<u>Article: Complexity and Sustainability: Perspectives From the Ancient Maya and the Modern Balinese</u>
V.L. Scarborough and W.R. Burnside
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Abstract
“Complexity is both a buzzword and a paradigm in the biophysical sciences and, increasingly, the social sciences. We define "social complexity " as the nonlinear escalation of costs and emergent infrastructure with rising energy use and concentrated power as societies develop. Two paths to social complexity are technotasking, which relies on technological breakthroughs and is often politically hierarchical, and labortasking, which relies on skilled labor pools and is often heterarchical. We suggest several pathways to greater degrees of complexity and present two case studies emphasizing the role of labortasking; an in-depth review of the ancient Maya and a shorter introduction to the recent Balinese. Both of these complex societies used labortasking to adapt to local ecological limitations in semi-tropical settings. These societies used heterarchical organizations to accretionally engineer and manage their environments, strategies that promoted long-term resilience. Case studies such as these provide a nuanced picture of different paths to social complexity and highlight their relative costs, benefits, and potential for long-term sustainability.” (p. 327)

-a stable human institution requires less energy than that required to bring it into existence
-energy beyond a certain point won’t necessarily go into increasing complexity further and subsequently leads to significant change
-theorising about social complexity has increased
-natural science views a system as complex if it exhibits nonlinear feedback (changes more/less than expected) and emergent phenomena (unexpected properties emerge/develop)
-anthropology must necessarily view complexity differently since cultural system inputs are vaguely understood and controlled lab tests are impossible
-is there a relevant complexity definition for the social sciences?

An Introduction
-an attempt to create a useful definition (2006) for viewing society concluded with it being “associated with increased costs of labor and material resources and ‘closely related in intensification’” (p. 328)
-the authors argue that a useful definition combines a broader complexity science understanding with an understanding of how societies change over time, maintain themselves, and collapse
-there exist many components of social complexity (e.g., politics, economics, ideology) and they correlate loosely with demographics, social hierarchy, access to information, and resource acquisition/refinement
-these variables are often viewed as a whole, although some consider them in isolation (e.g., Tainter→sociopolitical)
-this article focuses upon socioenvironmental relationships, especially around water management for the Ancient Maya and modern Balinese in a compare/contrast analysis

-complexity appears to be the result of increasing ‘throughput’

-natural and human processes (e.g., energy in an ecosystem, money in an economy) give rise to complex patterns/behaviours not predictable from inputs
-it is defined differently by individuals and disciplines
-all consider aspects such as: irreducibility, emergent phenomena, and nonlinear feedback
-but no common definition has arisen
-one for the subset of complex adaptive systems has evolved: “a system of diverse ‘agents’ that interact locally and adapt their behavior to their environment including the social environment formed by their fellow agents.” (p. 329)
-successful agents/strategies are replicated/enhanced leading to evolution/adaptation towards complex patterns without central control (e.g., market economy, human immune system, ecosystem)
-sociocultural systems evolve as they develop but adaptation occurs ‘in fits and starts’ with societies eventually ‘collapsing’
-within their biophysical environment, groups socially self-organise
-cultures change the environment (e.g., hunt certain species, change plant communities and/or soil characteristics, alter landscapes)
-while new systems are highly adaptable, they are also more fragile and a dead-end path is sometimes chosen, leading to an early demise
-with time, social modifications lead to stressed living conditions, frayed associations, and increased costs (i.e., economic, political, environmental)
-when conditions that are harmful begin to emerge but cannot be absorbed by the biophysical and/or sociocultural systems, there are 3 possible paths forward: “(1) the cultural system cuts its exaggerated and mounting social costs by lessening its intensity of resource use resulting in a partial reversion to an earlier lifeway of reduced costs and relative simplicity; (2) the system suffers from relatively abrupt social collapse; or (3) the system cultivates and focuses its energy and social capital on greater "complexity" associated with an evolved set of institutional structures–an emergent organizer of information and resources.” (pp. 329-330)
-social complexity is a nonlinear, step-like increase in costs as power concentrates, becomes more hierarchical, and experiences greater economic intensification
-rigid social structure hierarchies are not inevitable but can also exhibit heterarchical tendencies (i.e., unranked or can be ranked in several different ways)
-heterarchical interpretations focus upon the connectivity between social subsystems rather than the hierarchical, top-down separations
-state social costs appear most complex/costly with the construction of monumental architecture (e.g., large pyramid building)
-near future success appears to be associated with the amount of energy that is available (i.e., human/animal for pre-industrial states)
-an additional complexity is the development of densely populated centres (i.e., cities)
-if infrastructure is not developed to accommodate new energy (but rather diverted to elsewhere, such as monumental architecture), society remains vulnerable to collapse
-new institutions/organisational structures arise to allocate energy/resources, with surplus used to expand
-the path chosen to adapt to the biophysical environment becomes a group’s cultural identity

