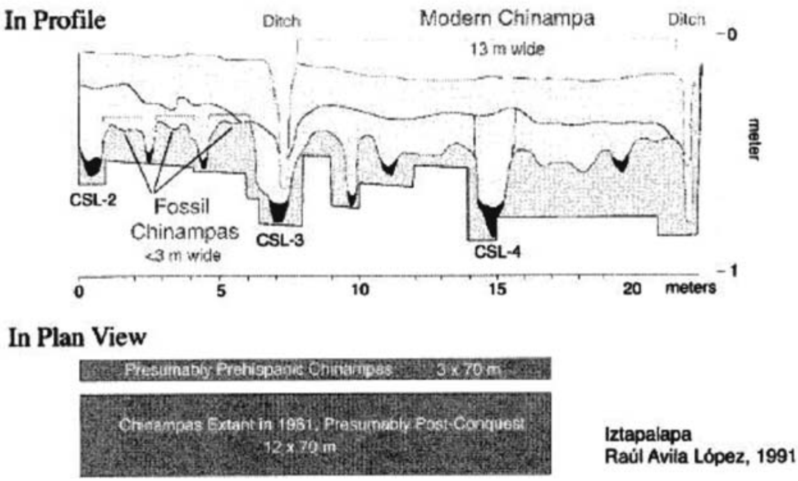


Figure 6. Schematic comparison of the width and stratigraphic relationship between pre-Columbian and post-Conquest chinampas at Iztapalapa (modified from Avila 1991). The stratigraphic drawing shown here was orginally presented in Avila's 1991 work, but in this illustration the original has been horizontally compressed and vertically exaggerated in order to facilitate visualization of the relationship between these two groups of fields.

This transformation increased the amount of cultivated land and possibly was related to technological or production issues. Knowing when it occurs is critical to understanding its significance. Avila argues that this was a post-Conquest transformation at Iztapalapa, and Rojas and Popper suggest that the shift is post-Colonial. Calnek (1972: 1 12), however, notes that *chinampas* in the southeastern portion of Tenochtitlan were larger than the small *camellones* within the city, and implies that this was a prehispanic attribute. Calnek's data were derived from documents in the AGN and are clearly post-Conquest. He does not cite the precise figures, so it is difficult assess the significance of this inference. Nevertheless, it underscores that it is unclear whether this transformation is prehispanic or post-Conquest. If it were found to be Prehispanic, it could be interpreted as a response to population pressure. If it occurred after the Conquest (as Avila, Rojas and Popper argue), the driving force behind the change is more likely to be something other than demographic (e.g. technological, social or economic). Indeed, Rojas (1985) argues that the change is attributable to a relaxation of state influence and shift towards individual construction, although she acknowledges that the change occurs in the wake of significant social and economic change.

Cross-sectional Geometry

A range of cross-sectional geometry is present among the fields studied thus far. The two major forms are reticulate or box-like and cambered. There are also clearly transitional forms between these two end members. It is apparent that if fields were originally reticulate and not rigidly constrained, use and run off during the rainy season would lead to the gradual change in cross-sectional morphology. Fields exhibiting the reticulate form include: Xo-Az-46, Op-A; many of the Iztapalapa fields. Cambered fields include the Mixquic *chinampa*, Xo-Az-47,Op-A and Op-C.

The relationship between internal stratigraphy and cross-sectional form may provide some information on the origin of the field geometry. For instance, the Mixquic field appears to begin as reticulate or almost so, and then assumed a cambered shape through the addition of increments of mud, some of which were either thicker in the center when applied, or were eroded at the edge of the field during use, leaving a slightly cambered form for the deposition of the next mud increment. Other fields, such as Xo-Az-47 Op-A field appear to have assumed a cambered form during the initial period of construction. The field at Ch-LT-77 is one that exhibits variable morphology. The internal strata are flat lying and not arched, as might be expected in a cambered field. However, the margins of this field appear to have been eroded or beveled, which may have occurred through use rather than as an artifact of construction.

WHEN DID *CHINAMPA* CULTIVATION BEGIN IN THE BASIN OF OF MEXICO?

In 1965 David Grove stated in an article in the *Masterkey* that "the time span of *chinampa* agriculture is unknown" (Grove 1965: 25). Unfortunately, that statement is still true today. The current information regarding the antiquity of *chinampa* cultivation is, to say the least, problematic. To my knowledge there are no *chinampas* in the Basin of Mexico that have been confidently and directly dated with either ceramics or radiocarbon to periods prior to the Postclassic. The majority of the published studies of *chinampas* (e.g. Coe 1964; Armillas 1971; Parsons et al., 1982; 1985) have *inferred* the oldest periods of *chinampa* cultivation based upon the presence of lakebed settlements (the age of which have been deduced from either non-systematic collection of sherds, survey, or excavation of settlement mounds; see also comments in Smith (1985:507-508). For instance, Armillas (1971:657-658) stated that the oldest ceramics he found among dispersed small settlement mounds on the Xochimilco-Chalco lake bed (and therefore the age to which *chinampa* cultivation could be extended to) were Late Toltec (13th century), whereas his excavations at Tlaltenco indicated that the site was settled in the Terminal Formative, and it was "presumably surrounded by *chinampas"*. Coe (1964) argued in favor of a Classic period origin for *chinampa* agriculture on the basis of figurines that have been found in the Xochimilco region by a local collector. Parsons et al. (1982; 1985) excavated a number of lakebed settlements and *chinampas* and concluded that none of the fields they found could confidently be assigned to periods predating the Postclassic. However, they also speculated that *chinampa* cultivation in the southern basin of Mexico was ongoing by the Early Toltec period, and potentially as far back as the Classic based upon settlement remains at Ch-Az- 192 (near Xico island). More recently these inferences have been cited as evidence of the antiquity of *chinampa* cultivation (e.g. Sluyter 1994).

Adding to this picture are linkages made by some authors to the apparent similarities between the construction of lakebed tlatels such as El Terremote (e.g. Tolstoy 1975; Serra 1988) and the widely cited construction method listed in Description A, above.

> "My own excavations at El Terremote (no. 51) indicate the practice there ca. 1000 B.C. (C-14 time) of some of the techniques of *chinampa* building (e.g. the layering of sedge and grass "carpets" between layers of mud). Whether these techniques were confined to the foundations of dwellings on the swampy shore or whether they were applied to garden plots as well, it seems plausible to see such sites as "choice locations" for the water table farmer seeking year-round moisture below ground surface (Tolstoy 1975:340).

Hence, claims of *chinampa* agriculture in the Basin of Mexico beginning in the Formative are unsupported by direct evidence. A literal interpretation of the field data is that *chinampa* cultivation was widely adopted during the Postclassic (A.D. 1400 to A.D. 1600). Whether it was initiated then or before is presently unknown. Where *chinampas* have been dated intensively by radiocarbon (e.g. the Ayotzingo *chinampa;* Frederick 1997) age discrepancies have occurred despite the seemingly good context and composition of the materials dated. Furthermore, in this particular instance, the ceramics recovered from the core of the *chinampa* were older than the peat upon which the *chinampa* was formed, indicating that these materials were probably imported with the earth used to make the *chinampa*. As a result, age assessments of *chinampas* based upon ceramic assemblages alone should be considered with care.

DISCUSSION

Numerous authors (Armillas 1971; Popper 1995:228) have identified attributes of Late Postclassic *chinampa* agriculture that suggest that its widespread adoption was state sponsored. The most convincing attributes are the orderly layout and the existince of major water control structures that permitted some control of lake level variation. However, as the previously cited evidence indicates, the methods of *chinampa* construction during the Postclassic were, to say the least, diverse. Although the present sample is very small and ill-described, some preliminary inferences may be drawn from these data.

Perhaps the most anomalous attribute of this review is the observation that the most widely recited historical account of *chinampa* construction appears to be rare among prehistoric excavated fields, with only one field matching this description. A functional interpretation of the evidence suggests that this method was an exception rather than the rule. It also implies that if *chinampa* construction was dictated by the state, that there was considerable latitude in how the actual fields were built. Indeed, the only aspect that appears to have been planned was the location and layout of the fields. The source of the sediment used in construction and the general construction methods appear to much more *ad hoc* and reflect a "do it yourself" approach to the actual construction. Perhaps best description for these data may be "politically planned but locally implemented" which is similar to some of the more formal new colonias in the hinterlands of Mexico City today.

Detailed attention to the structual attributes of the fields also raises other critical questions. Why do some fields exhibit extensive internal stratification and others almost none? Clearly this reflects either constuction or use processes, but the specific significance is unknown at this time. Were massive, non-laminated fields mucked (fertilized with canal mud) or merely composted? Were they maintained in a different fashion (turned or dug differently)? How were the thin bedded - laminated fields such as the Mixquic chmampa cultivated? Can such differences be linked to specific crops or functions? Can variations in apparent construction methods be linked to large scale variation in the appearance of *chinampa* settlements (i.e. with respect to levels of centrally controlled organization as has been inferred previously)? All of these questions are prominent, significant issues for understanding the development of *chinampa* agriculture.

The shift in *chinampa* size that presumably occurs between the late Postclassic and today is one issue in need of further study. In particular, the transformations that occur between today and the Postclassic hold considerable potential for understanding the metamorphosis of *chinampa* cultivation. Technological, economic, and social change throughout this period have been significant and it is reasonable to expect a concomitant significant shift in *chinampa* structure and morphology.

Going out on a limb, I am beginning to wonder just how old the *chinampa* landscape we see today actually is. When I say the *chinampa* landscape, I refer to the *ahuejote* lined fields and the large *chinampas*. If the mean prehispanic field is only 3 m wide, it would seem that the use of trees would be problematic; indeed, perhaps limited to areas around houses or major canals. I am not aware of any ancient narrow fields exhibiting evidence of trees along their margins, although admittedly, this is not something many people have looked for yet. So, is the *chinampa* landscape we see today of post-Conquest origin? Or does this transformation have its roots in the late Postclassic? Avila's data suggests that it is post-Conquest, but without more detailed examination and dating we cannot be sure. Furthermore, what was the impetus for this transformation?

Recommendations for Future Work

The results of this review make it clear that the impression of *chinampas* as well-studied agricultural features is an artifact of modern or historical research concerning ongoing *chinampa* cultivation and the seminal landscape archaeological studies such as Armillas (1971) work. Field studies of *chinampas* themselves, however, are rare. This observation has also been made previously by Wilken (1985) who laments the lack of detailed studies of *chinampas*, especially from a multidisciplinary perspective. The potential of such studies is great, in that they may provide a more realistic image of *chinampa* creation and use than the extant literature which is largely repetitive and extensively uses secondary or tertiary sources.

How can the current state of affairs be improved? I have a number of specific recommendations that may contribute to a better understanding of the origin and development of *chinampa* agriculture:

- Focus on *chinampas* themselves, not settlements in *chinampa* landscapes (this follows suggestions made by Jeff Parsons in the 80's (Parsons et al., 1985).
- Critically analyze the deposits for evidence of construction and maintenance techniques.
- Employ environmental archaeological methods (soil, macrobotanical, pollen, diatoms, ostracodes, and perhaps beetles may inform on the cultigens and their preservation, water quality during period of use and abandonment, and microenvironment).
- Actively prospect for ancient fields.
- Independently radiocarbon date each field that is analyzed in detail (which may require multiple ages: lakebed beneath the field, cultigens in the field itself, base of the canal fill, top of the canal fill, and if buried, an age from the overlying deposit; a minimum of 5 dates per feature!).
- View them as the dynamic and complex anthropogenic landforms that we know them to be.

From the meagre evidence we have in hand it is clear that *chinampa* agriculture has been far from static, despite the nearly uniform image presented in the modern literature. If future studies follow the suggestions above, we will be much better situated to address the historical trends in the development of this marvelously complex and productive form of intensive agriculture. Without more, preferrably directed field research, we will be merely speculating on the conditions that promoted this technology from the level of merely a novel innovation to a widespread and wildly successful agricultural industry. The answer, in part**,** lies in diachronic studies that directly address the functional aspects of this agricultural strategy.

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AGRICULTURAL INTENSIFICATION IN THE TITICACA BASIN[1]

Charles Stanish*

INTRODUCTION

For the past 100 years, anthropological theories of the evolution of complex society have been intimately linked to agricultural production. From the 19th century evolutionists and Marxists through V. G Childe, Julian Steward, and contemporary archaeological theory, agricultural production has figured consistently in our idea of what created the conditions for the emergence of sedentary populations, urban environments, and hierarchical political structures.

Contemporary research indicates that the use of domesticated plants in and of itself is insufficient to account for the emergence of complex society. Even hunter-gatherers routinely encourage the growth of semi-domesticated species. Rather, it is the means by which agricultural production is *organized* that is critical to the development of complex social and political organization. Organization of production is essentially about human labor, and complex agricultural production is properly understood as a kind of labor intensification. The intensification of agricultural labor, or simply "agricultural intensification" is the core process by which humans create the environment for the development of complex societies.

AGRICULTURAL INTENSIFICATION

As a concept, agricultural intensification is an analytical tool for addressing theoretical questions in comparative anthropology. Intensification can be defined in a variety of ways depending upon the problem or problems to be addressed. Definitions can be specific, focusing on technology, types of crops, and/or types of ener-

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getic balances depending upon the questions asked. Alternatively, intensification can be broadly defined to address evolutionary patterns of cross-cultural change in a variety of historical contexts.

In this paper, I adopt a traditional definition of agricultural intensification that borrows from Ester Boserup (1965:43). She defines intensification broadly as a shift in land use that allows a greater amount of food production than was previously possible in any given area of land. To this definition I would add a regional component and explicitly note that a "given area of land" includes the entire area where a political unit extracts agricultural resources. By political unit, I mean any group of people bound by at least some rules of cooperation. In short, agricultural intensification is a change in the production of domesticated plants and/or raising of animals in a politically-bounded region that increases the yield of resources. In premodern agriculture, i.e. prior to industrialized economies, agricultural intensification requires higher labor inputs. With industrialization, the use of machines that use fossil fuels substitutes for human energy. These higher labor inputs may be direct, and involve greater labor investment in the cultivation of the land itself. An example here would be an increase in the number of people from any political group working the land or herds, or, conversely, an increase in the total average per capita labor by that group. Alternatively, these greater labor investments can be indirect, invested in technologies that can increase the efficiency of agricultural production. An example here would be labor invested in manufacturing plows, axes, hoes, and so forth that increases the per capita labor efficiency of the farmer or herder. In either case, the intensified production implies either more work for people, or requires a new kind of specialized labor organization that increases economic efficiencies but involves a loss of autonomy over production. Agricultural intensification entails both economic and social benefits and costs to individual farmers. As such, these costs and benefits shift as the social landscape and physical environment change through time.

AGRICULTURAL INTENSIFICATION AND POLITICAL COMPLEXITY

The modern debate on the relationship between intensive agricultural systems and political organization most likely begins with Julian Steward's publications in 1949 and 1955. In this work, Steward referred to "irrigation civilizations" that depended upon large-scale canal constructions to feed large poplulations. As is fairly well-known, Steward cited Karl Wittfogel's work on China, published some twenty years earlier, that explicitly linked irrigation and political centralization. Steward, however, formulated these ideas into anthropological and comparative concepts. Wittfogel's later publications (1938, 1953, 1957 in particular) owe much to Steward's theoretical synthesis.

Steward saw the development of irrigation technology as a factor that increased the carrying capacity of the land. Karl Wittfogel was publishing some of his ideas about the same time. Following Wittfogel, some kind of theocratic political organization would have been necessary to manage the complex agricultural systems (Steward 1949:22-23). According to this Malthusian logic and classic cultural ecological theory, populations would continue to increase as an independent variable.

This increase would put pressure on the resource base and therefore force new cultural changes, particularly economic and technological ones.

Karl Wittfogel took this “hydraulic hypothesis” much further, arguing that state bureaucrats were a requisite for the proper functioning of irrigation systems. In his view, household and village level labor organization and technological skill were insufficient to manage irrigation systems. The control of the irrigation technology, or more appropriately, control of the managers as a subordinate class, essentially provided the elite of these civilizations with the ability to control their populations.

Throughout the 1960s and early 1970s, a host of ethnographic and historical studies demonstrated that the hydraulic hypothesis was wrong. Even Steward ultimately conceded that the control of irrigation agriculture was not the cause of complex societies in arid lands (and see Mitchell 1973). In fact, virtually no theorist today would suggest that the original hydraulic hypothesis, as formulated by Wittfogel, is correct (Stanish 1994).

I have maintained, however, that the rejection of the hydraulic hypothesis went too far (Stanish 1994). The hydraulic hypothesis has several components, and each have separate theoretical implications. Each part has been subject to empirical testing with varying results. One component—that villagers in nonstate societies were not capable of maintaining complex agricultural systems—is clearly incorrect. The idea that repressive states must necessarily develop by controlling irrigation systems fails the empirical test of comparative anthropology as well. However, one component of the hydraulic hypothesis—that there is a link between political complexity and agricultural intensification—cannot be discounted. There is a fairly strong empirical correlation between these two variables that deserves greater investigations by archaeologists and ethnologists.

Steward theorized causal links between polity and agricultural intensification. Agricultural systems do not just include irrigation canals, but a variety of other water management technologies. One of the major empirical tasks that we face, therefore, is to trace the evolution of agricultural intensification and political evolution in areas around the world. Finely-tuned studies of long archaeological sequences permit us to define much more precisely how agricultural production was intensified. If indeed the correlation exists, then we can propose models to define the causal links between political complexity and kinds of agricultural intensification that we see in the archaeological record? I now turn to a case study where we have sufficient data to conduct this empirical task.

THE TITICACA BASIN

The Titicaca Basin proper, as defined by its hydrological boundaries, covers approximately 50,000 km^2. This vast region was home to millennia of complex cultural developments including one indigenous first-generation state and countless complex chiefdoms and smaller polities (Figure 1).[2]

The geographer Pulgar Vidal (n.d.) divides the Titicaca Basin into two broad agricultural and ecological regions called the *suni* and *puna*. The *suni* is located between 3800 and 4000 m.a.s.l. It is characterized by rolling hills cut by steep gullies and low, flat plains called pampas. The higher and drier *puna* is located between 4000 and 4800 m.a.s.l. The *suni* represents the upper limit of plant agriculture while the *puna* is a grazing zone for the extensive camelid herds owned by many Titicaca Basin peoples. The traditional altiplano crops, most notably chenopods and tubers, do not grow above the *suni* zone in any meaningful quantity. The *suni* is the richest area and is where most modern and prehispanic settlement is located.

Overall, the most important animal product of the *puna* in the prehistoric past is the camelid, particularly the llama and the alpaca. Camelids provide wool and meat and serve as pack animals. The virtually unique capacity of the Titicaca Basin to support such large camelid herds has contributed to its position as a major center of complex society in the Americas prior to European conquest.

Lake Titicaca Basin Agricultural Techniques

There are a number of agricultural practices in the Titicaca basin utilized by people today and in the past. The following list includes all of the major agricultural types that would have been utilized prior to the Spanish conquest. The agricultural techniques, listed from the least intensive to the most intensive include camelid herd-

Figure 1. The Andes showing maximum extent of Inca empire and Andean culture area.

ing, the cultivation of small lakes called cocha, rain-fed terrace agriculture, irrigated land, and raised field agriculture.

Prehistoric Agricultural Intensification in the Titicaca Basin

In the last two decades, we have accumulated survey and excavation data from a number of areas in the Titicaca Basin including Albarracin-Jordan and Mathews (1990), Bandy (1999), Stanish et al. (1997), Stanish and Bauer (2004), and (Plourde 1999). These data permit a reconstruction, albeit subject to future testing and refinement, of the agricultural history of the region.

Systematic data from the Juli-Pomata region allow quantitative data on land use through time. These survey data can be used to define agricultural land use through time with criteria and assumptions as outlined in detail in Stanish (1994).

Early Formative

The establishment of the first permanent settlements defines the Early Formative period and date to circa 2000-1300 BC (Figure 2). These settlements were small, undifferentiated hamlets located near optimal resource zones. Settlement data from the Island of the Sun located in the far southern Lake Titicaca indicate that Early Formative sites were located near springs or naturally inundated areas near the lake edge. There is no evidence for raised field agriculture or canals or terraces during this period. Likewise, in the Juli-Pomata, Early Formative period sites cluster nearthe richest low, swampy areas near the lake. The settlement pattern represents a resource catchment-optimization strategy of mixed farming, herding, and wild resource exploitation. We also see that the transition to settled societies in this region was very gradual in the Juli-Pomata region as well.

From the settlement and excavation data in the region, we can characterize the Early Formative period lifeway as simply an extension of the earlier Late Archaic one with the addition of pottery within a context of very modest population growth. Data from other work in the Huancané-Putina area likewise indicate that a nonintensive, rain-fed agriculture near the rivers was a component of the subsistence during this period, but that lake exploitation, herding, and wild plant collecting were part of a broad subsistence strategy mix.

Middle Formative

Around 1300 BC in some areas of the Titicaca Basin, people created tribal or simple chiefly societies. These societies were characterized by a two-tiered settlement system. The major sites had small but complex architectural constructions. The smaller sites were modest hamlets and small villages usually less than 1.0 hectare. The period from 1300 to 500 BC is referred to as the Middle Formative and is defined as the time when simply chiefly societies were the dominant political organization in the region. Political organization varied over the landscape of course. In some areas agriculture was not as significant as the reliance on wild foods. Economic surpluses were small, and there was a corresponding lack of complex political

Chronology in the Titicaca Basin

	North	West	South	Isla del Sol	Stage	Ica
1500	Inca	Inca	Inca	Inca	Expansive Inca	Late Horizon
1000	Colla Late Huana	Lupaqa	Pacajes	Altiplano States	Regional Period	Late Intermediate
	Tiwanaku	Tiwanaku	Tiwanaku V	Tiwanaku	Tiwanaku Expansive	Middle Horizon
500						
			Tiwanaku IV			
	Early Huana	Late Sillumocco	Qeya Kalasasaya	Late Titinhuayani	Upper Formative	Early Intermediate Period
AD/BC	Pucara		Late Chiripa			
500	Cusipata	Early Sillumocco	Middle Chiripa	Early Titinhuayani	Middle Formative	Early Horizon
1000	Qaluyu	Pasiri	Early Chiripa	Pasiri		
1500					Early Formative	
2000					Late Archaic	

Figure 2. Titicaca Basin chronology.

organization. In the north and south however, the regions of Qaluyu and Chiripa development respectively, chiefdoms developed as the dominant political organizational type.

Data from the Island of Sun strongly suggest that terraces were first utilized during the Middle Formative, probably around or slightly after 800 BC. There was a substantial shift in the settlement location from springs near the lake to areas that today can only be exploited by agricultural terraces. The population of the island increased dramatically from the earlier period. The settlement shift is not explainable by a rise in the lake level since even the Early Formative sites were well above the lake shore. Most shore areas where the sites were found were cliffs very high above the water level. It is possible that there were some Early Formative sites near the lake edge that were inundated, and this could partially explain the apparent rapid rise in population. However, the shift from springs above the lake to higher land that is terraced today indicates a shift to terrace agriculture.

In the Juli-Pomata region, the vast majority of the Middle Formative sites were in the lower *suni* in rain-fed terrace areas. The data also suggest the use of raised field agriculture at this time. Research reported in Stanish (1994, 1997) indicate that the percentage of the population located in the raised field areas increased relative to higher pasture sites and nonraised field terraces in the *suni*. While low relative to later periods, there was a most likely some raised field land use in the region at this time. Likewise, Erickson (1988) has documented extensive use of raised fields in this period in the north, as has Graffam (1992) and Janusek and Kolata (2004) in the south Titicaca Basin. Raised fields were used on a modest level in the Juli-Pomata region.

In the Putina region, Aimée Plourde (1999) mapped and excavated a site called Cachichupa. This site has a substantial Middle Formative occupation. There is massive nonagricultural terracing at the site that dates to the very beginning of the Middle Formative period (Plourde, personal communication 2002). While not designed as agricultural features, the existence of these terraces clearly indicates that terrace construction was part of the Middle Formative period technological repertoire.

Upper Formative

By 500 BC, some areas developed complex chiefly societies characterized by multiple site size hierarchies, regional polities, complex architecture, fancy pottery production, and the importation of preciosities. This Upper Formative dates from 500 BC to AD 400. Around 200 BC, two major polities emerged in the region and represented the culmination of the late Upper Formative period complex chiefly development: Pucara in the north and Tiwanaku in the south. These primate centers pulled in populations from surrounding areas and created settlements an order of magnitude larger than any other settlement in the region. At its height, Pucara covered at least 100 hectares, and probably reached 150 or more. Tiwanaku during the late Upper Formative, known locally as the Qeya period, was probably equivalent in size and complexity to Pucara. Since Pucara collapsed and was essentially abandoned at the end of this period, we have a good understanding from the surface of the architecture, size, and complexity of this site. Late Upper Formative Tiwanaku, in contrast, was subsequently covered by later massive urban constructions and we cannot easily identify the size and complexity of the settlement during this period.

In the Juli-Pomata region, there was a significant shift to the raised field areas during this period. The most intensive use of raised fields occurred during this period. Three sites with complex corporate architectural constructions were built in the area. Two of these were architecturally associated with a formal complex of agricultural features, including the construction of aqueducts that fed the raised fields, a canalization of the river, and a formal raised field layout with satellite settlements. By architectural association, I mean that the habitation and agricultural features were integrated. The canal at one site was placed precisely between the fields and the edge of the habitation area. Likewise, the river was canalized away from its original discharge area to make room for the field systems. Later occupations built tombs and settlements on top of the fields indicating that they were not in use at that time.

A similar pattern was seen on the Island of the Sun. Aqueducts and a formalized field system were constructed in Challa including reservoirs and causeways between Upper Formative sites. This was partially confirmed by excavations in one of the aqueducts that had all Upper and Middle Formative period pottery. This indicates that the aqueduct had to have been constructed in the Upper Formative period or later.

In the northern Titicaca region, settlement data from the Huancané region indicate a correspondingly complex agricultural system with canalized rivers, raised fields, aqueducts, and other canals all architecturally associated with a settlement with a Middle and Upper Formative period site with elaborate corporate constructions. Similarly complex agricultural systems are found at the site of Maravillas in the north and other settlements in the northern Titicaca Basin.

Around AD 300-400, the site of Pucara collapsed as a major regional center, while the site of Tiwanaku continued to grow. Systematic survey data in the Pucara valley (Cohen n.d.) indicates a dispersal of the population into small hamlets. Raised fields continued to be used near the lake during this time by local polities that I have called Early Huaña (Stanish 2003), but there was a clear shift to extensive agricultural systems in the immediate Pucara area.

Tiwanaku Period

Around AD 600, the Tiwanaku peoples expanded out of their capital in the southern Titicaca Basin. The nature of Tiwanaku political economy remains poorly-known, but we know that they at least gained control of a number of colonies and territories outside of their heartland. Tiwanaku was the first indigenous state in the Andes south of Cusco. It was contemporary with the Wari state and it flourished two or three centuries later than the Moche culture on the coast, the first state in South America. Tiwanaku collapsed around AD 1100. The collapse of this state correlates with a major drought in the region although there had been earlier droughts during Tiwanaku expansion.

In the Juli-Pomata, the total *percentage* of the population in the raised field areas decreases from the previous period, although total population living near raised fields increased 50% from the Upper Formative. I interpret this to indicate that raised field agriculture had reached a maximum capacity, at least in this study area. A subjective review of the topography of the area supports the hypothesis that there was no more room for raised field construction. In this context, Tiwanaku peoples expanded the next most intensive techniques available to them, irrigated and rain fed terrace agriculture. A mere 4% of the population lived in the pasture lands.

In the southern Basin in the Tiwanaku heartland, Tiwanaku raised field agriculture dramatically expanded. The work of Juan Albarracin-Jordan, Gray Graffam, John Janusek, Alan Kolata, James Mathews, Charles Ortloff, and Matthew Seddon (Graffam 1992; Janusek and Kolata 2000; Mathews 1992, Ortloff and Kolata 1993; Seddon 1994; Seddon and Janusek 1994, and others) indicate an expansion of fields into the Tiwanaku and adjacent valleys to the north and south. Kolata (1993:201) estimates that at its height, the Tiwanaku state was cultivating 19,000 hectares of fields. While his population estimates of between 285,000-1,485,000 are based upon questionable assumptions (most notably his short to non-existent fallow time and assumed contemporaneity of all fields), his data still point out that a huge population could have been fed in the southern three valleys of the Titicaca Basin at the time of Tiwanaku ascendancy. Even if we allow for more reasonable fallow periods and land use and abandonment over time, we still have conservative population estimates of over 100,000 people in the Tiwanaku core area alone. In the entire Titicaca Basin, we can conservatively estimate populations of at least one half million during Tiwanaku times.[3]

Data from the north Titicaca Basin near Huancané provide a fascinating insight into Tiwanaku period political strategies for agricultural intensification. A few kilometers north of a large non-Tiwanaku size, Hu-03, is a small valley with a series of agricultural constructions including canals, fields, and reservoir. There is a major Tiwanaku settlement system in this valley. It is almost certain that the population at Hu-03 continued to work the complex field system around their site while the Tiwanaku state established an enclave a few kilometers away. There is no evidence of Tiwanaku influence at Hu-03, but the surface evidence at least suggests a Tiwanaku-contemporary occupation that I have called Late Huaña (Stanish 2003). Certainly, the agricultural resources at Hu-03 are substantially better than in the Tiwanaku enclave. At the present time without excavation data, the best interpretation of these settlement patterns is that Tiwanaku was permitted or forced their way into an adjacent valley near Hu-03 and exploited an independent water resource. This small enclave maximized the resources in the area with a sophisticated agricultural complex while the local population along the Huancané river continued to intensify their resources independently.

Tiwanaku ceased to be a regional political force by the 12th century AD, possibly earlier. According to Ortloff and Kolata (1993), the proximate cause of Tiwanaku collapse was a drought that began around the middle of the 11th century and lasted for two centuries or so to around AD 1300. This interpretation has been challenged by Erickson (1999). However, it would appear that this drought did indeed have severe consequences for the continued utilization of raised field agriculture. Throughout the southern Titicaca basin, there are numerous abandoned canals and aqueducts that run from now-dry quebradas and springs to fossil raised fields. They are rare in the north Basin where the topography precludes their efficient use. These can only be interpreted as a response to the drought, bringing fresh water to the raised fields from increasingly more distant and less productive rivers and springs.

Altiplano or Late Intermediate Period

The collapse of Tiwanaku political organization and the prolonged drought of the 12th century provided the context for the emergence of numerous smaller polities in the Late Intermediate or Altiplano period. These Aymara “señoríos”, as they were referred to by the Spanish chroniclers, were characterized by internecine warfare, a dispersed settlement system, the collapse of regional exchange, and a general collapse of centralized political structures (see Frye 1997).

These small polities relied extensively upon camelid herds as well as rain-fed terrace agriculture. While earlier cultures most certainly were pastoral as well, the Altiplano period people's intensified the use of the puna grazing lands, and created a much more dispersed settlement system to maintain the herds. The quantitative data from the Juli-Pomata area illustrate the dramatic shift in land use. Population in the puna grazing areas increased three-fold as a percentage, and increased by a factor of seven in the total number of sites. Even though there were modest population increases in this period, settlement in the raised field areas dropped almost in half, both in percentage and absolute terms. Furthermore, numerous canals and raised fields were used as architectural platforms for cemeteries and habitation sites suggesting that the drop in raised field use was even greater. That is, it is most likely that people moved into previous raised field areas as the water resources contracted, and used the area like they do today for grazing. While raised field use in the post-Tiwanaku times is documented in other areas of the basin as well, it was most likely on a household or at best village level of organization, not a state or regional level as in the previous period (but see Graffam 1992 for an alternative view). In short, raised fields increasingly became less viable in the drier environment of the post-Tiwanaku periods. Populations dispersed throughout region and refocused agricultural activities toward the pasturing of animals and terrace agriculture.

Inca Period

The Inca occupation of the Titicaca Basin represents the first nonindigenous conquest of the region in its history. The Collasuyu region was one of the most important territories in the Inca state. It was perhaps one of the richest set of provinces in the empire. More than any period, the Inca occupation represents a strong political control in the region with a state capable of moving populations, imposing peace, facilitating exchange, and organizating production.

Analysis of the Late Horizon or Inca period settlement data demonstrates several patterns: First, raised field agriculture virtually disappeared during the Late Horizon. Settlement data indicate a shift away from the raised field zones in the survey area to locations in the rain-fed terrace areas. Second, there was a substantial shift to the puna pasture lands from earlier levels. The shift to the puna lands was significant, particularly when compared with earlier figures. By the Late Horizon, this figure had increased to almost 20%. In fact, about 1/5 of the population lived in the pasture grazing lands, a pattern that emphasizes the importance of camelid wool and meat in the Inca economy. Third, the Late Horizon settlement pattern is heavily weighted to terrace agricultural and lakeside urbanized areas, suggesting a maximization strategy in the region designed to produce and move commodities and to locate populations in optimal agricultural land.

These data support both Graffam (1990:248-249) and Ortloff and Kolata's (1993) arguments that the fields were economically unfeasible by the time of the Inca conquest. The Juli-Pomata settlement data reflect this changed ecological situation. Less than 15% of the population lived in the raised field areas during this period, and most of that population can be accounted for by the presence of a major Inca road that runs through the pampas in areas of former raised fields.

In short, the Inca empire moved into an environment in which raised field agriculture was impossible, except in a very few restricted spots. They intensified the Altiplano period agricultural strategies focusing on rain fed agriculture, some irrigated terraces, and pastoralism. The Inca also dramatically increased exchange with regions outside of the region, particularly to the east and west where agricultural production was optimal (Wachtel 1982).

The Island of the Sun has a small area of raised fields that was one of the exceptions that proves the rule (Bauer and Stanish 2001; Stanish and Bauer 2004). These intensive raised fields were most likely utilized by the Inca. In the southern Kona Bay a small complex of canals, fields and reservoirs were used. The Island of the

Sun is warmer than the mainland areas due to the higher ambient temperatures provided by the lake. Where raised fields were indeed possible, the Inca utilized them as best as they could.

The Inca settlement pattern was one of a high quantity of dispersed, small sites plus the establishment of large urban settlements on the road system. This strongly bimodal settlement distribution indicates an imperial system of rural agricultural development combined with urban centers where craft production was intensified. The earlier Tiwanaku state had housed craft specialists (Janusek 1999). But the Inca strategy was to disperse these urban centers around the region. These centers were much smaller than Tiwanaku, with the largest being around 80 hectares in size and some as small as 5 hectares. However, we have identified scores of Inca urban settlements in the Titicaca region during their occupation indicating a conscious effort to disperse these productive centers (Stanish 1997, 2003).

DISCUSSION

The data from the Titicaca Basin permit us to trace the evolution of agricultural land use and intensification over more than two millennia. These data unequivocally indicate a correlation between political complexity and agricultural intensification. However, that pattern was not one of a slow, progressive increase in technology and labor investment through time. Rather, the pattern was one in which preexisting technologies were differentially utilized to optimize the political and ecological environment of any given period. All of the agricultural techniques were developed by as early as 800 BC, probably before. As political organizations became more complex from the Middle Formative to the Tiwanaku period, farmers would adopt the more labor intensive strategies at the expense of less intensive ones within the limits of the physical environment. When less complex societies followed more complex ones, agricultural strategies shifted to earlier patterns. It is not surprising that the Middle Formative and Altiplano period agricultural strategies are strikingly similar, even though they were employed in different cultural, ecological, and demographic contexts. In each period, chiefly societies relied heavily on the pasturing of animals and a strong focus on terrace agriculture. Raised fields were used, but most likely by household or village level farmers and not in any formal way.

