Rate and process of societal change in semitropical settings:
The ancient Maya and the living Balinese

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Abstract

Anthropological archaeology provides the best window into how ancient societies coped with environmental exigencies and to what degree society itself may have been responsible for environmental change. By examining two pathways to social complexity—one based on technological breakthroughs (technotasking) and the other on highly organized labor management (labortasking)—early statecraft is assessed. Both the ancient Maya and the present-day Balinese are examined as case studies of the labortasking trajectory. The significance of past social organizational systems for assessing the immediate future is suggested.

1. Introduction

Anthropological archaeology is uniquely positioned to address long-term social change and its complex interactions with the environment. Because the data sets are rich in carefully collected and assessed environmental parameters contextualized by societal activities and cultural adaptations, archaeology can significantly reflect on the stability and resilience of ecological communities broadly conceived through time. Temporal perspectives at both the centennial and millennial time frames permit the only controlled evaluation of natural resource consumption in the context of societal structures available at these interpretive scales.

Many of the biophysical data sets currently employed to estimate the severity of ecological change on the planet draw from carefully monitored observational studies conducted over the last half-century. These data emphasize highly controlled observational assessments of comparable units of analysis making for sophisticated scientific parameter modeling of current and future ecological relationships. Unfortunately, the initial conditions from which these assessment spring and the predictions that follow do not account for the deranging environmental effects of sedentary agriculturists beginning as early as 10,000 years ago (cf. Denevan, 1992; Scarborough, 2003a). About 5500 years ago, the impact of urbanism and the centralizing of natural resources in refined concentrations fundamentally heighten the pivotal role of humanity on all ecosystems in proximity to civilization.

Because archaeology has charted the rise and fall of civilization from several social and environmental contexts, it provides critical insights into processes of ecological change. Although a difficult undertaking with many interpretative pitfalls, archaeology remains the principal disciplinary division capable of judging the effects of environmental change on societal structures as well as the role of society itself on the overexploitation of environmental resources and their long-term consequences. This is the context for this article.

2. The many pathways

Cross-cultural examinations of the archaic state are the subject of several recent book-length assessments (Feinman and Marcus, 1996; Scarborough, 2003b; Trigger, 2003; Yoffee, 2005). What they document are the many divergent trajectories for state formation and socioeconomic complexity in the past and the difficulties that the social sciences have in clearly identifying material traits, or consistently recurrent variables, that allow inclusion of all early experiments in social complexity (cf. Childe, 1950; Whitehouse and Wilkins, 1986).
Another approach to evaluating the early state in the archaeological record is to focus on where a society has been—both geographically and ecologically, as well as the socioeconomic and sociopolitical structures that have guided it. By moving the discussion away from specific traits like urbanism or monumental architecture and their presence or absence, we can begin to see the sets of initial conditions that stimulated aspects of complexity. In keeping with the fundamental role of the environment in significantly charting the course of social complexity, the role of resource concentrations becomes a principal baseline. The extraction, distribution and consumption of the primary resources of food and shelter, coupled with subsequent wealth disparities embedded in increasingly refined and concentrated resources, provides a window into the outward expression of an early state and its development (Scarborough, 2000).

Since the rise of the recent Nation State and the florescence of market economies, the many other pathways that social complexity have manifested have been quelled (Nietschmann, 1987). This is not to say that these other trajectories have altogether disappeared (Scarborough et al., 1999), rather they are now highly constrained and limited in their material expression. Those with indelible architectural and artistic records, but present only to the archaeologist, reveal highly effective social systems with longevities several times greater than the highly resilient yet somewhat untested Nation State. Although the hegemonic state has appropriated or co-opted most other previous examples of social complexity, it behooves us, its practitioners, to assess other ways to cope with environmental degradation and social unrest (Scarborough, 2006a, p. 414). Lessons learned from the past may be incorporated, if the lessons are allowed full recovery and fair evaluation (Fig. 1). Here, I examine aspects of the dominant paradigm leading to the Nation State as well as an earlier socioeconomic and sociopolitical pathway that once successfully competed with the classic hegemonic state model.

The first pathway is identifiable by a well-established investment in technology and a marked centralization of resources. Elsewhere, I have coined the term technotasking to capture the economic and political effects of this kind of social system (Scarborough, 2003b, 2005; Fig. 2). It developed initially along the lower Tigris and Euphrates drainages of southern Iraq and western Iran, though other early manifestations were soon to follow. The lower Nile, the middle Indus, the middle and lower Huang-he rivers
provide good evidence for large-scale investments in aspects of urbanism, complex architecture, and craft specialization. What made these developments possible at an early moment in protohistory was their ability to amass sizable amounts and variable kinds of resources from landscape-altered and -controlled zones. Early cities were awakened by the challenges of a semiarid surrounding juxtaposed with a major set of exploitable waterways.

Irrigation probably has a truly ancient inception, but the earliest recorded canal diversion system was at Choga Mami in eastern Iraq at 5500 BC (Oates, 1973). By 3000 BC canalization was extensive and complex along both the lower Tigris and Euphrates (Adams, 1981). This was the “heartland of cities”—and though we no longer look to Wittfogel’s (1957) Hydraulic Hypothesis for the origins of the early state, riverine manipulations within an otherwise arid setting present a complicated set of linkage with the rise of social complexity. Rather than emphasizing canalization as the triggering agent, arid and semiarid states accent a set of technological “breakthroughs” that managed to buffer populations from the immediacy of an inclement setting. By investing in novel ways of redirecting and capturing water from the nearby drainages, the biophysical environment was rapidly, and sometimes radically, transformed. New ways of planting and harvesting incited surpluses that required storage and protection from environmental elements as well as unauthorized access by neighbors. The demand for new tools to manage best the centralization of resources including labor, water, and the bounty of the land was complemented by a rapid growth in the technology of weaponry. An increasingly rigid separation between groups—pastoralist vs. sedentist, villager vs. urbanite, commoner vs. elite—resulted in efforts to defend resource concentrations from behind city walls as well as to aggressively acquisition these same resources from a neighbor (Scarborough, 2005).