“For an extended period following the initial spike in energy use, the society operates smoothly without spending much to maintain itself, and manage its productive success. These periods of ‘plateau’ sustainability, diagrammed as the stepped treads in Figure 1a, are the manifestation of the new institutional structure and its degree of dynamism…a sociocultural system will tend to step up, down, or ‘off’ this profile as it strains under its new demands; it can either drift back toward a previous order, collapse, or push abruptly forward by exploiting new or refined resources and labor pools.” (p. 330)

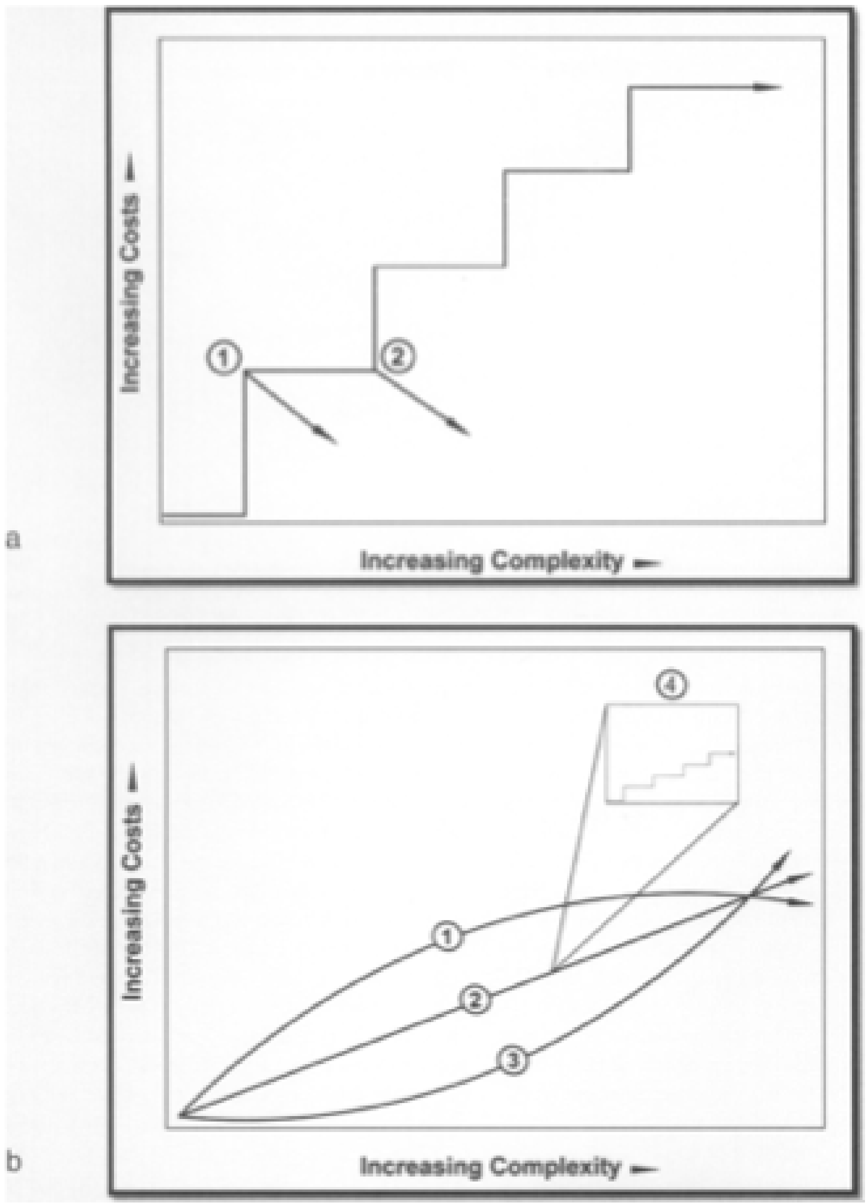


Figure 1. Schematic identifying two idealized types of complexity trajectories. A) A high stepped, steeply pitched pathway frequently associated with technotasking. A1 represents the juncture of successful phase transition to a new level of social complexity, though vulnerability exists. A2 represents the onset of change, either phase transition to new levels of complexity or partial reversion to an earlier adaptation or possible collapse. B) A highly monitored, low pitch, self-organizing pathway frequently associated with labortasking. B1, B2, and B3 represent possible complexity trajectories based on initial conditions and environmental perturbations. B4 reveals the same stepwise forces advancing change, but operating at an increased frequency and a greatly reduced ascent.

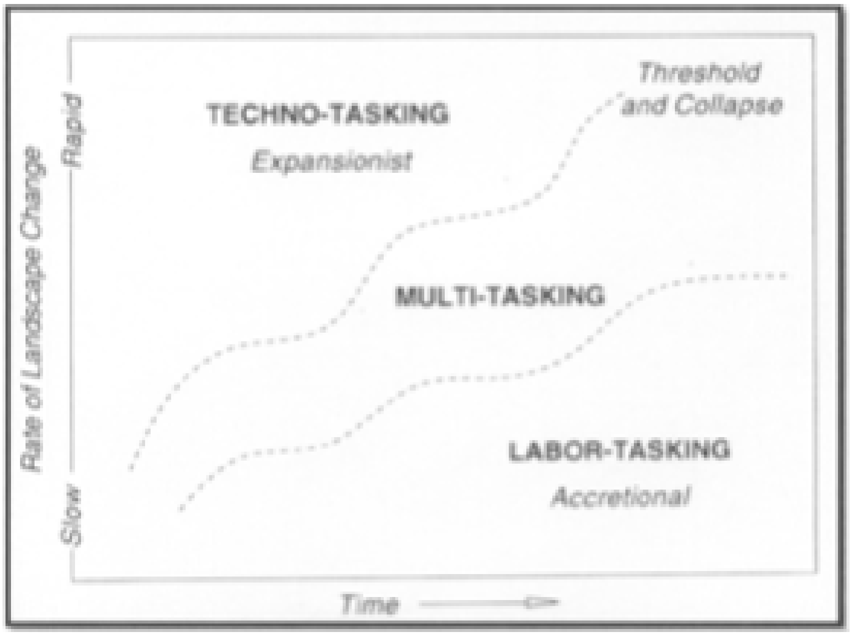


Figure 2. Schematic identifying idealized relationship between rates of landscape change and processes of resource use cross culturally.

-how a society incorporates new resources or resets old ones affects the speed of change and social structures
-labourtasking is a more incremental and extended management of the biophysical environment
-technotasking leverages technological 'breakthroughs' to expedite this management
-the hegemonic state trajectory (especially nation state) has been the most impactful on alternatives, co-opting/eliminating all other complexity options

Technotasking
-production deficiencies can be offset by investment in technologies
-this approach can help establish surpluses to serve as a buffer to environmental limitations, supplant labour, and/or increase yields
-in early/primary states, the manipulation of riverine drainage (i.e., canalisation) was a common approach
-such landscape exploitation was adopted rapidly, allowing unnatural resource concentration
-the development of urban centres was an emergent phenomena of this accumulation, processing, and maintenance of the resources this technology provided
-the deployment of such technology has high social costs given the change it created (particularly for the masses), but it benefited disproportionately those at the top of the socio-political/-economic structures and so was employed (and this inequality grew as the path was pursued)
"...those profiting most from the newly invented technologies accrued greater quantities, concentrations, and control of key resources." (p. 332)