During the Tiwanaku and Inca periods, the time of maximum political complexity in the region, agriculture was the most intense in the historical sequence. The drought of AD 1100-1200 most likely contributed to the collapse of Tiwanaku. However, and this is extremely important, the survey data strongly indicate that there was no demographic collapse that accompanied the Tiwanaku state collapse. In fact, there was a slight population increase in the Juli-Pomata region, and probably a leveling or slight increase in the Tiwanaku valley itself (Albarracin-Jordan and Mathews 1990, Stanish et al. 1997). What did collapse was the political structure that was able to provision the capital city. The post-Tiwanaku settlement landscape was one in which populations did not decline, but merely dispersed, relying a much more extensive economic system. *Therefore, the drought did not lower the carrying capacity of the land*. Rather, it slowly destroyed the viability of one kind of land use—raised field agriculture—as an intensification option. In the Altiplano period the populations once again adopted more extensive, risk-averse, systems of agricultural production and were able to maintain the Tiwanaku period population levels.

The Inca and Altiplano periods were characterized by very similar physical environments. However, the economic strategies of the latter represented a low risk strategy of a wide mix of land use and economic behaviors. The Inca, in contrast, faced with a very similar ecological environment, intensified commodity production and agricultural terrace production to their maximum. It also intensified camelid production to its highest level in the history of the basin to that point in time. While the physical environment was indeed a major factor in land use, the intensity of that land use depended upon the political structure that was, or was not, capable of amassing labor. The Inca empire took the same environment and overcame the obstacles through their ability to mobilize labor. They intensively produced food through a more complex system of camelid pastoralism and rain-fed terrace farming.

In short, we see a shift in agricultural strategies over time depending upon the political organization of the region. I conclude that pattern of land use in the Titicaca region demonstrates that intensification involved changes in the labor organization of existing technologies that were all in place quite early, and not the introduction of new technologies. This observation even holds for the Inca empire where the major changes were in labor organization (commodity specialization, economies of scale, divisions of labor etc.) and not the introduction of new technologies.

Agricultural intensification in the Titicaca Basin is best understood as a form of elite political strategies to maximize production. Population pressure was not a factor, however minimum population densities were most likely a necessary cause in the development of the various agricultural technologies by at least 800 BC, if not earlier. Agricultural deintensification, in contrast, was a result of altered physical environments and the breakdown of complex political organizations. In the absence strong political organization, households and villages opted for strategies that were optimal in the particular physical and social environment in which they existed. The shifts from raised fields to pastoralism, after Pucara collapse in the Early Huaña period in the north and in the Late Intermediate period in the south basin, illustrate these strategies in different cultures and at different times.

Earle (1987, 1997:86-87) argues that this kind of agricultural intensification was part of the political economy, the dynamic component of wealth production in complex societies that provides elite the material means to maintain their positions. The data here support his observation that agricultural intensification is a strategy to increase surplus production, and not a direct response to population pressure. Likewise, Spencer, Redmond and Rinaldi (1994:139) specifically see agricultural intensification as an elite strategy to solidify chiefly power and not as a response to demographic pressure. The data from the Titicaca Basin support this general theoretical position that agricultural intensification is a strategy used by populations to increase production under certain circumstances, both ecological and political. Political elites that can mobilize labor will adopt higher risk strategies when possible. When political organization is strong, agriculture is intensified. When political organization is weak, less riskier, more extensive strategies are utilized.

The causal link between political organization and agricultural intensification is complex. In the Titicaca region, the Inca were able to intensify agricultural and other economic productive activities to their highest level. In contrast, the immediate pre-Inca peoples who lacked a complex political organization maintained a very low risk, extensive agricultural system even though the environment was essentially the same. There is an undeniable link between political organization and agricultural intensification. Defining the precise causal relationships between these two variables will require more fine-grained chronologies and creative methodologies that can help define this classic question in anthropological archaeology.

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[1] A modified and expanded version of this paper appears in Marcus and Stanish (2006).

[2] A broad summary of the ecology and paleoecology of the region can be found in Stanish (2003).

[3] These figures are consistent with 19th and early 20th century population estimates. David Forbes (1870:200-202) lists a figure of between 750,000 and 870,000 Aymara for Peru and Bolivia, a figure that Tschopik considered to be too high (H. Tschopik 1947:504). Later, Marroquin (1944:1) noted that the Peruvian Department of Puno had 600,000 people in the 1940's. Likewise, Tschopik suggested figures of approximately 500,000 to 750,000 Aymara speakers between the mid-19th century to 1935 (Tschopik 1947:504, 506), basing this in part on a manuscript by La Barre who reported a figure of around 600,000 in 1935 (Stanish 2003).

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ANIMAL INTENSIFICATION AT NEOLITHIC GRITILLE

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The development of agriculture in the Near East was the result of innovative methods of plant and animal husbandry. The adoption of these new methods led to the domestication of plants and animals, that is to say the development of plants and animals that are dependent on humans for survival and reproduction. While these innovative methods of utilization were adopted deliberately, not all of the consequences of these changes could be foreseen; the domestication of plants and animals affected productivity in surprising ways and entailed a reorganization of subsistence activities. This reorganization had wide-spread ramifications in the social organization of these early farmers; it is this entire suite of changes that is presently understood as the Neolithic Revolution.

Most discussions of agricultural intensification have focused on the intensification of plant cultivation. Although animals may be included in such schemes, they are often seen as a mechanism for intensifying plant cultivation, either by being used as draft animals (Netting 1993), or as a source of manure to be spread on fields, increasing productivity (Stone 1996). Animal use itself is rarely discussed in terms of intensity of production, although it is clear that animal use systems can be more or less productive (cf Rick 1980). This paper will examine the process of intensification as it applies to animal husbandry and hunting at the late Pre-Pottery Neolithic B site of Gritille in southeastern Turkey. In doing so, it will not only demonstrate how the concept of intensification can be applied to animal use, but it will also illustrate new understandings about the intertwined processes of intensification and social change.

The fauna at Gritille demonstrate that animal use underwent a gradual process of intensification relative to land throughout the Neolithic occupation; this intensification also entailed a novel reorganization of agricultural labor. In the earliest levels of

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Neolithic occupation at the site, many different types of animals were being exploited but the range of animals is not as wide in the later levels. Sheep and goats dominate the assemblage throughout, with increasing percentages through the first three levels. In the latest level, however, the importance of sheep and goats decline relative to that of cattle and pigs. By relating these changes in diversity to the environment at the site of Gritille, I will demonstrate that the concept of intensification may provide a viable framework within which to discuss Neolithic subsistence change.

Since the process of agricultural intensification can no longer be viewed as a monolithic process of subsistence change driven by population growth, the changes in animal use which took place at Neolithic Gritille will be contextualized within their social framework. In the Neolithic of the Near East, the main locus of production was the household, which both created demand for production and organized productive labor. No evidence points to the existence of a political entity which created a demand or integrated households beyond the level of the community. The changes in diversity of animal use which occurred at Gritille, therefore, provide an opportunity to examine an example of agricultural innovation and intensification which can be related directly to household demands and the domestic organization of labor.

THE PROCESS OF INTENSIFICATION

Since Boserup's 1965 work *The Conditions* of *Agricultural Growth* reversed the traditional formulation of the relationship between agriculture and population by viewing agricultural systems as the dependent variable conditioned by population, anthropological inquiries into intensification have examined the conditions under which agricultural intensification takes place. Although Boserup viewed population as the driving variable, others have demonstrated that other variables, such as the availability of a market (Stone, et al. 1990: 8, Netting 1993: 15, Kates, et al. 1993, Guyer and Lambin 1993, Stone 1994, Stone 1996: 33) and risk aversion (Bronson 1972, Brookfield 1972, Nichols 1987, McGuire 1984, Stone 1994), may also stimulate agricultural intensification. Moreover, intensification has come to be viewed as embedded in environmental or social factors, such as the price of labor and produce (Morrison 1994 121-2), or land tenure systems (Netting 1993: 160) that may constrain or encourage the process of intensification. In the process of disaggregating intensification and population, anthropologists have emphasized that intensification cannot be viewed as a unilinear process, but must be seen as a multiplicity of strategies (Morrison 1994). Inquiries into intensification have shifted from explaining why intensification takes place to explaining how the process occurs (Kaiser and Voytek 1983, Morrison 1996, Stone 1996). Some of the ways in which agriculturalists may intensify, such as the construction of large-scale irrigation systems or terraced field systems, may require a large degree of community integration. Many others, however, such as interplanting crops, weeding more frequently, or increasing amounts of fertilizer applied to a field, may be carried out by households, or small work groups. Since the reasons why agriculturalists intensify production often condition the ways in which they intensify, in specifying how process takes place, anthropologists may gain a clearer view of why the process occurs (Morrison 1996: 586).

The origins of agriculture have been referred to as a process of intensification since as early as Childe addressed the question (Childe 1954). As with intensification itself, explanations for the origins of agriculture have shifted from explanations driven by population pressure and environmental change (Binford 1968, Cohen 1977), to include issues of social surplus and the accumulation of prestige (Bender 1978, Hayden 1990). Although typological schemes of ever more intensive plant and animal use have been constructed (e.g. Harris 1989, Helmer 1992), the framework of intensification has been used to explain very little about the process of domestication and the adoption of agriculture. Although this paper does not address the question of domestication itself, it does use a framework of intensification to examine the changes in the diversity of animal use which took place as animals were domesticated at the site of Gritille. Rather than seeking a factor or a suite of factors which caused this intensification to occur, this paper discusses these changes as a process and outline the factors which influenced how the process took place. Before discussing changes in the faunal remains, however, it is first necessary to outline some of the changes, in both subsistence and social organization, which took place in the Neolithic of the Near East, then to contextualize the discussion of the fauna at Gritille.

THE NEOLITHIC OF THE NEAR EAST

The Neolithic occupation at Gritille dates to between 6760-6050 B.C.[1] (Voigt 1988: 227). Although morphologically domesticated animals appear throughout the Near East, and specifically at Gritille itself, during this time period, this paper is not concerned with the changes which occurred in the animals themselves as they were domesticated, but will discuss instead the changes in the diversity of animal use as a whole. It is, nevertheless, important to understand, in a very general way, the changes in subsistence practices during and immediately preceding this time period in the Near East. It is, however, insufficient to examine changes in subsistence patterns as though they were occurring in a vacuum; these changes must be placed within the social context in which they are framed.

The development of agriculture in the Near East was a gradual process, taking place over several thousand years. Sedentary communities of hunter-gatherers first appeared in the late Epipaleolithic (l0,000-8300 bc); the first evidence for morphological domestication of cereals and pulses has been found in the Pre-Pottery Neolithic A (PPNA 8300-7600 bc). Although husbandry of sheep and goats was probably practiced during the Pre-Pottery Neolithic B (PPNB 7600-6600bc), these animals do not appear as morphological domesticates, along with cattle and pigs, until the late PPNB (6600-6000 bc) (Aurenche, et al. 1981). Evidence for methods of both plant and animal utilization is much more scanty, but these methods must have predated and caused the morphological changes which mark domestication. Kill-off patterns for sheep and goats in the PPNB, for example, suggest a practice of herd culling which focused on young animals; a change that occurs immediately before the size reduction that is widely recognized as domestication.

The path from sedentism to integrated agricultural systems, including both the cultivation of cereals and husbandry of sheep, goat, cattle and pig, was, however, not a straightforward trajectory. The site of Hallan Çemi, for example, was occupied during the Late Epipaleolithic; evidence suggests that pigs had been domesticated although no other animals appear to have been domesticated at the site (Rosenberg, et al. 1995). This is not only far earlier than other evidence for domesticated pigs throughout the Near East, but also considerably earlier than the appearance of domesticated sheep and goats, which are generally thought to be the earliest domesticates. In the late PPNB, although domesticated animals appear throughout the Near East, sites in the Black Desert in eastern Jordan, as well as other places in the Near East, have been characterized as the temporary camps of hunter-gatherers (Betts 1988). Examples such as these suggest that domestication occurred as part of a series of experimental changes in plant and animal exploitation, some of which were adopted more widely than others.

It is clear that the adoption of agriculture was a gradual process but was not uniform across the Near East. Research on the Near Eastern Neolithic has focused most clearly on documenting changes in subsistence practices. Several recent studies, however, have examined the social and technological context of the Neolithic beyond subsistence strategies (Hodder 1987, Voigt 1990, Cauvin 1997). Although some possibility of specialized labor in the Neolithic may exist (Voigt 1990: 1 l), most of these studies agree that the basis of labor was the households, which were "homogeneous with regard to wealth and status" (Voigt 1990: 7). While clearly non-domestic structures such as the possible defensive walls at Jericho (Bar-Yosef 1986) and Tell Maghzaliyah (Bader 1993), the Terrazo Building at Çayönu (Ozdogan and Ozdogan 1990), or the Kultanlage at Nevalı Corı (Hauptmann 1991) do exist at many PPNB sites, these structures do not appear to represent status differentiation. Rather they appear concerned with the physical representation of community definitions and rituals. The households of which these communities are composed, then, form the basis of production in the Neolithic of the Near East.

THE NEOLITHIC OCCUPATION AT GRITILLE

The Neolithic occupation at Gritille provides an ideal opportunity to study the process of intensification of animal use, as it provides a sequence of deposits in the Neolithic, all of which can be related to domestic activities, permitting an analysis of the changes in household production. The Neolithic deposits of Gritille have been divided into five architectural phases; faunal remains have been analyzed from four of these phases. Since one of the main priorities of the Neolithic excavation was to recover information about the economic basis for the Neolithic, all Neolithic contexts were screened, with eighty-percent being dry screened and the other twenty percent being wet screened, a process facilitated by the proximity of the river to the Neolithic deposits (Stein 1989: 89). The implementation of this screening procedure ensured that recovery of bones was not biased on the basis of size (cf Thomas 1969, Clason and Prummel 1977) and that recovery rates were consistent throughout the Neolithic (Monahan 2000). Analysis of the botanical materials indicates that einkorn and emmer wheat, as well as barley, lentils, bitter vetch, and grasspeas were present in domesticated form from the earliest levels (Voigt 1985: 15).

In addition to the wealth of subsistence data provided by the faunal and botanical remains from Gritille, the contexts from which these remains were recovered provides a framework within which this subsistence information may be discussed. The contexts from which the majority of the fauna was recovered at Gritille were primarily outside of houses in firepits and storage pits, as well as secondary trash deposits; very little *in situ* material was found. For this reason, the faunal remains from Gritille cannot be used to discuss how inter-household practices of herd management differ. Most of these contexts, although outside of the physical limits of the houses themselves, seem to have served domestic functions such as cooking and storage: that is, although the faunal remains from Gritille can not be attached to individual households, they are indicative of domestic activities. Not only are the faunal remains at Gritille undifferentiated by household, but the households are undifferentiated: there appear to have been no status markers in the Neolithic at the site. Gritille, then, provides an opportunity to examine intensification as a process centered on the household.

The Neolithic levels at Gritille were overlain by approximately nine meters of later occupation. The major occupation of the site was a Medieval occupation, dated to AD 1000-1250 (Ellis 1983: 246). Evidence for a short Achaemenid/Hellenistic occupation includes a round structure of unknown function dating between 440-396 BC (Stein 1988: 65). The Neolithic levels were directly overlain by Early Bronze Age deposits, dating to the third millennium BC (Ellis 1982: 85). The lowest stratum of these deposits contained many pits that cut into the Neolithic deposits and truncated the deposits in the latest phase of Neolithic occupation (Voigt and Ellis 1981: 93). The Neolithic levels at Gritille have been divided into five architectural phases. One of these, the Basal Phase, is not contiguous with the rest of the deposits, but is thought to predate the main sequence of the Neolithic occupation. The main area of excavation has been divided into phases D through A, with D being the earliest and A being the most recent.

As noted above, the Basal Phase is thought to be the earliest evidence for occupation at the site, since it rests on sterile soil, while the deposits of Phase D — the earliest phase documented in the main excavation area — were at least 0.5 meters above the original land surface (Voigt 1988: 220). In the limited area in which the Basal Phase was excavated, a plaster floor and an associated line of cobbles were found, but no mud walling was associated with this structure. A series of outdoor surfaces was also excavated, including one hearth (Voigt and Ellis 1981: 91). Additionally, numerous plaster floors could be traced along the section, where the tell was eroding into the Euphrates (Voigt and Ellis 1981: 91).

Phase D was excavated only in one small area, and was defined architecturally on the basis of a small change in the orientation of the buildings (Voigt 1988: 222). No faunal remains from this phase were analyzed because the limited exposure did not provide a sufficient sample for comparison to the other phases. Phase C entailed a minor change in the settlement pattern from the preceding phase. The two structures which were excavated in this phase were thick walled large roomed buildings (Voigt 1988: 220). Outside of these structures, the Phase C deposits were composed of many pits (Voigt 1988: 220).

The architectural remains of Phase B were the best documented of any of the phases: Phase B consisted of three relatively well preserved mudbrick buildings, to the east of which was a large open area with no architectural remains (Voigt 1988: 221). Of these three buildings, two were rectangular in plan and divided into a series of small rooms (Voigt 1985: 13). On the basis of the artifacts found in one of the rectangular buildings (the other contained only construction debris), these two buildings are thought to have been domestic structures (Voigt 1988: 221). The remaining building, also without occupation debris, was irregular in plan and less well-constructed than the other two; the excavator has suggested that this building served a different function (Voigt 1985: 13). The open area to the east of these buildings consisted of layers of eroded building material and trash overlying a hard packed surface upon which large fires seem to have been built. Other features of this open area included oval or round pits, filled with stone and ash and probably used for cooking, as well as shallow irregularly-shaped pits which may have been used to heat-treat flint (Voigt 1985: 13). Most of the artifacts, animal bones, and seeds from the Neolithic levels were found in this open area (Voigt 1988: 221). Phase A consisted of "a series of hard-packed surfaces cut by large shallow pits" and was separated from Phase B by a lens of fine white material (Voigt 1988: 219). Most of this phase was cut away by pits from the Early Bronze Age, and existed only in isolated pillars (Voigt 1988: 219). It is, therefore, almost impossible, to say anything about the architectural remains of this phase.

The similarity of the contexts from which faunal remains were recovered ensures that a comparison of the diversity of animal use across the Neolithic is consistent. These contexts represent discard from households or domestic activities of households that do not appear to be differentiated on the basis of function or status. The only exception to this is the part of the building excavated in Phase B, which is thought to have served a non-domestic function. The irregular design and poor construction of this building, however, suggest that it was not a status marker. Changes in the diversity of animals between the phases at Gritille, then, can be used to examine the process of intensification as it relates to households.

THE GRITILLE ENVIRONMENT

Since intensification does not refer simply to productive increase, but to productive increase per unit of some fixed quantity (Morrison 1996: 587), it is necessary to specify a constant in reference to which intensification is taking place. Although animal domestication can be seen as process of increasing outputs per herd of animals, this paper is concerned with changes in the diversity of animal use in general. The changes which occur at Gritille represent intensification of animal use per unit of land. In order to understand how these changes can be framed as intensification, it is necessary to have some understanding of the environment in which Gritille was situated.

Before the construction of the Ataturk Dam inundated the basin and covered the site with over a hundred meters of water, the site of Gritille was located in the Karababa Basin on the west bank of the Euphrates River, eight kilometers north of Samsat. The Karababa Basin lay in the center of the transition zone between the Taurus mountains and the north Syrian Plateau (Stein 1988: 27). Gritille itself lay at the point at which the basin narrowed to under five kilometers on the west side of the river (Wilkinson 1990). It was located on one of a series of river terraces, which slope up gently to meet the Urfa-Gaziantep Plateau and are suitable for cereal cultivation (Ozdogan 1977: 115), while above the river terraces lies a limestone "badlands" on which cereals can not be grown, but the slopes of which can be grazed by sheep and goats (Wilkinson 1990: 51). Along the river itself were swamps and near the site, several small islands lay in the Euphrates — islands that were used by the modern villagers as summer grazing for their cattle (Wilkinson 1990: 50).

The site lay near the juncture of three different vegetation zones: mediterranean woodlands, Irano-Turanian steppe-desert, and Kurdo-Zagrosian mountain vegetation (Stein 1988: 3 1). The mediterranean woodlands are mainly deciduous woodlands characterized by oak *(Quercus)* and juniper (*Juniperus*) at low elevations and at higher elevations by pine *(Pinus)* and fir *(Abies)* (Dewdney 1971). The Irano-Turanian steppe-desert is characterized by Artemesia shrubs, and in open parklands, is home to wild cereals such as wheat *(Triticum)* and barley *(Hordeum vulgure).* Animals found in the Irano-Turanian steppe-desert include gazelle *(Gazella),* jackal *(Canis aureus),* hyena *(Hyenus),* fox *(Vulpes),* wolf (*Canis lupus),* and the wild ass *(Equus hemionus)* (Stein 1988: 32). The Kurdo-Zagrosian vegetation is found primarily in the uplands to the north of Gritille and is characterized by oak-pistacio forest and is home to brown bears *(Ursus),* hyena, and fox, as well as a variety of deer, including roe deer *(Capreolus capreolus),* red deer *(Cervus elaphus),* and fallow deer *(Dama mesopotamica).* The variety of species found in the vicinity of Gritille is increased by its position along the banks of the Euphrates. On the plateau above the site, hawthorn *(Crataegus*) and Christ thorn tree *(Paliurus spina-christi)* grow, while on the banks of the Euphrates, willow *(Salix*), fig *(Ficus carica),* and sumac *(Rhus coriaria)* are present; in the floodplain willow, poplar *(Populus euphratica),* and tamarisk *(Tamarix)* grow (Miller 1990: 33).

The landscape around Gritille, then, is not uniform, but consists of patches of resources, responsive to the amount of water and soil cover present. Although the resources present in each area could be, and undoubtedly were, changed by the introduction of agriculture, the nature of the landscape excluded some resources from certain areas, while encouraging others. Productive land use around the site was also responsive to edaphic conditions such as the amount of moisture and soil cover. In order to understand the effect of changes in animal use, therefore, they need to be related to this landscape.

THE GRITILLE FAUNA

Diversity is comprised of two related qualities; richness or the number of taxa present in a sample, and evenness, or the relative proportion of each taxon within the sample. Since the sample sizes for each of the four phases at Gritille are different, however, diversity can not be discussed in any straightforward manner. Nevertheless, changes in both the richness and the evenness of the Gritille faunal assemblage will be discussed as a process of intensification. Since this paper focuses on diversity, the categories used for identification need to be mutually exclusive; for this reason, only mammals identified to at least the genus level will be discussed, with sheep and goats grouped together due to the difficulty in distinguishing between the two taxa. Birds (*Aves*) and fish *(Pisces)* are also included in the analysis as two additional discrete and mutually exclusive categories. The identified faunal assemblage at Gritille is dominated by sheep (*Ovis*) and goats *(Capra),* in all four analyzed phases (see Table 1). Fish and birds are found in all four phases in limited quantities, despite the intensive screening program undertaken at the site. The low quantity of these animals does not appear to be the result of recovery procedures, but does seem to indicate that they were rare in the diet of the inhabitants of Gritille.

In discussing changes in the proportions of identified specimens (NISP), the most obvious trend is that of sheep and goats, which increases beginning in the Basal Phase. Yet this change does not continue into Phase A, where the percentage of sheep and goats decline relative to those of pig *(Sus)* and cattle *(Bos).* Clearly, other factors are at work than simply an increased dependence on sheep and goats, factors which will be discussed shortly. Richness of a sample is largely a function of the sample size (Cowgill 1989), as illustrated in Table 1, which presents the total NISP from each phase at Gritille along with the number of taxa represented. Phase B, which has almost eight times the number of analyzed bones than any other sample, also has more taxa represented. Yet, although the Basal Phase is the smallest sample, it also contains more taxa than either Phase C and Phase A. When the difference in the size of samples is controlled for (see Jones, et al. 1983), richness in the Basal Phase, unlike the other phases, is greater than expected. It is fair to state, then, that richness is greater in the Basal Phase than in the other phases.

So, a decreasing richness in animal use, beginning in the Basal Phase, is balanced by an increasing focus on sheep and goats, through Phase B. It has already been demonstrated, however, that this increasing emphasis on sheep and goats does not continue into Phase A. Beginning in Phase A, a new trend occurs which concerns the proportions in which the domesticates, sheep and goats as well as cattle and pigs, were used. Although more complex measurements exist, the most straightforward measure of evenness is the standard deviation of a sample (Bobrowsky and Ball 1989: 7). In order to ensure the independence of all observations, the minimum number of individuals (MNI) will be used to examine the evenness of use among sheep/goat, cattle and pig (see Table 2). Although it is not as intuitively obvious, evenness, like richness, is driven by sample size: the relationship between the standard deviation and the sample size in the Gritille fauna is strongly linear (see Table 3). Yet, when the size of the sample is controlled for, the standard deviation is smaller than expected in Phase A, while that for all other samples is slightly greater than expected. Thus, it appears that evenness of sheep/goat, cattle and pig use was greater in Phase A than in the earlier phases.

Changes in the ways in which animals were used in the Neolithic at Gritille took place over all four phases. In the Basal Phase, a wide range of animals, both wild and domesticated, were being exploited. Fewer types of animals were used in Phases C through A. In Phases C and B, sheep and goat dominated the assemblage, but in Phase A, the relative importance of sheep and goats in the subsistence strategy declined, and the use of cattle and pigs increased.

INTENSIFICATION OF ANIMAL USE

To tie these patterns of animal use into questions about intensification, it is necessary to reiterate the definition of intensification used here: intensification is an increase in output per unit of land. This broad definition allows a variety of processes to fit under the rubric of intensification, but also permits the examination of the social conditions under which certain types of intensification takes place. Although concentration of production on a limited number of commodities such as sheep and goats is often said to increase productivity, such intensification is only viable if the environment is sufficiently uniform to support such specialized production, or if the political and social organization exists to mitigate the risk of failure that would arise in the case of a drought or other environmental disaster. In an environment with a variety of environmental niches, such as that which existed in the immediate vicinity of the site of Gritille, specialization underuses certain portions of the landscape. In such cases, overall productivity per unit of land increases if all of the various portions of land are utilized to their capacity. The increase in the use of cattle and pigs in the last phase of occupation at Gritille increased the productivity of the nearby swamps and islands in the Euphrates River, which were being under-utilized when sheep and goats were the main focus of the pastoral economy. Although kill-off patterns do not suggest that there was an attempt to increase the productivity of the individual herds of animals between Phase B and Phase A, there is a change in way the pastoral economy as a whole was being organized.

These changes in animal exploitation patterns must have required an innovative reorganization of subsistence practices. Herding domesticated animals, for example, requires greater amounts of labor to restrict the movements of the animals, as well as to feed and water them, but these increased labor demands could easily be mobilized by individual households, possibly by calling on under-used portions of the household, such as children, to provide such labor. No evidence at the site suggests that a level of authority beyond the household existed in the Neolithic. The types of changes that occurred, moreover, suggest that they were taking place on the household level. These changes were aimed at exploiting various portions of the environment rather than maximizing the production of a single commodity. This suggests that the main locus of demands for labor was the household rather than an outside source. It is also clear that the process of animal intensification at Gritille was a gradual and accretionary process, in which the adoption of novel methods of animal exploitation led to further changes, entailing further changes in the organization of agricultural practices. Rather than appearing simultaneously, these changes occurred across the seven hundred years during which the site was occupied.

The case of animal intensification at Neolithic Gritille, then, provides an example of the process of agricultural intensification. By examining the ways in which animal use changed over time in the Neolithic, this chapter has demonstrated that intensification can be a gradual process, the course of which is determined by the intensifiers. Additionally, by examining the social framework of the Neolithic, it illustrated an example of intensification in which the process was both initiated and organized by the household. It is in the examination of the courses of intensification that a clear picture of its causes will emerge.

Table 1. Number of Identified Specimens, Gritille PPNB.

	Basal Phase		**Phase C**		**Phase B**		**Phase A**	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Pecent**
Ovis/Capra	291	53.01	859	66.54	6556	77.64	532	64.56
Gazella	44	8.01	24	1.86	83	0.98	2	0.24
Bos	31	5.65	102	7.90	298	3.53	107	12.99
Cervus	8	1.46	0	0.00	12	0.14	1	0.12
Capreolus	0	0.00	1	0.08	2	0.02	0	0.00
Dama	2	0.36	1	0.08	18	0.21	1	0.12
Sus	73	13.30	230	17.81	1269	15.03	156	18.93
Canis familiaris	0	0.00	0	0.00	2	0.02	0	0.00
Canis lupus	0	0.00	0	0.00	1	0.01	0	0.00
Vulpes	0	0.00	0	0.00	12	0.14	0	0.00
Lepus	18	3.28	30	2.32	35	0.40	17	0.85
Mus	0	0.00	0	0.00	7	0.08	0	0.00
Rattus	0	0.00	0	0.00	7	0.08	0	0.00
Aves	26	4.73	9	0.70	26	0.31	1	0.12
Bufo	11	2.00	0	0.00	0	0.00	0	0.00
Testudo	1	0.18	3	0.23	2	0.02	0	0.00
Pisces	4	0.73	5	0.39	25	0.30	1	0.12
Crab	1	0.18	0	0.00	2	0.02	2	0.24
Unio	39	7.10	27	2.09	87	1.03	14	1.70
Total	549		1291		8444		824	

Table 2. Minimum number of individuals, sheep/goat, cattle and pig, Gritille PPNB.

	Basal Phase		Phase C		Phase B		Phase A	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Bos	1	10.00	2	14.29	5	3.88	3	15.79
Sus	3	30.00	3	21.43	13	10.08	4 2	1.05
OVCP	6	60.00	9	64.29	101	78.29	12	63.16

Table 3. Standard deviation for sheep/goat, cattle and pig, and sample size, Gritille PPNB.

Phase	Standard deviation	Sample size
Phase A	4.933	19
Phase B	53.267	129
Phase C	3.786	14
Basal Phase	2.517	10

[1] All dates are uncalibrated dates.

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INFIELDS, OUTFIELDS, AND BROKEN LANDS:

Agricultural intensification and the ordering of space during Danish state formation

Tina L. Thurston*

INTRODUCTION

Even before the advent of the well-known "prime mover" theories of the 20th century (i.e. Wittfogel 1957, Boserup 1965) fired the imaginations of contemporaneous archaeologists, scholars had long been asking questions about the connections between political power, agricultural intensification, and economics. While enthusiasm for these ideas has faded, there is still an active debate about the role of state governments in what archaeologists interpret as intensification attempts, and all the ramifications – social, political and economic – that may be inferred from them. Despite some earlier calls for a deeper look into the causes and consequences of intensification (i.e. Bender 1978), until the 1990s, a fairly simple line was usually drawn, connecting large agricultural "improvement projects" and the idea of top-down directives from authoritarian rulers. Even with a continuing accumulation of contradictory data, many researchers continued to assert that only those who could see from the top of a "pyramid" – both literally and figuratively – could have the perspective to organize and plan such complex undertakings. More recently, several authors have called this into question – while some cases surely illustrate the power of elites to demand or support increased production, in other cases, both labor and organization can be traced to farmers and farming communities, who turn out to be fairly capable of both creating and maintaining large, complicated systems of terracing, irrigation, land reclamation, and other laborious intensification schemes (Erickson 1993, Frederick, this volume, Lansing & Kremer 1993). This has led some researchers to re-

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place the top-down assumption with a generalized skepticism about the extent of elite authority in organizing agricultural intensification.

The fragmented archaeological record, and our sometimes fragmented theoretical perspectives being what they are, our tendency is to reject one paradigm in favor of another. However, as Morrison (this volume) points out, one thing we may usually predict with accuracy is the fact that the courses of the past are more complex than we imagine, or than we might wish them to be. Since the ethnographic trajectories of such intensification sequences are so invariably complicated, it is useful to study archaeological cases that have some ethnohistoric context, testing various scenarios against the physical and textual evidence. This gives insight, of course, into the case itself, but more importantly, suggests a range of possible explanations for what archaeologists see on the ground.

As a protohistoric culture, with well-preserved archaeological landscapes and a small yet important corpus of textual fragments to illuminate the mostly prehistoric sequence, Denmark, during it's Iron Age and Early Medieval state formation cycle, makes a good laboratory for examining such transitions. My work has focused on the development of 'secondary' states, which often rise from several pre-existing groups brought together by political leaders to create a single entity. I have been especially interested in the shift from decentralized, multicephalous power to centralized leadership, and the conflicts brought on by changes in the power and agency of rural agricultural communities in relation to expanding state authority. One way of understanding these changes revolves around questions of agricultural intensification. In this chapter, I assess first *whether* intensification (or intensification attempts) have occurred, then I seek to understand the *impetus* for this strategy, then *how* it occurred – what measures were taken and by whom? Perhaps most tellingly, does it occur evenly and ubiquitously, or is it uneven and dependent on other variable conditions, whether social or ecological? Finally, I follow the trajectory forward and consider the outcome of the social, economic and political pressures that force and/or induce farmers to attempt elevated levels of production. Was the strategy successful? Who benefited? Did it result in a peaceable kingdom or a legacy of violence?

CASE STUDY: STATE FORMATION IN DENMARK

The goal of the research discussed here is to study the development of political complexity in Denmark, and the changing social, economic, and political relationships between upper and lower classes, local and central elite, and urban and rural dwellers during a period of state formation between AD 700-1200, when several chiefdoms were transformed into a single, unified polity.

During Denmark's formation, areas in the core of the state's territory required one set of rulership policies, while outlying target regions, each resistant in unique ways to domination, pushed the state to test different strategies: of cooperation, cooption or coercion. This is not atypical – it can be seen in many prehistoric and historic sequences of secondary state formation, from Peru to Mexico to China.

Sometimes the process of unification takes many generations, due to negotiation and compromise between state and region. Sometimes there are rapid changes, violent purges, and the removal of local leaders. In Denmark, local farmers and central authorities wrestled over control of various legal and economic activities, but surely some of the most important were, first, the *levels* of agricultural production in each region and second, the *control* of this agricultural production. Among the state's primary strategies appears to have been inducing intensification, carefully targeted at specific regions, while carrying on different strategies in other areas. They were met with cooperation in some regions, and resistance elsewhere.

Production and Intensifcation During Denmark's Formation

> "Scania is the province of Denmark fairest to look upon…well provided with men, opulent of crops, rich in merchandise and now full of churches…The soil in Jutland is sterile; except for places close to a river, nearly everything looks like a desert. It is a salt land and a vast wilderness…the land is avoided because of the scarcity of crops, and the sea because it is infested by pirates. Hardly a cultivated spot is to be found anywhere, scarcely a place fit for human habitation. But wherever there is an arm of the sea, it has very large cities (Tschan 1959:187, 191)."

So wrote Adam of Bremen, a German scholar and prelate, on his understanding of Denmark and the Danes at the end of the Viking Age in ca. AD 1075. Adam, who was personally acquainted with the Danish king Sven Estridsen (d. 1074), states elsewhere in his narrative that he had traveled in Denmark many times. He accurately describes Scania, and although his description of Jutland is extreme and overly generalized, it does reflect prevailing 11th century conditions for much of the central, southern and western parts of the peninsula (Figure 1). Strikingly, he conveys the preoccupation that eleventh century northern Europeans had with the potential of soil for agricultural production. Numerous, prosperous towns in Jutland's "wasteland" were of far less import in Adam's mind than the availability of arable land.

By the time Adam wrote his *History of the Archbishops of Hamburg-Bremen*, Denmark was well along on its course towards secondary state formation, a process that typically involves the integration of several distinct political and ethnic groups. Various historical fragments, like Adam's *History* – written almost entirely about other concerns – suggest that state building in Denmark did indeed unify a number of previously autonomous regions: Scania, Halland, Blekinge, the south Jutlanders, the north Jutlanders, the Isle Danes, and possibly others. Archaeological data, in this instance, does not belie these inferences. The road to unification was not easy, though: for elites and non-elites alike, each region presented different challenges in its course toward integration with the core. This integration process occurred, in the broadest sense, between AD 700 and 1200, and was accompanied by many social, economic and political changes. Some were slow and rather unremarkable: several waves of rural village foundations, a mostly unhurried and non-violent transition to Christianity, a course toward urbanization in many areas, and slowly, rulers gained more centralized power within their formerly heterarchically organized societies.