The rudiments of the present-day Nation State were set in motion when highly concentrated and refined resources were accumulated, stored, and made accessible to a restricted set of stakeholders. The incentive for this pathway was making a living in a highly circumscribed environment only successfully augmented by increased amounts of watered and fertile land (Carneiro, 1970). The ability of established sedentists to crop land that was formerly undeveloped desert waste represents a sea change in economic and political life. The establishment of significant resource concentrations allowed the evolution of the earliest cities.

But this trajectory was not the only pathway to social complexity (Fig. 2). Another was grounded in those environments and social conditions that prevented the rapid concentration of resources with or without technological breakthroughs. Labortasking is a societal way of making a living in which dispersed resources are slowly integrated and organized in situ to provide for sizable sedentary populations which are also frequently dispersed.

Although several environments may accommodate a labortasking approach to resource extraction and use, semitropical settings reveal our best window into the factors initiating this alternative pathway. There are several reasons for this environmental circumstance; principal among them is the distribution of species. Tropical and semitropical environments are renowned for their species diversity, several times greater than that manifest in temperate or semiarid settings. Nevertheless, this abundance belies the complementary fact that any one species is significantly limited in richness, or numbers within any one patch or microenvironment, when compared to similar sized temperate or semiarid settings (Scarborough, 2000, 2003b). The implications of this observation to humans are legion when examining notions of sedentism and subsequent state formation. Attempts at concentrating critical resources and establishing urban populations as dense as those driven by a technotasking pathway were seldom made. Humans tended to mimic the natural order of dispersion by adapting to the myriad of resource patches. When they tried otherwise, environmental degradation was quick to dissuade them from another potential pathway to social complexity. Moreover, elevated rainfall regimes frequently associated with slow-moving drainages discouraged formal irrigation; shallow tropical soils sometimes restricted domestic plant productivity; and elevated humidity and temperatures accelerated organic decay and diminish prospects for successful storage. Generally speaking, technological breakthroughs only exacerbated the delicate balance. How, then, did any notion of social complexity take root?

The key to social development in these latter environments is tied to a slow, more measured harvesting of resources. Degrees of resource concentration were possible, if the constraints and limitations to their extraction were contextually understood. By incrementally altering the natural world by way of substituting or transplanting useful plants in proximity to increasingly dense human populations (cf. Geertz, 1973; Wiseman, 1978; Campbell et al., 2006; Clement, 2006; Erickson and Balee, 2006) [and perhaps implementing associated animal conservation measures (Linares, 1976; cf. Pohl, 1981)], an interdependency and longevity developed between society and an evolving engineered landscape. Elsewhere (Scarborough, 2003b; Scarborough et al., 2003), several researchers have referred to this set of flexible, highly adaptive interactions between societal structures and the engineered landscape as self-organization (after Lansing, 1991, 2006).

We know quite a lot about the technotasking pathway given its indelible imprint on most quarters of the world today. It represents the hegemonic hierarchical control structures affecting all present-day economic and political organizations, and it has significantly compromised other previous forms of social evolution. Even anthropology, the discipline defining “otherness,” is colored by the pervasive-ness of hierarchical scales and notions of absolute power. For example, anthropological archaeology has attempted to distance itself from multilinear evolutionary models that embrace a band-, tribe-, chiefdom-, state-staged
development, a scheme based on successive levels of social complexity supported by increasingly steep-sided hierarchical ordering and control. Nevertheless, we are implicitly wedded to these models (Scarborough, 2005b). Because of entrenched views and the pervasiveness of the hegemonic socioeconomic and sociopolitical pathway, archaeology, too, remains embedded in terminology and a disciplinary history that impedes its ability to assess non-technological data sets.

Nevertheless, another way to assess our global resources is presented here drawing from two case studies: the ancient Maya and the living Balinese, both examined in the context of their semitropical settings. Although both examples demonstrate similar labortasking developmental pathways, significant differences exist between their respective environments and culture histories. Three potential deranging factors hindering ideal comparisons between the Maya and the Balinese are respectively:

1. basic (karstic) vs. acidic (volcanic) soils
2. gentle vs. steep-sided relief
3. maize vs. rice agricultural cropping

To be sure, these are significant contrasts. Nevertheless, complementary comparisons trump these differences and demonstrate the role of broadly similar sets of environmental variables and the shared effects of comparable economic and political decision-making situated a hemisphere apart.

3. The ancient Maya

Associated with shallow but fertile soils derived from karstic bedrock, the southern Maya Lowlands extend well-over 100,000 km² with a projected population of 5 million by AD 700 (extrapolated from Rice and Culbert, 1990; Fig. 3). Although topographic differences are sometimes abrupt, pronounced surface relief is slight when compared to the adjacent volcanic highlands of southern Guatemala or the Mexican highlands, farther to the west. As typical of wet-dry tropical forest settings, precipitation is heavy for 8 months of the year, but 4 months of drought-like conditions follow in which less than ten percent of the annual rainfall becomes available. Because of the karstic terrain, water does not tend to collect or runoff for any distance. Although a few perennial rivers exist, most surface water percolates away through the highly jointed and fissured bedrock. Without modern bore-hole technologies and diesel-driven pumps, access to these sometimes distant aquifers and “underground streams” is frequently impossible. In northern Yucatan, where the water table is more elevated than in the south, deep and open cenotes, or sinks (dolinen), were accessible by ladder and permitted year-round potable supplies. Nevertheless, this was seldom the case in the southern half of the peninsula, the core area for much of what we view as the pinnacle of ancient Maya civilization.