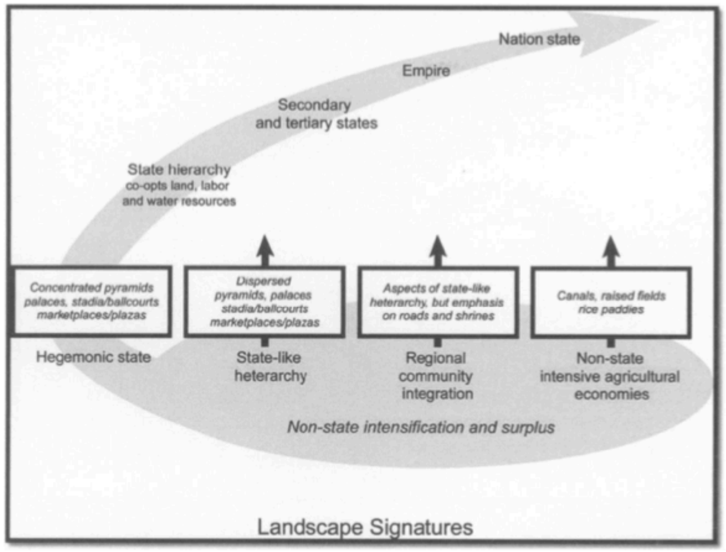
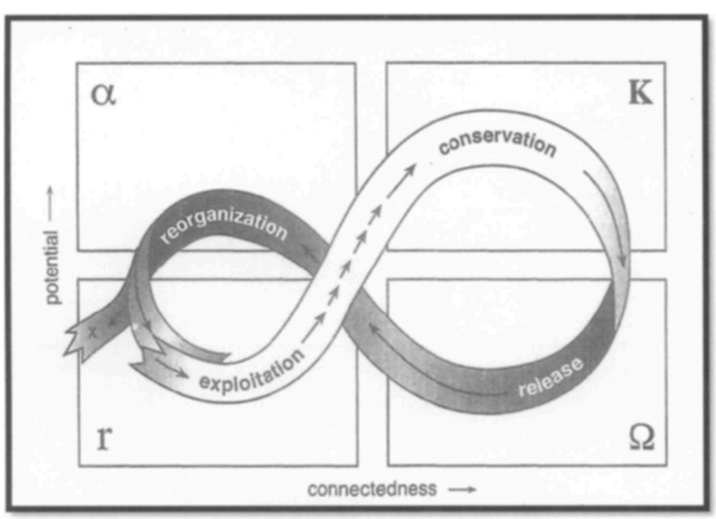


Figure 3. Landscape Signatures. Kinds of engineered landscapes and associated socioeconomic and sociopolitical organizational schemes appropriated by hegemonic states with time.

-significant growth in labour and resource concentration were allowed by such technological adaptations
-step-like increases in complexity were experienced with 'breakthrough' technologies and associated with food production and refined resource increases
-initial costs were high but surpluses due to the new technologies helped to offset them
-failure was common with societal collapse a common result
-a successful transition to a new level of complexity would result in a 'plateau' of social and environmental costs
-deployment of new technology is costly in terms of society and its environment but even after costs 'level-out' time and entropy can begin to increase costs
-these increased costs can lead to a slowing of growth, collapse, or, with a new technology, a restart of the process
-with time, reduced output occurs and may be compensated for via structural/organisational shifts (i.e., increased complexity), but may lead to worker alienation