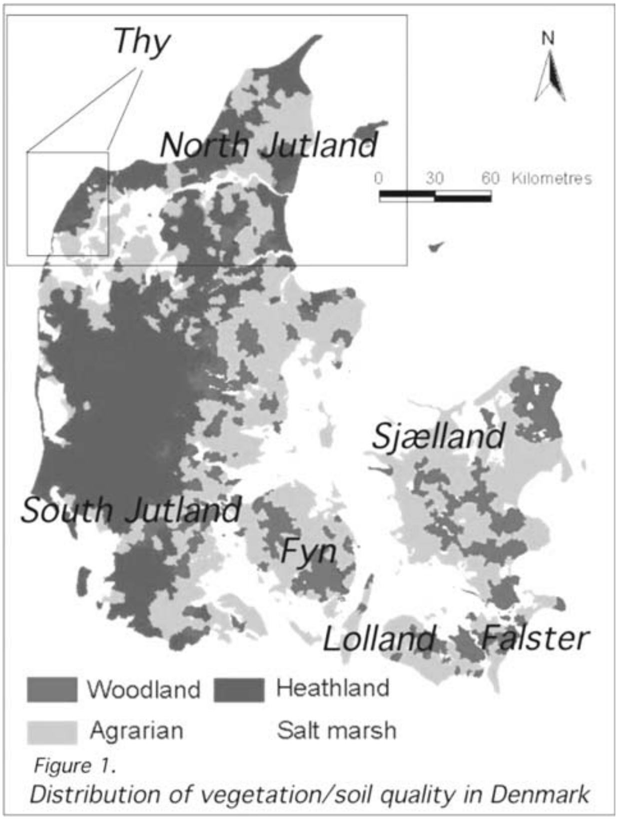

Figure 1. Distribution of vegetation/soil quality in Denmark.

On the other hand, some rather extraordinary changes occurred too: In only a few decades spanning the transition from the first to the second millennium, a new tier of urban centers were artificially "planted" in previously non-urban regions, uniformly designed military/administrative hubs were established throughout the coalescing state, and new taxes and laws were imposed. There are hints, too, both archaeological and ethnohistoric, that rulers during this time of rapid change shared Adam's concern with the agricultural productivity of their rural subjects. Out in the countryside, some areas saw the entire fabric of the rural landscape rapidly altered by episodes of colonization in previously uninhabited landscapes, in certain provinces older settlements experienced reorganization, and the introduction of new farming technology and cropping rotations occurred. Simultaneously, in several of the previous peer polities, uprising, rebellion and warfare against the central state flared. Was this coincidence or a response to rapid and sweeping alterations? How are these interconnected events linked to Denmark's origin as several peer polities who shared a corporate ideology and a heterarchically organized society?

If we look at the unusual spurt of *rural* changes mentioned above, together, they might be interpreted as a concentrated period of agricultural intensification and innovation. Was such widespread and simultaneous intensification a strategy or a result of the state-building process? If so, what was it's impetus – a top-down directive from elites, or a local response to changing conditions by farmers – or both? For the Danish case study, we can examine the entire sequence, and attempt to find the source of both steady trends and more rapid flurries of transformation toward new agricultural conditions, in search of both their origins and their impact.

Intensification in the Archaeological Record

A comprehensive definition of intensification for archaeological contexts has only recently been articulated. For archaeologists studying long cultural sequences, not only the result or effects of intensification, but the *process* itself, must be studied (Morrison, this volume). Failed or aborted efforts at intensification should be considered equally with successful ones, as the perceived need for such efforts is an important indicator of conditions at the time.

Generally, the intensification of agricultural activity entails a greater rate or quantity of resource use relative to another resource – generally land area – in relation to either greater productivity (but see below) or greater access to valued social, sacred, or politically important items. Resources important for agriculture which can be "plugged in" to land area are numerous, and include human labor, animal labor, biological and chemical resources such as organic and inorganic nutrients, new technology, and also knowledge or information. Intensification often calls for activity to be more efficient, more complete, or more scheduled and synchronized. These changes can be accomplished in two ways, either by using internal, pre-existing resources in a more rapid or cycled way, or by introducing new, external ideas, technology and organizing principles into an extant agricultural system, sometimes referred to as agricultural innovation (Kirch 1994). Both of these strategies seem to occur in the south Scandinavian case.

While large-scale trends throughout the entire state will be considered in the following pages, to understand if and how intensification was attempted in Denmark, and by whom, two differing regions will be examined at a detailed, local-scale level. In terms of their resources, economies, agricultural and geographic conditions, no two of Denmark's formerly independent provinces could be more *unlike* than Scania and Thy, in North Jutland. Yet in some ways, they present fascinating parallels both in their pre-state development and in their incorporation into the state. Both were foci of earlier, pre-state elite activity, and had distinct ethnic and regional identities that were deeply ingrained and fiercely upheld. Scania was in earlier times home to the Langobards (Lombards), Thy, to the Teutones, ethnic groups who become known (too well, perhaps, in the eyes of contemporary Europeans) during both the expansion and collapse of the Roman world and the following Migration era. Both areas were reluctant to become incorporated into the state, and elites and commoners alike resorted to protest, then uprising, to forestall the state's growing power. While the outcomes of these uprisings were very different, ultimately, each became a province of the Danish state. Through parallel study of these two regions, not only might political processes of unification become better understood, but a comparative model of the role of agricultural intensification in state-formation may be constructed.

Theoretical Issues

Are there connections between the development of the state and the conflicts enfolding it, changing political economies, and the new and different agricultural activity in the rural landscape? Or are the factors purely external – related to changes in the environment or population increases? These questions have been considered by archaeologists, historians, and geographers in Scandinavian studies for decades.

Berglund et al. (1991:436) espouse a fairly typical perspective when they state that in early Denmark, “Population pressure has undoubtedly been the essential condition behind all phases of expansion in settlement and cultivation,” reflecting Esther Boserup’s (1965, 1981) theory that agricultural expansion, intensification or innovation is invariably linked to an ever-increasing population. Boserup's work must be addressed, not only because of its broad and lasting influence on archaeological theories of agricultural production, but because Boserup was Danish, and the model was both implicitly and explicitly based on her observations on the historic development of agriculture in Denmark. This elegant and then-innovative theory, often referred to as the "population pressure" model, became extremely popular, worldwide, among archaeologists in the 1960's and 70's, and is still clearly entrenched in many research programs that attempt to explain agricultural change. Time and accumulated archaeological findings have shown that in many cases, the data do not support the theory's implied causal relationship: that inevitable population increases and resulting food stress must necessarily precede rounds of intensification. While some archaeologists view Boserup's arguments as so dead that they do not even constitute an argument anymore, her theory is, in reality, still ubiquitous, and still hotly contested in some areas.

Boserup saw labor intensification as a substitute for land – if there was no more new land to break, more effort must be put into what existed. Yet such models “assume that the increase in yields that accompanies this substitution does not fully compensate for the increased labor entailed by the necessary new techniques, and so labor productivity…declines accordingly (Eder 1991:246)”. This idea is based on the idea of “least effort” – that a excessive increase in labor is not justified by the relatively small increase in yields. What farmer anywhere in the world would labor so much harder to get just a few extra baskets of wheat, maize or potatoes? However, the relationship between productivity and intensification is not as simple as Boserup's theory implies: increased productivity, if it can be estimated, is not necessarily a good indicator of whether people were intensifying or attempting to intensify. Perhaps one of the most important things to consider is whether intensification occurs in order to increase subsistence food production for hungry people, or for other reasons.

Intensification has been called an "elastic" response (Eder 1991:246) to changing demographics, technology, economics, social/political conditions and various combinations of these forces. It is probable that the debate over whether increased labor is justified stems from a lack of good data on such transitions, which compare different social and agricultural systems and ignore geographic and temporal variations (Conelly 1992:204). Boserup's theory does not fully consider market demand, production subsidies, or the farmer’s ability to participate in non-agricultural economies as a strategy for making ends meet, yet when examining ethnographic instances of intensification in societies practicing traditional, low-tech agriculture, these are central to sequences of intensification (Eder 1991). Farmers often grow for market value, *not* caloric value, and make decisions based on how much cash (or trade goods) they can earn per hour or day, not on how many kilos they produce. When fertilizer and "pest" control is factored in (and pest control can come with the adoption of new plowing methods, not only through modern chemicals), this translates into what might be imagined as greater “management” by farmers (Eder 1991). Yields can increase so much that labor increases are indeed well-justified. In addition, as Morrison notes (this volume) the social value of certain products may mandate intensification of their production, even if other crops or strategies would produce higher yields. And of course, if one must pay taxes or be punished by the state, it doesn't matter if intensifying is really “worth” an extreme effort or not - as long as one can squeeze out enough extra bushels to meet the obligation.

Despite the complexity that such sequences usually display ethnographically, I hope to develop a model in which such problems can be addressed archaeologically through comparative study of Scania and Thy, demonstrating that while both provinces were subject to highly concerted elite *attention* during the state-building era, in Scania there were many abrupt, even radical changes in settlement organization and farming, while in Thy, the changes in agriculture during this era were less drastic. Elites from the central state did indeed leave an imprint on Thy and the rest of North Jutland at this time, but it appears to have had a different focus. I will also demonstrate that in Scania, where we find the greatest amount of evidence for reorganization of the landscape and agricultural intensification, *contra* Boserup, there were no remarkable increases in population preceding this activity; rather what is striking is a large-scale redistribution of population, through changes in patterns of nucleation and dispersion. While a number of other agricultural changes can be argued to have local impetus, ethnographic data indicates that widespread uprooting and resettlement is unlikely to have been initiated by local people.

By examining the geographic, economic, and political differences between the two provinces, perhaps the issues surrounding intensification from both perspectives, top-down and bottom-up, elite and farmer, central and local, may be illuminated. Better understanding stems from examining these phenomena at two scales of analysis. First, we can look at large-scale evidence for settlement and agricultural change to weigh the possibility that it was part of a state-sponsored strategy for increasing surplus and revenue. Then, we can examine the local landscape in an attempt to understand if and how the state induced farmers to conform to new modes of land tenure, production, taxation, and regulation, or if such changes may have been spontaneous local adjustments to new demands.

The Context of State Building and Central-Rural Economic Relationships

The pre-state context of the macro-region is important to our study of the later state for several reasons: it establishes the fact that non-elites had considerable governing and decision-making power during this earlier time, that the public had a mandate to protest and even remove leaders who were unpopular or overly controlling, and that sub-regions within what was to become the state enjoyed relative autonomy from outside authority. All these traditions were to become important factors in the trajectory to come.

Archaeological data has been used to convincingly argue that prior to the unification and the state-building process in Denmark, the region consisted of a number of smaller polities, each with its own warlord, upheld by a group of warrior-supporters and provisioned by a local constituency. This political organization can also be seen quite clearly in the archaeological record, as a multiscalar hierarchy of chiefly centers, in which different levels of elites are indicated by a fairly predictable hierarchy of rank-appropriate grave goods (Hedeager 1992, Thurston 2001:215-218). This fits well with the reports of the reliable Roman author Tacitus, writing in the first century AD, who tells us that in return for their support, local people received protection, reciprocal patronage, and ritual leadership. Probably, based on what we know about Iron Age conceptualizations of success and leadership, a warlord's status was also predicated upon on his "luck" (a magico-religious concept) and how that might impact the luck of his followers (Hedeager 1992, Hansen 1987, 1990).

Add to Tacitus a few historical fragments left by the Goths, Anglo-Saxons and Franks, plus a few indigenous chronicles, and we can piece together that the state was forged from an mutual protection alliance of peer polities, with a strong tradition of equality among peers, agreed to by all. Over this alliance, during times of war with outsiders, one or another intermittent paramount chief was normally in control. Later, this alliance became a hegemony, and later still, a unified state.

From Tacitus, we know that the community had certain powers over warlords, even in the arena of warfare itself. The social code curbed their decision-making powers on behalf of the community, requiring that a voting assembly made up of free men concur with the chieftain's wishes. If a leader's military powers or initiative were suspect, his warband could abandon him in favor of others. Outside of militarism, warlords had even more limited powers. The exchange of prestige items was controlled by these elites, and they received tribute to support their households, but the public could withdraw support in the assembly if they opposed a leader. Most people were farmers, and thus farmers had strong political influence in the voting that took place at these meetings, called the *folcmoot* or *folkting*.

As early as the first century and as late as perhaps the eighth century, several such peer polities continuously coexisted, and during warfare with external enemies, i.e. the Romans and later the Franks, the warlords would elect a temporary paramount from among their number, but if he seized too much power, or attempted to retain it past the time of threat, he was killed. Assassination of overly-ambitious leaders was actively encouraged. Only over time did a paramount "leader" gain recognition as an actual "ruler", recognition at best grudging, at worst barely tolerated.

This system, like all political and social systems, did not remain static. By the time Rome fell, paralyzing the prestige goods network, local internecine warfare was frequent and furious. One faction, associated with the island of Fyn, eventually emerged as primate. Frankish chronicles hint tangentially that this primacy may have emerged through the Fyn elites' ability to lead the other Scandinavians in successful warfare against the Franks in the late 8th through early 9th centuries. This was a protracted period of war during which, due to the aggression of the Franks and their brutal, and probably portentous conquest of neighboring Germanic peoples like the

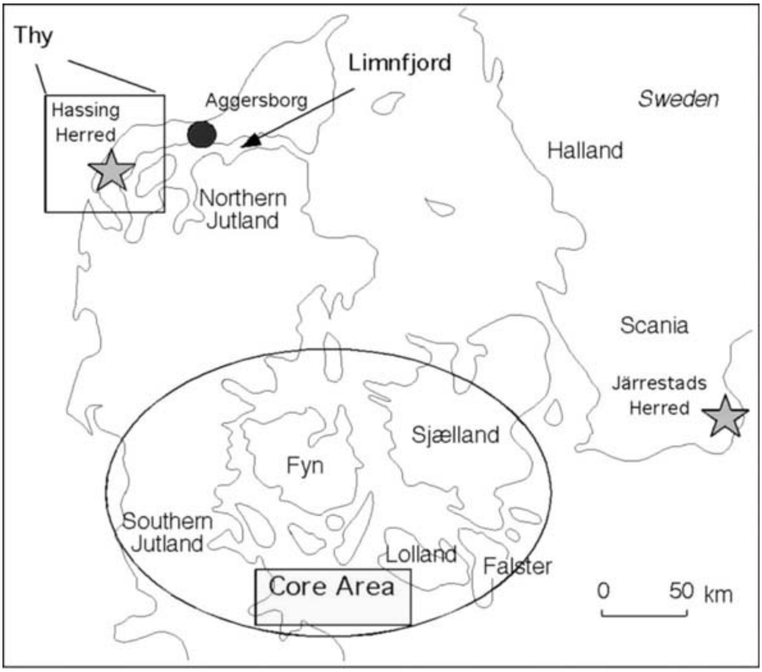

Figure 2. Scania and Thy in geographical and political context.

Saxons, a paramount chief would have held authority for extended periods rather than short intervals.

The agreement for collective leadership during warfare eventually opened the doorway for institutionalized kingship. By the early 9th century, "Danish" armies, led by “Danish” kings, were described by the Franks. It has been argued (Saitta 1994, Bender 1978) that communities often do not recognize that such turning points are occurring; they only know that they need to “authorize” whatever is necessary to accomplish important tasks. Once the war is won and the enemy deterred, as was the case with the Franks after the demise of the Carolingians, it can prove nearly impossible for once-autonomous farmers and even local elites to suddenly shake off the hierarchy which they intentionally helped into power – intentionally, but without realization of the unintended consequences of that shift.

Despite this development, paramount rulership continued to be unstable. Considering how sparse are *any* contemporary historic records of the still largely preliterate Danes, it is remarkable that several unequivocal accounts of the assassination of Danish kings by their own kin or followers appear in the various narratives. While context is not always provided for these acts, later texts often justify or explain what public dissatisfactions caused these rulers to be eliminated – threats against traditional farmer's rights, too many new taxes, restrictive laws, unfair “new” treatment of other elites. This supports the probability that swift or unpopular changes were still met with community-sanctioned regicide, as they had been in the Roman era several centuries earlier. The Danish state thus coalesced slowly, was highly decentralized, and Danish rulers were relatively weak.

In the ninth century the court moved from Fyn to southern Jutland, probably due to the concurrent rise of a new royal family line and the rise of towns on the peninsula, which lay in an active trade corridor. This ascendant faction largely succeeded in unifying south-central Jutland and the Islands into a single kingdom. During the same period the state's control over Scania, Halland and Blekinge in the east, and north Jutlanders in the north, seems to have been somewhat tenuous, perhaps consisting mainly of lip service with an underlying assumption that things were still as they had always been. The violent events to come indicate that even in the 10th and 11th centuries the union was uneasy at best.

Both Scania and Northern Jutland, including Thy (Figure 2), were coveted by central elites, but for different reasons. Scania was desirable because it had relatively vast stretches of highly productive farmland and a dense, wealthy, stable population to tax. Scania is today the most southerly portion of Sweden, but before 1654, it was a longstanding province of Denmark. Ceded in the early modern period as a spoil of war by the Danish king to the Swedes, only then did it lose its identity as Danish.

But in the so-called Viking Age, Scania had only recently become associated with Denmark. Traditionally, Scanians had a distinctly different ethnic and cultural identity. Scania was referred to by the earliest textual sources as "Scandza", the source of the word Scandinavia (Goffert 1988), and is the setting of the story told in the Beowulf narrative. Between 100 BC and AD 1000, the site of Uppåkra flourished in the western part of the province, a major chiefly center and cult place, which disappeared abruptly during the period when the state consolidated its power in the region. As noted above, to the Germanic invasions of Europe, beginning in the first century BC, Scania contributed the "tribe" known as the Langobards, later called the Lombards (Jones 1987:22), though whether they were associated with the chiefs at Uppåkra or other important chiefly centers in Scania, such as Vä – where local chieftains also abruptly disappeared – (Stjernquist 1951, Thun 1984) is unknown. In Frankish documents of the early 9th century, references are made to elites "of Scanowae" as opposed to other elites “of the Danes” in the same passage, indicating this distinct identity, even at a time when the state was probably already in the first stages of unification (Thurston 2001:66-67).

To give a sense of agricultural conditions under optimal modern farming conditions, only 7-8% of all modern Sweden is arable. The region of Scania is 11,346 square kilometers, less than 3% of modern Sweden's 450,000 km2, but today produces 40% of Sweden's agricultural output. Although this of course reflects modern agricultural methods, in the Iron Age, a large part of the cultivable land in Scania was already under production, while in northerly areas, without modern augmentation, far less was arable than even today. In part this is due to climate differences, with Scania, Halland and Blekinge lying in the temperate oceanic zone, while further north, the temperate continental zone sees earlier freezes and colder average temperatures. However, most of the divergence in agricultural potential is due to terrain and soil differences between the Scanian plain and the mountainous, forested north.

Turning to Scania as a part of Denmark, as it was before the mid-17th century, we find that although Denmark, past and present, has several areas of rich agricultural lands, Scania was still immensely valuable. Denmark's two large islands, Sjælland and Fyn were comprised of soils similar to Scania, as were many of the ca. 500 smaller islands. However, out of Denmark's approximately 43,094 square kilometers, Sjælland, at about 7,450 and Fyn, at about 2,980 comprise only about 25% of Denmark's landmass. Jutland, on the other hand, with only a small percentage of it area suitable for long-term field farming under Iron Age conditions, comprised almost 30,000 square kilometers, making up most of the other 75% of land area. Scania, with over 11,000 square kilometers, was more than equal to the area of the two large, grain-producint islands. Scania thus is, and was also in the Iron Ages, the largest continuous agricultural tract in the region, in fact in all of Scandinavia, in terms of arable land, climate, and grain production – hence Adam of Bremen's description in 1074 as "opulent of crops". Evidence for reorganization of rural economics is remarkably strong here.

Thy, in Northern Jutland (Figure 1), is a very different type of landscape. Thy, about 18-20 kilometers across at its widest expanse, is a relatively narrow strip of land which separates the Atlantic Ocean from the Limfjord, a major inland seaway. While it is more northerly than Scania, the climate, though windier, is nearly as mild, due to the passage of the warm ocean currents off the western coast of Denmark. The region had only small expanses of good farmland, and while arable land was enough for local needs, there is much less evidence of agricultural reorganization.

Driving through Thy today one would be surprised that the areas of productive land in the Iron Age and early Medieval periods were so limited. Fields of grain wave in virtually every local environment. While modern farming has transformed many previously unsuitable areas, in pre-modern times much of Jutland was generally quite poor, a combination of heath and marsh underlain by poor soils formed in glacial outwash plains. This included the central portions and Atlantic side of Thy. There are bands of soils along the interior Limfjord coast that are rich in clay and could support long-term agriculture, and it is here where most Iron Age villages were located, but even in the more clay-rich portions of Thy and similar parts of the east coast of Jutland, villages were smaller, the population more sparse than in Scania, and settlement dynamics were different.

This does not mean that North Jutlanders produced no cereals. Field farming *was* undertaken, although it grew less important over time. Archaeological studies elsewhere in Jutland show a transition from early Celtic field farming with fair-sized cultivated fields, to very small infields being farmed for household subsistence around the nucleus of the settlement by the mid- to late Iron Age. In the absence of substantial management, these soils can support limited agriculture for only short periods of time, a couple of hundred years of shifting cultivation, or less (Vad Odgaard 1988). This can be seen both in indications of 6th-8th century AD falloff in Jutland's farm settlements, and changes in farming reflected in pollen cores (Muller-Wille 1988b:54). The "walking villages" of Jutland's Iron Age, which moved every 150-250 years, may be in part a reflection of the need to change not only fields, but entire field territories every few generations, although social or ritual causes may have been involved as well. Thus, despite poor conditions, local people found ways to produce for their own consumption.

Grain production, however, is not the only type of production. Given the labor intensive management needed for field farming, farmers in Northern Jutland instead turned to other staples. The region's natural heath vegetation is far more conducive to stock-raising, and archaeological investigations show that as field farming was abandoned, it was replaced almost exclusive by cattle husbandry during the mid- to late

Iron Age (Vad Odgaard 1985). Another important part of the economy was the Limfjord waterway, a rich marine resource as well as a transportation route linking settlements and local markets on the inner Danish seaways to the Atlantic Ocean during all of the Iron Ages. The military uses of the fjord system would, during the Viking Age, become of primary interest to the state.

Settlement Studies of Denmark's Regions During the Late Iron Age

Between 1992 and 1994, extensive survey and testing was conducted by the author in and around the district of Järrestads Herred in southeast Scania (Figure 2). A *herred* is an ancient administrative unit that appears to date back to the Roman Iron Age, and was certainly extant in the later Iron Age, or Viking Age, and so, as a meaningful prehistoric administrative unit, is a good boundary for survey projects. Sixteen village territories in the herred were analyzed, eight of them were subjected to soil chemical characterization, full coverage survey, surface collection, and eventual testing.

Since 1997, a new project area has been under investigation in and around Hassing Herred (Figure 3), in the region of Thy, Northwest Jutland. As in Scania, the landscape in largely open for survey and sites are not difficult to locate, and additionally, villages established in different phases have well-analyzed associated placenames (Brink 1984, Kousgård-Sorensen 1979). Unlike in Scania, where villages stayed put, in Jutland, as noted above, villages moved every 150-250 years, although they remained within their own “territory”, and thus left a series of many single-component sites, different versions of the same village, dating to within the study period. Several such territories have been investigated with full-scale excavations elsewhere in Jutland; in each case, several phases of the same village, spanning 400, 500, even 900 years or more, have been found, each version within 100-300 meters of its predecessor. The latest versions of these villages often originate in the late Viking Age/Early Medieval transition, and are still inhabited, each retaining a form of its original, early name (Hvass 1983). The name of the current village establishes when the village as an entity was first founded; subsequent sites are in the immediate vicinity. Thus, it is possible to discover village phases, changes in their location through time, and in their size between incarnations, all-important for reconstructing the course of cultural landscape change during unification and centralization.

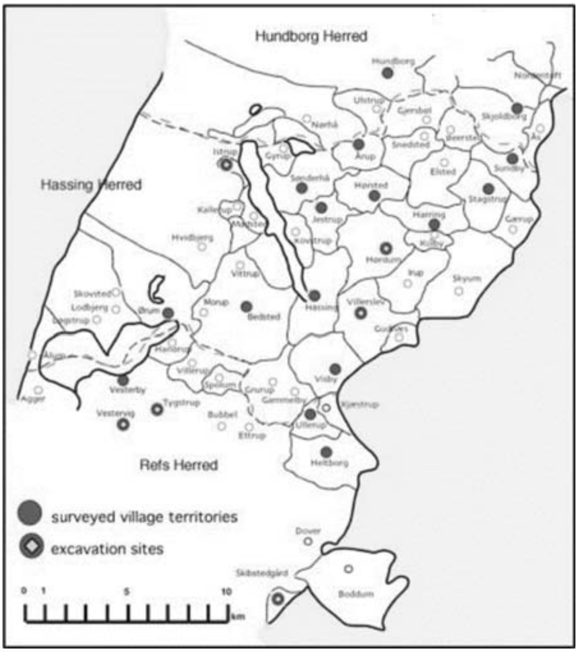

Figure 3. Project area.

Thy is comprised of 1776 km^2 with seven *herreds*, approximately 200 km^2 each. Since the scale, ubiquity, and uniformity of change in Scania was one of the most powerful gauges of central planning, the question of whether similar or different changes occurred in North Denmark should be answered with study of an entire *herred*, as in Järrestad. Hassing Herred, which is approximately 231 km^2, in the center of Thy (Figure 3). and, as in Järrestad, cultural landscapes are preserved largely intact, permitting diachronic and synchronic analysis of change in their internal relationships and their articulation with the greater state. As in the study of Järrestad, selected sites from neighboring *herreds* were also included. The project was conceptualized to be comparative with Järrestad; thus, similar studies have been carried out with the mapping of soil chemical distributions and full coverage surface survey and extensive testing.

INTENSIFICATION IN CONTEXT

In other venues, I have focused explicitly on social, political and economic factors during unification, and how they were expressed in various ways across the region (Thurston 1997, 2001). In the following pages, I will focus on the role of agriculture during this period, arguing that while much long-term change in agricultural practice and organization was clearly rooted in local knowledge and agency, rural and community-generated in origin, one brief and concerted sequence can be rea-

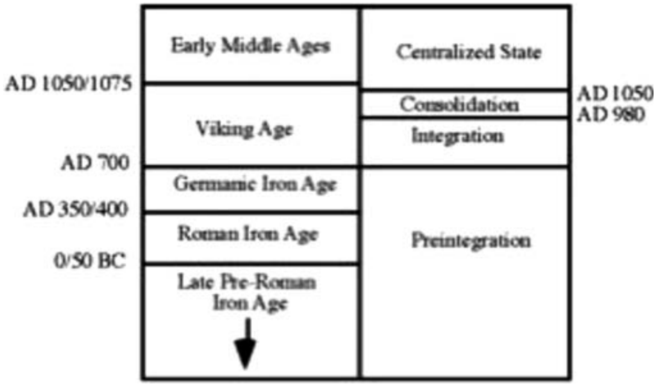

Figure 4. Chronology/phases for Denmark.

sonably argued to have been inspired by emergent central authorities, not only for purposes of increased productivity, but for increased economic, political and social control over unruly provinces. Because the exigencies for incorporating these areas had different motives, and because the underlying conditions varied, the methods used to incorporate these territories were diverse. The pitch and parameters of the top-down push for intensification and control of resources in Denmark varied from region to region. It is also my intention to balance the study of top-down processes with a look at bottom-up processes as well, for conversely, one could say that state power was expressed differently in different regions because central authority was weaker.

Chronology and Phases

In Figure 4, a chronology for the study can be seen, compared with traditional chronologies for Denmark. Rather than focusing on the culture-historical record, as do typical current chronologies, we approach the problem as a series of changes in regional political, economic and social integration as several polities traveled a course toward unification. Thus we refer to the Preintegration Phase, comprising the centuries of the first millennium up until about AD 700, an Integration Phase from 700 to about AD 980, when slow and cautious steps were taken by rulers to unify what would come to be called Denmark, and finally a Consolidation Phase, a short, intensive period of rapid change and formal state-building around the turn of the first millennium. While trends in Denmark as a whole are discussed in terms of these phases, data from the author's two study regions, Järrestads Herred in Scania and Hassing Herred in Thy, will be specifically referenced.

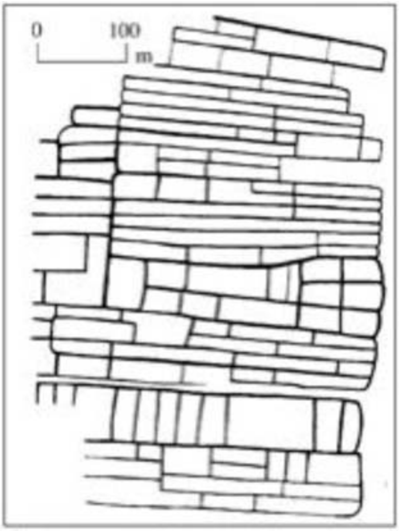

Figure 5. Iron Age field boundaries, such as these from Himmerland in Jutland, were not too different than those of the 17th century. While some farmers hang onto larger plots, many others are only ten meters wide (after Nancke-Krogh 1982:34).

Land Tenure in Iron Age Scandinavia

In both Denmark and Scania, specific forms of inheritance, combined with average population increase, made village expansion and growth problematic. First, neither region practiced primogeniture. Sons inherited equally and land was divided between them. After several generations of divisions between numerous heirs, the valuable manured fields consisted of tiny strips (Figure 5), seen in excavated remains of Iron Age field systems (Nancke-Krogh 1982:34).

In addition, while cropland was not held corporately by the whole village, there were certain leveling mechanisms in place which prevented some farmers from growing wealthy at other's expense. The *vang* system, often referred to as the “open field system”, was a method whereby large areas of land around the village were classified as to land quality. Then, each farmer got a section of that land, so that each had equal portions of poor soil and good soil. These cultivated fields are referred to as *infields*, while the *outfields* consisted of bog, grass, or hay meadow pasturage near which each village was purposefully situated. In medieval times, just after the end of our study period, the infields were divided from the outfields by fences. This may have been similar in the Late Iron Age (Berglund et al. 1991:57). Originally, the arable portions would have contained broad, good-sized fields, one in each of two areas, since the evidence suggests a two-field rotation system in place during the Preintegration and Integration Phases. One area was cultivated, while the other was left fallow (Berglund et al. 1991:192). In Scania, for example, this area might typically be 10-12 hectares for a village with 6 or 8 farms. Each *vang* might originally, at the

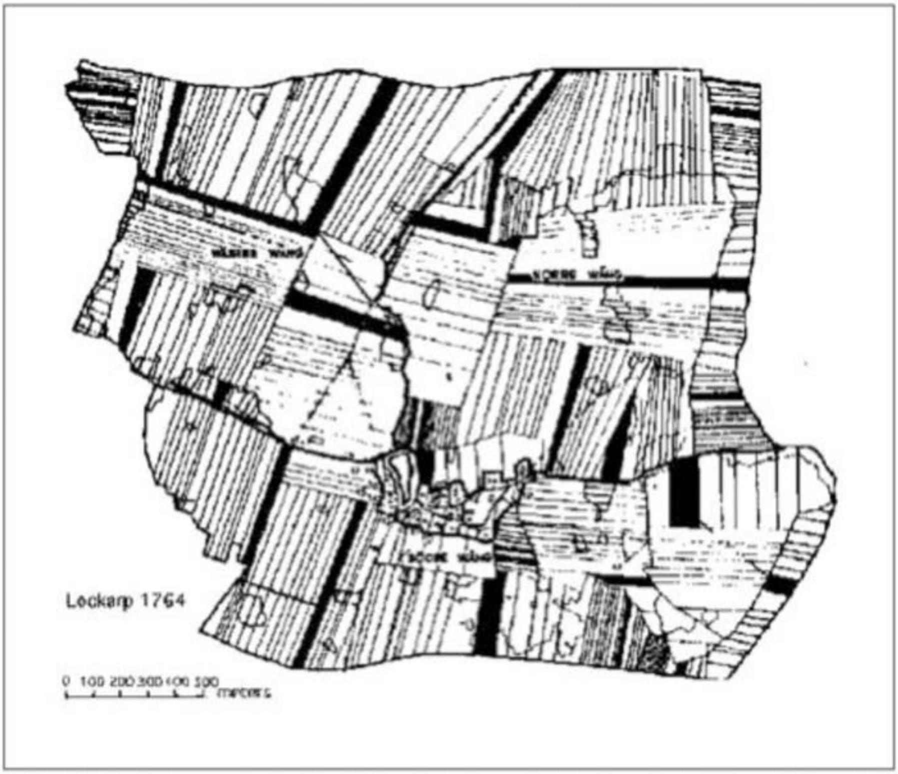

Figure 6. Lockarp village in 1764. All black strips belong to household #1 (after Pred 1986:53).

village's founding, have been 5-6 hectares, with several large fields (Berglund et al. 191:190-91).

With families producing several children in each generation, as is indicated in early historic sources (Berglund et al. 1991:190, Sawyer and Sawyer), half of which might have been male, after several generations each parcel had been divided many times through inheritance and other types of division, such as trade. It is possible that one strip would remain with whomever inherited the farm itself, other brothers would divide the rest and start new farms. Over generations, this resulted in each farmer owning strips distributed all over the large infield area. The cultivator must work in one field, then travel to other more distant fields to accomplish his work. About 100 hectares of outfields for grazing in summer and cutting fodder in winter might surround such a village.

Using a direct historical example, the problem of division, seen in relict field systems of the Viking Age, was still apparent (Figure 6) in the earliest maps and descriptions (Nancke-Krogh 1982:28) from the 18th century. Each black strip belongs to ‘farm number one’ – fragmented and scattered fields which while familiar and acceptable within each farmer's daily practice, made sowing, weeding, and harvesting complex and inefficient. We don't know exactly how Iron Age farmers dealt with their land tenure problems, but we *do* know that in the 18th century, farmers jealously guarded their rights to equal quality lands, argued and pored over every change of hands or shift in tenure. This became evident when the central government tried to rectify the dramatically poor productivity of this system, which required excessive travel time and complex sowing and harvesting scheduling. Accounts from the 18th century state that reapportioning land so that farmers' holdings were consolidated took not months, but *years* of negotiation between government officials and locals, to make sure that previously perceived equity was maintained (Pred 1986). This was due to the fact that talks often broke down amid great acrimony, and government officials would sometimes decide to wait several years before reapproaching locals concerning land reforms.

While we may suggest a similar social picture for the Viking Age, we cannot be sure – however, we *can* be sure that during the pre-state period the infields of the villages were indeed eventually divided into narrow strips, which are visible, archaeologically, at a number of excavated sites, as seen in Figure 5. By AD 700-800 in Scania, Thy and the rest of Denmark, not only was the land extensively carved up, but the residential areas in the center of the villages appear to be highly infilled. In Scania, where villages were quite large, based on their size and probable density of about 20 persons per hectare, some village populations might have grown to several hundred people, while the actual *size* of the village core did not grow larger. To grow the core of the village, one would have to encroach on fields, and this apparently was not a favored alternative. Our work in Järrestad indeed indicated this to be the case (Thurston 2001:228-9). Through phosphate distribution and diagnostic, datable artifacts in situ in upper and lower culture layers, we compared late Viking Age occupation (AD 980-1050), to the early Viking Age (AD 800-950). We found that in the earlier phase, activity was less dense, and less concentrated. By later village phases, infilling was apparent, but there was little evidence for actual site size change. This type of crowding could lead to two possible solutions: expand into the croplands, which from direct historic analogy would have been an extremely contentious undertaking, or found new villages in either outfield pasturage or areas wholly beyond the village territory. With this understanding of land tenure problems in mind, the following sections will detail what decisions were actually made in the two study regions.