The high humidity and temperatures together with the overall amount of precipitation resulted in levels of organic decay unimaginable in more temperate or arid settings. The numerous depictions by the Maya of their underworld consisting of rot, fetid orders, and skeletal remains accurately portray the rapidity of decomposition (cf. Tedlock, 1985; Schele and Miller, 1986). Stagnant waters collected in numerous reservoirs and tanks required frequent human-induced circulation and/or water-purifying plants to curb the growth of deleterious bacteria and the spread of water-borne disease (Ford, 1996; Lucero, 1999, 2006). Concentrating resources required significant effort, especially with respect to resources like water, food, and fiber. Food storage facilities are little understood (but see Smyth, 1990). Year-around food access likely emphasized rapid production associated with complex networks of immediate exchange as opposed to centralized and long-term storage arrangements.

Corn, beans, and squash have characterized the economic literature of Mesoamerica since Kirchoff's trait list (1952) identified the region as a “culture area.” Although the prominence of maize in pre-Colombian diets is questioned at some ancient site areas (Feinman and Nicholas, 2005; Kowalewski et al., 2006), its pivotal role in the development of long-term settled populations throughout Mesoamerica remains unchallenged. Nevertheless, maize was seldom a mono-cropping adaptation. Ethnographic and ethnohistorical accounts of the Maya
indicate that several different plants and planting strategies contributed significantly to a balanced diet including the triad of corn, beans, and squash (Nations and Nigh, 1980; Schwartz, 1990; Atran, 1993; Peters, 2000). The ancient Maya tended and likely cultivated wild plants that contributed significantly to the diet—and when milpa fields were planted with domesticates, maize was poly-cropped with beans and squash among other semitropical domesticates (Marcus, 1982; Scarborough, 1998). This kind of harvest diversity mimicked the constraints and rhythms of a semitropical, wet–dry forest ecology.

As outlined, high species diversity juxtaposed with low numbers of any one species in any one microenvironment cultivated dispersed settlement, especially during the earliest periods of social complexity. Coupled with storage difficulties and poor access to potable bodies of freshwater, the Maya were constrained in what developmental pathway they might tread. Because the ecological setting was fragile, abrupt and rapid alterations to the environs frequently were met with similarly abrupt and rapid degradation. By slowly deploying accretional modifications to the landscape, however, the Maya cultivated interdependence with their surroundings mimicking the natural and expeditious pathways of a jungle ecology. Economic, political, and ideological structures evolved in concert with the altered environs resulting in an integrated and self-organized ecological community, broadly defined.

Intensification on the landscape was accomplished by several slowly evolving social and physical adaptations. Because of the difficulty in concentrating and storing large amounts of food, year-around, resource availability was first and foremost a scheduling problem. Given the overall abundance that careful management might extract from the environment, a coordination of agricultural production cycles evolved. Although the Maya calendar continues to be assessed in terms of ritualistic astronomical associations and commemorations to the birth, ascent, and demise of deities, kings and their kingdoms (Sharer and Traxler, 2006), it likely had a mundane economic dimension like the origins of writing and associated scheduling in other quarters of the world (Schmandt-Besserat, 1992). The calendar’s intricacies suggest a highly flexible system of scheduling and prediction that likely coordinated the movement of goods, services and information rapidly and openly allowing for adjustments in deranging seasonal and microenvironmental change. Multifaceted in execution, the calendar accommodated political agendas literally carved in stone—but it also provided the necessary exchange controls for several scales of economic interaction between communities and their environments (cf. Scarborough and Valdez, 2003).

In the labor tasking world of the Maya, it was human bearers that moved bulky goods. Trigger’s observation (2003, p. 123) about the sheer size of New World populations prior to the Spanish entradas—when contrasted with comparable levels of societal development elsewhere—supports an emphasis on labor and the scheduling of work routines over technological breakthroughs like the wheel, the sail or devices associated with domesticated beasts of burden. Furthermore, a recent compilation of the ancient road systems in the Maya Lowlands suggests that goods were moved rapidly (Shaw, 2001). When coupled with the most sophisticated assessments of time known for any New World civilization, it is not difficult to project a highly integrated extraction and distribution of resources in the absence of truly large surpluses concentrated for extended periods at a few primary “cities.”

Nevertheless, to enhance and sustain an economic system dependent on the kinds of interdependencies projected required some degree of storage. The ubiquitous appearance of chultuns, or subterranean, bottle-shaped depressions, at nearly every community in the southern Maya Lowlands suggests a widespread attempt at individual residential storage. Unfortunately, reconstruction experiments have not clarified their function, as chultuns may have had several different uses besides storage (cf. Puleston, 1971). One well-reasoned interpretation suggests that they were used to accelerated fermentation rather than curtail it in producing a mild and easily digestible alcoholic drink (Dahlin and Litzinger, 1986). Given the expected incidence of water-borne disease, widespread consumption of a mildly fermented water source follows from the premium placed on potable water availability (Vallee, 1998; cf. Miksic, 1999). This scenario, of course, suggests the limited utility of the chultun for grain (maize) or related organic storage—though maize preparations for long-term storage was surely accomplished (Smyth, 1990).

Natural storage of certain root crops in their undisturbed and unharvested field settings remains a strong prospect (Bronson, 1966). Manioc is a staple in the Amazon and is reported as starch granules and/or a pollen print at several Maya communities (Jones, 1994; Piperno and Pearsall, 1998; Dunning et al., 2003) and as casts of tubers at the Ceren site (ca. A.D. 590; Lentz et al., 1996). Presumably, it was “stored” for a year or two before harvested and rapidly distributed and consumed (Cock, 1982; Ceballos, 2001). The scale and significance of salt production, too, has been recently accent by McKillop (2003) as has its implications for organic preservation—especially that of fish. Nevertheless, the actual methods and extent of food dehydration in preparation for storage are not well understood (cf. Forbes 1955, pp. 187–189).