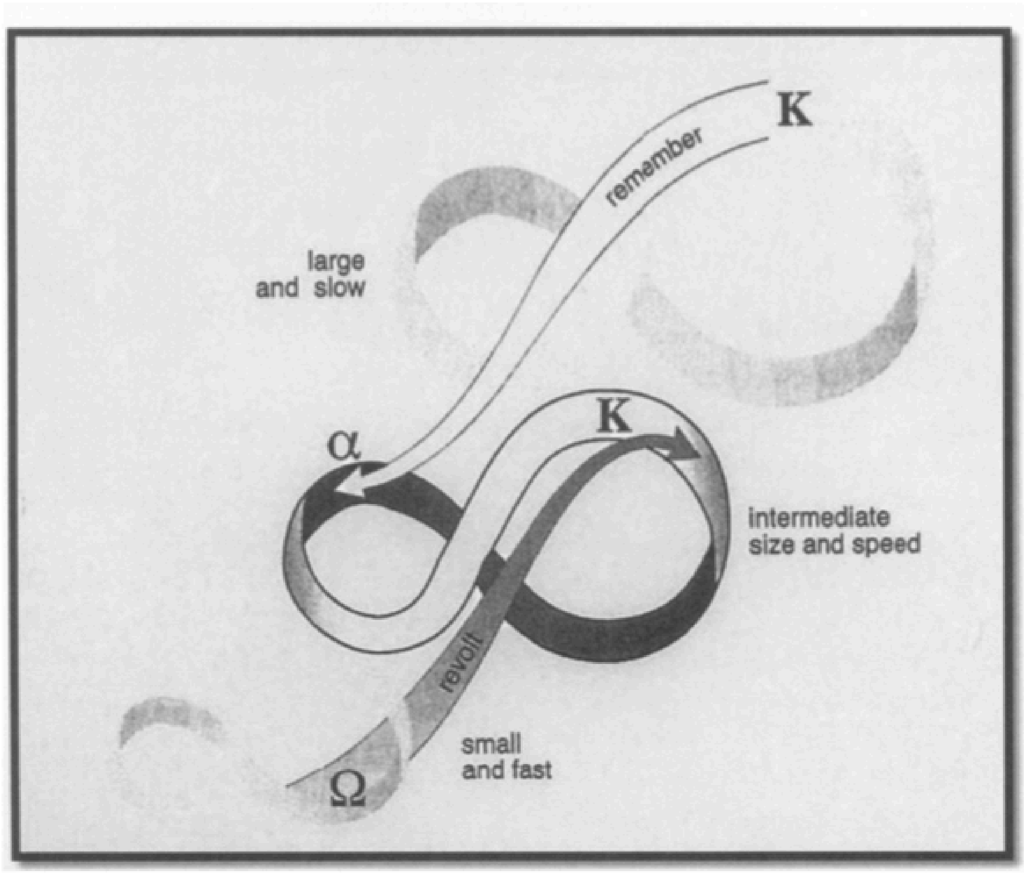


Figure 4. Holling and Gunderson's (2002) "figure eight" diagrams (from Holling and Gunderson 2002).

-this process appears to follow ecological resilience theory (see Redman and Kinzig, 2003) where "social resilience is the ability to sustain adaptive change in a society in the fact of internal and external perturbations." (p. 334)
-societal continuity over time being the result
-changes in development tend to be large and slow adaptations followed by small and fast organisational shifts
-transitions to greater complexity seem to be triggered by these rapid reorganisations
-successful and long-term shifts are limited by immediately available resources
-such change creates vulnerability if the new structural complexity cannot adjust to resource use/demand
-"If the new structure and the necessary resources are not synchronized and compatible, then the social system will collapse or at least slip back to an earlier, less complex social order." (p. 335)

Labourtasking
-landscape modification and societal development can also occur via trained labour pools
-in this situation, change is incremental, long lasting, monitored, promoted generationally, and refined according to local conditions
-in both cases of the Maya and Balinese, labour pools were dispersed but abundant

-hinterlands were relatively densely populated with formal cities sparsely so (technotasking societies display the opposite)
-complexity and its social costs increase over time but in a smooth, uninterrupted manner
-there are no abrupt transitions preceded by breakthrough technologies
-complexity costs increase but at a smaller ratio than in technotasking societies

Semitropical Societal Case Studies
-the ancient Maya and living Balinese regions are characterised as semi tropical forests with heavy seasonal precipitation followed by prolonged dryness
-while displaying high species diversity, animals are not in great abundance
-ecological interdependencies are reflected in societal change that are incremental with flexible/adaptable structures
-both developed microwatershed adaptations but via different technologies