Preintegration Villages on Jutland

Iron Age villages with many inhabitants appeared quite early in Jutland, and there are hundreds of villages from the Pre-Roman and Roman Iron Ages, as old as 200 BC, on the peninsula. Several have been excavated in full or nearly so, giving good indications of their organization. Some of the villages, with the oldest types of place-names, such as those still ending in "-um", are found on the islands, but are most concentrated on the Jutland peninsula, showing a great deal of continuity of settlement. After founding, the villages moved every 2-3 centuries, though usually only a couple of hundred meters from their previous location. Over a millennium or more, such settlements dislocated several times, leaving a "trail" of abandoned locales behind, which results in their sometimes being referred to as "walking villages". The most famous site of this type is perhaps Vorbasse, a settlement in central Jutland where several phases of the village were almost completely excavated, dating to the first century BC to the Viking Age, with the Medieval (final) phase still extant today. In Thy, there are indications of many large villages from the Roman Iron Age, some with modern counterparts where place-names have been preserved and others without modern analogues. Many villages moved for the last time at the transition between the Viking Age and Middle Ages, or, per our project's chronology, during the Consolidation Phase between 1000 and 1100, when a stone church was built, presumably anchoring the village to the vicinity. In addition to very old villages dating to the first centuries AD, and continuing up through the present, there were several expansion phases during the later Iron Age when completely new villages were founded, the first at about AD 500 to 700, the next at about AD 850 to 980, and the final wave beginning at about AD 980 and continuing until 1100. However, in our portion of North Jutland, Thy, the timing of this last phase does not seem to correspond to southern parts of Jutland or elsewhere in Denmark and Scania. Here, a parallel settlement wave did occur, but later, perhaps not until AD 1200-1300.

Preintegration Villages in Scania

In the region of Scania, combined evidence from several contiguous regional projects and the author's research area of Järrestad, confirms that unlike Jutland and other parts of Denmark, the agglomerated agricultural village was a late development, following a long period of single or double farms that housed extended families (Berglund et al. 1991, Strömberg 1980, Stjernquist 1955, 1981, 1993a&b, Thurston 2001). In Scania, villages did not exist prior to AD 500 or so; this means that we can use AD 500 as an absolute baseline for when the original village size and *vangs*/fields were laid out to accommodate the original population. These then underwent a great deal of field division and village infilling. New villages, established later in time, would have had new fields, broad and undivided, ready for a new generation to begin dividing. In Järrestad, and Scania as a whole, the first wave of agglomerated, nucleated villages was settled between AD 500 to 700, marked by many village names ending in “sted” or “lev”, then there were two more successive waves of settlement, the next at about AD 850 to 980, with many villages ending in “by”, and the final wave beginning at about AD 980 and continuing on until perhaps 1100. These villages typically end with the placename element “torp”. These settlement phases in Scania parallel and coincide with expansion phases found in most of Jutland and the rest of Denmark, usually with the same phase-specific place-names. In Scania, villages in the inittial AD 500-700 wave each had a core with loosely organized houses and farm buildings, surrounded by infields, outfields, and semi-wooded areas where forest or shrubbery products were managed and collected. These villages have an organic shape and an unregulated internal structure. Also in large contrast to Jutland, in Scania, villages, once founded, rarely moved (Callmer 1986) and generally lie today in the same general “footprint” as when they were founded in AD 500.

The Integration Phase in East and West

The settlement wave between AD 850-980 in both areas, Scania and Thy, falls in the phase we call the Integration Phase, and occurred through the process of *interior colonization:* the founding of new villages carved out of the areas at or beyond the territory's periphery. Villages from this time period, as noted, often end with the suffix “by”. In this wave in Scania, the infields and outfields of the original villages were left undisturbed, and new villages were usually established in areas between the territories of older villages in places that had previously not been cultivated or managed. In both Jutland and Scania, the relatively long time (150-300 years) between the end of the previous “sted/lev” wave and the beginning of the “by” wave of settlement supports an interpretation that these were the result of long-term slow population growth, and were planned by producers who needed to establish new houseplots and break new fields due to the long-standing kinship, inheritance, and land tenure rules they adhered to. In Jutland, the “sted/lev” wave, while not the first, occurred around AD 500-600. In Scania, the the first, original villages were settled over a 200 year period, largely between AD 500-700. The oldest would have been, by AD 850, 350 years old, and the youngest, 150 years old. In both areas, the new wave of “by” village offshoots were founded between AD 850 and 980, about 130 years, and were similar in layout and organization to the earliest villages. The comfortable pace of village establishment in this wave, and their generally organic shape and organization appears to indicate that they followed the same rules of organization as the earliest settlement.

Many previously founded Jutland villages extant at AD 850 had been in existence for a thousand years. In these areas where, unlike Scania, villages moved every few generations, it is possible that the very small fields used for subsistence were laid out anew and land consolidated with each move, thus permitting a village, through moving, to avoid fissioning for much of the first millennium. Villages moved due to the failure of soil nutrients, not because of internal crowding, as can be seen in the relatively similar size of the sequential village incarnations at sites like Vorbasse. On the other hand, eventual slow, long-term population growth created a need for new villages, which then joined the cycle of occasional dislocation.

The appearance of "by" villages across the region is a moderate case of expansion. Density of these villages is extremely low in all areas, but there is some regional variation. Table 1a shows the density of "by" villages in Scania, table 1b shows the same data in the eastern parts of Denmark (areas with good soils) broken out by modern counties. Table 1c shows similar data for Jutland, where soil quality was much poorer. In Scania, the extremely low density of new villages founded in this wave indicates that there was no huge upsurge in population needing new accommodation. The density of these villages in the Islands, with their similar soils and conditions for agriculture is marginally higher, and Jutland, largely with poor soils, is nearly identical. The difference in site density for this first "interior colonization" between the richer agricultural parts of Denmark and the poorer area of Jutland is negligible, even the better Limfjord side of Jutland only differs by a small amount.

Table 1a. Scania – villages in “by.”

County	km^2	# "by"	Density
Scania	11,346	112	.0098

Table 1b. Island Denmark – villages in “by.”

County	km^2	# "by"	Density
Fyn	3485	82	.023
Roskilde	891	18	.020
Vestsjaelland	2983	46	.015
Frederiksborg	1347	18	.013
Storstrøms	3398	80	.023
København	528	10	.018
Total	13160	254	.019

Table 1c. Jutland – in “by” –poor soil = *, mixed soil **, no notation = good soil.

County	km^2	# "by"	Density
Viborg**	4122	54	.013
Nordjylland**	6173	68	,011
Ribe *	3131	32	.010
Århus	4560	69	.015
Ringkøbing*	4853	97	.019
Sønderjylland**	3939	50	.012
Vejle	2997	33	.011
Total	29775	403	.013

The Consolidation Phase

By AD 980 in Scania, the "*by*" villages were still significantly smaller than the original villages, and had room to expand before fissioning. However, in a very short time another group of offshoots appeared throughout much of Denmark. This wave of villages did *not* follow a similar pattern.

This third wave almost exclusively end in the suffix *torp*, that means, literally, "settlement dependent on an older village" (Brink 1984:166) indicating a fission or splinter from a home village. These were founded in Scania and most of Denmark between AD 980 and 1100. Several thousand tiny places with only 2-3 homesteads were established, not only on good farmland between older places, though little was still available, but on former outfields of extant villages, and also in previously uninhabited "broken lands", marginal places at the edges of the steep and rocky interior of Scania which had seen virtually no habitation until this time, and even at the edge of coastal marshes where poor drainage made settlement conditions extremely uncomfortable (Petterson & Brorsson 2002). Our collection and testing of the *torp* sites in Järrestad yielded late Viking Age ceramics dating no earlier than AD 980-1000, followed by early Medieval wares.

In contrast, the *torps* in Thy, Jutland, deviate substantially, having bben established later, yielding ceramics only of the 13th century and later. This contrast between the early establishment in Scania and North Jutland's much later process, at the the very tail end of the *torp* settlement expansion phase, is notable. An examination of *torp* densities, in contrast with earlier settlement waves, is also remarkable.

Upon examining the variance in density of these later villages (tables 2a, b, c), several things can be said. First, the density in Scania is remarkably high, on average nearly double that of the Islands, with their similar soils and conditions. Then, the Islands, while they have half the density of Scania, still have nearly double that of Jutland. And the richer, Limfjord-side counties of Jutland (most of Viborg, Århus, parts of Nordjylland) are substantially higher than those dominated by central and western portions of the peninsula with their very poor agricultural soils (Ribe, Ringkøbing, Sønderjylland). This may also have some relation to locations close to centers needing surplus. The counties containing the royally controlled cities of Aalborg and Viborg have the highest density of *torps*.

Table 2a. Scanian villages in "torp."

County	km^2	# "torp"	Density
Scania (total)	11,346	1550	.136

Table 2b. Island Denmark villages in "torp."

County	km^2	# "torp"	Density
Fyn	3485	211	.060
Roskilde	891	64	.071
Vestsjaelland	2983	239	.080
Frederiksborg	1347	99	.073
Storstrøms	3398	164	.048
København	528	17	.032
Total	13160	810	.061

Table 2c. Jutland villages in "torp" – areas of poor soil = *, mixed good and poor soil **, no notation = good soil.

County	km^2	# "torp"	Density
Viborg**	4122	199	.048
Nordjylland**	6173	279	,045
Ribe*	3131	58	.018
Århus	4560	260	.057
Ringkøbing*	4853	143	.029
Sønderjylland**	3939	112	.028
Vejle	2997	89	.029
Total	29775	1191	.040

The “planted” appearance of small, dispersed agricultural settlements near large centers is a cross-cultural phenomenon; colonization of less desirable areas in Classic-period Oaxaca was also based on proximity to urban hubs (Feinman 1991). This “piedmont strategy” occurred in phases where government was strong and centralized. As in Oaxaca, where marginal settlements were abandoned at a later, less centralized time, certain of the Danish *torps* were eventually abandoned, the largest number on the east coast of Jutland where these large towns were found (Jørgensen, pers. comm. 2003); it may be that this town-rich area absorbed farmers and rural laborers into the increasingly nucleated populations of the later Medieval period, where a “new” urban economy and a more complex transport and marketing system ameliorated the need for nearby food surpluses. One way or the other, the need for these *torps* was removed, and so they disappeared.

Regional Strategies of the Danish State

The distinct regional variation in this *torp* wave of settlement, so different from the previous ones, supports the suggestion that all things were not equal, either due to top-down directives or bottom-up initiatives, or some combination of both. The differences between Denmark’s islands and Jutland are remarkable, but perhaps most striking is the difference between Scania and the large islands of Fyn, Sjælland, Lolland and Falster, which despite their similar conditions differ so much, indicating that demands were highest upon the Scanians.

We know from early textual records that at this time, the Danish kings enacted far-reaching new laws and taxes, and new burdens were imposed on manpower for the *ledung* or royal naval levy. On top of this, in the 12th century a church tithe, for the support of the church hierarchy, was added, and was hotly disputed by many Danes. Were these signs of increased land under the plow caused by a demand for higher taxes, pressing farmers to open new lands on their own initiative in order to pay? Or does it represent some form of encouragement from the state to unequally press its provinces for more production? Scania's twofold investment in these tiny, purely agricultural hamlets is a case meriting further investigation. In fact, a great deal more was occurring on the ground than just the foundation of the *torps*.

Reorganization of Scania’s Settlement, Economic, and Agricultural Landscapes

Computer simulations, in juxtaposition with on-the-ground ethnographic data, such as Lansing’s study of agricultural innovation and intensification among Balinese farmers (Lansing 1991, Lansing & Kremer 1993), show that the spread of new agricultural cropping methods, through nodes of communication in local contexts, can lead to rapid adoption of new farming methods purely on grassroots initiative in as little as 8 to 35 years (Lansing & Kremer 1993:106). As the authors note, the systems are not planned in advance but build themselves over time (Lansing & Kremer 1993:99). In addition, as communication and planning between the farmers increased, during regular meetings at their local temples, the more efficient they became at organizing themselves and the more successful the whole region became at increasing yields. Farmers throughout Denmark did indeed meet on a regular, probably monthly, basis at the local assembly or *ting*, and less often at regional and national *tings*. After the adoption, by the masses, of the new Christian religion around 1000-1050, they continued to meet at these assemblies but additionally met at the local churches, which were built at the same time.

During this time of change in taxes and military obligations, were there any changes in farming that might match this ethnographic pattern of self-organized innovation? There are, in fact: precisely at this time, the long-standing two-field crop rotation was replaced by the more intensive three-field rotation, with three *vangs* instead of two, thus keeping two-thirds of the village's field areas in production at any time, rather than half. This, incidentally is the pattern observed by Boserup, inspiring her theory of agricultural growth, which was then presented as a prime mover to be applied wherever similar observations were made. Boserup attributed this change soley to population growth and dwindling food supplies; it can be demonstrated, however, that population growth was probably not a factor in this new regime.

At the same time that the cropping system changed, the primitive ard plow, that had been largely unchanged since the Neolithic, was replaced by the more productive moldboard plow. The ard, which only makes a shallow scratch-like furrow for planting seed, creates conditions in which weeds and insect pests are extremely high (Emanuelsson 1985). The moldboard, which actually turns the soil to a substantial depth, eliminates these problems, and was a large technological advance in terms of production and yield. This new type of plow was first used in continental Europe somewhat earlier than in Scandinavia. Given the high level of direct communication between the continent and Denmark, as farmer-Vikings both traded and raided abroad on a regular basis, it is likely that Scandinavian farmers were aware of it's existence, yet did not adopt the new technology until this era. While one might argue that the changes in cropping and plowing were top-down directives, these types of changes reasonably match Lansing & Kremers ethnographic observations and computer simulations. Thus it is possible that farmers in Denmark could have spontaneously acted to increase yields in order to meet their new tax burdens.

On the other hand, other aspects of intensification, beginning at around AD 980, seem to mark this era as a different type of case. In addition to these probable locally controlled efforts to increase yields, seen broadly across Denmark, there were other simultaneous changes that seem unlikely to have come from farmer themselves. The founding of the *torps* themselves certainly involved a large amount of labor. However, they also would have caused a great deal of community and personal upheaval, at a time when the relatively new *by* villages were still quite small and comfortably under-populated. This makes it unlikely to have been undertaken as a local self-organized initiative, so broadly across Denmark. This is reinforced by a notable element of pre-planning and regulation in many *torps*: data from some excavated *torp* hamlets show that they can display several identically sized lots, or *tofts*, each with a house in the left corner by the street, indicating a pre-determined layout and standard land divisions. Agricultural and rural historians in Denmark typically call them "regulated villages" (Porsmose 1988, Ridderspore 1988, Stenholm 1986; Söderberg 1994). Historic enclosure strategies, as well as many archaeological cases show that widespread founding of such dispersed settlement often reflects intensification efforts, as the remote location of agricultural workers reduces labor and travel time to new fields (Drennan 1988:274).

Lansing & Kremer state that those farmers who communicate fare better than those who do not, at successfully adopting new methods on their own, through local networks. Since the system of assemblies was at least 1000 years old, and was used in voting on local and non-local issues even as early as the writings of Tacitus in the 1st century AD, we can assume that Danish farmers around AD 1000 had uniformly good communication with each other. We would expect to see a uniform adoption of new cropping and plowing methods, and we do. However, we do *not* see uniformity in the density of new settlements, which is so remarkable high in Scania, despite similar agricultural conditions on the Islands. *Torps* in Scania's rural hinterland were founded in an even shorter period than in Denmark proper, perhaps only 20-40 years. Colonization with over 1500 of the tiny, dispersed agricultural communities effectively opened up more arable land, and woodlands almost disappeared (Berglund, Hjelmroos & Kolstrup 1991:112).

If this was the only evidence it would make a compelling argument for the existence of a non-local push factor – but in addition to *torp* foundation several other dramatic changes occurred, only in Scania, which, when contrasted with other areas, highlights the province's unique trajectory. Only in Scania, simultaneous with this colonization, *older* villages were restructured and reorganized (Ridderspore 1988, 1991). They were demolished and rebuilt, contracting by up to 60%, and their internal order was altered (Thurston 2001). Mirroring the layout of *torps*, structures became highly organized within a new *toft*, or farmyard, and the new farmyards, instead of being loosely scattered, are lined up in rows along a village street.

There is some insight into this otherwise inexplicable uprooting and resettlement: early law codes state that farmers had to equip themselves and man longships as warriors. Documents from the Middle Ages indicate that siting the household on a regulated *toft*, whose size reflected the size of the farm, signified the farmer's wealth. Referring to Figure 6, it is clear that a tax-collector, riding into the village center, could hardly assess what total lands a farmer owned, scattered as they were in small strips all over a village's *vangs*. There were no written tax records kept at this time, and we can assume that if possible, then as now, taxpayers would prefer to underestimate their taxable lands if they could get away with it. But, with a regulated *toft*, established one time only, as a landscape text that would be read in perpetuity, royal officials could estimate taxes and military obligations in a time of widespread illiteracy. Land reform and reorganization around AD 980 probably marks the beginning of this system (Randsborg 1980:69, Ridderspore 1988).

Also at this time, we see the creation of new urban infrastructure: the first cities were rapidly founded in Scania, a previously completely rural area with no towns or cities at all. Historical texts indicate that the four cities, one in each corner of the square-shaped province, were royal foundations, that is, chartered by the king of Denmark, just at AD 990-1000. Many services, such as marketplaces, courts of law, religious authority, and the "authorized" grinding of grain, which was carried out by the state in order to retain a percent as taxes, were relocated from their previous, non-coinciding rural locales to these royal towns.

Substantial demographic shifts were concomitant with these changes. The *torp* colonization/older village contraction appears to have been accomplished not by slowly sending new, excess population into the small hamlets, but by uprooting and resettling extant farmers. Using Järrestads Herred as a typical example, regional population standards for rural settlement in Scania by AD 1000 (Olsson 1991:190) of ca. 20 people per hectare, that is, 8-10 people per typical .5 hectare *toft,* or farmyard, a large nuclear family and their servants or thralls, Järrestad's earlier villages had a total population of about 4900 adult people. Contraction reduced this capacity to about 2500. Similar estimates for *torp* hamlets show that they absorbed about 1000 people, while the rest, 1000-1200 people, went to the new town, Tommarp. This indicates not growth, or so-called population pressure, but change in nucleation and dispersion.

This is an important indicator of a non-local initiative. It is well-documented, ethnographically, that such resettlement is highly disruptive and almost universally negative in its effects, even if the distances are short and people initially believe there may be some advantage to long *or* short distance migration: a traumatic experience that has been well-studied among farming people from Africa to China to rural America (de Wet 1993, Scudder & Colson 1982), Ethnographers call this phenomenon *forced resettlement*, though in fact it may seem voluntary, especially in cases of economic needs or government development plans. It may also be "forced" only in that the victims perceive a need or a benefit in moving. While details differ by case, they all produce the symptoms of physiological, psychological, and sociocultural stress. Physiologically, illness and morbidity rise, especially in the elderly. Psychologically, studies show that even with voluntary, short-distance moves, there is a strong, long lasting, negative syndrome of depression, anger, loss and grieving, for homes as well as landscapes if they involve origin myths, historical accounts, or religious symbolism. Finally, sociocultural stress results in many measurable changes. First, a loss or replacement of behavioral patterns, economic practices, institutions, and symbols is invariably observed. Politically, uprooted people suffer a temporary vacuum in local leadership, rendering the community impotent against central authority. This coincides with behavioral modification in respect to risk and change.

Taken together, this makes it highly unlikely that the total demolition and restructuring of older villages – what would have been "home" for many generations – was a voluntary experience. Ethnographic studies in Africa (de Wet 1993) for example, show that anger at the government for the woe brought on by uprooting and resettlement were still raging many decades after the plan had been executed, and is intergenerational, as children remember the deaths of elderly kin and misfortunes of their parents. The historic record in Denmark, discussed in more detail below, indicates that in the decades just after this reorganization, anger was erupting, and a few generations later was even more explosive.

On the other hand, if we take the perspective of the administrator in charge of collecting new or newly higher taxes, an analysis of travel time and labor saved by conflation of services in one urban location, a town that was rapidly built in the same short era, plus colonization, settlement and reorganization, show huge savings in time and effort, which would have raised yields even more than what farmers had accomplished themselves through self-organized shifts (Thurston 1999).

Evidence for Top-down Strategies in Scania

I have suggested elsewhere (1999, 2001) that this second wave of interior colonization in Scania, plus the several intensification strategies that were rapidly deployed at the same time, were directly related to state expansion. To reiterate: evidence includes 1. *en masse* founding and regulated nature of new *torp* villages at double the rate or density of other Danish provinces; 2. sudden regulation and reorganization of extant village structure; 3. evidence for large scale uprooting and resettlement; 4. documentary records of newly imposed taxes and tax collection methods; 5. sudden urbanization by royal charter and the relocation/conflation of services in urban areas, 6. adoption of new cropping methods and farming technology, and 7. the widespread and ubiquitous nature of these phenomena. While self-organized efforts are not "top-down" in an of themselves, they seem to be in response to a top-down demand for more taxes.

Thus, several types of intensification and innovation strategies mentioned in the first part of this chapter were in operation, some of which may have been state directives, while others may have been coping strategies for dealing with increased state power, implemented by farmers on their own initiative:

- The same number of people were redistributed into more villages with more arable land; more human labor and animal labor was input into a combination of old and newly cleared areas. The clearing itself and the substantial demolition and reconstruction of older settlements represented a large investment. Forests with old growth had nearly disappeared by this era and many timbers were probably removed and reused in new locales.
- Biological resources, in the form or organic nutrients, were used at increased levels, as new village fields, cut out of areas previously used for pasturage, were fertilized with manure, while old ones continued to be fertilized and worked.
- New technology was introduced, first, internally, through the new three-field rotation. This increased land under production from 1/2 to 2/3 of village crop areas, a shift to a new land-use strategy from one that had existed for millennia. Second, external technology was introduced in the form of the moldboard plow, first invented and used somewhat earlier in continental Europe.
- New information – external ideas about what constituted farmer's obligations in terms of taxes and tribute came from the state. Ideas about new technology and how it should be applied came from other regions in Europe. In fact, the idea of taxation itself (as opposed to a less formal tribute) may have originated elsewhere in Europe and was quickly adopted by Danish central elites, especially after they conquered and ruled England in the 9th and 11th centuries, where such taxes were in effect much earlier in time (Sawyer 1986).

Per the initial discussion of what constitutes intensification and innovation, the use of more labor and manure to establish new, dispersed villages themselves and their increased croplands, cut out of land that had previously been used for extensive, pastoral production, exemplifies the use of internal, pre-existing resources in a more efficient way; the new fallow system shows the use of extant systems in a more rapid or cycled way, while the introduction of new plow technology, leading to more fertile and pest-free fields, introduced new, external ideas, technology and organizing principles into an extant agricultural system.

Contra Boserup, farmers were farming not for increased food, but for market value – to pay taxes in coin or in kind – with subsidies like fertilizer and new plow technology that dramatically increased yields and decreased pests. Farmers were clearly under duress to make surplus for new taxes, whether or not the labor input was "worth the effort". In many villages, for example, there are still field-names reflecting the effort of paying taxes and tithes: fields called *præståker, munckåker*, or similar, meaning "priest's or monk's field". Historically, we know these were not fields farmed by priests or monks, but areas that were farmed with shared village labor to pay the tithe that was first enacted during the Consolidation Phase.

Contra Boserup, population increases were not the driving factor – demographic change came in the form of rearranging people on the landscape rapidly, not as large increases in total numbers of people. This means that intensification, in general, was not focused on increasing production for food, but for political and economic reasons, related to the rise of a centralized political elite and the consolidation of the state's power over rural constituents. The new cities, where central elites' representatives were newly situated, reinforced this increasing power.

Our survey district of Järrestads Herred embodied the core/periphery relationship of Denmark and Scania in microcosm: local changes mirrored the larger context. It is especially evident that Scania was subject to inordinate pressure to raise yields to a maximum level, far greater even than other suitable regions, as well as unusually swift changes in settlement, involving alteration of long-term rural patterns.

Power, Agency and Conflict: Outcomes of Intensification in Scania

A final source of data that we have briefly mentioned above supports the theory that in Scania at least, agricultural changes were not all bottom-up entrepreneurship: indigenous chronicles (Palsson 1986), indicate that just after Consolidation became effective, on several occasions and at various places, the Scanians met with the king in the assembly in AD 1081, demanding that ancient obligations and entitlements be restored, and rejecting and refusing new taxes and increased military service requirements. When the king intimidated them by executing the loudest protesters, the Scanians quieted for a while, but in AD 1180, they demanded that "foreign" leaders be removed (core-area Danes), proclaimed independence, and elected a king from a pool of pre-state elite (Andersson 1947). After a series of slaughters called the Scanian Uprising, Scania lost its war with the Danes and was subject to whatever tax burden the king imposed at will.

Both protests and uprisings have roots in the Nordic/Germanic tradition, in which an archaic democracy operated via the assembly, or *ting*, and farmers were originally able to protest and sometimes over-ride the power of leaders. In fact, throughout the Viking Age, kings were "elected" at a national-level *ting* in the city of Viborg on Jutland, although in most later cases it was simply an affirmation of the heir apparent. Notably, however, there were occasions quite late in the period (i.e.

1074) when the former king's chosen heir was rejected by the public in favor of another. In addition, the view of the "Danes" as outsiders continued to be a perception of the Scanians, through the legacy of peer polity alliance vs. the centralized state, which was largely built over their heads during the Consolidation Phase, probably without the full realization of how this would later impact local power and agency. Finally, the tradition of rejecting or killing overbearing rulers was clearly still strong among rural Scanian lords and their followers at the time of the protohistoric uprisings. In the end, Iron Age institutional landscapes were overlain by a new system in which locals had far less power, and Iron Age social codes were replaced with centralizing ideologies.

Thy's Iron Age: Agricultural Conditions and State Formation in Northern Jutland

While convincing evidence supports widespread, state-sponsored landscape change in Scania, it is not clear that elsewhere in Denmark similar sequences occurred. Our regional project in Thy, North Jutland, has begun to reveal how elite and non-elite strategies differed across the state of Denmark. We are beginning to understand how Integration and Consolidation in this region diverged dramatically from Scania during the same relative time-frame.

As noted above, it is generally accepted that the region of Thy (pronounced "tew") was the region of origin for the Teutones (Jones 1987:21), one of the Germanic tribes that accompanied the Cimbri (from neighboring Himmerland in North Jutland), when they advanced on Rome in the first century BC, at the same time that other Scandinavians were on the move, such as the Langobards from Scania. Because of North Jutland's origin as at least two autonomous cheiflly polities (of the Cimbri and Teutones) in a purposefully decentralized system with the same corporate pre-state social ideology as Scania, we expected to find archaeological evidence that during the state-building process, Thy was resistant to the centralizing state. This hypothesis is supported by the protohistoric record: in the 1080's, at the same time that the Scanians were protesting new taxes and facing execution, 100 years *earlier* than the Scanian Uprising, the North Jutlanders also rejected the Danish king, invaded Denmark's core area with a large army, and killed him and his inner circle (Pahlsson 1986). The chronicles make it clear that this was their perceived right, because of dissatisfaction with new taxes and restrictive laws. One might hypothesize that such actions would bring reprisals from the state and reinforce the Jutlander's autonomy, prolonging their unification sequence. Yet it apparently did neither. Other than later chronicler's accounts of the Christian god's striking the king's enemies with various and sundry biblical-style pestilences (Christiansen 1980:90-91), no documentary or known archaeological evidence indicates retaliation, as there was in Scania a hundred years later, and soon after, the various groups on Jutland seem unified with Denmark. What was different about the nature of domination and resistance in North Jutland? What were the costs and benefits to each side? How did they differ from the balance found in Scania, where rich farmers and magnates were slower to disrupt their lives with warfare, yet had no use for the institutions of the state unless they were forced to accept them? How did 11th versus 12th century social conditions differ?

To answer this we look to many important interregional differences. North Denmark was *relatively* agriculturally poor; yet the region was of essential strategic importance, controlling the economically and militarily vital internal waterways of the Limfjord, and it bordered Norway, a nation that at various times both posed a threat to the Danes and was the target of Danish conquest. The construction of the Aggersborg fortress at a narrow, defensible strait on the Limfjord marks the importance of the waterway. Aggersborg is one of the largest of a series of state-built fortresses, all constructed simultaneously in about AD 980, which served not only as military outposts but as administrative centers with resident central elite. In addition, the probable presence of a state-built canal, not far from Aggersborg, leading to the strait between Denmark and Norway, indicates a monumental labor input. We also find the presence of levying-places where wartime fleets would gather. The levy-place called Skibsted fjord was, for example, not a small local levy place where the men of a single or a few *herreds* would gather, but a national-level levy spot, one of only a few others, from which large, gathered fleets would sail directly to England and elsewhere. This military and transport focus indicates North Jutland *did* attract elite attention during the state-building era, but for non-agricultural reasons. Scania too had a major levy-place at Falsterbo, which was surrounded by a large number of local export markets where the region's agricultural products were probably gathered: they were perhaps important for the provisioning of expeditionary forces. Scania also had administrative fortresses, but as the province did not serve a geographically strategic purpose other than to provide food and manpower for the armies, their focus may have been different. Skinner (1977) noted that methods of control are often predicated upon whether a region is a danger-fraught borderland with military concerns, or a bucolic region of farmers. The former needs more concerted administration and control, the former primarily needs tax-collectors, supported perhaps with a small force to remind taxpayers of the state's coercive power. Unlike the Danish fortresses, those in Scania do not show the same sort of internal militaristic order as sites like Aggersborg, Fyrkat and Trelleborg (Denmark). The fortress extensively excavated in Scania, Trelleborg (Sweden), where the author worked for two seasons, is primarily a large empty fortification, which may have served more as a tax-collecting locale rather than a military one.

Jutland also saw the development of trading places and urbanization with markets under central control as early as the 8th century, nearly 300 years before Scania's artificially introduced towns. Town trade generated wealth for some in North Jutland, and large areas of pastureland enriched great lords whose extensive livestock barns for cattle and horse have been excavated in several parts of Jutland. Even average farmers kept several cattle. However, grain production was far less profitable than in Scania. Poorer in cereal staples, locals may have seen advantage in a state urban/market system that the already rich Scanians did not see. The state certainly saw advantage in managing commercial harbors and towns, and there are many textual and archaeological hints that they collected taxes on trade in goods and livestock that it could not collect on grain, as it did in Scania, where the royal mill taxation monopoly collected large amounts of flour.

Agricultural intensification and the reorganization of villages seem to have been key strategies for exploiting Scania, aimed at increasing production in an already rich area, uprooting and changing local organization to make it more efficient. Is there similar evidence of land reform in North Jutland? Was it necessary? Although at a much lower density than in Scania, many new villages *were* established, albeit at the very end of the *torp* expansion, but did they have the same form and function as those in Scania?

Our survey area, Refs, Hassing and Hundborg Herreds, is a good representative sample of North Jutland since it has both a narrow strip of good farmland on the Limfjord side, and a large central to coastal heath on the Atlantic side, and so is Jutland in miniature. To understand local settlement dynamics and compare them with Järrestad, in a region were villages move across the landscape through time within a village territory, a large area, between .3 km^2 to over 1.5 km^2 was surveyed around each chosen settlement, beginning close to the early Medieval (current) village, and working our way out to encompass all prior versions of the village. Hypothetically there are 34 territories inside Hassing available for survey and several territories of special interest just outside of it. "Target" territories were distributed to focus on 12 within and 10 outside of Hassing Herred. This stratified sample included 50% of territories surrounding sites founded in the Preintegration phase, 75% founded in the Integration era, and 30% of Consolidation phase site territories (*torps*), in order to obtain a wide variety of data.

In each surveyed area, we found a complete or near complete series of sites dating from the village's foundation to the modern incarnation. Hassing village territory (Figure 7) is illustrated here. As in Scania, research questions for the Thy project are concerned with connecting *herred* and state by studying local political and economic organization during state formation in Thy: first, the state's role in organizing the local agrarian economy, and second, the changing control of political and economic institutions from local to non-local. After several years of survey and testing, we can begin to compare and contrast Hassing with Järrestad, Thy with Scania, synchronically and diachronically, especially between Integration and Consolidation.

As expected, at most sites investigated, we found typical settlement debris reflecting activities of cultivation, husbandry, food-processing, and household ceramics, while at some we found evidence of broader functions. We documented the growth of Hassing Village from perhaps 1-2 ha. in the Preintegration phase, to 2-3 scattered farms (about 5 ha.) during Integration, to a huge settlement of nearly 60 ha. by the end of, or just after, the Consolidation phase, possibly revealing it as a local administrative hub for central government by AD 1100-1200, an important indicator of when power relations were shifting. Today it is a very small village, the only indicator, other than archaeological, that is was once a center, is that the *herred* is named after the place.

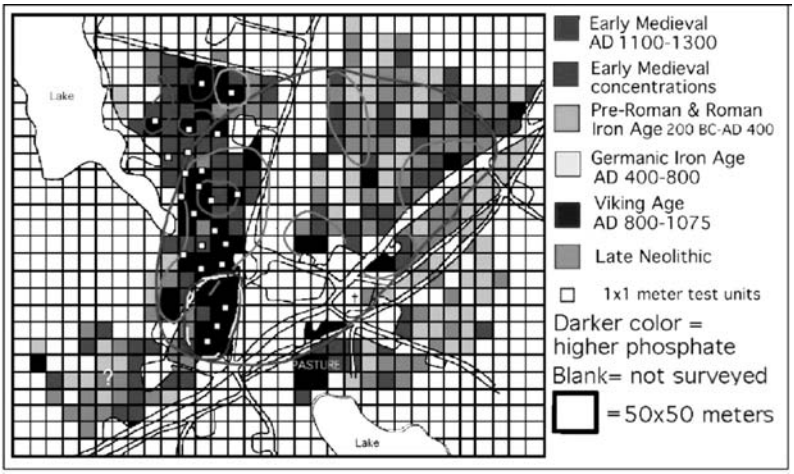

Figure 7. Hassing Village.

In light of the earlier findings in Scania, an important issue we examine in Thy is how villages were internally organized during the Preintegration period and how this changed in the Integration and Consolidation phases. This issue really encompasses two separate inquiries: first, did older villages undergo reorganization and regulation during the course of unification as they did in Scania? Second, were the new *torp* villages in Thy established at the same time and in the same way as in Scania, that is, around AD 980, at the end of the Viking Age, as pre-planned regulated sites? To answer these questions, we examined a number of individual farmsteads in the three phases. In Scania, during the unusual restructuring of the consolidation phase, older villages were internally reorganized, contracting toward the village street up to 60%, with excess population probably moving simultaneously to the new *torps* and towns. In previous large-scale studies in southern and central Jutland, which were parts of the state's original core area, instead of contraction, there was a shift of the village's location at the same time period.

We investigated clearly demarcated individual farmsteads at several villages and found that in Thy, many Viking Age farms directly underlie their early Medieval counterparts, showing continuity between the Integration and Consolidation Phases, rather than change: Medieval remains (AD 1100-1300) underlain by earlier farm buildings and a thick Viking Age culture layer.

In Scania, it is typical for *torp* villages to produce artifacts dating from the late Viking Age up into the Medieval and beyond. *Torps* in Thy have not produced any late Viking material, and do not seem to have been founded until around or after 1200. In fact, from investigations at numerous locales, it seems quite typical that around the time when *torps* were being founded in Scanian and the Islands, that new settlement activity in Thy occurred within extant, rather than new villages. Unique transitional ceramics, and houses of a style made with cut-turf "bricks" dating to the Consolidation Phase are found not in *torps*, but in these much older places. This is not only different than Scania, but different than southern Jutland which formed part of the state's core area.

This supports the hypothesis that Thy, while it did undergo later colonization with new *torp* settlements, was subject to less concerted interference from the central state in the control of local settlement and crop production during Consolidation. The later time-frame for new *torps* in Thy may reflect the region's possible success at putting off new taxes until a later date. It would seem that taxes, paid in grain and flour in Scania, were also ultimately unavoidable in Thy, but probably not paid in the same currency. The notion that North Jutland's *torps* may not have been meant for crop production at all is supported by the far larger number of *torp* village names on Jutland than in other parts of Denmark which incorporate the words for domesticated animals of all types – goats, sheep, swine, and cattle – like Gettrup, Farup, Svinstrup and Kovstrup. In Scania, *torps* are almost always called after a man's genitive, the name of its "founder" or for terrain features that describe their locale.