3.1. The built environs of early Maya society

Within the contexts outlined, the Maya developed a highly complex economic and political environment. Elsewhere, I (Scarborough, 1983, 1993, 1994, 1996, 1998, 2003a, b, 2006a, b, 2007a) have argued that the Late Preclassic Maya (400 BC–AD 200) altered their environment by gravitating toward natural depressions, modifying those natural basins to best collect and maintain seasonal runoff, while constructing adjacent civic and residential
architecture. In some cases, where water was trapped naturally year around, sizable populations concentrated in proximity. Dubbed “concave microwatersheds,” these landscapes were expeditiously modified for collecting and managing water (Fig. 4).

The Late Preclassic community of Cerros lies on the leeward side of a small peninsula defining the eastern margins of Corozal Bay, Belize and projecting into greater Chetumal Bay, Mexico (Figs. 3 and 5). When the site was established and most densely occupied, it had a population of perhaps 3000 inhabitants (cf. Scarborough and Robertson, 1986; Scarborough, 1991a). Population estimates are difficult because a portion of the community is submerged as a result of a meter or more of rising sea levels since Late Preclassic occupation (Scarborough, 1991a). During six seasons of field work, a carefully rendered contour map was produced and juxtaposed with present-day vegetational communities and associated soil types (Scarborough, 1983, 1991a; Fig. 6). These data sets permitted a reconstruction of the past environment and revealed the degree to which post-abandonment sediment distortion had infilled ancient depressions and quarry space. Cerros had been systematically landscaped from within a naturally low-lying locality. Although the interior crest of the shallow peninsula was only 6 m higher than the shoreline margins where the central precinct was located, the peninsular elevational difference provided a year-round water source for the site given deliberate channeling and collecting of runoff.

To construct the pyramids, ballcourts, and numerous housemounds at Cerros, quarried limestone and marl was systematically removed from the site. This was expeditiously undertaken to enhance the collection of water given the highly seasonal and frequently variable rainfall regime. One of the most distinguishing artificial features at Cerros is the main canal or ditch that circumscribes the inner core of the site enclosing 37 ha, the ditch itself extending 1.2 km in length with a variable width of 6 m and a depth of 2 m. At the outset of discovery, the feature was conjectured to have been a natural meander or distributary of the now submerged mouth of the New River only 2 km away. Five cross-sectional excavations in concert with a fine contour-interval, mapping effort demonstrated that the feature was
deliberately cut into the indurated, runoff-impervious, limestone caprock at the site. The northeastern-most excavation exposure demonstrated the utility of the feature for water entrapment (Fig. 7). Defined by two steps carved into both banks of the canal, it opened near its bottom reaches onto a sill that dropped again into a small pool-like depression at the feature’s absolute base. Two small dipping pots rested in situ, one on the sill and one on a step. Our reconstruction of the original excavation and use of the canal suggests that during the wet season the canal filled and even crested, illustrative of water abundance and its collection. With the onset of the dry season, supplies were consumed and affected by evaporation resulting in a dropping surface water table. Nevertheless, the steps into the canal allowed continued access to the source. By the driest period of the year, water was contained in the lowest reaches of the basin and obtainable by kneeling on the projecting sill and dipping one of the diminutive pots into the small concentrations of ponded water—presumably filling one of the common three gallon ollas, or water jars, which are found in fragments at nearly every domestic house mound. With the return of the rains, the entire cycle was repeated.

During the rainy season, water availability was abundant and likely necessitated drainage control managed by the canal and its inward-flowing drainage channels. When coupled with the numerous small tanks and adjacent catchments, considerable quantities of water were collected for the following dry season. The main canal positioned at the periphery of the inner site core received the bulk of the runoff from the peninsular gradient sloping toward the shoreline. At capacity, this “elongated reservoir” held over 14,000 m$^3$ of water (Scarborough, 1983, 1991a).

Our base contour map of the architectural structures at Cerros revealed an overall volume of 210,986 m$^3$ (Fig. 6). When compared to the visible and reconstructed depression volume of 190,651 m$^3$, it is apparent that most of the quarrying at the site was done in immediate proximity to the many artificial mounds. Rather than focusing quarrying efforts in a haphazard manner, however, the built environs at Cerros emphasized the import of a drainage system. Because the caprock at Cerros is indurated to a depth of 2 m, ancient excavations seldom descended
deeper. Although the coastal caprock is a somewhat unusual natural surface when compared to ancient site areas in the interior of the southern Maya Lowlands (cf. Reeves, 1970; Scarborough, 1991a, pp. 35, 36), it prevented premature percolation of runoff without investing in major artificial pavements. Digging deeper for quarried fill at Cerros would have interrupted the lateral movement of runoff.

Cerros was a socially complex early town in the Maya Lowlands. Its pyramids and plaza space were thickly plastered and painted with elaborate iconographic and artistic expression. Numerous cache offerings suggest its role in a complicated long-distance exchange system (Freidel, 1979). The two well-defined ballcourts suggest it was a regional locus for pilgrims and traders (Scarborough et al., 1982; Scarborough, 1991a, b). Nevertheless, its investment in landscape alteration and water management are especially revealing of the trajectory the Maya charted in coping with their fragile environment. In keeping with the centrifugal forces of a dispersed biological setting, Cerros was compacted but not nucleated. The modifications to the natural environs, and especially the water system, allowed the degree of resource concentration attained.

Other examples of water management accompanied by growing concentrations of people and associated architecture are identifiable in the Maya area during the Late Preclassic period. The elaborate canalization efforts at Edzna, Campeche, Mexico (Matheny, 1976) and the significant alterations to bajo margins at El Mirador, Peten, Guatemala (Hansen et al., 2002) at a comparable time as the earthmoving modifications at Cerros indicate a shared landscape strategy. Although these engineered systems were elaborate for their time, they were always an interplay with the immediacy of their local environmental circumstances. Generally speaking, they were passive systems in that the residents responded to the natural movements of water by locating their communities near naturally low-lying settings to catch and divert the resource for usable ends.