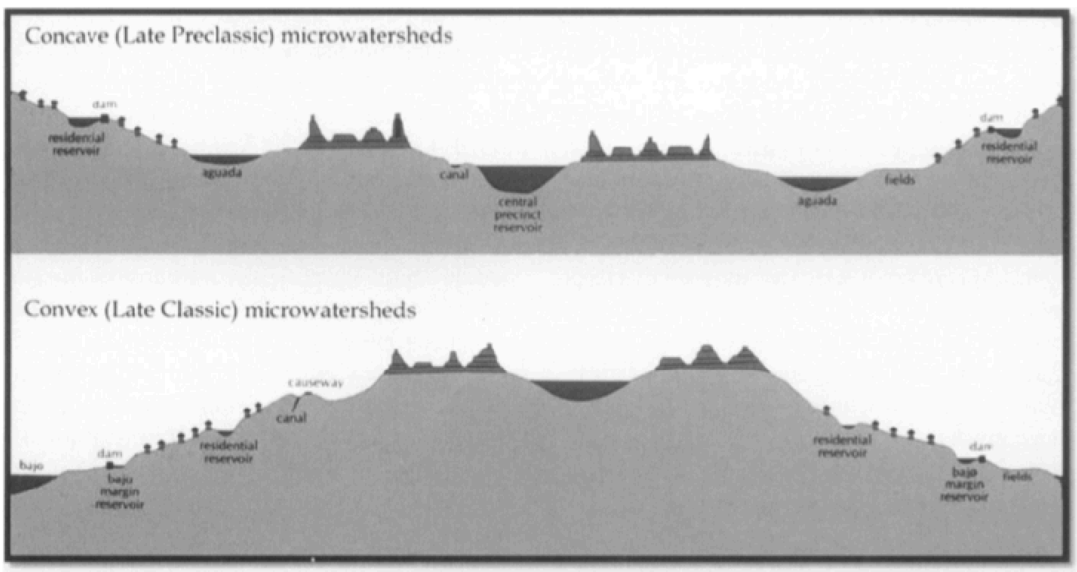


Figure 5. Concave to convex microwatersheds. A) Late Preclassic period concave microwatershed, B) Late Classic period convex microwatershed.

-food storage is difficult given high humidity (causing rapid organic decay)
-both developed sustainable resource harvesting/consumption intensification
-concepts of time and scheduling (i.e., elaborate calendar system) aided resource harvesting while road systems its distribution
-the Maya also developed extensive salt production along its coastlines to aid in food preservation
-Maya Lowlands and Bali differ in geologic terms with Bali having rich but acidic volcanic soil and the Lowlands shallow but calcium-carbonate-rich basic soil
-little surface water exists in the Lowlands making water access problematic during the dry months
-Bali contains greater surface water, much used for rice paddies
-the volcanic island of Bali is close to larger islands such as Java and contains steep-sided regions, creating somewhat independent valleys
-the Lowlands are not so separated physically but ecological variability led to resource-specialised communities

-maize, beans, and squash dominated agricultural intensification
-although different in many aspects, their labortasking similarities allow for comparison

Maya
-of the preindustrial world, the Maya Lowlands was one of the most densely populated (about 10 million circa 700 A.D.)
-they adapted to less-than-ideal soil and a lack of water
-initially, settlements were dispersed reflecting the ecological environment
-the population developed interdependencies where energy/matter was produced/consumed at a high rate due primarily to a sophisticated calendar and complex road and information-exchange system (refined writing system)
-these aspects helped to sustain their success for 1500 years
Late Preclassic Period Labourtasking: Cerros and related Communities
-the arrival of sedentary agriculturalists in the Lowlands was the result of slow and incremental adaptations to seasonal wetlands via landscape alterations
-this period also witnessed the first Mayan experiment with statecraft
-typical of this time is the site of Cerros in northern Belize