As noted, there are numerous archaeological indicators that cattle in particular were a major part of the Jutland economy in the Iron Ages: due to climate conditions, cattle were kept indoors in winter and foddered; excavated byres and barns, with stall divisions usually preserved, show unprecedented numbers of cattle kept even in small-holdings, and large market places like the Viking Age town of Ribe in central Jutland have produced archaeological strata made up of cattle dung many meters thick, suggesting that permanent stockyards were a major economic feature in these trading places. The main Viking Age roadway up the peninsula, parts of which are still preserved, had two names: *hærvejen* and *oksevejen* – the army road and the ox-road – clearly a major droving route for both warriors and cattle. Thus cattle and other animal intensification, at a somewhat later date, may have been a way for Jutlanders to pay increased taxes without having to intensify field farming.

On the other hand, it is possible that in part, the lack of interference seen archaeologically was not due to state disinterest in directly or indirectly pressing for more grain production, or the lack of arable land, but to local resistance. If they indeed did manage to put off their tax increases for several generations, how did they manage to do it? It is useful to examine the ethnohistoric record in more detail, to see how rural power and agency fared in North Jutland as opposed to Scania, where farmers complaining to the king in the assembly, as was their perceived ancient right, were executed in 1080 by the Danish king.

In 1086 the reigning king commanded that a large regional military levy be called in Thy, where local leaders, men and ships gathered to attempt a new conquest of England, at the levy place known as Skibsted fjord – the "place of ships". According to several chroniclers (Christiansen 1980:249), the king was detained by other business and failed to appear, and the army dispersed, as was traditional – a warchief could be abandoned by his men if found lacking.

During the Consolidation Phase, with a more powerful central authority emerging, their dispersal led to severe punishments. While several early historic texts have somewhat conflicting accounts, the ruler appears to have imposed a large fine on all captains who had abandoned the levy before his arrival, and even a heavy price was exacted from each oarsman. Other sources state that this was only part of the problem: the "unpopularity of the king's moral policy in general and on the rigour with which his servants collected his ordinary revenues (Christiansen 1980:251)". Magnates that were most heavily taxed may have asked the king's brother to represent their grievances, although this is confused in various texts; one way or another, the king's brother, who had the magnates' and farmers' support, was arrested and imprisoned.

Certain ethnohistoric traditions, which may or may not be factual, relate that the king traveled to North Jutland to confer with his tax collectors and ensure that the penalty was collected, and that some of his servants, upon their attempts to collect, were run through with swords – an event that according to the Knytlinga Saga occurred near Sjørring village in Thy. The various texts also indicate rebellion fomenting in other parts of northern Jutland. A large army gathered, and led by local elites, marched down the peninsula after the retreating king. They found the king taking refuge in a church with his bodyguard, and killed him and most of his warriors. Saxo Grammaticus, who wrote of the assassinated king as a martyred saint some 100 years after his death, admits that "…the people exulted over the slaughtered king…and coloured it in the name of tyrranicide (Christiansen 1980:86)." Although there is no indication that the king's brother was in any way associated with the rebellion itself, which was led by northern elites, the North Jutlanders had positioned themselves together with him by asking him to represent them to the king in an appeal to lift the tax. Since traditionally, brothers, and not sons inherited kingship first in Denmark, his brother was soon made king in his place; thus their payoff may have been a reprieve from the taxes they had been protesting in the first place. The success of the popular rebellion may have also prompted the new king to back away from further demands.

Comparing the successful Jutland rebellion with the failed synchronous protests and eventual failed revolt of the Scanians, 100 years later, what can we say about changing social conditions between the 11th and 12th centuries? The Scanians, when they protested new taxes, yet failed to revolt in 1080, were wealthy and comfortable, which may have made them far less motivated to jeopardize their lives and livlihood. The North Jutland lifestyle was hardscrabble, and several sagas note the "hardness" of the people there. Thus, despite the fact that both areas had been independent polities who wished to retain autonomy, the social and economic conditions differed enough to prompt divergent courses of action in the face of domination by the state.

Perhaps equally important as the state's experimentation with managing its regions, is the effect of this early North Jutland rebellion on the course of later state development. Political scientist James C. Scott gives insight into the sequence when he writes

> "...for all their importance when they do occur, peasant rebellions – let alone peasant revolutions -- are few and far between. The vast majority are crushed unceremoniously. When, more rarely, they do succeed, it is a melancholy fact that the consequences are seldom what the peasantry had in mind...they also typically bring into being a vaster and more dominant state apparatus that is capable of battening itself on its peasant subjects even more effectively than its predecessors (Scott 1985:xv-xvi)."

It is possible that the North Jutlander's rebellion, while freeing them from forced reorganization and disruptive intensification schemes, and may have forestalled their own tax increases, actually helped ready the state against the coming uprising of the Scanians.

Along more political lines, agricultural intensification and settlement reorganization in Scania, in addition to increasing the wealth of the state, also served a less obvious purpose, the dismantling of traditional rights accorded farmers and the substitution of an authoritarian central government. Rulers far beyond the borders of Scania could create embedded administrative nodes among the formerly unmanageable rural communities, once they had established an urban infrastructure during consolidation. In their weakened position of power, long coopted in many ways by the government, the Scanian attempts at uprising were crushed by a state which had learned, as Scott suggests, from its earlier failure to decisively and ruthlessly manage dissent in North Jutland, and the civil order of traditional society was turned upside down for most of the second millennium.

It is interesting that this sequence, which formed a large part of the inspiration for Boserup's theory of agricultural growth and change, can be reanalyzed in a new way at this time. While the changes in fallow systems and labor allocation that influenced her reasoning did indeed occur, the non-demographic developments behind it, such as the economic and political relationships between local and non-local interests at this time of enormous social change, were largely overlooked, not only by Boserup, but by the archaeologists who quickly endorsed the theory. Perhaps in the more naïve historical imagination of the 1960s, European yeoman farmers could easily be idealized into an indiscriminately reproducing, apolitical mass entity. It should be seen as a positive sign that our discipline has become more discriminating about assigning causality based on intuitive reasoning without supporting data.

As I have discussed previously (Thurston 1999), Klavs Randsborg noted quite long ago (Randsborg 1980) that bureaucratic control in Denmark was ultimately useless without power, and while power can be promulgated through ideological manipulation it ultimately must be bolstered by force, paid for through economic institutions. It is true that during the Consolidation Phase, up to and including the time of the regicide discussed here, bureaucracy, political economy, power and coercion were interwoven in the segue from the Iron Ages to the Middle Ages. In 1080, kings had one foot in the world of their weak ancestors and one foot in a new social order. The enforcement of new policies, based on strict legalities and punishment with death, marked decisively the completion of a trend that began long before. Yet resistance was high – not only the king killed during the 1086 uprising, but several of his descendants were removed from the throne by popular and elite-led assassination. While some of the events described in sagas, ethnohistories, and various other early texts may be confused or fictionalized, it is clear that they either recount or symbolize a long erosion of rural and local autonomy, and attempts to combat it, as farmer-soldiers and royal tax-collectors negotiated changes in ancient laws and agricultural organization. The archaeological signs of disproportionate, yet concerted efforts at intensification, as well as some of the remarkable landscape changes executed unevenly across the region, reflect this era of change. In Scania, producers seem to have experienced the greatest amount of reorganization: they were moved across the landscape like game pieces during the Consolidation Phase, were threatened and executed in the 1080s, then disposed of in all-out warfare in the 1180s. In Jutland, only a few years after the Scanian's first protests, local, rural constituencies resisted successfully; they experienced far less meddling in local settlement and farming. Differing levels of resistance and submission to central authority, and differing state perceptions of the value and exploitability of resources found in these highly different areas, may be the key to understanding the variations in the course of political and economic integration during state formation and consolidation during this era.

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COD FISH, WALRUS, AND CHIEFTAINS:

Economic intensification in the Norse North Atlantic

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INTRODUCTION

Just over a thousand years ago, Scandinavian voyagers crossed the grey waters of the North Atlantic to briefly explore the coast of North America. These now well - publicized transatlantic trips were part of larger economic, environmental, and social developments of the Viking Age, and were the product of an Iron Age chiefly society with a complex economy incorporating both classic "prestige goods" and "staple goods" components. The Viking Age expansion was the result of linked factors of economic intensification, military and technological advances, climate change, and intense competition among chiefly elites and between elites and commoners. The period saw escalating Nordic impact upon North-West Europe and a dramatic expansion of European settlement into the offshore islands of the North Atlantic. This paper will focus upon the economic development of two of the most western of the Norse Atlantic settlements, Iceland and Greenland, and seeks to bring fresh data to bear on the knotty problem of pre-state economics. In both examples, complex political and economic structures were supported through intensification in both domestic consumption and export to European markets. The particular resources, terrestrial and marine, domestic and wild, that were the subject of intensified economic effort differed in Iceland and Greenland. We examine the production and utilization of these resources and effects that changing demand for these products entailed for the fortunes of the Norse settlements of Iceland and Greenland, and for their would-be magnates. We are fortunate to be able to draw upon new work by many scholars

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in several disciplines through the research cooperative of the North Atlantic Biocultural Organization (NABO), as well as new zooarchaeological and locational evidence.

BACKGROUND: THE VIKING AGE

The Viking Age traditionally begins with the well documented raids on monastic centers of early medieval literacy in the late 8th century AD, but Scandinavian merchants, mercenaries, and pirates had long been active in the North Sea, Baltic, and the river routes to the steppe khanates of central Asia (Jones 1985). For at least a century before the first recorded attacks on the monasteries of Northumbria and Ireland, wealth had flowed into South Scandinavia. Massive amounts of silver were being deposited in graves and hoards all over Scandinavia which lacks any local sources. Trading emporia in what is now South Norway, Denmark, and South Sweden attracted literate visitors from Latin, Byzantine, and Muslim worlds, and rich burials in the lake Malaren area (South-Central Sweden) provide archaeological confirmation of the written accounts picture of prosperous, turbulent, and adventurous, if uncouth and heathen, entrepreneurial society awash in imported goods (Sawyer 1982). Central Asian silver, Baltic amber, Mediterranean glass ware, Irish bronze and gold as well as a small bronze Buddha probably from North-West India, all appear as grave goods in burials of well traveled elites in these pre-Viking entrepots (Hedeager 2000). As several art historians have noted, Viking age jewelry and ornamental metal work is both more widespread and often also less technically precise in its craftsmanship than the limited distribution high quality work of the earlier Vendel age (Graham-Campbell 1996). Some commonly occurring ornaments like brooches and belt hardware were clearly mass produced from common moulds- lower priced knock offs of the designer interlace decorating royal objects. A wider range of consumers were able to afford items of decorative metalwork and were bold enough to flaunt these highly visible marks of wealth and status. Late Iron Age Scandinavia was enjoying an economic boom, probably further enhanced by a period of relatively warm and stable climate punctuated however by some colder episodes (Hughes & Diaz 1994, Ogilvie, Barlow & Jennings 2000, Ogilvie & McGovern 2000, Ogilvie & Jonsson 2001, and McGovern 1991). Settlements appear to have expanded in many areas, moving up mountain valleys and into former woodlands, and surplus labor was clearly available for the construction of massive earthworks, roads, bridges, and causeways across marshes (Randsborg 1981). At the same time, steady improvements in ship building produced the wide range of elegantly designed sea going ships now well documented by maritime archaeology (Christensen 2000). Less well understood advances in Scandinavian navigational skills allowing for long voyages out of sight of land had probably an even greater impact, a breakthrough in seamanship with both peaceful and warlike applications (Víhjalmsson 2001).

In arctic Norway, powerful chieftainships grew up on the Lofoten and Vesterålen islands during the late Iron Age, creating a power center that was to long contest primacy with the expanding petty kingdoms of Western and Southern Norway. These northern islands held huge boat houses, extensive farms, and at least one huge feasting hall at Borg equipped with imported gold and glass that must have rivaled any similar structure below the Arctic Circle (Munch & Johansen 1987). While the warm currents of the North Atlantic drift allow some barley growing in these offshore arctic islands, most barley production was probably reserved for beer rather than porridge and the majority of the diet was supplied by meat and milk of domestic stock, birds and bird eggs, sea mammals, and especially the abundant stocks of marine fish, whose spawning grounds surround Lofoten and Vesterålen. These rich fishing grounds but rather marginal grain growing potentials apparently gave rise to an intensive winter fishery for cod, haddock, and other cod-family (*gadid*) species. Gutted and beheaded, these gadids could be preserved for over five years without salt by a process of air-drying on racks set up on windy points. While fish size (ca 65-110 cm length) and narrow temperature range during curing (+/– 1 degree C) had to be carefully controlled, the resulting *stockfish* provided a high-protein storable staple product that could be consumed locally, employed in redistributive strategies, transferred as tribute or debt payment, and used in inter-regional trade. Stockfish production seems to have been well underway in arctic Norway by at least the later Iron Age (Perdikaris 1999). This early fishing economy was to have a major role in the North Atlantic islands during the Viking expansion.

However, dried fish was far from the only product handled by Nordic entrepreneurs. A frequently cited account by a North Norwegian chieftain, Ottar, was recorded in the court of King Alfred of Wessex in the 10th century and provides a description of chiefly economics, mentioning income from “tribute” collected regularly from the Saami, reindeer farming, whaling and walrus hunting (Lund ed 1984). A wondering Anglo-Saxon scribe noted that this North Norwegian chieftain owned far fewer cattle than any respectable thane of Wessex, but was “accounted wealthy in his own country”. As King Alfred knew all too well, Nordic seafaring skills allowed for the acquisition of wealth from raiding, protection racketeering (Danegeld collection), and large scale slaving as well as fishing and maritime trade. In the three centuries between AD 800 and 1100, Iron Age Scandinavians became major players in the royal politics of North-West Europe, and for a brief period in the early 11th century a single Scandinavian dynasty controlled most of England, Denmark, and Norway. Several scholars have argued that the escalating raids and massive wealth generated by Viking activity contributed greatly to social changes that eventually promoted stable monarchies in Scandinavia and thus contributed to the demise of chiefly Viking-age politics in Denmark, Norway, and Sweden by AD 1100 (Randsborg 1981).

During the same period, Scandinavian settlers also colonized the islands of the North Atlantic. The islands of the eastern North Atlantic (Faeroes, Shetland, Orkney, Hebrides, Man, and Ireland) probably saw substantial Norse settlement soon after AD 800. Further west, Iceland was traditionally settled ca. AD 874, Greenland ca. 985, and the short lived Vinland colony survived a few years around AD 1000 in Newfoundland/Gulf of St. Lawrence region. Around AD 1000 a common language and culture stretched from Bergen to the St. Lawrence, and colonists drawn from both Scandinavia and the British Isles were attempting the dangerous business of Landnám (land-taking, first settlement) over a diverse range of island ecosystems. Some of these Landnám attempts were to fail rapidly (like the ill fated Vínland colony), some (like the Earldom of Orkney) were to prosper greatly in the Middle Ages, and others (like Norse Greenland) were to become extinct after hundreds of years of apparently successful economic and social adaptation (for reviews see McGovern 1990, 2001, Bigelow 1991, and Morris & Rackham 1992). Iceland endured profound environmental degradation, climate change, epidemic disease, and foreign rule and survived while producing the impressive written vernacular corpus of law codes, histories, hagiographies, and sagas that provide such unique participant's view of N Atlantic chiefly society and its transformations (for discussion of these sources see Vesteinsson 1998, 2000). This rich literature is an invaluable resource, but it has some flaws from the economic perspective. None of the sources are contemporary with the Viking Age, and most report events occurring 200-300 years before their date of composition (Vésteinsson 2000a, b). More seriously, the focus of these works was upon the doings and sayings of important men and women. The details of every day life and much we would like to know now were then deemed too commonplace to record. Fortunately the impressive expansion of archaeology and environmental science in the region over the past two decades has provided much of the basic economic information only indirectly hinted at in the saga literature.

VIKING AGE POLITICAL ECONOMY

The economic basis of the Viking expansion has attracted a growing body of scholarship, increasingly based upon a rich archaeological record (Durrenberger 1989, 1992, Hastrup 1985, McGovern 1985b, 1992, Perdikaris 1990, 1996, 1998, Vesteinsson et al. 2002, Barrett 1995, Barrett et al. 1997, 2000, Amorosi et al. 1996, Bigelow 1984). As Thurston's work (this volume, Thurston 1999) illustrates, economic power, military power, religious authority, and competitive display were interlocking elements in elite strategies for aggrandizement- and key points of friction with the long established leveling mechanisms of Iron Age Germanic society. A widespread heroic ethic stressed the importance of competition for glory, search for personal and family honor, sanctity of vengeance, and the ability to provide for clients and kin. An ideal Iron Age/ Viking chieftain had sharp elbows and a quick temper, expanded his holdings opportunistically, defended his own aggressively, and was always ready to reward loyalty with silver and treachery with iron. While ancient aristocratic lineage was an important element of chiefly power, newly acquired wealth and fame could also easily promote or topple individuals and families. Combined with leveling mechanisms that tended to make paramount kingship a dangerous and short career path (Thurston 1999), this ancient North-West European social structure generated a great many ambitious but unfulfilled actors at many social levels looking for an angle and leverage. These are the characters we probably meet in the Arabic accounts of Scandinavian (Rus) slave traders on the mid-Volga, and most certainly meet in the adventurous *drengs* (variously translatable as "stout lads" or "good old boys") pulling the oars in the early 30-40 man raids on vulnerable monastic centers in Atlantic Europe. They were not all aristocratic, but all aimed to become rich enough to marry, obtain some flashy jewelry for the girls at home, start a lineage, and (fates willing) plot to replace the local chieftain or set up on their own someplace new. While their allegiance would be valued by any rising chieftain, such individualistic actors were hardly a stabilizing influence in a context of rising opportunity and improving access to power for the bold and ruthless.

As more wealth (from whatever sources) flowed into this competitive and decentralized society, it was as likely to provoke more intense jockeying for power, resources, and followers by a wider range of potential chieftains as to promote the creation of a successful state administered by a few hereditary lords. As shipbuilding and seamanship improved, initially small scale trading and raiding ventures (in multiple directions) provided wealth not directly tied to long standing patterns of land holding, and not always easily captured and channeled by traditional elites. The new lands in the islands to the west likewise provided an expanded range of options for aristocratic ambition, refuges for losers in chiefly competition, and a fresh start for people of all ranks. This open frontier to the west may have absorbed many troublesome characters impeding royal ambitions, but it also provided alternative power bases potentially dangerous to mainland Scandinavian authorities. While the eventual outcome of the Viking Age may have been centrally administered, literate, Christianized states, the early Viking Age was certainly a much more turbulent and dynamic period, destabilized rather than ordered by new wealth and improved technology.

Prestige Goods Economy

As Gelsinger (1981) noted, Viking age chiefly economics was ultimately not about money, but about honor and power. Wealth generated from successful farming, intensified fishing, loot, trade, or protection-selling was not an end in itself, but a means to acquire the key elements of chieftainship - well armed retainers, loyal clients, fine clothing, jewelry, weapons, exotic objects for display and award, spectacular architectural settings for glorious feasts and impressive ritual moments. Wealth without chiefly power was a dangerous possession, and several Icelandic sagas recount how commoners or minor chieftains who acquired wealth and the trappings of elite status (but neglected to collect enough well armed *drengs* in the process) were rapidly relieved of these inappropriate burdens by more powerful men better able to make use of them. Evil dragons and short lived misers hoarded riches, but successful chieftains were founts of generosity bestowing carefully graded jewelry, clothing, and fine weapons on supporters ("ring-giver" and "hoard foe" are repeating positive epithets in surviving skaldic elegiac poetry). This skaldic vision of the ideal chieftain thus has stood as an icon of the pre-state "prestige goods" economy based on the acquisition, display, and exchange of rare, rich, and expensive items (Carneiro 1981, Earle 1987, 1991, Feinman & Neitzel 1984). While there is no question that the prestige goods which figure so strongly in the saga accounts played a critical role in the new chiefly societies of the North Atlantic, current archaeological evidence indicates a more complex interaction between subsistence production, prestige goods, and exchange.

Economy of Landnám

The work of the past two decades by many scholars has generated a substantial and growing number of fully quantifiable animal bone collections (archaeofauna) from sites across the North Atlantic (McGovern et al. 2001). Figure 1 presents a selection of these data, arranged in approximate chronological and geographical order from earliest (Åker, Norway) to latest (GUS, Garden under Sand) in Greenland. The site of Åker near Hammar in Eastern Norway is an extremely rich magnate farm, and its archaeofauna arguably represents the socially and economically ideal stock mix for chieftains of the Viking Age: many cattle, many pigs, some sheep and goats (together termed "caprines"). In South Iceland, the ideal mix was relatively smoothly transplanted, with the early (probably elite) collection from Tjarnargata 4 under modern Reykjavik showing close similarities to the Norwegian magnate farm collection. In more arctic North Iceland, conditions were far less like South Norway, but the probably mid-ranking farmer at Sveigakot (SVK) managed a respectable proportion of both cattle and pigs in the late 9th century. At Sveigakot, the early layers show substantial proportions of goats as well as sheep in the "caprine" category. A growing number of large (1,000 – 15,000 NISP) archaeofauna from nearby 10th century sites in North Iceland show a range of strategies, and considerable fluctuation in the mix of domestic animals between sites and between phases of the same site. By the 11th-12 centuries, comparative stability returns, pigs have become rare in the collections, cattle are generally reduced in relative proportion, and the caprine category is dominated by sheep. This pattern was to continue into late medieval modern Iceland, with a tendency for cattle to further decline relative to sheep on most sites (McGovern et al 2001). Thus by the time Greenland was settled from Iceland ca AD 985 (just over 100 years after the Icelandic Landnám) the most common mix of domestic mammals had changed considerably from the cattle and pig-rich ideal farmyard of Åker. However, the Greenlandic settlers did not import their contemporary Icelandic farmyards to the new (even more arctic) home, but again attempted a mix of domestic species strongly reminiscent of the old country ideal (especially at the elite site of W51 Sandnes). Unsurprisingly, pigs rapidly became extremely rare in Norse Greenland,and early and on most sites cattle decline relative to sheep and goats in later layers (McGovern 1994, 1985, Enghoff 2003). Clearly social rather than purely biological factors are behind the patterns in the domestic mammal bone collections in this period.

While domestic mammals imported from Europe formed a core of the Landnám economy in the North Atlantic, local wild species provided a vital supplement to subsistence economy and a source of trade goods. As Figure 2 illustrates, if we expand our view of the same Settlement Age archaeofauna compared in Figure 1, we gain a better appreciation of the comparative role of domestic mammals, wild birds, mammals, mollusca, and fish. The developed chieftain's farm at Åker in East Norway made some use of birds and fish (both freshwater and marine), but the vast majority of the archaeofauna is composed of domestic mammal bone. This was not the case in the two 9th century South Icelandic sites Tjarnargata 4 and Herjolfsdalur, where birds make up 60-75 % of these archaeofauna. This pattern probably reflects

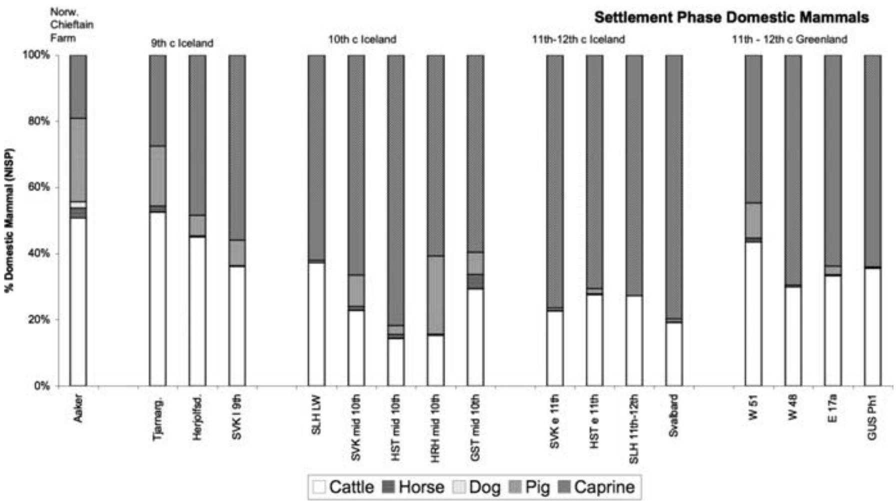

Figure 1. Domestic mammals in Norse settlement phases.

initial human impact upon nesting seabird colonies previously not subject to human predators, leaving the birds "unwary and easily killed" as later sagas recalled (see Vesteinsson et al. 2002). In North Iceland, freshwater fish and birds are the only major supplements, though as we will see their species and element distributions raise some important economic questions. A few walrus bones (ribs and long bones) were recovered in the Tjarnargata 4 excavations in downtown Reykjavik, including a few from newborn walrus too small to swim far. The discovery of three complete walrus tusks in the very early long hall at Aðalstraeði a block away in 2001, and the documentation of a number of walrus-element place names along the Reykjanes peninsula further contribute to the impression that there was a resident walrus colony in South-West Iceland at Landnám. The tusks show marks of their extraction from the dense maxillary bone, but all three were successfully removed without major damage (McGovern in Roberts and Snaesdottir in press). In the 10th – 11th century archaeofauna (all inland sites from North Iceland), freshwater and marine fish, birds and small amounts of marine mammal bone (seal and porpoise) make up a highly variable portion of the existing archaeofauna. By the 12th-13th centuries, both inland and coastal Icelandic archaeofauna are increasingly dominated by marine (especially cod-family) fish, which often make up 70-80% of late medieval and early modern archaeofauna (Amorosi 1996, Amundsen 1999,2004, Amundsen, Perdikaris *et al*. 2004). Locally available wild species of animals and plants thus provided an initial "natural capital" (in the sense of Cronon 1997) that could potentially underwrite economic and social agendas based upon control and expansion of the imported domesticate economy. This natural capital like any bank account could be left untouched, totally expended in a short period, gradually expended over a long period, retained for emergencies, or managed for a sustainable long-term yield.

ICELANDIC FISHING: SUBSISTENCE, LOCAL EXCHANGE, COMMODITIZATION

In Iceland, while grazing land was finite and subject to reduction through erosion or climate change, marine fisheries provided far greater scope for intensification. The increasing focus on marine fishing evident in the later archaeofauna was to produce a complex pattern of economic intensification and social reaction. In early medieval times, fisheries were apparently managed both locally and regionally, with great magnates and churches owning fishing rights in distant parts of the country (Edvardsson 1996, Vésteinsson 2000). In later medieval and early modern times, agrarian elites became increasingly concerned about the social effects of semi-permanent fishing stations and proto-villages developing independent of the cattle rich landed aristocracy, and efforts were made to curb these unruly settlements and closely regulate access to imported goods, effectively reining in further intensification of fisheries until the 19th-20th centuries. It appears that social stratification, intensification of fishing, and control of overseas trade were closely interacting variables, and all were tied to changing relations between humans and fish. It may be useful to consider more broadly how the intensification of fishing and the economic and social role of fish and stockfish changed through time.

The transformation of gadid fish in the depths of the sea into a processed product that could be stored for later consumption was the result prehistoric technology and skills probably long pre-dating the Iron Age. This reflects a simple dietary use described by Cronon (1997) as a product of “first nature”- direct interaction between product and producer. The assignment of value to this ancient preserved product and its assimilation into local level redistribution and exchange was probably an Iron Age development (Perdikaris 1998). In the Middle Ages (after ca AD 1100) this local product became far more widely traded and acquired considerable value in an

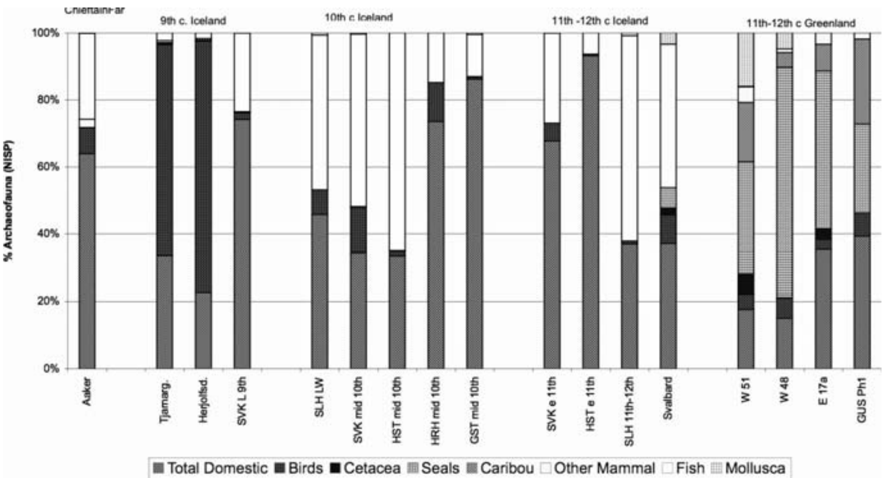

Figure 2. Wild and domestic animals in Norse settlement phases.

emerging international system of banking and credit. The difference between the Iron Age and the medieval times lies in the focus and scope of the processing and exchange activity as well as the nature of the controlling elements. In both eras, elites were changing fish into objects of abstract value (Cronon's "second nature"). In the Iron Age fish was transformed into chiefly prestige by facilitating the purchase of barley for beer making, exchanged for getting furs that were then traded for luxury items in distant ports, and was of course used for feeding people both at home and during voyages (Perdikaris 2000). All these transactions had the ultimate product of "honor", prestige and lineage power. In medieval times the transformation was of a different nature. It was no longer aimed mainly at acquisition of prestige useful for local and regional competition with other chieftains, but rather aimed at acquiring coined fully monetized cash that could be spent anywhere by anyone. A fish thus did not just change from an individual item of food into an object of value (first to second nature), but was further altered to become an abstract and standardized commodity (a third order abstraction). Its value as a commodity went beyond the local/regional level to truly international scale by the high Middle Ages.

The medieval transformation of fish is a more profound transition than the one observed in the Iron Age. During the commercialization era, 12th—13th century AD, local power was not autonomous any more in North Norway. The king and church were now the ultimate power foci. Taxation and tithes were to be collected by the state for the state. Profits driven through intense fishing became a domain of the new centralized government. The growth of trading places and towns during this period expanded the physical settings for impersonal proto-capitalist exchange, and the spread of coinage and monetization broadened familiarization with ideas of abstract value and impersonal transfer (Randsborg 1981; Hodges 1982, 1983). Medieval kingdoms were usually small, courts and wars were expensive, and agricultural tribute income was often hard to predict, collect, and convert to cash. A product that could be directly and reliably converted to cash, and which could be further pledged as security for loans against expected future production, was thus immediately attractive. Management of surplus and extraction of natural capital moved from the hands of local lords to the hands of the state. During the high Middle Ages, the Nordic states rapidly converted gadid fish into armies, art, architecture and a persistent pattern of indebtedness to German bankers ready to lend money in exchange for fish not yet caught.

This transformation of fish to a monetary commodity requires imposing standardization on an inherently variable product. Neither fishermen nor fish are in fact totally interchangeable units and the loss of identity and the social links of honor, family, land, place, genealogy and personal skills, that were so critical to economic transactions in the Viking Age required some profound conceptual reordering of first and second nature. Today we are used to standardized products such as wood, bread, cheese (all often now packaged in shrink-wrapped plastic). By the use of these words we think of interchangeable standardized items and can buy, sell, and borrow against them as abstract and standard units without ever touching tree, wheat, or milk. Even though standardized, they are still affected by the first nature of the raw material and the individual skill and ability of the person who transformed them from tree, grain, milk, to salable product. This transformation of variable, individual fish to a standard

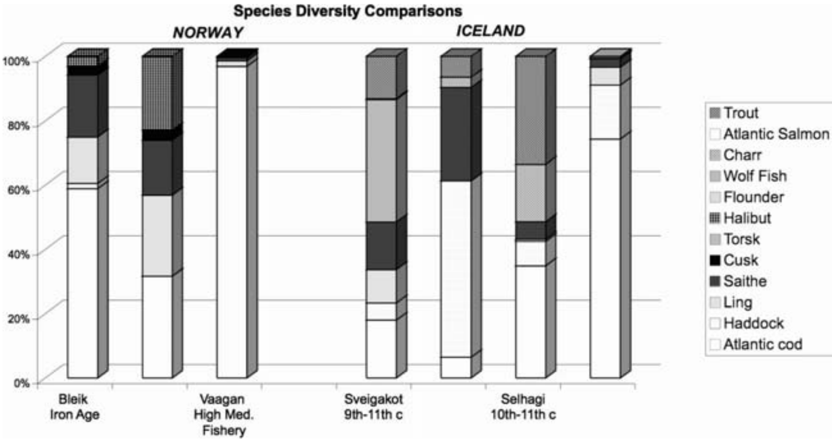

Figure 3. Comparisons of species diversity.

product of specific weight, length and standard processing, was not only one of the first such transformations that are part of everyday modern life, but one of the most significant ones, as it provided a model for many subsequent transformations in the AD 17th-19th centuries. The connection of *commoditization* to *standardization* of a variable natural product makes it possible for us to create a set of archaeologically visible indicators that enable us to use zooarchaeology to track some of these changes through tiime.

Signatures of Commoditization: Species Diversity, Body Size, Element Distribution

Species diversity of fish landed depends upon many factors besides the natural patterns in the sea: different bait, gear, boat type, and seasonality of fishing effort will all affect the species and age-classes taken, but in most cases fishing effort aimed at one species usually catches a wider range ("by-catch" is a major modern issue in fisheries conservation). It is thus not easy to take only one or two species of fish in a given catch, and a "natural" landing pattern will show fairly high species diversity. Where archaeological deposits show a reduction in fish species diversity to focus upon one or two target species we are thus seeing human economic selection more often than environmental change. In north Norway gadid species diversity in excavated archaeofauna drops dramatically with the full commercialization of the high Middle Ages as preserved fish products shift from an artisanal product exchanged locally as an element of natural capital in socially embedded trade and tribute relationships (a product of "first nature" in Cronon's terms) to becoming a standardized commodity of known size, weight, and ranked quality that could be bought and sold in counting houses distant from the actual process of fishing, butchery, and curing (a product of "second nature"). Figure 3 compares the fish species diversity at two Iron Age sites in North Norway (Bleik and Toften) with an archaeofauna from the high medieval fishing center at Vågan in Lofoten, and also compares the fish species diversity at the Landnám period phase at the North Icelandic sites of Sveigakot and Selhagi near Lake Mývatn with a large (NISP 60,000+) 18th-19th century deposit from Tjarnargata 3c in downtown Reykjavik. In the Norwegian case, the transition to a simplified, cod-dominated bone collection is clear and dramatic. In Iceland, the early settlement period sites mirror Iron Age patterns in the Norwegian homeland, with the addition of substantial amounts of locally available freshwater salmon-family fish (brown trout and charr). The early modern urban collection from Reykjavik seems to be a mix of cod and haddock, both commercial species during the early modern period, though the haddock also seems to have been locally consumed as fresh fish (Perdikaris et al. 2001).

While gadid fish grow throughout their lives and form age/size classes with different niche requirements, only a restricted size range of fish is useful for making dried fish. The “stockfish window” is between ca 60 cm and 110 cm live length: smaller fish desiccate and larger ones tend to rot. Where measurable elements are present in sufficient quantity, regressions allow reconstructed live length to be compared. Figure 4 compares the distribution of measurable cod mouth parts at the small island farm of Miðbaer on Flatey with the distribution of the early modern collection from Reykjavík. While the Reykjavik cod appear to be solidly within the stockfish window, the distribution of reconstructed length of the cod from Miðbaer suggests subsistence consumption of smaller individuals as well (Perdikaris et al. 2001, Amundsen in press).