3.2. The subsequent built environs

During the Classic Period (AD 200–800), another significant landscape alteration occurred. Like Cerros in typifying Late Preclassic water systems, Tikal provides our best case study for the subsequent set of changes to the built environment (Fig. 3). Tikal is the most well-studied and visited ruin in the southern Maya Lowlands (Harrison, 1999; Harrison and Laporte, 2005). It is considered one of two core site areas contending for control of the entire Maya region at AD 700 (Martin and Grube, 2000). With a population approaching 65–80,000 within a ditched alignment encircling an area of 120 km, Tikal may have been the largest “city” in the Maya Lowlands (Puleston, 1983; Rice and Culbert, 1990). In addition to its pivotal role in the political and ideological composition of the Maya area, Tikal was a massively engineered landscape with some of the largest Classic Period monumental architecture crowned by the tallest building, Structure IV, in the New World (Sharer and Traxler, 2006). As typical of most Classic Period communities, the core architectural district was at the summit of a hillock or ridge. Among the numerous ballcourts, towering pyramids, palace-like structures and courtyard groups were huge reservoirs and tank systems. Unlike Cerros and earlier Late Preclassic communities, Tikal was seemingly constructed away from the flanks of low-lying and naturally ponding water sources.

Because of Tikal’s heavy investment in monumental architecture and associated pavements at the top of a hill, its water planners and engineers established two fundamental conditions: (1) summit localized construction quarries that were rapidly converted into reservoirs and (2) a sealed cap of imperious plaster covering most of the central precinct and acting as a catchment surface for surface runoff (Fig. 8). Elsewhere, I (Scarborough and Gallopin, 1991; Scarborough 1993, 1994, 1996, 1998, 2003a, b, 2006a, 2007a) refer to this deliberate landscaping effort as a “convex microwatershed” (Fig. 4). Within the 62 ha identified by the summit of the hillock circumscribed by three elevated causeways linked at their vertices forming a near right triangle, all runoff drained into itself. Although elevated with respect to the topography around it, this internally draining, central precinct zone permitted the collection of precipitation shed from the paved catchments into the sizable summit reservoirs (Fig. 9). Given a 1500 mm annual precipitation rate with 90% of it falling during an 8-month rainy season, over 900,000 m³ of...
precipitation would fall and run off the pavement surfaces within this zone. The volume of the six central-precinct reservoirs was 100,000–250,000 m³ permitting the collection of as much as a quarter of the total rainfall for subsequent use during the dry season. Because of the elevated position of the tanks, water was released down slope, in part controlled by the same processional causeways that coordinated ceremonial pageantry and movements between central precinct sectors. Acting as dams, causeway features held back sizable volumes of water and then released it to a residential population encircling the summit center. Canals and channels moved water through the highest density of settlement at Tikal along the hillock’s slope. Water was consumed, sometime used to recharge small residential tanks, and then channeled ultimately to four or five large tanks located at the foot of the slope but immediately above a slight down hill gradient into a huge bajo, or seasonal swamp. These latter tanks collected the gray or residentially fouled water for agricultural ends, using it to irrigate posited field systems at the margins of the present-day bajo. Elsewhere, field systems were frequently deployed at these recessional floodwater-like localities (Scarborough, 2007b). By introducing a late source of moisture during the driest times of the year, portions of Tikal were capable of cropping a third yield (Scarborough, 1998).

Keeping the summit water source clean and potable during the course of the year was a considerable challenge for Tikal and other Classic Period communities. Several researchers have indicated the purifying role of certain water filtering plants, especially water lilies (Ford, 1996; Lucero, 1999, 2006; Fash, 2005; Fash and Davis-Salazar, 2006). Today they are an index of potential potability for milperos, or local farmers, because the plants filter high nitrate, phosphate and deleterious organic levels. Judging from the iconographic displays of the Classic Period, water lilies as headdress elements and related trappings of nobility are suggestive indicators of genealogical purity further supporting their understood cleansing properties (Fash, 2005). Other adaptations that slowed organic impurities from entering potable water sources include the paved catchment surfaces themselves, kept clean of debris that otherwise would have been washed into the elevated reservoirs. During the 15 years of the University of Pennsylvania’s campaign of survey and excavation at Tikal, little true primary midden was identifiable in the central precinct (Harrison, personal communication) indicative of a deliberate attempt to remove waste from potential catchment surfaces. Nevertheless, potable water supplies were at a premium even under the most fastidious conditions.

3.3. Water and landscape modifications at La Milpa

Recent mapping and excavation efforts at the ancient Maya community of La Milpa, northwestern Belize (Tourtellot et al., 2003) provide critical connecting data for explaining the transition from Late Preclassic to Classic Period water and landscape management adaptations. These and related data sets permit the developmental linkages for explaining how sites like Cerros were replaced by landscaping efforts like those at Tikal. This was a period of far-reaching institutional change in which stylistic and functional developments in the material record reflect significant societal restructuring. Although many of the stylistic indicators were present by the Late Preclassic (see especially Saturno, 2006; Saturno et al., 2006), their subsequent clarity of message and ubiquity of display reflect a heighten level of information exchange and control during the Classic Period. The establishment of new and pervasive socioeconomic and sociopolitical measures changed the organizational structure of the Maya. The vivid and graphic depictions of life, death and afterlife scenes with the advent of highly portable polychrome pottery reveal the spread of codified symbolic knowledge accessible to a wide cross-section of society. Stela monuments carved to convey the life histories of kings and their institutions appear in abundance coupled with a refined writing and calendrical system to further elucidate their message. Although monumental architecture was a hallmark of Late Preclassic development, it, too, was massively transformed with the widespread use of corbel vaulting and steep-sided, multistoried architecture—the former permitting the elevated interior spaces for enhanced public theater and increased attention to precise message transmission between elites as well as subordinates. All these material trappings crystallized with the advent of the Early Classic Period (AD 200–550).