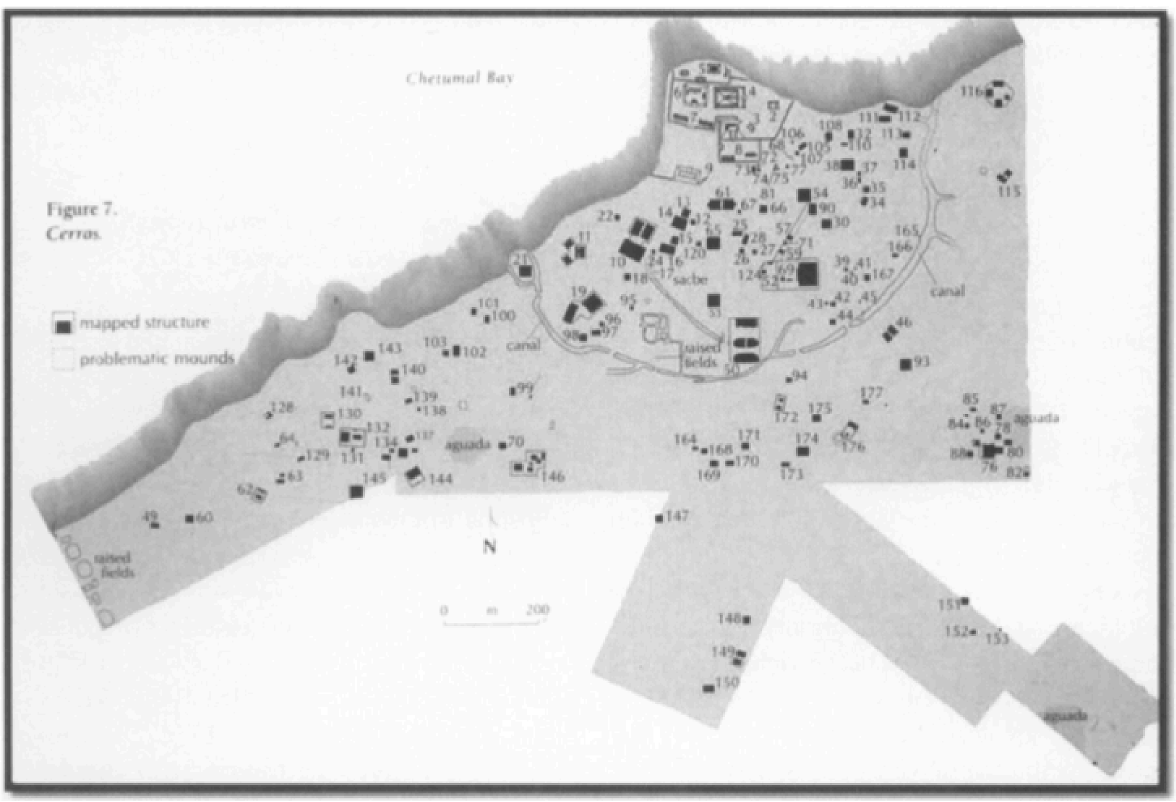


Figure 6. Base map of Cerros.