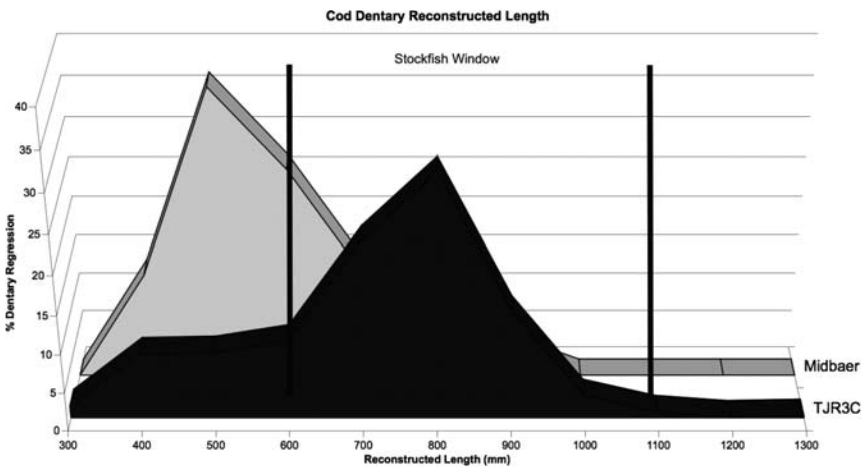

Figure 4. Cod dentary reconstructed length.

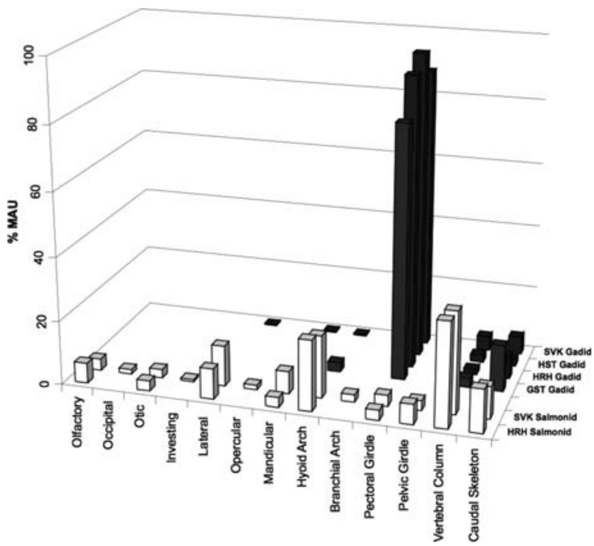

Figure 5. Element distribution.

Element distribution analysis has become increasingly feasible as reliable characters for species level identification of both cranial and axial fish skeletal become available. Figure 5 illustrates one such comparison between the distribution of gadid (cod-family) with salmonid (trout and charr) at four settlement period inland Viking Age Icelandic sites near Mývatn. In each case there is a consistent pattern-the salmonids are represented by virtually all skeletal elements, but the gadids are mainly represented by bones from the pectoral girdle (especially the cleithrum) and the lower (caudal) vertebrae. Gadid cranial skeletons produce a set of dense mouth parts that generally preserve well and are immediately identifiable, but these are completely absent in these early inland sites. This element distribution is consistent with a fish preparation strategy that removes and discards the head at the processing point but leaves the cleithrum attached to the exported body to help keep the fish carcass together and to aid in spreading the body cavity for drying. This retention of the cleithrum with the exported body is seen in ancient as well as modern Norwegian stockfish production. A marked difference is in the distribution of the upper (thoracic) vertebrae. In stockfish these elements are left in the exported fish body, as stockfish is left in the round and virtually the whole vertebral column travels as a unit. Figure 6 contrasts the distribution of cranial and axial bones of cod (bodies exported, heads retained) and haddock (both heads and bodies deposited locally) at the early modern site of Tjarnargata 3c, illustrating the contrasting commercial and subsistence patterning in these elements expected from the residue of stockfish production and export.

In Viking Age Northern Iceland however, the fish were processed differently than they were to be in later times. They were beheaded, gutted and then the thoracic

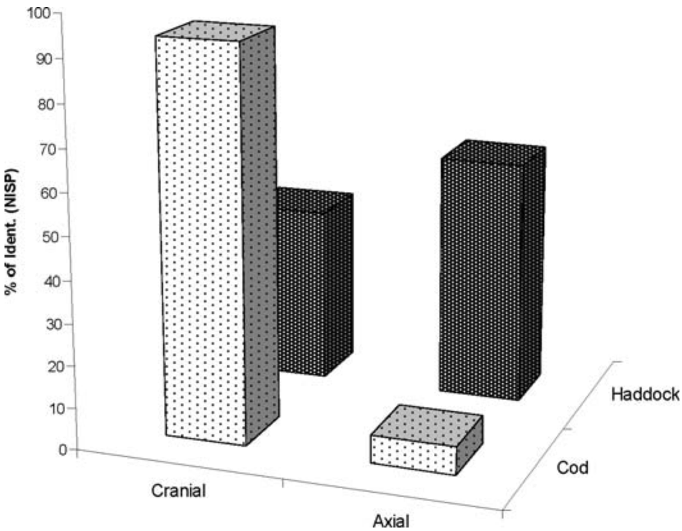

Figure 6. Tjarnargata 3 C.

and precaudal vertebrae were removed, apparently during splitting and opening of the body into a flattened form. Ethnohistoric evidence suggests that in South-East Norway where the climate is warmer and wetter than Northern Norway and stockfish cannot be reliably produced, a flattened dried fish was produced. However, the closest zooarchaeological parallel to the pattern of gadid distribution in Viking Age Mývatn is in the Northern and Western Isles of Britain where solid evidence for intensified Viking period fishing and at least local level exchange is becoming increasingly well documented (Barrett et al. 2000, 1997, Barrett 1995, Bigelow 1984). Since we know that many early Icelandic settlers were from the British Isles (both slaves and aristocrats), this similarity may warrant more extensive investigation.

In any case, the Viking Age fish bone collections from sites up to 70 km from the sea indicate that some sort of regular mechanism existed to bring fish (and marine birds and a few sea mammal bones) far inland to consumers (McGovern, Perdikaris, Einarsson & Sidell in prep). The combined signatures of high species diversity and specialized element distribution indicate the robust existence of a regional premodern, not yet fully commoditized staple goods economy involving fish and possibly other wild products. The early establishment of this network underlines both the importance of wild species in supporting subsistence and the importance of such mundane bulky items alongside the more saga-worthy fine cloaks and decorated weapons in Viking Age Iceland.

ECONOMIC PATTERNS IN NORSE GREENLAND

In Greenland, a very different mix of wild species greeted the first settlers. Caribou were present in both the settlement areas colonized (Eastern Settlement in the far South-West, Western Settlement in modern Nuuk district further North). Caribou were hunted in a variety of ways by the Norse, as upland drive systems, caches, crossbow bolt holes in caribou crania, and the widespread presence of large long limbed dogs (most similar to the modern Norwegian Elk hound) suggest (McGovern & Jordan 1982, McGovern 1985). Caribou bones are found in all archaeofauna, with the greatest concentration on high status sites and on inland sites near modern caribou hunting areas (McGovern 1994, Enghoff 2003). Analysis of element distribution suggests that meat rich upper limb bones were differentially transported from upland kill sites to the chieftain's farm at W 51 Sandnes (McGovern et al. 1996). Though caribou were rapidly hunted out in the Eastern Settlement area by Inuit hunter-gatherers after the introduction of firearms in the 19th century, caribou were not driven to local extinction in either settlement area in the Middle Ages despite the much greater density of permanent settlement in the core grazing areas and the competition of domestic sheep and goats. Some social factors prevented this particular tragedy of the commons, and allowed a sustainable us of the caribou population of South-West Greenland by the Norse colonists for over 400 years.

In medieval Iceland, access to communal resources like upland pastures and in some cases access to seal colonies and stranded whales were regulated by the local community (*hreppur*) of ca 15-30 neighboring farms in an often successful bottom-up attempt to regulate the commons (Simpson et al. 2001). In high medieval Europe, wild animal resources tended to be the property of secular or ecclesiastical aristocracy and their exploitation was strictly regulated by ferociously enforced top-down "forest laws". We do not know what mix of management strategies was employed in Norse Greenland, nor if the balance shifted through time towards top down strategies (as it generally did in continental Europe), but the zooarchaeological record from later sites clearly indicates that there were plenty of large caribou being taken down to the end of the colony.

Seals appear to have played an even more important role in the subsistence economy, and their bones regularly make up 40 % to over 70% of the later archaeofauna (McGovern 1994). Stratified collections from the small low status farm W48 in the Western Settlement indicate that seal bones increased steadily from 11th to 14th century layers (McGovern 1994, McGovern et al 1983, 1996, 1988). Isotopic evidence of increasing participation in marine food webs by later Norse Greenlanders (Arneborg et al. 1999) suggests that the expanding use of seals to supplement domestic mammal products was a widespread strategy. The 13th century source *Kings' Mirror* (Transl. Larsen 1917) accurately describes all five species of seals in Greenlandic waters (migratory harp and hooded seals, harbor seals, ringed seals, and bearded seal), but the zooarchaeological record indicates that only harp seal, hooded seal, and harbor seal were regularly taken by Norse hunters. In both settlement areas, the migratory harp seal makes up the majority of the bones identifiable to species. Tooth annuli indicate that the great majority of these seals were killed in early spring, mainly during the annual migration northwards from their pupping grounds off Newfoundland. Seasonal round reconstruction (McGovern 1981, Barlow et al. 1997) indicates that early spring would have regularly seen provisioning shortages, as stored food ran short on many farms, and domestic stock were not yet eating enough to produce milk. The spring harp seal migration (still numbered in the millions of individuals) seems to have filled this critical seasonal gap from first settlement times down to the end of the colony. Traditional Norse/Scottish sealing with nets and clubs was clearly effective against masses of harp seals and harbor seal colonies, but seems to have been less effective in taking the more solitary (but widespread) ringed seal. The bones of this species are extremely rare in all Norse archaeofauna, though modern catch records indicate that they are common in the Norse Settlement areas. Ringed seals (present in the arctic year round) are a staple of Inuit sealing, and are the main target of the elaborate complex of ice edge and breathing hole hunting technology well documented by excavation in Alaska, Canada, and Greenland. No toggling harpoons or even barbed spears have ever been recovered from any Norse site in Greenland, suggesting that this technology was not widely adopted by Norse sealers. This failure is remarkable in light of recent evidence for regular contact between the Norse and the Late Dorset of Greenland and (probably) arctic Canada (Sutherland 2000) for at least 200 years before the arrival of the Thule culture Inuit in North Greenland from Alaska ca AD 1200.

Equally remarkable is the absence of the large number of marine fish bones recovered so regularly from contemporary Icelandic and British Isles sites. Despite repeated fine-mesh and flotation recovery strategies and modern zooarchaeological analyses by multiple workers, no substantial quantity of fish bones have been found on any site in Greenland. Despite conditions of organic preservation far better than found on most Icelandic sites, and recovery strategies that produced substantial collections of insects, hair, and small seeds, Norse Greenland's archaeofauna show only trace percentages of fish at the same time that Icelandic sites are often dominated by gadid bones (McGovern 2000, 1994 Enghoff 2003). Measurement of carbon isotope ratios in domestic mammal bones (both cattle and caprine) do not thus far suggest that these were regularly fed large amounts of fish or other marine fodder in Greenland, and we know historically that fish offal was also fed to stock in Iceland and the Northern Isles without so completely altering the zooarchaeological record. While negative evidence is always weak in archaeology, enough work has been done by enough scholars to indicate that fishing simply did not play a major role in Norse Greenland subsistence in either the Viking Age settlement period or the later Middle Ages (McGovern et al. 2001, Amorosi et al. 1996).

Differences in marine climate, shortage of boats and of material for effective hand line fishing, distance to markets, or even a dietary preference for high-fat sea mammals have all been proposed as causes for this puzzling de-emphasis on fishing in Greenland in contrast to the rest of the Norse N Atlantic. Recent demographic reconstruction work by Niels Lynnerup (2000, 1998) suggests that conflicting labor requirements may be another cause for de-emphasis of fishing in Norse Greenland. Working from a number of lines of evidence, Lynnerup has argued that the traditional maximum estimates of population in Norse Greenland of about 3-4,000 in the Eastern Settlement and about 1,000 in the Western Settlement are too high, and proposes a substantially lower estimate in the neighborhood of 2,000 settlers total (Lynnerup 2000:385).

While any archaeological reconstruction of population size is inevitably imprecise, Lynnerup's study suggests that labor may have been a far scarcer commodity in Norse Greenland than in Iceland or the rest of the contemporary North Atlantic. In Iceland, fishing was possible year round, and the most productive fisheries were actually in winter, targeting the cod spawning grounds. In medieval and early modern times, unemployed paupers, low ranking farm hands, and some middle ranking boat owners concentrated at seasonally occupied coastal stations (booths) to take large amounts of cod and halibut during the agricultural low season (Edvardsson 1996, Edvardsson et al. 2004, Vesteinsson 2000). As in Iron Age Norway, the fish taken were usually preserved as stockfish or split fish by drying and used as a storable subsistence product as well as an item of local and (later) international trade. The production of stockfish (requiring temperatures fluctuating close to the freezing point for prolonged periods) is also a winter activity. In Greenland, winter fishing with traditional open boats would have been far more difficult, facing regular winter sea ice and lower winter temperatures that would have made stockfish production less reliable. If a winter fishery was not possible in Greenland, then any summer fishery would compete for scarce labor with both the labor intensive portion of the farming cycle and with the long distance hunt to the Northern Hunting Grounds (Norðursetur). This remarkable long distance hunt produced the low bulk, high value, arctic prestige goods that were the mainstay of overseas trade with Europe from Viking times down to the end of the settlements.

Norðursetur: Walrus Hunting in Greenland

The Norse Greenlanders are known to have provided a range of items to traders from Europe: falcons, seal skins, sea mammal oil, hides, and soapstone. The helpful *King's Mirror* which provides this list also notes that one can charge the Greenlanders remarkably high prices for commodities bought cheaply in Europe, making the long voyage profitable: "...whatever comes from other lands is high in price, for the land is so distant from other lands that men seldom visit it. And everything that is needed to improve the land must be purchased abroad, both iron and all the timber." (*King's Mirror*, ca AD 1217-1260, Transl. Larsen 1917:142). But the most important and valuable items that were not available closer to the continental markets were the arctic products of walrus ivory and walrus and polar bear skin. The dense tusk ivory was in considerable demand in 10th-13th century Europe for both secular and ecclesiastical consumers: book ornaments, reliquaries, and chess men (the most famous being the Lewis sets, Stratford 2001, Mann 1977, MacGregor 1985, Roesdahl 1985) and was a widespread substitute for scarce elephant ivory. Walrus hide was cut into strips for high quality ships line, and polar bear skins (and the occasional live bear) were royal status objects providing extremely high prestige. In AD 1127, the Greenlanders are reported to have traded a live bear to the King of Norway for their first bishop (who proceeded to acquire the largest and most productive manor at Gardar in the Eastern Settlement, *Snorri Sokkason's Story*, Transl. Jones 1987).

While some walrus and polar bear appear all over Greenland, the largest concentrations of walrus have probably always been in the Holstiensborg-Disko Bay area in the central west coast (Vibe 1967). This area still produces most of the walrus taken by modern Inuit Greenlanders, and was the center for 18th-19th century European walrus hunting (McGovern 1985). The few documentary references to the Norðursetur also appear to place these “northern hunting grounds” in the same area, and a few Norse structures (including the well-known stone building at Nugssuak on the north end of Disko Bay) likewise seem to localize Norse arctic hunting in this region (for discussion see McGovern 1985). This Northern Hunting Ground was nearly 800 km north of the northernmost permanent Norse farm, and we know from a few references that it took weeks of sailing in the “six oared boat” used for standard voyage estimates (Gad 1970) for hunters to reach this prime walrus hunting area. If we assume that the summer hunting season was from the end of June though late August, the transit time alone would ensure that any Norðursetur hunters and their valuable boats would be unavailable for any intensification of summer fisheries.

Our zooarchaeological evidence suggests that participation in the Norðursetur hunt was widespread. While tusk ivory or artifacts made from ivory is extremely rare on most sites, and post-cranial bones are also rare, the extremely dense maxillary bone fragments from around the tusk roots are common finds in archaeofauna from both Eastern and Western Settlements. These fragments are the result of a specialized butchery pattern (still practiced by Bering Sea Inuit communities) in which the tusk-bearing maxilla is cut from the heavy skull and transported home for tusk extraction. The deep roots of the tusks make in-field extraction impossible, and the breaking away of the maxilla to loosen the roots is a time consuming and skilled task. While a few of the peg-like post canine teeth were retained for local craftwork, nearly all the extracted tusk ivory was saved for transatlantic consumption. The Norse Greenlanders were thus not themselves consumers of walrus ivory, but they were intensively involved in its production. Virtually every animal bone collection larger than a handful of fragments has produced one or two of the distinctive maxillary bone chips, even those from inland sites many hours walk from the sea. It appears that some individuals from most farms participated in the hunt at one time or another. This pattern is made understandable by Lynnerup’s revised population figures, which suggest that generating Norðursetur boat’s crews would have required mobilization of a large percentage of the most physically active young men (and perhaps women as well). We have some scattered evidence for magical reinforcement for this long and dangerous trip in the form of widespread pierced walrus post canines carved into walrus, bird, and polar bear forms (Gullov 2000:321) and the presence of a line of narwhal and walrus skulls buried inside the sacred churchyard dyke at the bishop’s cathedral at Gardar (Degerbøl 1929). The Norðursetur hunt appears to have become firmly embedded in the cultural framework of Norse Greenland, with magic and ritual (and perhaps rites of passage?) associated with participation in the exciting and dangerous long hunt north.

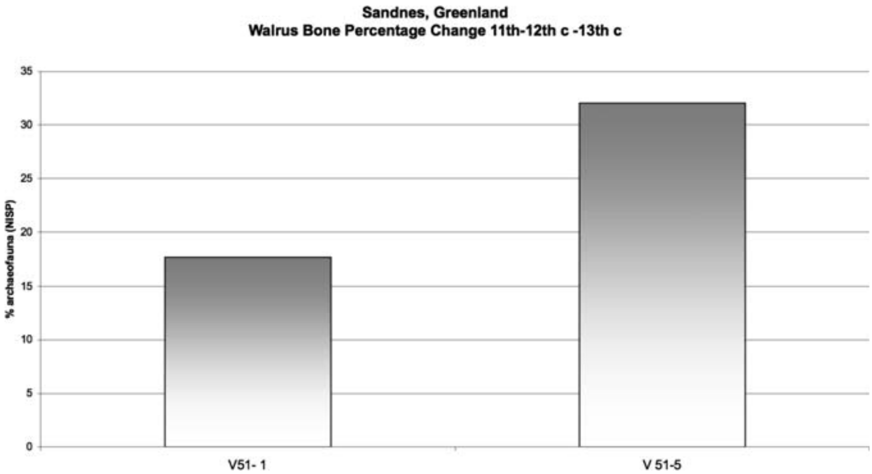

Figure 7. Walrus bone percentage change.

Zooarchaeology also provides evidence of more prosaic craft processing of walrus and bear products on the home farms after the Norðursetur hunts. Polar bear bones are less common than walrus maxillary fragments, and the bones that survive (mainly cranial and foot bones) suggest final finishing of skins taken from bears killed some distance away (McGovern 1985). The widespread walrus skull fragments are rather hard to reasonably quantify (one skull could generate a great many fragments), but the deeply stratified middens at the chieftains' farm of W51 Sandnes excavated 1984 (McGovern et al 1996) may provide some useful evidence. W51 has the highest overall percentage of walrus bone from known archaeofauna in the Western Settlement, and the percentage increases through time from the 11^{th}-12^{th} century to the 13^{th} century (Figure 7). Not only do absolute numbers of fragments increase, but so does the average fragment size so that the increase is not simply due to increased fragmentation. As figure 8 illustrates, the craft workers at W51 Sandnes seem to have become more skilled at extracting the ivory without chipping it as time passed, as there is a marked reduction in the proportion of ivory chips and flakes

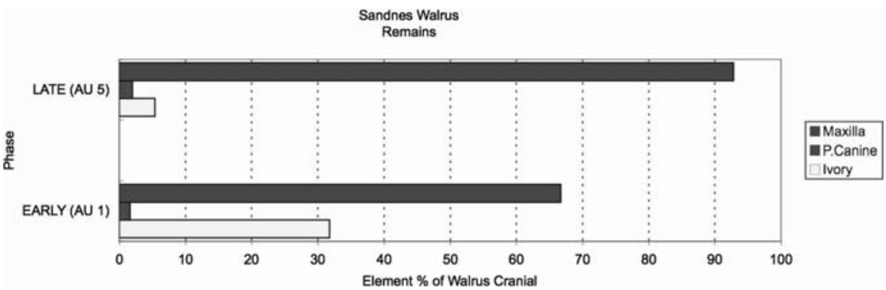

Figure 8. Sandnes walrus remains.

relative to maxillary or post-canine fragments. The household at this elite farm continued to be active in hunting walrus and processing walrus ivory throughout the 350-year period of occupation, if anything showing increased activity and increased professional skills as the Viking period passed into the high Middle Ages. The few documentary sources indicate that this was not an atypical pattern. While their relatives elsewhere in the North Atlantic were intensifying fishing for subsistence and trade in high bulk, low value staple goods, the Norse Greenlanders seem to have been modestly intensifying their Norðursetur hunt and the production of low bulk, high value prestige goods.

In 1327 the Greenlanders contributed about 668 kg of walrus ivory to a crusade against heretics and for the support of the papal household (Gad 1970: 136-137, see discussion in McGovern 1985:290-91). However, by the 14th century walrus ivory was going out of fashion as a prestige good throughout Europe, and much of the surviving correspondence about the papal contribution concerns the best strategy for unloading such a large shipment without glutting the limited market and depressing prices still further. Our last written evidence for Norse society in Greenland dates to 1408, when a group of merchants who had been blown off course and forced to over winter in Greenland reported that they had been compelled by the Greenlanders to buy Norðursetur trade goods (which they were not licensed to carry) as well as provisions (Gad 1970). While there may be a bit of fiction in this account, it is clear that by the 14th-early 15th centuries demand for walrus ivory, polar bears and other Viking Age/early medieval prestige goods had waned in Europe, and closer sources of similar arctic products were being developed in Karelia and Northern Norway (Edgren 2000). The Norse Greenlanders seem to have been intensifying the production of a commodity suffering falling demand.

As the climatic cooling of the later Middle Ages set in (Ogilvie and Jonsson 2001, Barlow et al. 1997, Buckland et al. 1996), the risks of both the Norðursetur trip and of transatlantic merchant voyages increased dramatically, especially with the onset of summer drift ice between Iceland and Greenland after AD 1250 (Jennings & Weiner 1996, Jennings et al. 2001). Contact with the immigrating Thule Inuit is still poorly understood, but most current models see possibility of growing conflict between the Thule and both Late Dorset and Norse (Appelt & Gullov 1999,Gullov 1999, McCullough 1989, Schledermann 1990, 2000, Sutherland 2000). Sometime in the late 13th-early 14th centuries, Thule people established a large and unusually nucleated winter settlement at Sermermuit in the southern end of Disko Bay (Mathiassen 1958). If hostilities broke out between Norse and Thule people, the Sermermuit settlement would be well placed to interdict Norse travel to the most productive parts of the Norðursetur. It would seem likely that costs of the Norðursetur hunt were rising as demand for its products was dropping, and the possibilities of catastrophic loss of life and irreplaceable wooden boats was likewise climbing. While the causes for the end of the Norse society in Greenland are still subject to debate (McGovern 1992, Berglund 1991, Arneborg 1991, Keller 1991, McGovern 2000), one contributing factor is certainly their failure to attract and expand transatlantic European contacts and to achieve a better balance between the requirements of their subsistence and export economies. While it is easy to blame Norse elites for mismanaging their economy (McGovern 1981) if the Norðursetur hunt was indeed as complexly integrated into the fabric of this small society as the magical items indicate, it may have become enwebbed by a multitude of social reinforcements and inducements that may have promoted its maintenance and survival long past any strictly economic threshold of profitability. For whatever combination of causes, the Norse Greenlanders seem to have become extinct by the mid-15th century.

STAPLES, SUBSISTENCE, AND SURVIVAL

Iceland and Greenland thus present closely related, but strongly contrastive cases. The Norse Greenlanders appear to have established the basic outlines of both subsistence and export economies soon after the 11th century Landnám. While their subsistence economy was driven towards increased sealing, their Viking Age export economy continued an increasingly dangerous Norðursetur voyage that produced growing piles of inedible and increasingly unsalable walrus tusks. Given their different seasonal round, the Greenlanders probably had fewer options for deploying their scarcer labor supplies than did their Icelandic relatives. Icelanders also lacked a significant external military threat, while the Norse Greenlanders may have faced increasing competition for seasonal sealing grounds from the Thule people in the 13th and 14th centuries. The cooling of the early and mid 14th century (Barlow et al. 1997) certainly had more direct and more adverse impact on the Greenlandic settlements.

On the eve of the 14th century climate changes, many similarities existed between the related settlements of Iceland and Greenland. Both societies had inflicted significant environmental impacts upon their landscapes, and both had constructed high medieval societies boasting major churches, manors, and monastic centers. Both appear to have been dominated by cattle-rich great farmers (secular and ecclesiastical) whose wealth ultimately rested upon rich pasture vegetation soon to be threatened by climate change. Both to some extent had created vulnerabilities to environmental change of any sort. Both provisioned their societies as much from marine resources as from imported domesticates. In both islands, only marine resources were capable of further significant intensification - even before the cooling of the 14th century pasture areas - and productivity was certainly in decline in both settlements.

Still, the contrast between the pathways of economic intensification followed by Iceland and Greenland is profound. The Icelanders built upon an Iron Age strategy that allowed them to combine marine fishing and fish curing to reliably produce a storable bulk staple good that could eventually undergo commoditization and become one of the key resources of the European mercantile states. The Greenlanders instead seem to have pursued some of the Viking Age prestige goods mentioned so prominently by Ottar (who does not mention stockfish in his boasts to King Alfred). As the European economy developed, it was to acquire a nearly insatiable appetite for cured fish but was to lose interest in walrus ivory ornaments. Even if demand for walrus products had remained high, the Norse Greenlanders were still faced with scheduling conflicts with subsistence tasks in an environment of increasing risk. While Iceland had the potential for further intensification of fishing (ultimately underwriting political independence after AD 1944 and a flourishing urbanized Scandinavian society today), the Greenlanders' choice to devote scarce labor and resources to the Norðursetur hunt led literally to a dead end.

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INTENSIFICATION AND PROTOHISTORIC AGROPASTORAL SYSTEMS IN EAST AFRICA

Sibel B. Kusimba and Chapurukha M. Kusimba*

INTRODUCTION

Agricultural systems can become complex in many different ways; nor do they necessarily intensify. In local histories, people employ varying agricultural strategies over time. In East Africa, the archaeological and ethnographic records demonstrate considerable variation in the use of extensive and intensive agricultural methods. After defining our terms, we will review some African examples of intensive agricultural systems and their comparative value in studying intensification. We will present an archaeological and ethnographic example of intensive agropastoral production from Mount Kasigau in the Taita Hills of southwestern Kenya.

INTENSIFICATION AND ARCHAEOLOGY

Intensification has been defined and measured in numerous ways. Boserup's *The Conditions of Agricultural Growth* (1965) provided anthropologists and archaeologists with a useful and developmental scheme for the progress of agricultural systems from simple to complex and with a means of understanding how population growth led to agricultural intensification. Although her model was intended for development economists, it gave archaeologists a way to order agricultural systems from simple to complex and to integrate diverse geographic sequences. At the time, when general evolution was enjoying resurgent interest, the model was favored for its emphasis on population growth as a prime mover in the evolution of agrarian systems.

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Archaeologists have debated whether intensification, or an increase in production and labor inputs, is a result of population increase (Netting 1993), the demands of markets or trade (Bender 1985, Bronson 1975), or environmental change (Sutton 1998). Part of the debate results from ignorance of the tremendous variety of agricultural systems. Definitions of intensification have focused on aspects of the agricultural system, such as plowing, weeding, transplanting, seasonal scheduling of labor, mulching, irrigation, seedling nurseries, intercropping, crop rotation, the use of multi-purpose crops, manuring, terracing, or crop storage structures, technological innovations or even genetic manipulations that function to increase yields per unit of land (Hakansson 1989; Kirch 1994; Leach 1999; Morrison 1996; Smith and Price 1994; Stone 1991, Stone, McNetting, and Stone 1990).

Often, however, intensification is easily confused with specialization by households or other social units, on specific crops or agricultural activities (Morrison 1996:587). Indeed, intensification is often likely to lead to production of a smaller number of crops (Geertz 1963; but see Conelly and Chaiken 2000). Similarly, diversification, that is, the use of many different crops, locations, planting times, specific social relationships of labor or land use rights, or the integration of agriculture and pastoralism or even the use of diverse wild resources, can be employed with the intent to increase yields (Netting and Stone 1996). Even the diverse use of a single food crop is another route to increased yields (Brandt et al. 1997). Conceptually, diversification could be a form of intensification even if its physical signs are few (Morrison 1996:587; Sutton 1998). “Intensification” is also used to describe the protoagricultural practices of hunter-gatherers, such as storage, culling much of a particular resource, or attempts to control a resource, which increase yield (diLernia 1997; Hayden 1984; Leach 1999:314; Klein and Cruz-Uribe 2000). Few have seriously considered that the concept of intensification may be too broad to be useful (Leach 1999: 311).

Along with argument over what intensification is has been argument over how archaeologists can recognize intensification. Some features such as irrigation canals, field borders, ridges, and terraces are found through survey. However, these proxy features do not necessarily reflect greater yields per unit area or cropping frequency. In fact, they may inject bias into archaeological field surveys, since areas with the greatest investment in features may have been marginal areas, and not necessarily the most intensively used in antiquity (Leach 1999; Sutton 1998). Other strategies related to intensification might not leave archaeological traces—such as social relationships of land sharing that spread risk, lineages and other kin-based land tenure systems, or cooperative labor groups.

Just as farming traditions and farming systems are diverse, so have archaeologists’ means of measuring intensification been diverse. Morrison (1994) used pollen diagrams to show periods of land clearance and more intensive agricultural activity in changes in the abundance of trees and charcoal, which she relates to field clearance burning. Charcoal has also been related to land clearance in Oceania (Leach 1999). Soil organic carbon may indicate something about manuring practices, although these models are still being developed (Adderley et al. 2000). Other studies have measured intensification through the abundance or density of artifacts, patterns in field boundaries, and linguistic and ethnohistorical evidence (Morrison 1996; Stone 1994).

A further question asks whether increasing intensification always characterizes local sequences. For example, in the Pacific agricultural systems have often been assumed to develop from swidden into more complex raised, drained, or irrigated field systems (Leach 1999). Local histories often, however, demonstrate the complex interplay of intensive and extensive strategies (which might in itself demonstrate "intensification", depending on one's definition), and the oscillation from intensive to extensive or even the collapse of intensive systems (Wiegers et al. 1999). In one of the most densely populated areas of East Africa, Western Kenya, farmers' use of intensive and extensive soil management practices has oscillated over time in response to migration, social class formation, and economic change during the last 100 years, even as population densities have increased (Crowley and Carter 2000). At the same time, complex patterns of intercropping, the use of multi-purpose crops, and integration of crops and livestock show that overall, the food production system is intensive (Conelly and Chaiken 2000). Although specific histories offer complex trajectories of agricultural development, in terms of general evolution the concept of intensification, as tied to population growth, can explain major inflection points such as the origins of agriculture and the "secondary products revolution" (Fall, Falconer, and Lines 2002).

AFRICAN INTENSIFICATION: AN OVERVIEW

Throughout much of Africa food production systems are considered extensive rather than intensive as a kind of norm, often attributed to poor soils, low population densities, or abundant internal frontiers where populations can expand (Hakannson 1989; Iliffe 1995; Sutton 1989). Development specialists confronting East Africa's food crisis have taken particular interest in the possibility of establishing and re-establishing intensive agriculture in many areas where these strategies are overall very rare. In Kenya, for example, studies in the 1970s showed that only 1% of "potentially" irrigable land was irrigated by small-scale farmers (Fleuret 1985). Boserup argued that population growth when land is limited will be met with shorter fallow periods, increased labor input in soil conserving techniques and manuring, but that these practices will achieve new levels of productivity. Because of labor costs, she argued that farmers do not intensify until they have to because of population pressure. In Africa, soils are often low in fertility, suggesting certain limits to population density and the success of intensification practices. Furthermore, it is argued that low population densities have made mobility a more frequent response to population pressure or poor soil fertility (Sutton 1998). The numerous studies of intensive agricultural systems in precolonial and modern Africa which we review below are poorly served by such generalizations. One might also add that agriculturalists may actually intensify or make other investments in order to avoid movement (Stone 1991).

A complete review is impossible in this short paper, but suffice it to say that simple generalizations about extensive African agriculture are of little value. This

Figure 1. Areas of intensive agriculture in Africa mentioned in the text.

review covers several areas with archaeological evidence of intensive agricultural systems (Figure 1). Throughout East Africa areas of intensive agriculture are often treated as islands of high population density. The Chagga of Mount Kilimanjaro had irrigation canals. They penfed stalled cattle to collect manure for fields (Allan 1965). Intensive systems are also known on Ukara and Rusinga Islands in Lake Victoria, where obviously circumscribed farmers increase their yields up to 50% with manuring (Ludwig 1968). Manuring practices and terracing are also documented among the Matengo of southern Tanzania (Basehart 1973). Other well-known examples include the Taita Hills (Fleuret 1985), the Kerio Valley (Kipkorir 1983), the

Nyanga Hills of eastern Zimbabwe, and the Pare and Usambara Mountains of Northern Tanzania (Sutton 1985), where in the nineteenth century farmers used irrigation, terracing, and manuring. In some cases intensive agriculturalists were bounded by extensive but militant ethnic groups, such as the hilltop peoples of Northern Nigeria who were eventually absorbed by the Hausa. Their agricultural surplus was exported to the coast for trade items. Today, these areas have experienced food shortages, but historical practices are often marked by extensive rather than intensive farming.

Terracing methods are also commonly employed in Africa (Grove and Sutton 1989). Terraces check soil erosion and make planting, weeding, and other work easier. They may also assist water runoff and irrigation systems. They are most commonly constructed with field stones or, as among the Mount Elgon Teso, with wood or with debris from bush clearing, and areas vary in the degree of investment in construction. These areas are widespread and include hills of central and northern Nigeria and Cameroon, Northern Ethiopia, and the Jebel Marra and Nuba Hills areas of Sudan, where extensive terracing was practiced along with manuring, irrigation, and stall feeding of livestock, and the Great Lakes region, including Burundi, the Kigenzi region of Uganda, and the Lake Victoria island of Ukara, and the Nyanga Hills of Eastern Zimbabwe. Similarly, numerous means of controlling rainfall have been overlooked in an overly narrow definition of irrigation, including floodwater or flood recession cropping, well known on the Niger delta; residual soil moisture cropping; rising flood cropping; tidal irrigation; hill furrow irrigation; pumping of groundwater; river floodplain cultivation; rainwater harvesting, runoff farming, and furrow irrigation (see a review in Adams 1989).

Unlike many archaeological communities, African archaeologists have been much more likely to discuss agricultural intensification in terms of trade opportunities, warfare, or iron technology, rather than in terms of population growth arguments more common in New World archaeology (Holl 2000). Agriculture in African societies was often considered a subsistence activity and rarely the basis of social stratification. Rather, prestige goods and iron technology were considered to be the basis of elite control. Trade, competition, social complexity, craft specialists, ritual, and markets are often linked to intensification much more often than population growth (Sutton 1989). Furthermore, African agriculture has often been approached from a synchronic ethnographic perspective rather than from a historical one, although recent attention paid to droughts and famines has encouraged historical study (Sutton 1989).

More sophisticated models that bring population growth and complex food production systems, as well as consideration of social organization and market forces into archaeological modeling are needed. As far as precolonial Africa is concerned, many pressing questions remain regarding why these intensive systems developed, how they functioned both from the economic and the sociopolitical point of view, and why in many cases they collapsed during the period of European colonialism.