Correspondingly, the changing landscape transitioned from a “concave microwatershed” to a “convex microwatershed,” or the movement of water from a passive collection system to an active control system, the latter based on a highly engineered set of catchments and reservoirs associated with regulated, gravity-released flows. Was the timing of these developments correlated or do they
simply represent coincidence? Our recent work at La Milpa suggests the former. Although environmental triggers are seldom the explanatory determinant of societal trajectories, they do have a significant influence especially when ecological alterations are precipitated by society itself.

The carefully mapped data sets retrieved by Hammond and Tourtellot (Tourtellot et al., 2003) suggest a population of 50,000 by AD 700 at La Milpa (Fig. 10). As with all southern Maya Lowland communities, the population was compacted around its center but dispersed in its rural hinterlands. Our investigation of the water management system reconstructed from several data sets (Scarborough et al., 1995; Dunning et al., 2002, 2003; Kunen and Hughbanks, 2003; Kunen, 2004) indicates that during the Late Preclassic period a sizable population dispersed across the landscape and occupied the immediate margins of a small bajo less than a km from the subsequent elevated center of Classic Period florescence (Fig. 11). Dunning’s team (Dunning et al., 2002, 2003) has demonstrated that the present-day bajo was a shallow perennial lake during the Late Preclassic period, given the incidence of peat and cattail pollen buried 2 m below the surface. Because of the premium place on natural water collection, Late Preclassic colonists successfully harvested the landscape probably employing a short fallow slash-and-burn field system. Nevertheless, their agricultural successes led to significant degrees of localized deforestation and accelerated runoff. This erosional cycle was only exacerbated during the Early Classic when the population relocated to the adjacent hilltop and established major architectural modifications and the “convex microwatershed.”

With the accelerated hill slope runoff and associated soil loss, rapid sedimentation of the depression ensued accompanied by an interruption of groundwater recharge into the shallow lake. The seal of clay that helped contain water was broken, and when coupled with seasonal desiccation, the predictable water source was gone (Dunning et al., 2002). Although we cannot generalize widely about the losses associated with sediment infilling of postulated shallow lakes elsewhere in the southern Maya Lowlands (Dunning et al., 2006), the effects of sea level rise (Pohl, 1990; Pohl et al., 1996) and an overall trend during the Late Preclassic–Early Classic transition toward increasingly drought-like conditions (Gunn et al., 1995; Haug et al., 2003; Hodell et al., 1995; Hodell and Guilderson, 2001) suggest both environmental factors and societal decision-making conspired to change the Maya world.

3.4. The end

In the context of this presentation, the most significant observation is the degree to which the ancient Maya were socially resilient. The Maya reinvented themselves based on a long history of success with their fragile semitropical environment. By cultivating a history of interdependence within the web of resources harvestable from the evolving jungle ecology, one mirroring the impact of every earlier generation of sedentists, the Maya maintained an uninterrupted occupation of the Lowlands for 1500 years (Scarborough, 2000). Nevertheless, when collapse came at ca. AD 800 it was nearly complete and likely induced by attempts to pattern their economic and political system after a more hegemonic technotasking model, a sociopolitical worldview emanating from the great center of Teotihuacan in the Valley of Mexico near present-day Mexico City (Scarborough, 2003c, 2007a, b). The highly integrated ecological and social parameters embedded in the economy and political organizations of the Maya were severally challenged by the growing demographic success of
the Lowlands, they forcing the aggregation of populations in ways not previously experienced. To marshal these populations, communities like Tikal and its long-time rival Calakmul resorted to rigidly hierarchical controls (cf. Martin and Grube, 2000; Sharer and Traxler, 2006). This short-lived order broke with past integrative exchange systems coordinated by centers as small as Late Preclassic Cerros or as large as Late Classic Tikal—i.e., systems based on an open, self-organizing set of actions and responses to rural communities and their ecological balance. The hegemonic “city” model drastically interrupted the kinds of information upon which the Lowlands had become dependent. External forcings like drought and overpopulation were factors in the widespread social catastrophe, but it was the disruption in the movement of goods, services and information between communities and a lack of flexibility in scheduling of exchange that spelled the end. The embedded sets of socioeconomic and sociopolitical pathways as well as their complementary tropical ecological networks had limits.

4. Bali: a world apart

To best assess labortasking from a current ethnographic context, the island of Bali, Indonesia is presented. We have archaeological time depth for the development of ancient Maya landscape alterations, but nuanced historical and present-day social and environmental assessments gleaned from the ethnographic record are understandably lacking for the questions addressed here. Bali provides significantly strengthened ethnographic detail. By comparing two labortasking case studies from semitropical settings, dramatically separated both spatially and temporally, we are best able to evaluate the critical factors leading to this social trajectory.

Bali is a small, highly volcanic island 150 km east/west by 110 km north/south (Fig. 12). It nearly abuts eastern Java separated by a strait less than 2.5 km wide. The eastern shore of Bali is defined by the Wallace Line and the dramatic ecological differences that separate Balinese flora and fauna of mainland Indochina from Austronesia (Whitten et al., 1996). One of the principal geomorphological characteristics of the island is the steepness of the terrain. Knife-like valleys cut by cascading streams isolate villages along the island’s east/west axis and force social and transport linkages vertically mostly along north/south descending ridge tops. Even today, the movement of east/west traffic is highly restricted. Although the archaeological past remains in its infancy, historical records indicate that the Balinese state was an imported development introduced from southcentral and eastern Java by the 11th century (Kempers, 1991; Scarborough et al., 1999; Lansing, 2006).

Prior to statecraft on Bali, an Early Metal Phase (AD 200–800) of sedentary agriculture was preceded by the earliest evidence for rice in Indonesia identified on Bali’s north shore at more than 2600 years ago (Ardika and Bellwood, 1991). We do not know a great deal about the Early Metal Phase sedentists except that they were well integrated into an interaction sphere associated with bronze artifacts and elaborate sarcophagus interments (Kempers, 1991; Bellwood, 1997).

By AD 800, Buddhism had established itself in southcentral Java with the world’s largest architectural monument to Buddha constructed at Borobudur (Miksic, 1990). Consisting of over 55,000 m$^3$ of stone fill, the stupa-like monument was highly sculpted with a series of carved volcanic stone reliefs spiraling to its summit. At its circumambulated summit were over 70 life-size, stone carved, seated Buddhas enshrined in stone-enclosed reliquary caskets. In spite of the brute labor and the craft-specialized artisans responsible for the architectural wonder, no evidence exists for a complementary “city” to support the population responsible for its construction (Miksic, 1990, 1999). Nevertheless, Borobudur represents
the material manifestation of a labor resource concentration. Because other spectacular monuments are scattered over the Kedu plain, also unassociated with urban settlement (including the 9th century Hindu shrine of Prambanan) (Bentley, 1986; Dumarcay, 1986; Miksic, 1999), a different social pathway to complexity is revealed from that of technotasking. Positioned between several active volcanoes, dispersed settled populations developed on naturally productive, water abundant, and topographically level terrain (cf. Murwanto et al., 2004) allowing the labor resource to construct the monuments identified.

By the 11th century, the monument-building communities of central Java disappeared with an eastward migration on the island (Miksic, 1999). This movement carried some of the elite into southcentral Bali where they immediately attempted to erect monuments and living quarters comparable to their former splendor. Without the kinds of concentrated resources associated with the technotasking model, the new arrivals endeavored to increase resource concentrations by securing control over rice production to support a fledgling palace economy. Nevertheless, the landscape was not naturally flat and fertile like Java and required extended hours of skilled labor to alter the terrain. The ability of the elite to monitor labor and harvest productivity while maintaining a kingly political profile proved too costly (Scarborough et al., 1999; Lansing, 2006). In fact, the only moderately sized investment in a civic center for elite managers was Gunung Kawi, Guanyar District, southcentral Bali, though several other sacred localities with political influence appeared about the same time (Kempers, 1991).

What transpired on Bali was the same expression of adaptability and ecological interdependency as demonstrated in the Maya Lowlands during the Late Preclassic to Early Classic transition. This time the adaptation was toward decentralization of the political system. The elite political apparatus of ancient Bali could not consistently meddle in the production and allocation strategies of the rice economy and hope to support the complex interplay between society, its growing numbers, and the evolving built environs. In order for the highly dissected valley rice systems to support the fledgling elites at sites like Gunung Kawi, farmers were released from restrictive controls and allowed to manage their landscapes in a manner responsive to their immediate microenvironments. A series of self-organizing adaptations evolved to link farmers to the immediacy of their rugged topography—rapidly and expeditiously. By incrementally modifying the landscape, a highly engineered environment developed—one in which social relations between groups of farmers combined to form subak, or rice and water cooperatives (Scarborough et al., 1999; Lansing, 2006).

Today, the many subak are organized around water temples that are answerable, in turn, to higher order temple groups positioned topographically above the water temples and located near principal drainage confluences (Lansing, 1991, 2006). The water temple unites the subak membership ostensibly through complicated rituals and several calendrically linked events attended by the many pilgrims supporting the temple (Geertz, 1980; Lansing, 1995, 2006). As was the case for the ancient Maya, a highly developed calendar system is a display of religiosity, but it also reveals a highly scheduled set of work routines associated with the intensity of paddy rice cropping. Water temples are staffed by a priest or their functionaries who aid in coordinating the ritualized celebrations and displays. They consult auguries, examine calendars, but also listen to their constituents during their frequent visits. In addition to offering spiritual advice, they collect and evaluate information about the conditions of the paddy fields. Although outwardly consumed with ritualized display, priests provide pivotal information to the paddy farmers concerning...
when and where to plant and harvest (Lansing, 1991, 2006). Acting like agricultural extension officers, they identify the severity and extent of weevil infestation as well as the availability of limited water resources over extended reaches of the paddy systems (Lansing and Kremer, 1993). By coordinating labor scheduling and resource availability, the rice cooperative maintains a highly interdependent set of linkages between societal structures and the microenvironments in which they live. Lansing (1991, 2006), Lansing and Kremer (1993), and Scarborough et al. (1999) identify these webs of exchange as a self-organizing system. Using a set of agent-based algorithms, Lansing and Kremer (1993) demonstrated that a farmer will adopt and deploy those behaviors and adaptations that enhance the productivity his paddy, if they first prove successful on a neighbor’s field. In spite of the fragmentation and isolation of valley groups, the occasional outside visitor carrying in a good idea frequently accelerated the incidence of local experimentation and increased the pace of overall landscape alteration. The copying of successful skills and rejecting those less useful to a specific valley or drainage is supported by computer simulations and accurately predicts the geographic size of individual subaks.

Our mapping, soil coring, and “ecofact” analysis of the water temple at Sebatu (Scarborough et al., 1999; Fig. 13 and 14)—only 3 km from the 11th century civic center of Gunung Kawi—suggest that water temples (and by extension, the subak cooperatives) were a decentralizing force complementing notions of the Negara or Theatre State by the 14th century (cf. Geertz, 1980). The forces pulling at centralization and the limited accumulation of resource concentrations were the same as those in the Maya area, though on a diminutive scale. Because of the difficulties associated with making a living in a semitropical environment similar to the dispersed characterization of biological resources as noted earlier for the Maya, the ancient Balinese developed another way of accretionally altering their colonized landscape. Rice paddy farming permitted the nutritional abundance to accommodate an expanding population, but only if the landscape were significantly engineered. By allowing farmers to develop their own immediate and micromanaged skill base to incrementally enhance their crop productivity over time, the more traditionally defined elite were distanced from the economic underpinnings of rice production.