Part of the problem of the usual supposition that African agricultural systems were extensive rather than intensive is the issue of scale. When considered from ethnographic time scales and human decision making, African farmers have a broad repertoire of soil management practices. In Maragoli, Luhya farmers have maintained their soils using a variety of intensive and extensive management practices that depend on migration, social position, economic change, and so on (Crowley and Carter, 2000). Often, the archaeologist's perspective on long-term change misses the short-term array of choices and practices. Extensive practices, such as the extension of acreage due to soil deterioration or for any other reason, often coexist with intensive practices, as in most areas of the world (Netting 1968). Nevertheless, African archaeologists have also been able to document sequences of increasing population density and intensification. In many ways the Victoria Falls Region of southern Zambia typifies the poor opinion of African environments expressed by many academics. The area has low rainfall and poor nutrient soils. Most people live in small villages where subsistence production has long been the major economic pursuit. Vogel's (1989) case study of Iron Age settlements is a good example of an ostensibly "extensive" system that has much that is intensive about it, and archaeological evidence allows us to see how it became more intensive over time. Farmers here preferred settling around *dambos*, seasonally flooded grasslands, which were used to water cattle and fields. The *miombo* woodlands were preferred for farmland clearance. Bridewealth systems ensured the exchange and dispersion of cattle, the major source of wealth. Beginning in the eighth century AD, shifting, extensive agricultural systems became longer term and more sedentary as fallow times shortened and populations increased (Vogel 1989).

Because African case studies involve intensification, specialization, and diversification, Hakannson (1989) has proposed a broad definition of intensification as any process that increases yield per unit of land. These practices may involve more work, or time, in, for example, the construction of canals, dams, terraces, the use of ploughs and animals, or a change in technology, crop diversity, shorter fallow, the use of pest control, and so on. These might be broadly contrasted with extensive systems that involve little investment in features, defensibility, soil improvements, or other labor inputs.

East African studies of intensification necessarily must give important consideration to cow and goat pastoralism and strategies to increase yield of meat or secondary products in herd management, such as culling, pen-feeding, separating animals of different sexes and ages, and so on. In many areas pastoralism and cultivation are very tightly integrated. As with intensification in general, many precolonial food production systems placed much greater reliance on cattle than has been the case in the late twentieth century (Heald 1999; Sutton 1998).

A few case studies, one from our own research in Kasigau (Kusimba, Kusimba, and Wright 2005), will give some idea of the variety of intensive agriculture practiced in Africa (Figure 1). The historical and social context of intensification also varies, showing that a variety of incentives are associated with intensification, including population growth, environment, market and trade opportunities, and social factors.

Case Study: The Konso of Ethiopia

The volcanic highlands of southwestern Ethiopia are inhabited by many ethnic groups, among them the Konso (Alborn 1989). Rainfall is irregular, between 500-1000 mm a year, but is successfully planted with cereal crops, as well as enset above

1900 m. The Konso system was a well-known intensive system for farming of sorghum, beans, eleusine, cotton, and enset. Methods included permanent agricultural cultivation on terraced fields, irrigation, soil conservation and manuring, cattle watering and tending, and methods against soil erosion and moisture loss. The system reached a high point in the 19th century but collapsed when the Konso were conquered by the Ethiopian Empire; Amborn's (1989) reconstruction is based on survey and excavation of visible features. The system included concentric zones around settlements of intensive, fertilized and irrigated fields, cattle grazing areas where crops were rotated at intervals, and finally zones of extensive crops with longer fallow times.

The most populous zone of the highlands is around 1500-1800 meters, and stone-walled terraced fields are found from 700-2000 meters in altitude. Terraces with dry stone walls have cultivable surfaces, counteract erosion, assist drainage, aeration of the soil, and soil formation. In areas where rainfall is not sufficient, the Konso have substantial terraces with a great deal of architectural investment, unlike many areas of sub-Saharan Africa where terraces are rough and informal (Grove and Sutton 1998). Lava nodules are collected and size sorted to make walls; wide walls serve as pathways but also gardens for bushes which serve as fodder and mulch. Terraces are placed into trenches dug into the ground 10-25 cm and the walls are around 40 cm higher than their fields. On flat terrain, ridges and certain long-rooted plants rim fields, hold and channels rain water, and prevent soil slippage, creating a checker pattern of fields

Irrigation canals on valley sides redirect seasonal stream runoff through channels with stone linings. Irrigated fields are about 1000 m^2, larger than standard fields. Permanently irrigated plots are found along riverbeds. Channels leading to fields are also stone-lined, and divide fields into smaller, rectangular plots 10 by 30 meters in size. Amborn (1989) reports dams and aqueducts over rivers made of rocks or hollow logs. Cattle are an important part of the systems; water is also directed into dry valleys to create cattle watering spots closed off by earthen walls reinforced with stones. Trees and shrubs planted along the perimeter of these watering areas provide fertilizer, cattle feed, and human food.

Case Study: Lake Baringo

The Lake Baringo area was long a rich oasis of farmable lands and rich volcanic grasslands. Numerous wetlands provided clearable farmlands, and the area also had high densities of wild animals known to East African and later European hunters (Little 1996). The Il Chamus, Maa-speaking agriculturalists, practiced irrigation agriculture here during the late nineteenth-century, when the area was known as a rich breadbasket and elephant ivory source. Agricultural products were raised to sell to caravan traders bound for the Kenya Coast, along with ivory. The Il-Chamus abandoned irrigation after 1870 when elephants became overhunted and the British abolished full-scale slave raiding, but irrigation canals are still visible (Anderson 1989). This case study demonstrates the role of markets as an incentive to intensification.

Case Study: The Kofyar

Netting (1968) documented intensive agriculture on the Jos Plateau associated with high population densities. Although many Kofyar have since colonized lowland areas, population densities and intensive strategies have also increased (Stone, Netting, and Stone 1991). On the Jos Plateau, the Kofyar planted a high diversity of crops, including millet, sorghum, cowpeas, as well as many vegetables, tobacco, and peanuts. Land was planted every year and manured from stall-fed cattle. A similar broad range of foods was imported into the lowlands when Kofyar moved there in the 1950s. Labor inputs were high in terracing, weeding, harvesting at many points of the year, ridging and ditching. Labor inputs were much higher than among many neighboring groups, and the equitable use of both male and female labor in most phases of the agricultural cycle, as well as the use of festive labor parties and cooperative labor groups, works to effectively distribute labor across the extended agricultural calendar. Kofyar population densities are high, around 100 persons per square kilometer, although they maintain a diversity of wild and domesticated foods (Netting and Stone 1996). Their intensive agriculture can be compared with the extensive system practiced by the nearby Tiv, who live at much lower population densities but use a variety of social means to keep populations more mobile and relatively half as dense as those of the Kofyar. Antagonistic boundary maintenance is a part of this strategy.

Case Study: Ukara

In Ukara, terraces, irrigation canals, crop rotations, stall-feeding of cattle, and manuring sustained high density populations. Some settlement in the area is related to seventeenth century immigrants escaping slave raiding. Ludwig's (1967, 1968) studies documented an intensive agricultural system that probably began in at least the seventeenth century, and that had survived European colonialism intact. Ukara's population of smallholders, each with around 2.5 hectares of land, was around 17,000 people at the beginning of the twentieth century. Intensive agriculture on Ukara focused on intercropped millet, barbara nuts and other legumes, enriched with manuring and also rotated with nitrogen – fixed crops. Cattle were stabled and their manure collected for the fields, as much as 165 kg applied to fields per household per day; overall labor inputs exceeded ten hours per day; wetland farming of grass fodder made a rich diet for cattle. Population densities and emigration from the island continue to be high (Reader 1997:257).

Case Study: Engaruka

The ancient field system of Engaruka in northern Tanzania is located at the foot of the Rift Valley, in an area of only 400 mm of precipitation, which evaporates quickly in this lowland semi-desert. It is a system of terraces and irrigation works that was laid out 300-600 years ago to exploit river runoff from the Rift escarpment from the Engaruka River as well as smaller streams, many of which are seasonal today (Sutton 1998). Small dams and canals were created near highland streams.

The canals were stone-lined and carried water to furrows in to plots. The canals measured about 1 m wide and divided as needed to reach fields below.

Sorghum was the main crop of these fields, which were fertilized by stall-fed cattle. There were around 5000 people supported by this field system in seven villages. Villages were located on high ground above the furrows, thus maximizing the amount of land that could be reached by irrigation and placed under cultivation. Most likely, however, other settlements were also supported by ancient terraced and irrigated fields, which cover an area of around 24 km. Sutton (1998:3) attributes the eventual abandonment of at least seven hilltop villages around 300 years ago to environmental degradation.

Fields are demarcated with lines of stone. Angular cairns of stone represent stockpiles of stone from field clearing, and round stone pens held livestock. In the villages, homesteads with granaries and goat pens were placed on terraces of 1-2 m in height. Canals were raised in order to carry water to high points near the river so as to water as much surrounding terrain as possible. At one point, the canal crosses a large stream and would have required frequent maintenance. Evidence of canals, stock enclosures for manure collection, sluices and embankments demonstrates considerable investment in intensive agriculture. At many times during the occupation of Engaruka, canals and furrows were realigned and reconfigured; a large canal was constructed perpendicular to these streams to bring Engaruka water to neighboring valleys. These valleys had been irrigated from their own streams, but Sutton (1998) argues that progressive aridification made Engaruka the only dependable river. Similar terraced and irrigated highlands are common in northern Tanzania around Kilimanjaro and the Pare, Taita, and Meru highlands, as well as the Sonjo highlands around Lake Natron. Linguistic evidence suggests that present-day Sonjo peoples are related to the Engaruka inhabitants.

The appearance and disappearance of Engaruka-like phenomena is still debated. Although Sutton discounts the factor of coastal trade in the need for Engarukans to intensify production, cowrie shells and glass and copper beads do imply Coastal contact. Coastal trade may indeed have created the climate of intensification. In the Usambara highlands sites demonstrate Coastal contact beginning in the late first millenium. Engaruka's remains still warrant more research into the question of why this intensive system was created and later abandoned.

Case Study: Mount Kasigau, Taita

Mount Kasigau, hereafter Kasigau, forms one the three or four prominent hills in Tsavo, Southeast Kenya, commonly referred to as the Taita Hills (Figure 2). It is one of the major cultural landscapes in the Tsavo region that has continuously been inhabited for over 12,000 years (Kusimba, Kusimba, and Wright 2005). Today, the hill is far more sparsely populated than other Taita Hills. However, visible terraces and ridges on Kasigau's slopes bespeak a history of much more intensive occupation. After the First World War, Kasigau's population was forcibly removed to the Coast near Malindi by the British as punishment for supposed traitorous collusion with German forces. In the 1950s they were allowed to return, and a small population of Wakasigau has resettled the hill in small villages around the hill's base,

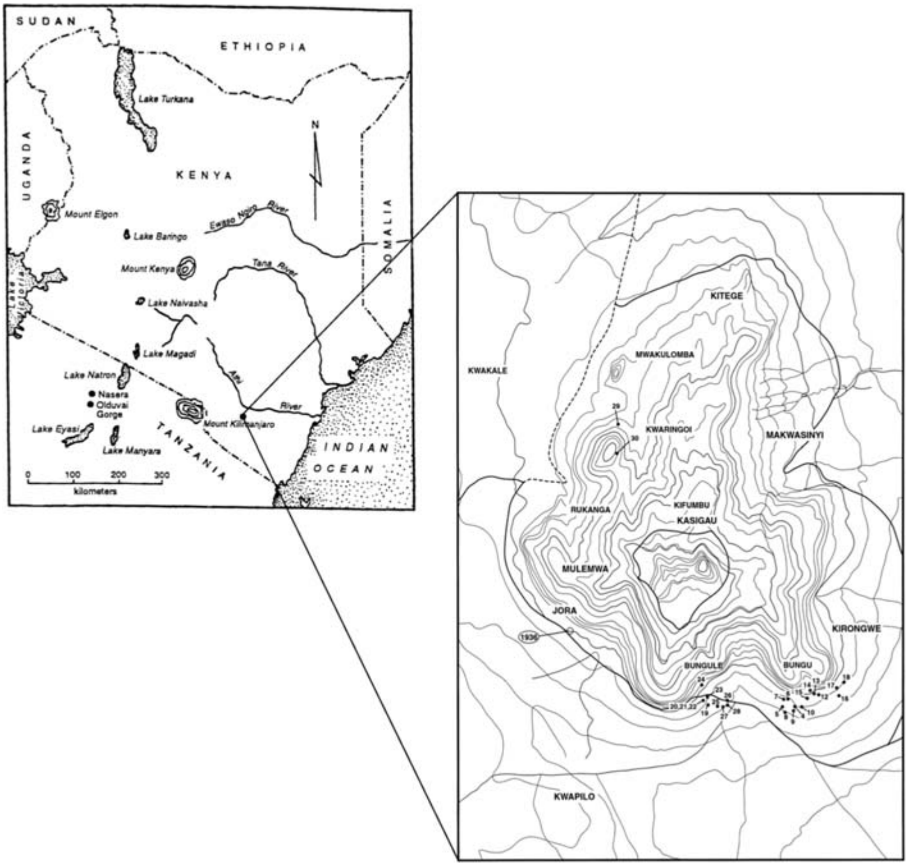

Figure 2. Mount Kasigau, south-eastern Kenya.

where they practice maize and bean farming and small-scale herding. Precolonial occupation, however, was substantial and focused on the high, steep slopes of Kasigau Hill, where rockshelters, terracing, ridging, and secondary forest attest to high densities of human settlement.

Using the variation in landforms and environment on and around precolonial Kasigau, agropastoralist communities created a logistical land-use system that maximized the amount of space available. Our surveys and excavations here in 1998-2002 revealed 40 archaeological sites of several types that were contemporaneously occupied components of this land-use system. The sites date to the last 500 years (Kusimba, Kusimba, and Wright 2005). This land use system was coordinated through the work efforts of gender and age-set groups, managed by lineages and families, and included:

1. rockshelters, used for penning and feeding goats;

2. terrace sites with terraced homestead platforms at many altitudes along Kasigau’s slopes, and cross-cut by ridges designed to channel water runoff downslope;
3. iron smelting sites;
4. burial cairns; and
5. ancestral shrines for display of human cranial remains.

Over the course of the project, we mapped a variety of sites and extensively excavated at eight rock shelters (Bungule 7, 9, 20, 28, 31, Kirongwe 1, 4, 5), a terrace (Bungule 29B), and an iron smelting site, Kirongwe 7. We also mapped three mortuary sites (Bungule 30, Makwasinyi 1, and Sungululu 1) and extensively and studied skulls from two sites—Makwasinyi and Sungululu 1.

Rockshelters

Rockshelters (Figures 3 and 4), according to our informants, were used by a young male age-set for watching and feeding penned goats and cows. These rockshelters had a clear two-lobed structure created from dry stone architecture (Figure 5). One lobe was used as an animal pen, and our excavations at 8 sites revealed 50 cm to 1 m of dung in this lobe. The other lobe was for human sleeping, and sites had preserved hearths and grass bedding in these areas. Our excavations revealed that some goat pens had substantial architectural investment in dry stone walls and foundations; one site, B20, was obviously created with defensive concerns in mind, including offset doors, deep foundations and high, thick walls (Kusimba and Kusimba 2005).

Comparatively few archaeological finds were recovered from all the enclosures, suggesting that they primarily functioned as animal pens and as refugia for humans during periods of warfare and slave raiding, as our informants recounted (Hobley 1895). Based on our survey and excavation data, a number of features characterize dry stone architecture in the Kasigau area. First, all rockshelter enclosures date from the last 300 years BP. That is to say, they were constructed after the Portuguese conquest of the East African Coast and the institutionalization of large-scale slavery and slave trade by Europeans and Arabs in Africa (Kusimba and Kusimba 2005). The building of dry wall enclosures in rockshelters signaled a departure from traditional practice of erecting wooden frame enclosures or using open rockshelters as temporary camps. Second, all the enclosures have partitioned areas: one section for livestock and the other for people. The former contained large amounts of dung and was often on uneven ground. The second lobe had little or no dung piles, and contained cultural materials like a wooden bed, hearth, pottery, gourds, and calabashes. Third, all three sites had an entrance and an exit. The exit was not always easily detectable from outside and appears to have been designed to allow humans to leave the enclosure either undetected or without having to use the main entrance. Fourth, dry stone walls were built by an elaborate system which involved a fairly deep foundation which was dug to the natural rock, a strong wooden frame firmly held together by twine from local tree barks, and termite clay to strengthen the wall giving it an impregnable character. As in Engaruka, Ukara, and in other areas of the

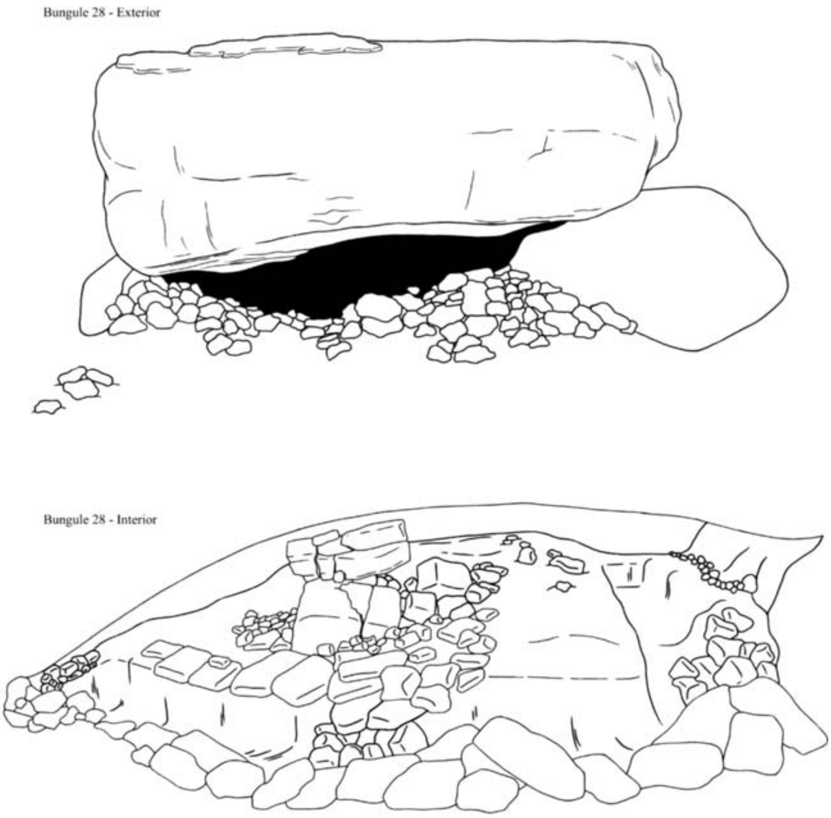

Figure 3. Bungule 28 at Kasigau.

Taita Hills (Sutton 1998; Fleuret 1985), rockshelters were effectively used as a convenient catch-basin for manure. A young age-set could defend the livestock against raids and slavers (Kusimba 2003) and maximize the amount of surrounding land dedicated to cultivation.

Terraces

Kasigau Hill's steep slopes above present-day village settlements are extensively terraced, although unlike the heavily populated Wundanyi Hills, these abandoned terraces are overgrown and barely visible. We fully mapped and excavated one terraced site, Bungule 29, in 2001. Excavations show that larger terraces were constructed specifically for building houses and the smaller ones for farming (Figure 3). Each terrace extended from one edge of the small spring or stream to the next. Based on ethnohistorical information from villagers, each terrace belonged one ex-

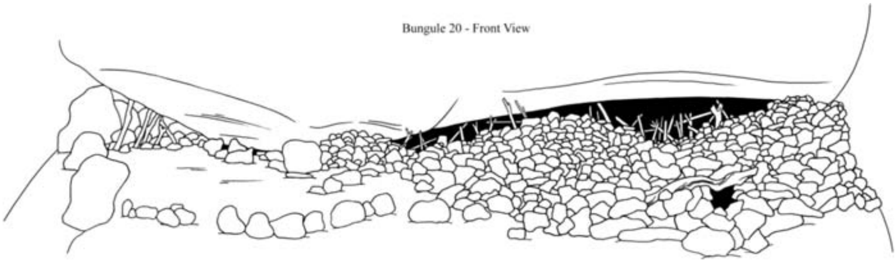

Figure 4. Bungule 20 at Kasigau.

Figure 5. Map of Bungule 1 at Kasigau, showing bi-lobe structure of human use area adjacent to cattle/goat pen area.

tended family. Thus, lineages would have occupied several terraces adjacent to each other. The elders interviewed emphasized that the system of land tenure recognized and respected individual rights to terraced land. Abandoned and/or poorly maintained terraces endangered their neighboring terraces and thus would have been leased to individuals or families in need of land for short periods of time. The lineage was the key social unit that defined inheritance of land rights and accorded use rights (see also Fleuret 1985).

Much of the south and west facing slopes of Kasigau Mountain east of the village of Bungule and north of the concentration of rockshelters around Bungule 1 (Figure 2) had been terraced. These now abandoned settlements consisted of about 5 columns of at least 20 terraces separated horizontally by ridged, somewhat broad and shallow irrigation canals that brought water from streams further up the mountain, made of ridged earth shored up with occasional stones, and measuring about 50 cm wide and 20 cm deep. These streams also provided fresh water for drinking, cooking, washing. Easily identifiable from a distance, the terraces were frequently marked by useful trees such as baobab, mango, and tamarind, and the steps could

Figure 6. Terrace habitation on Mount Kasigau.

even be seen in the heights of the tree cover (which could indicate abandonment at roughly similar times).

Some limited hiking in the terrace area revealed that the terraces were of two types: large, relatively flat spaces with stone retaining walls of about 1-1.5 meters in height and shorter, more angled terraces with retaining walls of at most 30-50 cm. One hypothesis is that the larger terraces are the sites of homes and other residential activities, while the small terraces are for farming and/or horticulture. A similar division of terrace type was observed during a day trip to the near-by Taita Hills region where terrace farming is still in practice.

The large flat terraces frequently had clusters of two or three firestones (usually with a grindstone directly adjacent), multiple grindstones, and occasionally complete ceramic pots. Almost all of these grindstone-firestone occurrences were associated with small mounds or slightly raised linear mounds which could represent households or enclosures. Most terraces had more than one such association which could indicate multiple houses, probably for various elements (wives, son's families, etc.) of an extended family.

Excavated residential terraces at Bungule 29A and 29B had shallow channels running north-south through almost precisely the middle of the terrace. At the southern end, the terrace wall was absent, and it seemed likely that the gap was left purposefully. Several meters to the south of the gap was a pit ~1.5-2 m deep with the edge lined by stones. Access to this probable latrine could have been a reason for the gap. On the terrace itself, there were several small circular mounds which may be house remnants. There was no evidence of a particularly large or central house as identified on Bungule 29B.

Our excavations at Bungule 29B have uncovered terraces, using spring runoff, with previous habitations on top, above fields, to maximize the area of arable land. There is evidence of specialized labor parties of young age grade males who took care of pen fed cattle; using existing rockshelters for this purpose maximized arable land for cultivation. Note the close integration of pastoralism and agriculture. Intensification and labor specialization are evident - manuring requires a young age-grade to take part of the herds for grazing in the lower land and stalling near the irrigated fields. This creates the logistical system of Kasigau.

CONCLUSION

Archaeology and history demonstrate that intensive agricultural practices were well-established in Africa. They are associated with highly specialized and integrated agricultural systems and, as in many places in the world, are not simply a result of population pressure; Indian Ocean trade was a key incentive in Kasigau, Lake Baringo, and probably other areas as well. Often intensive systems exist in highland "islands" and are practiced by people ethnically distinct from non-intensive neighbors.

European colonialism or indigenous conflict destroyed the social bases of many intensified agricultural systems, such as among the Konso or the royal canals and alluvial gardens of Baretseland (Sutton 1998). Today's food crisis in Africa has many causes, but archaeology can contribute an appreciation for storehouses of indigenous knowledge of agricultural practices. In East Africa, trade and market forces as well as population growth and circumscribed agricultural land have provided important incentives for intensification.

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RETHINKING INTENSIFICATION:

Power relations and scales of analysis in Precolonial South India

Kathleen D. Morrison*

Most archaeological discussion of intensification has centered around identifying the conditions under which it emerges – that is, around problems of cause. Secondarily, disciplinary effort has focused on the consequences of intensification, most notably its supposed undergirding of complexity, by which we often simply mean institutionalized inequality. In part, this dual focus on cause and effect reflects basic archaeological biases about what the major issues of the field are, or ought to be. If we consider intensification to be a *process* rather than a *thing*, as such, it may seem curious that its causes and consequences rather than the process itself should have become the focus of archaeological attention. I briefly discuss issues of cause and consequence below; however, the majority of this paper is concerned with neither cause nor effect, but process.

For a discipline that is sometimes said to be dominated by processualists, archaeologists have produced startlingly few detailed analyses of specific trajectories of productive intensification. This shortage, though by no means absence (e.g. Kirch 1993; Leach 1999; Hastorf 1984, 1993; Nichols 1987; Stahl 1993; Stone and Downum 1999), of close studies of specific courses of change makes it very unlikely that the discipline is going to have much success in delineating process in any empirically sufficient or satisfying way. As I have argued (Morrison 1994, 1996), we need to pay close attention to actual trajectories of intensification, both to begin to understand intensification as a process and to appreciate the importance of context and contingency. Here I refine that charge slightly, and suggest that attention to courses of change also requires more systematic consideration to both analytical scale and power relations. Refocusing attention on specific, contextualized trajectories of intensification does not imply a move away from a comparative project. On

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the contrary, I suggest that such long-term studies constitute the only reasonable base for comparison. It would follow, then, that the construction of what we take to constitute a case of intensification is critically important and, to the extent possible, cases ought to consist of scalar and social units that are at least broadly comparable. I explore this point very briefly here with a series of data sketches from precolonial southern India. In the end, case construction turns out to be always ambiguous and contingent; a recognition that in no way releases us from the need to delineate analytical units or to draw broader inferences from specific analyses.

Definitions, Causes and Consequences

Surprisingly little archaeological effort has been expended on definitions of intensification or even on carving out a clear domain for the concept, separating intensification from related concepts such as expansion, specialization, and indeed, even evolution, adaptation, or simply change (but see Kirch 1993; Morrison 1996; Stone and Downum 1999; Stone, Netting, and Stone 1990). For example, the term is used radically differently by those studying different domains of production so that analyses of changes in, say, ceramic or stone tool production are often incommensurate with those of agricultural production or animal husbandry. Food production may the classic domain of intensification theory; discussions of intensification of non-food products are often more concerned to link intensity to other, more developed concepts such as specialization than to elaborate the notion of intensification itself (e.g. Stark 1995; White and Piggott 1996). Obviously, this lack of agreement about basic definitions greatly obscures the debate and ensures that we will be speaking past each other much of the time.

Any definition of intensification must start with a discussion of the nature of production itself, a task I cannot undertake here (cf. Morrison 1994). If, however, we set this aside for the moment, the simplest definition might be that the intensification of production refers to *attempts to increase the concentration of production*, further assuming the salience of production effort or production input, leaving room in this definition for efforts that fail. That is, agriculturalists who try to increase productive concentration[1] by building irrigation features that are immediately washed away in a flood are still intensifying, notwithstanding the fact that they never actually succeed. The labor they put into the irrigation features is no less real because of the flood and subsequent lack of an increase in productivity. Definitions such as that of Kates, Hyden, and Turner (1993) eliminate this possibility of failure. Skipping the process of intensification altogether and moving right to its presumed effect, they write (1993:10), “The measure of agricultural intensification has taken on a rather precise meaning as the total production per unit of area and time (typically per hectare and year). Its obvious measure, therefore, should be that of total output.” Obviously, this definition is of a result, not a process and as such really defines *productivity* and not intensification. However, even suggesting that output necessarily measures intensification works to erase the process of production itself[2] and eliminates from discussion efforts at intensification that fail to raise productivity. Furthermore, there are ways other than intensification to raise productivity – to call the introduction of new, high-yielding crops an example of intensification because they raise productivity even while requiring no additional labor is to stretch the concept beyond reason.

Finally, it seems clear that there is no necessary relationship between intensification and productivity; people may intensify production to obtain a highly-valued product, such as rice in southern India, even though they could obtain much more sorghum from the same input of labor. Measuring intensification by productivity was also contested by Boserup (1965, 1990), who argued that intensification of agriculture brought with it falling marginal returns (an assertion contested by many; e.g. Clark 1985; Conelly 1992; Padoch 1985; Waddell 1972)[3]. Paradoxically, however, intensification of non-food production is usually assumed to lead to increased efficiency and not to declining marginal returns (Morrison 1994). I suggest, then, that there is merit in keeping the process of intensification analytically separate from its presumed consequences, whether those are more (increased productivity) or less (social or political changes) proximate.

In any case, definitional discussions of intensification are usually, and necessarily, subsumed by methodological concerns. How might we identify intensification archaeologically? A range of proxy measures are generally employed, often based on the appearance of physical features that suggest changes in broad forms of production, forms for which we have a general sense of both labor requirements and productivity. To use measures of what we presume to be the consequences of intensification – output, social complexity, changes in settlement – as proxies for identifying this process, is, however, a clear case of the fallacy of affirming the consequent.

Why people might intensify production is certainly important and interesting, although it does seem paradoxical that so much effort is spent to account for why something occurs when that something is such a poorly-developed and under-defined concept that it would seem difficult to link to causal accounts to actual cases except by leaps of faith. That is, if we cannot agree on exactly what intensification is, or, equally important, how to measure or even recognize intensification, then one wonders how we can realistically address the conditions under which it is likely to occur. Nevertheless, a multitude of causal explanations for intensification (almost all for the intensification of food production) have been offered. There is a vast literature that considers such factors as population density, pressure, and distribution; sedentism; market-driven, prestige-driven, or politically-driven demand; risk, climate change; and many others (see Morrison 1994 for a review; for more recent discussions see Janetski 1997; Larson 1996; Latefoged et al. 1996; Lourandos and Ross 1994; Morrison 1996; Raab 1996; Stone and Downum 1999; Wohlgemuth 1996). Indeed, it may be fair to say that causal concerns, stimulated by the work of Boserup (1965), whose then-radical population pressure hypothesis restructured a debate that had previously seen (successful) intensification itself as a cause for population increase, constitute the largest part of the archaeological literature on intensification. In some sense, many of the arguments about cause are probably correct. Causes are often multiple and cascading, and no doubt vary somewhat from case to case. There seems to be no universal account of why intensification takes place; looking for one seems to me to be a waste of energy.

I have already touched on the issue of consequence briefly, if we may consider one possible consequence of intensification to be increased productivity (this being presumably one of the most common consequences). Most archaeologists, however, are much more interested in less proximate consequences, seeing production as something of a material support for social or political forms and, as such, intensification as simply an aspect of the road to complexity (e.g. Minnegal and Dwyer 1998; Schurr and Schoeniger 1995). I take this to be a serious concern, although I would suggest that we would find it helpful to unpack the notion of complexity. By complexity, archaeologists may mean anything from a large(r) number of social, political, or economic roles in a given context; the vertical and horizontal arrangement of those roles; to simply institutionalized inequality. When we discuss complex societies, we tend to mean the latter. However, as I discuss below, a more explicit concern for power relations will go some way toward eliminating the ambiguity of this notion, as well as the way that it tends to naturalize inequality and hierarchy by assuming its congruence with mere differentiation. Nevertheless, concern for the consequences of intensification is extremely important. I suggest here that understanding *how* intensification takes place, an understanding developed from close analysis of specific courses of change, will help us to approach issues of consequence, both literally and figuratively. In the following section on trajectories of change, I note that the consequences of intensification can immediately ramify and create new conditions for production – as such, we will see that courses and consequences of change cannot be fully disentangled.

Taking Process Seriously: Courses of Change

To this point, I have considered what intensification might be, why it happens, and, to a more limited extent, what its human consequences might be. However, all this still skirts around the process itself and leaves us with little notion of how actual trajectories of intensification might play out. What little systematic thinking there has been on the course of intensification has largely suggested that is a regular and, in general, unilineal process from less intensive to more intensive strategies of production or patterns of land use (Boserup 1965, 1981). Such perspectives suggest that one can characterize land use intensity in terms of one or a few variables (fallow length, labor input, produce generated) and that intensification is fundamentally a program of replacement (more intensive modes of production replacing less intensive ones rather than a diversity of productive strategies co-existing). I have discussed these issues at some length in print (Morrison 1994, 1996), so I simply note here that it is my view that such simplistic views of the course of intensification fail to do justice to its complexity *as a process*. In the data sketches presented in this paper, intensification can neither be measured by nor did it always lead to shorter fallow periods, or higher production, or increased effort. In some cases it pushed swidden agriculturalists into the role of specialized forager-traders who operated in an international market; it led to the spatial expansion of low-intensity dry farming; it compelled the extension of canal zones, but it also *in so doing* forced some people off the land entirely or into the role of landless laborers. Some of these (and other) people moved to new regions to clear new lands for agriculture; thus, as I have suggested, expansion may be seen as one strategy of intensification (Morrison 1995). These diverse paths of change, and indeed their implications for the omnibus concept of intensification, become possible to see only by playing off analyses at a variety of spatial and human scales.

Before moving to specifics, it may worth emphasizing that I can no way do justice in this short essay to the complexity of concerns implicated in issues of analytical scale and units – among them space, time, and what I call here human scale, by which I mean units of human action or organization. In this paper I focus primarily on space, and secondarily on human scale, but I do not mean to imply by this that time is somehow less problematic. In fact, what we see is that time and space often figure very differently in studies of agricultural production on the one hand, and almost all other kinds of production on the other[4]; a situation that should make us wary of the approaches that structure such conceptual disjunctures.

Lost in Space: Or, What Are We Studying? Building Toward Comparison

Analytical Scale

It is, or ought to be, a truism that we study the archaeological record. One of the first facts of the material record is that it is spatial, a dimension deeply implicated in the term *land*. In inferring that *land use* has intensified, we populate that land, but of course we rarely study people in any direct rather than inferential way. Thus, issues of spatial scale refer to the amount of land surface (and subsurface) we take in. However, changes in land use intensity do not always map on to changes in the economic strategies of particular groups of people. If we use people, not land, as the basis for discussion (that is, if we employ different analytical units) we may again see trajectories of intensification quite differently. We might ask for whom or for what intensification matters. Plots of land? Groups of people? Here scale matters on either dimension. It is certainly also the case that similar place-based changes can lead to divergent human-based changes – the construction of a canal might mean better, more secure harvests or eviction, depending on one's social position. From the point of view of land, these distinctions disappear. Alternately, a change in economic status of one local caste group through royal patronage might impel some of them to purchase land and take up farming, while others maintain their traditional occupation; here a unitary social process may have variable effects on land use.

Many models of intensification are explicitly constructed on some notion of individual choice, or on sets of expectations about decision-making. Very often, such models employ western microeconomic assumptions about what individual human beings will tend to do and the kinds of choices that they will make. Both these microeconomic perspectives and the more explicitly culturalized versions of them focus on productive choices made, not dissimilarly invoking the analogy of a vast consumer supermarket of behavior in which either culture or economic rationality dictates product selection. Both economistic and cultural determinist positions tend to set up the problem in simple behaviorist terms and both employ some form of methodological individualism, with a key analytical unit being the individual person.

Elsewhere (Morrison 1996), I have critiqued the way in which both the seminal Boserupian analysis of intensification and its least-cost descendants employ a sliding scale of what they take to constitute appropriate analytical units. On the one hand, the logic of economistic models relies in the end on assumptions about individuals. On the other hand, the scale of analysis is usually immense. Boserup, for example (1965, 1981, 1990), used units such as nation-states, cultures, and language groups in her studies of agricultural intensification. Intermediate social groupings such as families, occupational groups, associations, classes, castes, and so on are mostly ignored and, in fact, larger spatial units are primarily viewed as *aggregates of individuals*. That this anthropologically vacuous view leaves a strangely depopulated middle ground should be clear enough. This sliding spatial scale leaves no analytical role for cultural practice, as such (or in some of the culture and technology literature, simply reifies and essentializes it). Further, the focus on (either rational or essentially cultural) choice leaves no room for the real constraints of unequal power relations. Considerations of human action, even *within* the confines of various decision-oriented approaches, need to take into account the actual social and political contexts in which production operates. In the case of precolonial southern India that means that we must consider not only individuals, but also households, kin groups, communities, associations, and institutions such as temples that operated as more than simply aggregates of individuals. Ideas about decision making in this context are complicated by issues of scale and varying scales of analysis will lead to rather different pictures of the course of intensification.

Inside the Human Dimension: Power and Choice

The second half of my suggestion on how we might improve our understandings of specific courses of intensification has to do with the problem of power. Just as an analytical focus on individuals or massive aggregates of them may elide the role of intermediate social groupings, to say nothing of the conceit that western notions of individualism should enjoy analytical priority, so also decision-making models that propose either rational choice or culturally-inflected decisions on the part of individuals may erase or make transparent the powerful constraints under which most people in the world at most times have labored. Choices are rarely free and in the cases discussed here, most decisions about agricultural production were made in a context of radically unequal economic, social, and political relationships. That these conditions had implications for the course of agricultural intensification is perhaps not surprising. That issues of power are not, then, a routine part of our thinking on intensification is.

I highlight issues of scale – spatial, temporal, human – and, in the human arena, problems of power, because they are fundamental to a comparative project. If we really want to understand intensification as a process, complex, variable, but a process nonetheless, then we must build coherent comparisons. It is simply axiomatic, then, that whatever we take to constitute cases are in some sense *comparable* things. Thus, the construction of cases needs some serious attention and it is here that we tend to move most awkwardly between units and scales of analysis. What are we trying to study – properties of space in a temporal framework? The intensification of human productive activity, of human economies? The answer, of course, is both, but we need to be clear how both the approaches and answers to our questions will differ as we move between these fields. Let us then consider some examples of varying spatial scale and its effect on how we can see trajectories of agricultural intensification. I focus here primarily on land use as an aspect of the properties of places, partly because as archaeologists we never can (and never should) lose this perspective, and partly for brevity. I further refer to these different spatio-temporal frames as cases, so that we can keep in mind issues of comparison. The following are meant to serve only as brief illustrations; more detail can be found in Morrison (1995, 2001, in press).

Looking More Closely, Looking Differently: Scale and Unit

Case 1: South Asia in the Late Precolonial and Early Modern periods

The time period I consider here is roughly the fourteenth to the seventeenth centuries AD and the spatial unit of analysis is something close to the contemporary Republic of India (cf. Boserup 1981, who uses similar units, as do some cross-cultural studies, e.g. Burton and White 1984). Generalizations about the course of agricultural change across this period in this large region are necessarily gross but we could point to an *overall* process of intensification and to a growing commercialization of certain kinds of produce in some places (Randhawa 1980). There existed a number of powerful regional states and empires, but these by no means encompassed the entire population; thus the constraints and opportunities of unequal power relations would have been of variable importance. This perspective glosses over massive regional variation and I doubt if I need to linger here.

Case 2. The Vijayanagara Empire

Here we move in quite a bit to consider the large, if sometimes loosely-defined empire of Vijayanagara, which claimed control over most of southern India between the fourteenth and early seventeenth centuries. The empire incorporated a range of ecological zones, including lowland tropical forests, montane tropical and semi-tropical areas, dry thorn scrub, grasslands, marshes, and coastal zones. Like most empires, it incorporated a range of linguistic, ethnic, religious, occupational, and kin-based groups; statuses which could be, and often were, cross-cutting.

On this near-subcontinental scale, it is certainly possible to talk about intensification. If we are willing to ignore some regional variation, we can say that there was an intensification of agricultural production, particularly in the sixteenth and seventeenth centuries, that focused, depending on region and community, on rice, millets, liquor-producing palms, spices, or other crops either singly or in various combinations (Appadorai 1936; Karashima 1992; Mahalingam 1951; Morrison 1995; Palat 1987; Stein 1979, 1982). However, it is also the case that some people in the empire left areas of intensive canal-irrigated agriculture to pursue less-intensive dry farming or reservoir-supported production, while others moved to new areas while still maintaining their basic agricultural repertoire. Still others, as I mentioned, moved into specialized gathering, leaving agriculture altogether. It is probable, but not definite, that some regions were partially abandoned as huge cities grew by in-migration. I could go on, but it is probably quite clear that at this scale of analysis there is

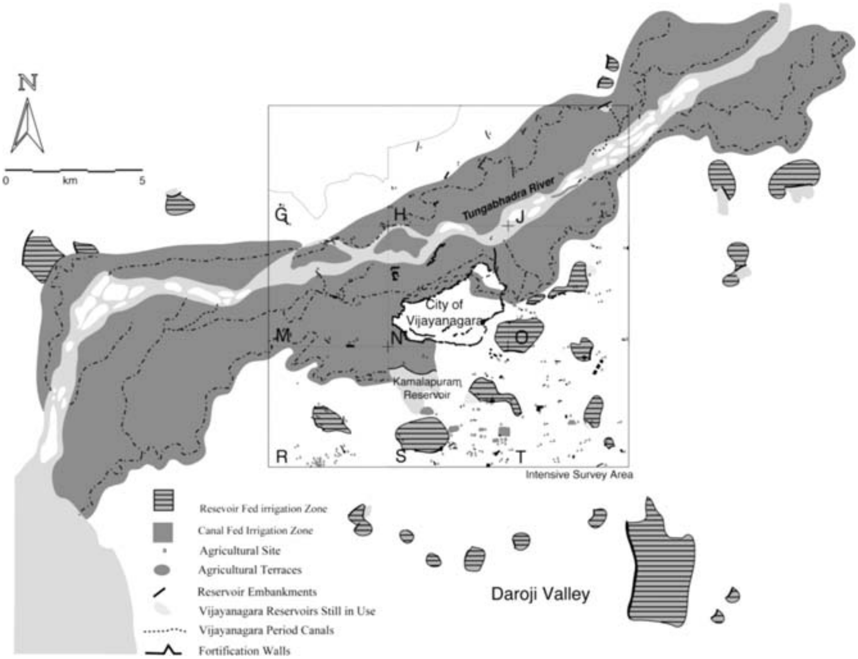

Figure 1. Vijayanagara.

precious little to say about the course of intensification that does not have to be hedged in with regional qualifications or which has much to say about the actual organization of production by real human beings.

Now obviously it makes a difference where we move in next, and in fact, a certain amount of scholarly disagreement about this polity seems to stem from scholars different vantage points in the empire. Here I focus on my own study area.

Case 3: the Vijayanagara Metropolitan Region

Finally, we have approached a scale which has something like a real chance of being studied archaeologically, a scale we loosely refer to as the region. In this case, the Vijayanagara Metropolitan Region is an area of some 350 km^2 surrounding the capital city, a region that has been the focus of a ten year project of systematic survey and test excavation (Morrison and Sinopoli 1992; Sinopoli and Morrison 1995, 2001). Combined with nearly twenty years of work of scholars focusing on the city itself, we have a reasonable archaeological base on which to build. This is just to make the rather obvious point that decisions about scale have serious implications for the allocation of our time and effort.

In any case, at the level of the Vijayanagara Metropolitan Region as a whole, it has been possible to define a course of agricultural intensification, a course whose tempo has dual peaks in the fourteenth and sixteenth centuries, and which involves a complex set of changes in regional land use, facility construction, and social-political organization. My own work has focused primarily on this regional scale, not least because it is the scale for which we designed most of our data recovery strategies. Overall, one can say that the course of intensification in the metropolitan region involved an early focus on very intensive forms of irrigated agriculture – canals and canal-fed reservoirs for instance – and a later expansion and intensification that included the expansion of extensive dry farming, of labor-intensive but risky runoff-fed reservoirs, and growth in areas under perennial irrigation, among others. I have suggested that there was no single course of change from more extensive to more intensive strategies and that the maintenance of productive diversity was always an important part of the overall agricultural repertoire (Morrison 1995).

It is perfectly reasonable to ask whether or not this regional scale is the only or even the most relevant one to consider. Our larger survey area takes in most of the land included in the various fortification systems surrounding the city of Vijayanagara and is tightly connected to the city by a network of roads and paths. For these and other reasons, it makes sense as a coherent region. However, lest we imagine the study area to be some kind of essential unit that can be unambiguously compared to other such units, a closer look at two different parts of this region will make clear that the view of change I have just sketched out is, again, created by blurring finer distinctions. These distinctions are significant, both for the study of human economic organization and for appreciating the changing uses and role of place.

Case 4. Survey Blocks H and J North of the River

Our survey area is broken by the perennial Tungabhadra river, the only source of water outside the seasonally-concentrated monsoon. The city itself was built along the southern bank of the river at a place with longstanding sacred associations. Urban growth stayed primarily on the south bank, but there were several smaller settlements in the agricultural zones north of the river. If we consider an area of some 40 km^2 just to the north of the river, what we see is an earlier pattern of irrigation by runoff-fed reservoirs and probably a very small zone of inundation agriculture perhaps supplemented by lifting water out of this partially entrenched river. In the sixteenth century, a large weir or *anicut* in the river was constructed, diverting water into a major canal, the Anegondi channel. This canal allowed for the expansion of intensive wet cultivation in the zone north of the river, making the reservoirs redundant. It is also worth noting that this is more or less the situation today as well. This latter period also saw the construction of a massive aqueduct that carried water from the Anegondi canal to a large island in the river that was largely under cultivation. Following the abandonment of the city, the aqueduct fell into disrepair, but the *anicut* and canal have been consistently maintained and used into the present. Here the sequence of change runs from seasonally-supplied reservoirs to canal irrigation. During the Vijayanagara period, the course of intensification was relatively simple, even one-directional, and certainly led to increased productivity and decreased fallow periods. However, for those holding rights to land and its produce before the canal construction, for those who formerly grazed flocks on the land in between crops, these changes, now that there were no seasons in between crops, were probably devastating.

Case 5. The Daroji Valley

If we consider instead the Daroji Valley, a long east-west valley about 15 to 20 kilometers south of the river, the sequence of change and indeed the organization of production looks very different. Far from the river, there is little scope for canal irrigation in the Daroji Valley. Beyond this topographic fact, however, is the relative position of the valley vis-a-vis the city; its distance from urban consumers is as important as its situation as colluvial valley like so many others. Here, early Vijayanagara period occupation of the valley seems to have been sparse, with one village and a couple of runoff-fed reservoirs that may have been constructed in the fourteenth century. It is likely, though not yet well established, that some land in the valley was dry farmed and that most of the valley was used for grazing and collecting. In the sixteenth century there was a massive expansion of runoff-fed reservoirs into the Daroji Valley, a spate of construction and settlement that resulted in a complex landscape of interconnected reservoirs that led, in the main valley, into the enormous Daroji reservoir, a facility with a water-spread of over 800 hectares and a dam some 4.6 km long. The sixteenth-century landscape was one of many small nucleated settlements, pockets of seasonally-irrigated land under reservoirs, expanses of dry-farmed terraces and gravel-mulched fields, a few small but well-watered gardens and orchards, and rocky hills and fallow fields where grazing and collecting continued. With the abandonment of the city, the population of the valley dropped and almost all of the reservoirs and some of the settlements fell out of use.

Our understanding of the social processes of reservoir construction suggest that the consequences of intensification in the Daroji valley may not have included radical loss of land and produce rights, but instead may have led to higher and more consistent yields on land already under cultivation. This may be the case because many reservoirs were often built under the patronage of temples, who did not cultivate land themselves, and for whom shares of increase in produce were the reward. Others were financed by local political leaders, for whom they were both an investment and an act of merit (Morrison and Lycett 1994). The levels of profound powerlessness that are often associated with the virtual necessity for landless laborers in wet-rice areas are not as marked under reservoir cultivation and thus power relations play out differently where both initial social conditions and the physical/ecological structures of production vary.

Discussion

If we take intensification seriously as a process, then we must attend to its actual pathways or courses of change. Without a clear understanding of lived trajectories of change, arguments about cause and consequence are largely sterile. However, if we are to build comparisons, we will also have to attend more closely to the constitution of what we usually call cases. If our views of change are radically different depending on both our units (land, human economies) and scales (spatial, temporal, human) of analysis, as I have suggested that they are, then we must concern ourselves with those differences. What I am suggesting, finally, is that there no one correct scale of comparison; it is not simply a matter of setting our analytical microscope on the right objective and then proceeding on to comparison. I am not *only* suggesting that we look at smaller (and more consistent) scales than the Maya, the Bemba, or Bellary District, but I am also making the far less pleasant suggestion that we must constantly shift scales and units of analysis, depending on the nature of the question we are asking. Views of intensification trajectories that center on land differ greatly from those centered around human practice. Further, inside the question of human economies, whether or not we employ perspectives that depend on assumptions about individual choice, any consideration of human practice has to take into account issues of power, of constraint as well as opportunity.

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[1] That is, production per unit of land, or some other fixed quantity; intensity is always a relative rather than absolute measure.

[2] If, further, variable courses or strategies of intensfication exist, a definition based only on the presumed consequence of intensification makes all of those strategies analytically equivalent and thus irrelevant. I would like to thank Mark Lycett for pointing this out.

[3] At least Boserup's (1965) measure of intensification—fallow length—had the advantage of stressing agricultural practice. I have suggested that this criterion is grossly insufficient as a measure of intensification, failing to account for the complexity and diversity of actual agricultural strategies (Morrison 1995, 1996), which is not to say that fallow lengths are unimportant (and see Bray 1986 for a critique of Boserup's proposed technological sequence of agricultural implements).

[4] In studies of production that are artifact-centered, we often imagine that the key scalar dimension is time. Thus, a study of the intensification of obsidian blade production (although note how rarely production of non-edible goods is conceived as intensifying—such changes are more often accommodated under the rhetoric of specialization) may be described in terms of its change across temporal periods (the production of prismatic blades intensified from the Late Formative to the early Classic). In this hypothetical case, the spatial scale may be a site or region, but scalar variation in space tends to be held constant, or discussed in the language of distribution (i.e. exchange) rather than production. Obviously, there are serious implications both of parceling out space into tidy packages and of thinking of changes in production in terms of the time chunks we call periods, but my point here is only that changes in scale can create significant changes in our perception and that there are more and less anthropologically-informed scales that could be considered.

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INTENSIFICATION, INNOVATION, AND CHANGE:

New perspectives and future directions

Tina L. Thurston and Christopher T. Fisher*

You can judge your age by the amount of pain you feel when you come in contact with a new idea – Pearl S. Buck

The contributors to this volume have tackled fundamental archaeological issues that have long been taken for granted – subsistence intensification, innovation and change. As an underlying assumption in many 'bread and butter' problems in prehistory – domestication, social complexity, state formation – the theoretical importance of such processes cannot be understated. What the editors found striking, leading to the development of this volume, is how little attention these topics have actually received. Since the intense flurry of activity around Boserup's initial publications many decades ago, only a handful of treatments, as noted in our introductory chapter, do more than superficially reiterate these now-questionable theories. Instead, these long-held but unsupported assumptions borrowed from other disciplines have served as paradigmatic 'place holders'.

As we have stressed, Boserup's (1965) influential explanatory model proposes that population pressure is a prime mover both of agricultural change and intensification. While revised and revamped versions of Boserup have appeared, they generally restate its basic tenets. Perhaps because so much has been staked by so many on the universal "truth" of this thesis, well-argued critiques and valid alternatives have been rebutted or simply ignored. Thus, despite indications that many specialists in past agricultural strategies now wish to put Boserup to rest, we are obliged to continue the debate.

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In this volume, Morrison continues to reject Boserupian population pressure (Morrison 1994, 1996), calling for more sophisticated and less rigidly evolutionary schemes for understanding agricultural change and intensification, stressing that until we have more detailed data from individual case studies, it will be difficult to resolve issues of cause and consequence in broad comparative terms. We concur, and hope we have provided examples examining many general theoretical issues surrounding intensification, its causes, correlates, and consequences, yet which also provide a wide range of specific and detailed cases that add depth to the study of this important topic. Using her study area of South India, Morrison stresses the study of intensification on many scales of analysis, revealing a complex, multi-faceted interweaving of social and cultural motivations and constraints, agricultural strategies, and changes in production. Such complex combinations of intensive strategies are by no means found only in South Asia (see Fish 1995, Lang 1995) nor are combinations of intensive and extensive strategies (Scarry 1993).

In a related vein, Thurston's chapter also discusses the importance of multiscalar research and emphasizes what Morrison calls "the lived trajectories of change" in local populations studied on the small scale, nested within subregional and regional scales of analysis. Thurston addresses the possibility of variable underlying causal factors for intensification, even within a single region, and the circumstances under which agricultural intensification is undertaken. In a complex political context, is it a sure indicator of central elite involvement, as many assert (Kolata, 1991,1993, 1996; Stanish 1994, Sanders et al. 1979) or can it be undertaken at a local level? While many intensification projects may indeed point to central elites, recent studies (Erickson 1993, Scarborough 1991) indicate other possible explanations. The results of this study show that both may be occurring at the same time, and that agricultural changes that look similar on the surface may in fact be related to entirely different processes. Both social and ecological factors may be involved; in this case, variability in agroeconomic conditions combined with the ability of some groups to resist the state more successfully than others.

Fisher's paper questions several basic assumptions that have long been the sacred cows of intensification studies: that terraces, irrigation systems, and other forms of “landesque capital” represent intensification – since the classic definition of intensification refers to increased labor input per unit of land. In fact, after initial investments, such features are labor *saving* devices, that reduce labor, over time, to mere maintenance. In addition, there is no clear evidence that farmers in the Lake Patzcuaro Basin, where his research was conducted, intensified “from” some other form of agriculture like swiddening, as Boserup’s theory implies – landesque capital features may have simply been the methods of choice from the outset. This raises many interesting and provocative questions – are landesque capital features truly *not* intensive forms, or must we redefine intensification to include not only increased labor but “smarter” allocations of labor? In addition, with the emphasis on process (Morrison 1994, 1996, this volume) must producers be intensifying “from” something for a sequence to be explained as intensification? Morrison (1994, 1996) and Leach (1999) also argue for multiple starting points and trajectories – thus we may be better off redefining intensification rather than applying a rigid template for origins and processes.

Frederick addresses a similar subject: how should we interpret chinampa agriculture around Aztec Tenochtitlan? It has long been assumed that this method, dictated by the state, enabled the rise of the Aztec Empire from humbler Mexica beginnings. Yet Frederick argues that many of these features, when actually excavated, indicate construction methods so diverse that it calls into question the idea of whether such features constituted a state-sponsored project. Only detailed examination of such landesque capital investments, combined with a large-scale overview, can answer this question in the future.

Stanish takes a look at intensification in the highly debated Lake Titicaca region, where many arguments in favor of either exclusively top-down or bottom-up intensification have been fomented. While acknowledging critiques of top-down models for the region, Stanish suggests that rejection of such models is too complete, and argues that while raised-field and other forms of intensive agriculture existed before the rise of the state, the expansion of these methods and shifts in labor organization can be linked to the political economy of the Tiwanaku state and the Inca. He cites less risky and more extensive methods both before and after these complex horizons as indicators of a pull-factor for intensification. This position substantially revises this region's original prime mover explanations, based on demographic pressure, and moves toward more complex, mixed social and environmental explanations for intensification.

Baker's contribution also examines the construction of intensive features in this more detailed light, in this case, those constructed by the Maya. After assessing recent paradigm changes regarding both dry and wet agriculture in the region, he gives us a farmer's eye perspective of how Maya agriculturalists may have used the landscape – often with data belying our current reliance on ethnographic analogy. Stressing the difficulty of unpacking the construction sequence and dating of intensification features like terraces and raised fields, he urges Mayanists to undertake more careful excavations focusing on agricultural features, and suggests a reassessment of the reliability of palynology, artifactual cross-dating and other methods we take for granted when assigning phases to the expansion and contraction of farming.

An oft-neglected area of the intensification of subsistence production is that of animal intensification strategies. Four chapters in this volume address this issue. Monahan deals with early Neolithic Turkey, and agricultural strategies of innovation, specialization and diversification (Leach 1999) such as specialization and diversification in the ancient Near East. This example, drawn from one of the earliest sequences of agricultural strategizing, uses zooarchaeological data to illustrate the many approaches that early farmers used to experiment with enhancing and maximizing production in a so-called pristine environment.

Thurston compares intensification strategies in regions whose agricultural bases differed: one conducive to cereal production, the other suited primarily for cattle-raising and other animal based pursuits. During several centuries of increasing political complexity and integration, taxation, market forces, and the need to supply an expanding military sector were probably the primary forces behind intensification, rather than population increase or hunger. The cereal versus animal economies of these regions offered the state different resources, and the dissimilar ways of life associated with these economies created different local contexts for intensification.

Kusimba and Kusimba take up similar themes, revealing the frequent integration of agriculture and pastoralism, and the importance of animal intensification for trade, wealth and status creation and maintenance, as well as more traditionally cited needs for increased food supplies. They also note that while at the largest scale observable, population increase may be linked to intensification, in Africa one must examine practices at the local scale or miss a wide variety of strategies, not always in accordance with Boserupian demographic predictions. In Africa, the typical concerns of modern development organizations and governments link increased food production by any means with hunger and need. This, of course, was Boserup's context as well. However, the archaeological record clearly shows that with status often linked to cattle, iron, and imported goods, market activity and the trade of subsistence surplus was the main incentive for many past farmers to intensify, specialize, or diversify.

Typically, Africa is described in both modern and historic literature as having poor soils and extensive agriculture, while the true picture in the present, recent and distant past shows varied resources and extensive methods interspersed with the most intensive of regimes, such as terracing, irrigating, and manuring. The collapse of such complexity, sometimes with the onset of colonialism, has led to a largely ahistorical perspective, which posits little change through time. In fact, case studies show that among other trajectories, many regions disintensified through time, due to intrusion or conquest by African or European polities. Neighboring groups living in similar environments also practiced highly differing strategies, some intensive, some not. Another important feature of intensive production systems in Africa is surely the varied and complex methods of labor organization along kinship, age, gender, and household lines; these and others organizing principles are rarely considered by most archaeologists and among the considerations that Morrison asks us to weigh when undertaking archaeological explanations.

Perdikaris and McGovern also examine a case involving the intensification of animal products, within the context of the long and agonizing debate over whether or not ecological conditions prevent intensification and act as "limiting factors" on social complexity. While some may imagine that these debates belong more appropriately to the history of archaeology in the 1950s, 60s, and 70s, this is not the case. This debate, still ongoing, is perhaps best known in regards to Amazonia. Some time ago, for example, archaeologists began to call for better interpretations, stating that the early and simplistic models of environmental determinism in Amazonia were no longer the norm (i.e. de Castro 1996), but more recently others (i.e. Wilson 1999) have presented detailed and exhaustive works on South America, which while rejecting many of the more antiquated ideas of old-style cultural ecology, still extol the virtues of Steward and Meggars' environmental concepts. While distancing his research from these older models, Wilson still asserts that "the overwhelming consensus of evolutionary anthropologists is that states arose in environments that were particularly suited to relatively high subsistence productivity (1999:341)."

This argument, and others like it around the world, show that while individual case studies are vital for the development of a cross-cultural database, studies of intensification conducted in isolation may become over-preoccupied with region-specific problems, or even highly localized circumstances (Binford 1983, Raish 1992). These particularistic processes and events must be evaluated both alone and as generalized phenomena. Addressing the ever-present topic of the role of environment, climate change and variability on human subsistence strategies and their relation to the development of political complexity, we feel that a global perspective is highly valuable. In Perdikaris and McGovern, we discover how two closely related societies dealt with marginal environments in the best of times, as well as the undeniable impact of drastic climate change – the Little Ice Age – in the worst of times. Social choices dictated the collapse and extinction of one, the Greenland colony, whose inhabitants chose to intensify the exploitation of walrus to produce prestige goods, while the Icelanders intensified their staple goods economy based in fisheries, enabling them to tie their fortunes, both as individual producers and as a state, to the expanding proto-capitalist economies of later medieval Europe. This gives new perspective to the relationship between inhospitable climate, intensification, and complex societies: ecological conditions alone cannot predict the complexity of social organization, population density, or levels of surplus and productivity.

Feinman, Nicholas & Haines take up a related topic in a different ecological zone: the arid and inhospitable portions of the Valley of Oaxaca during the Classic Period. It has long been noted that dramatic shifts towards nucleation around large centers during this period would have placed farmers in marginal areas for maize agriculture, while at the same time squeezing them into crowded conditions. Yet through much of the Classic era state, these communities remained populous. What were they doing up on the dry terraces that was both possible under harsh conditions and valuable enough to make a living from? Does the region's inhospitability itself imply coercion? Or can it be viewed as economic entrepreneurship in a marginal environment? Or will we find some combination of the above? Feinman et al. demonstrate how xerophytic plants played a large role in this economy, until recently a largely unknown and unexplored part of the suite of possibilities for agricultural intensification in highland Mesoamerica.

As Blanton (this volume) reminds us, the ramping up of agriculture, herding, hunting or fishing rarely occurs in a vacuum; it is frequently associated with intensification and change in other part of society. While our main focus has been on subsistence techniques and their context, it is clear that the authors collected here acknowledge this, actively pursuing the multiple subsistence strategies developed by past societies, and also the links between food production, other sectors of the economy, social and political change, and ideological transformations, among many other key factors.

FUTURE DIRECTIONS FOR SUBSISTENCE CHANGE STUDIES

In addition to the overarching concept of intensification, the contributors to this volume discuss a wide variety of responses to the need to adjust, realign, or transform subsistence practices, such as the often simultaneous or related processes of diversification, specialization, extensification/disintensification. Behind these lie factors of labor organization, gender, class, and ethnic impacts of subsistence activities, and further study of these processes will, in the future, form the beginning of a more substantive archaeological theory of intensification. We would like to present three future directions, distilled from the contributions in this volume, that we feel can begin to supplant ideas that have lived well beyond their time. These are diversification, specialization, and disintensification.

Diversification

Diversification, as the term implies, involves the cultivation, breeding or harvest of a wider variety of crops, animals, or other resources, either for consumption or sale in the marketplace. While Robert Netting, a well-known source for archaeological borrowing, discussed the existence of diversification among smallholder agriculturalists (Netting 1993), few ethnographers have yet to closely consider this phenomenon (Dorsey 1999), and perhaps lacking a model, neither have many archaeologists (but see Monohan, this volume, on both diversification and specialization). More about diversification has been written by development specialists and economists of various types. Agricultural economists distinguish between *farm diversification* which refers to production activities on the farm and *farm income diversification* which refers to the diversification of market outlets or income producing activities (Ilbery 1991). The dynamics of diversification change in relation to scale, balance between subsistence and surplus production, and the "prosperity" level of the farmer (Dorsey 1999:179).

After the failure of Boserup's original theories in many observable modern cases (i.e. Ho 1985, Lele and Stone 1989) an alternative *market demand theory* was proposed, stating that intensification methods come into play when farmers producing for a market respond to demand by attempting to maximize their profit (Dorsey 1999:181). Research on modern farms in "economically lagging" regions, where new strategies are needed to turn around declining success, indicates that diversification can bring substantial benefits, but the main obstacle is convincing farmers to diverge from traditional practices in ways that involve expansion or investment (Bowler 1999), reflecting a general fear of risk that limits some farmers actions: some immediately see rewards and adopt such strategies, while others refuse to consider them (Alam 1993). This phenomenon may be idiosyncratic and uneven: psychologists have discovered that farming decisions involving economic strategies and choices are substantially linked to personality type, intelligence and outlook, with marked tendencies toward or against strategies like diversification predictable along these lines (Austin et al. 2001).

Another key dynamic is local or regional *resource endowment* (Dorsey 1999:181). The relative presence or absence of good local conditions for agrarian, pastoral or other subsistence pursuits is related to decisions about whether or not to improve (or innovate) through technology – a model that avoids any necessary links to population pressure. This has led to the development, in economics, of what is termed *induced innovation theory* (Binswanger and Ruttan 1978; Dorsey 1999, Hayami and Ruttan 1985). This proposes that farmers are more likely to innovate technologically when their holdings are in poor or less optimal territory.

Specialization

Specialization, when practiced as a single strategy, is a risky approach in which farmers take a chance on producing a single or narrow range of crop or animal species in order to supply a lucrative niche, but one which may prove unstable and lead to economic trouble (see for example Perdikaris and McGovern, this volume). Sometimes such schemes are imposed from above, in colonial situations, for example, well known from 19th and 20th century history (i.e. the classic piece by Lappé and Collins 1977). Such specialization in the past may well have similar impetus.

Specialization, however, can also be combined with diversification for a highly successful result that has little to do with top down processes. For example, in a recent case study, Dorsey (1999) proposed and tested several hypotheses about the conditions under which traditional farmers would make certain choices. He found little significance between the scale of production and the farmer's net income-larger farm operations were not necessarily more productive. Rather, his most interesting finding was an important link between specialization and diversification: they were highly correlated and also had a strong effect on net income. Dorsey (1999:192) notes that this may at first seem "theoretically contradictory, as diversification implies a wide variation in products, whereas specialized commercial production involves the opposite, a narrowing variation of products." In fact, when observed on the ground, it turns out that "a greater number of crops under production provides the smallholder with a broader portfolio from which to select crops for the market (Dorsey 1999:192)" in specialized niches. This strategy also appears to help farmers maximize opportunities from fragmented land holdings, as the various products, with different preparation, planting, growing and harvesting seasons, must be separated due to their nature, and the typical lack of efficiency seen in unconsolidated land becomes less important.

One main constraint on this strategy is the lack of means to recruit or hire help, spend resources on new technology and other problems related to investment (Dorsey 1999:192). In cultures past and present where large kin groups or other aggregates can be called upon for labor and other forms of support, this might not present a problem, instead acting as a community unifier. A second constraint (ibid) was the availability of land. Yet in this study, the cultivated land areas were generally quite small – only 1.2 to 1.6 hectares for the diversified farms where some extra land was needed to experiment with new crops. Given the findings that large-scale production is not well-suited to diversified production, there may be an upper limit to this effect.

Two hypotheses tested by Dorsey (1999:193) and supported with his data were that households whose production is primarily focused on subsistence may suffer hardship in times when the food supply is disrupted, as they have less means to purchase or barter for food in the marketplace. And, as urban populations rise, more people are at risk when there is little local surplus food production.

Thus, specialization with diversification may be an effective way for ordinary people with limited resources to successfully intensify production and their own well-being through integration with complex markets. In addition, in relation to Boserup's and other population driven arguments, such studies indicate that increasing population, leading to smaller average landholdings, need not be problematic in terms of increasing production, and more importantly, the market value of what is produced.

The detection of such strategies might provide extremely useful clues for archaeologists: "smallholders face considerable risks in diversifying production, and favorable market conditions are critical to success (Dorsey 1999:192)" due to the inherent instability in markets for such highly specialized "niche" products. The existence of specialized production within a framework of diversification might point to the existence of fairly specific economic conditions and demand for specialty products from other sectors of society.

These findings show promise for specialization/diversification theory, as well as the related induced innovation theory discussed above. Small farm size does not necessarily mean poverty. Evidence of relatively small holdings of land managed with intercropping, multicropping and new technologies might provide insight on the direction of agricultural change, and archaeological correlates for the complex interrelationship between diversification, specialization, subsistence production, surplus production, and income. Intensifying production and accumulating surplus, in archaeological terms, are often linked with the welfare of economic and political elites. However, seen through the lens of induced innovation theory, it has significant ramifications for the non-elite as well. Increased income potential can be related to many things, from the local improvement of farmers' status to a high tax or tribute burden that takes most of the benefit out of local hands and into distant treasuries (see Thurston, this volume). This will prove to be an interesting model for future archaeological research as well.

Disintensification

Disintensification refers to the relinquishment of intensive methods of subsistence, a process that can occur under varying circumstances. Some ethnographic studies have found that reduced intensification, in order to obtain other income sources, is a rational strategy - putting less into farming was a good or an only choice in some cases, due to regional conflict, economic, labor and other problems (Conelly 1994:167). This type of disintensification, as a choice or strategy in some subsistence trajectories, has only been explored by a small group of archaeologists (Leach 1999, Morrison 1996, Farrington 1985), but will hopefully gain ground as a concept that might revolutionize interpretations. Currently, most authors only refer to disintensification briefly, as a possibility that may occur due to abandonment following crisis or population crash. Despite Brookfield's (1972) discussion, it has not been an area of extensive study by geographers either (but see Whitmore and Turner 1992 and 2001 for an example), although Doolittle (1984, 1988) explores the implications of intermittent land use, as well as what varying 'stages' of intensification comprise. Ethnographers have also somewhat neglected this process but what findings have been reported are important for archaeological models. Comparative studies of adjoining areas where intensification has contrastingly continued or ended show that economics and historic context are the key factors – not environment.

For example, in parts of Kenya, formerly intensive agriculturalists have abandoned their traditional farming methods, which included sophisticated terrace systems created at least two centuries ago, complex methods of erosion control, fencing and intercropping. They have disintensified despite rising populations and food shortages in their immediate region – not a situation of territorial abandonment or population decline (Conelly 1994:145). This is not an isolated instance; similar abandonment of intensive methods is also seen in Zambia and Tanzania.

In Kenya, causal factors can be traced back to 19th and 20th century colonial times, when epidemics wiped out up to 30 percent of the population lying close to colonial centers, and when demographic recovery began, men in areas closest to these outposts were encouraged to migrate for various reasons: local military and labor took many, with some traveling to Europe (Conelly 1994:154-55). This led to a ‘new’ tradition of labor migration and the current problems of out-migration for higher wages in urban and fishing industries, exacerbated, but not caused by local soil problems. Women, who once did the majority of farming and were also key figures in fishing business management and marketing have also lost ground as society became more mobile and less traditional – female relatives within one district would, in the past, band together to work. The mobility of the men they married caused them to become scattered, leading to a decline in cooperative labor (ibid). Yet in nearby regions where colonial rulers were more distant and had less influence, traditional intensive methods remain intact and continue to be used to this day, despite nearly identical ecological and agricultural conditions.

The process of abandonment in Kenya is an archaeologically observable one: Conelly reports that by the 1980s, disintensification was seen materially in the abandonment of terraces, decreases in fencing, and the deterioration, through lack of upkeep, of certain kinds of check dams.

The combination of factors for those most greatly impacted in Kenya is not at all unusual – see Fisher, this volume, for example, on the impact of European colonialism on complex agricultural strategies in the Tarascan Empire. It is also similar to the Aztec case as discussed by Whitmore and Turner (1992). Comparison of differential regional responses to colonialism may have utility for modeling other archaeological examples, including earlier, prehistoric cases. Historic cases of disintensification illustrate the fact that historical issues with substantial time depth can account for many local choices and decisions. Wider political and economic conditions may be equally or more important than ecological concerns (as in Thurston, this volume). As seen in the Kenyan example, such changes can also impact the gendered division of labor, a growing consideration in current archaeology.

Finally, Boserup’s thesis and its successor theories cannot predict these conditions, because they assume that people farm for subsistence and that populations are self contained, all over-simplifications (Conelly 1994:166). Even if populations are rising and people are indeed hungry, this does not always result in intensification.

CONCLUSIONS

It is clear that many archaeological contexts could benefit from the exploration and development of empirical methods with which we can "tease out" intensification, specialization, and diversification (Farrington 1985) and the like, and also examine the issues behind “disintensification” (Conelly 1994, Wiegers et al. 1999).

Some of the components of these processes have clear material correlates, and will no doubt be incorporated into future archaeological model-building. Others are not easy to see archaeologically, but must be investigated by material proxies. Some rely heavily on inference or analogy from the ethnographic record. Yet, as may authors contributing here and elsewhere have noted, the understanding of these complex processes are vital to the direction of our interpretations. While we may not be able to test whether some of these processes occurred in the past with complete surety, neither can we assume that the past is as easy to figure out as earlier theorists imagined. A few decades ago, archaeologists could not imagine the questions we ask today, or the methods with which they can be answered. We end this volume by introducing a renewed imperative to the study of past subsistence change – to proactively pursue these promising areas of research and press the study of subsistence change into new and thought-provoking territory.

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