One surprising fact from our coring efforts in the rice paddies immediately adjacent to the water temple at Sebatu was the depth of sediment associated with valley-bottom paddies (Fig. 14). Our coring device was designed to descend to a maximum depth of nearly 5 m, but we were frequently unable to contact a bedrock surface. Nevertheless, in adjacent drainages too narrow and steep for agricultural alteration, bedrock outcrops are visible to their...
incised bottoms. Where our teams examined valley-wide paddy fields, deep sediments were apparent. Elsewhere in Southeast Asia, some scholars (Padoch et al., 1998) have noted the demise of traditional slash-and-burn agriculture because of deliberate hilltop and hill-slope, soil-erosional efforts directed into planned, low-lying paddy fields. Erosion is deliberately induced to accommodate and “build” sediment-rich planting beds.

The Balinese paddy system was and continues to be partially dependent on reservoir storage given the seasonal rainfall regime. Reservoir dams were frequently placed above field systems within the same narrow valleys identified with the earliest paddy farming communities likely associated with the 11th century Javanese colonization (Scarborough et al., 1999). In keeping with the accretional self-organizing interdependencies affecting farmers, slash-and-burn farming and associated construction activities upslope of the narrow and constricted drainages excited large loads of eroded sediment. Reservoirs were rapidly infilled, in spite of the best efforts to keep them clean. This seemingly damaging situation, however, proved extremely helpful as it elevated the valley floors with volcanically rich sediment expanding the valley-wide surface area for level cropping. The reservoir dam walls were converted into shallow berms that now separate paddies. Because additional reservoirs required construction, the same process of accretional infilling occurred over and over again adding immeasurably to the adaptive success of the economic system. The model of self-organization driven by labortasking activities was further enhanced by the adaptive success of tunnel construction which also occurs after the 11th century (Scarborough et al., 1999).

Over several centuries, Bali was transformed into an artificially built landscape identified by steeply ascending, stair-step, rice paddies maintained by intensive labor and highly scheduled work routines directed by a heterarchically organized, subak system (cf. Crumley, 1995; Scarborough et al., 2003; Scarborough, 2005). Today, Bali reports a population density of 520 people/km² (Lyons and Wheeler, 1997, p. 25) with the village of Sebatu registering a local density of 571 people/km over an area of nearly 11 km² (Desa Sebatu, 1988). These figures reflect the same kind of densities identifiable in the Maya Lowlands at AD 700 and characterize the manner in which the engineered landscape is altered using a labortasking pathway.

5. Conclusions

What then do labortasking societies and the landscapes they built have to teach us about the world today? Firstly, this pathway emphasizes the web of interdependencies that connect society to its environment and, in turn, to itself. By remaining open and flexible to the immediacy of changing social and environmental circumstances, humans can discern subtleties on a landscape and then direct or coax biophysical resources in ways that enhance societal well being. Unlike technotasking, the emphasis is not on rapidly altering the environment or exploiting it. Among labortasking societies, the accent is on monitoring ecological relationships, looking for ways that inevitable change can be directed to incrementally improve social ills like drought, starvation, and disease. Labortasking evolved in a less deliberate and planned manner in the past, but society is now in a position to acknowledge labortasking’s accretional rates of change and the appropriateness of the adaptive process. If present-day society could route some of its rapidly acquired technological breakthroughs—achieved through technotasking—toward a more measured and sustained worldview of careful ecological monitoring and societal development, the benefits would be legion. To be good stewards to the earth’s resources means to be good stewards to humanity.

Whether technotasking, labortasking or some other pathway, social structures embedded in the deeply profound culture concept guide all human decision-making. By identifying another way of assessing social development, labortasking recognizes specific parameters for addressing another perspective for what it means to be
human. It further identifies a viable manner in which to live well. Labortasking indicates that other strategies exist for interacting with one another and the environment, and that these adaptations may provide useful models for assessing and integrating social organization.

The ancient Maya and the living Balinese provide two widely separated views of labortasking. Nevertheless, they illustrate a shared economic and political pathway contextualized by their similar semitropical ecologies. In the case of the Maya, a set of successful landscaping adaptations during the Late Preclassic Period led to a degradation of the environment that, in turn, induced a degree of centralization and resource control—principally affecting water management—during the Classic Period. On the other hand, the Balinese transformed a version of labortasking—in place previously on southcentral Java by the 8th century—and downsized it to accommodate the initial conditions/constraints of a small island, both environmentally and socially. The Maya were an experiment in greater centralization; and the Balinese, one of decentralization—both reflecting the flexibility and exediduous social dimensions of labortasking.

Perhaps the most significant lesson for society today is that long-term projections of the future require judicious planning and flexible expectations. Technotasking is frequently driven by the hubris of predictable progress, the latter assessed from only recent generational experience and review—less than 50 years. Under these conditions, the emphasis is on technological breakthroughs, because they are viewed as the only way to buffer society from the drudgery of work and the caprice of the changing environment. Nevertheless, there are other ways of coping with societal interactions and our relationships to the biophysical setting. By taking stock of the immediacy of our local environments, but also assessing what they are telling us about societal decision making beyond the pollution of a specific water source or the extinction of a particular species, we can better interpret our long-term future. Planning is not an all or nothing endeavor; it is a system of negotiations within the context of changing social and environmental parameters. Like other aspects of labortasking, planning and prediction need to be incremental and slowly evolving processes sensitive to immediate social requirements.

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