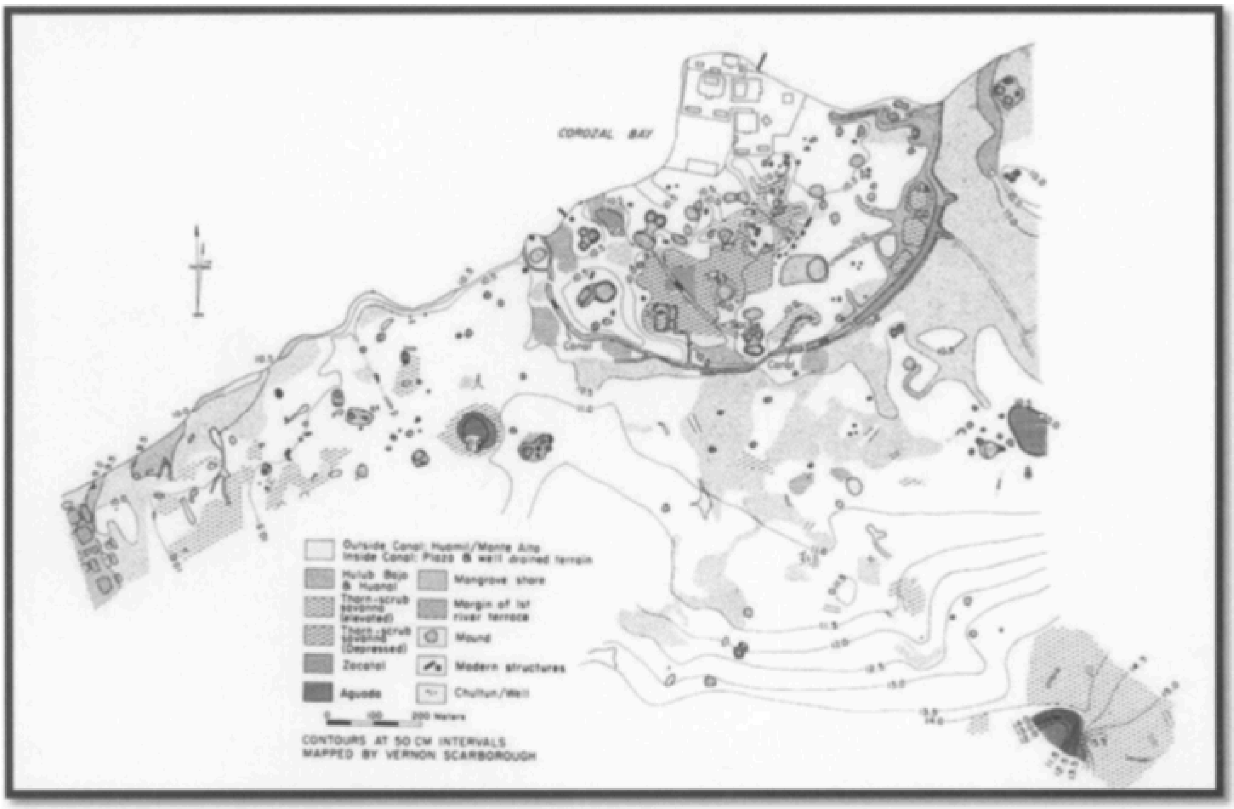


Figure 7. Map of Cerros Environs.

-it took advantage of a natural drainage catchment and enhanced it via landscape modifications (channel systems and reservoir) with household and monumental architecture mound volume equivalent to drainage volume
-"...the system was likely a communitywide effort monitored by a collective interested in sustaining the entire group." (p. 338)
-some groups were drawn to shallow lakes, although most were internally draining
-covering 40% of the Lowlands, they greatly influenced how the ancient Maya adapted via landscape engineering
-naturally perennial lakes attracted sizable populations
-one, El Mirador, compared to its Highland contemporary–Teotihuacan, but was abandoned at the onset of the Early Classic (300 A.D.)

Early Classic Period Transition: A Technotasking Response

-the transition to the Early Classic is characterised by rapid landscape alterations and a social shift during a vulnerable period
-a change in the idea of kingship was accompanied by more formal writing, monumental stela, and grand palaces
-massive landscape modifications correlate with significant social investments in complexity
-although labourtasking was their primary economic means, the Maya shifted into and out of technotasking
-their resilience and engineering permitted a Mayan resurgence

-the Late Preclassic witnessed growing populations around natural depressions that allowed for creative landscaping and productive agroecology
-as time passed, several communities outgrew their resource base as soil erosion filled water reservoirs
-the Early Classic sees new/refined technologies reclaiming catchments (e.g., berm and terraces to reduce soil erosion)

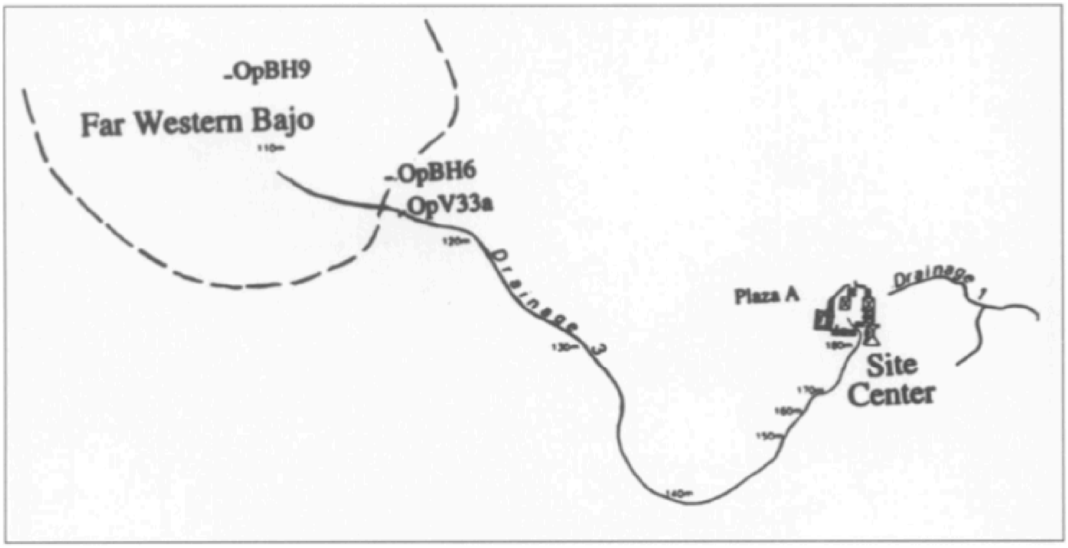


Figure 8. Schematic map of La Milpa center and bajo.

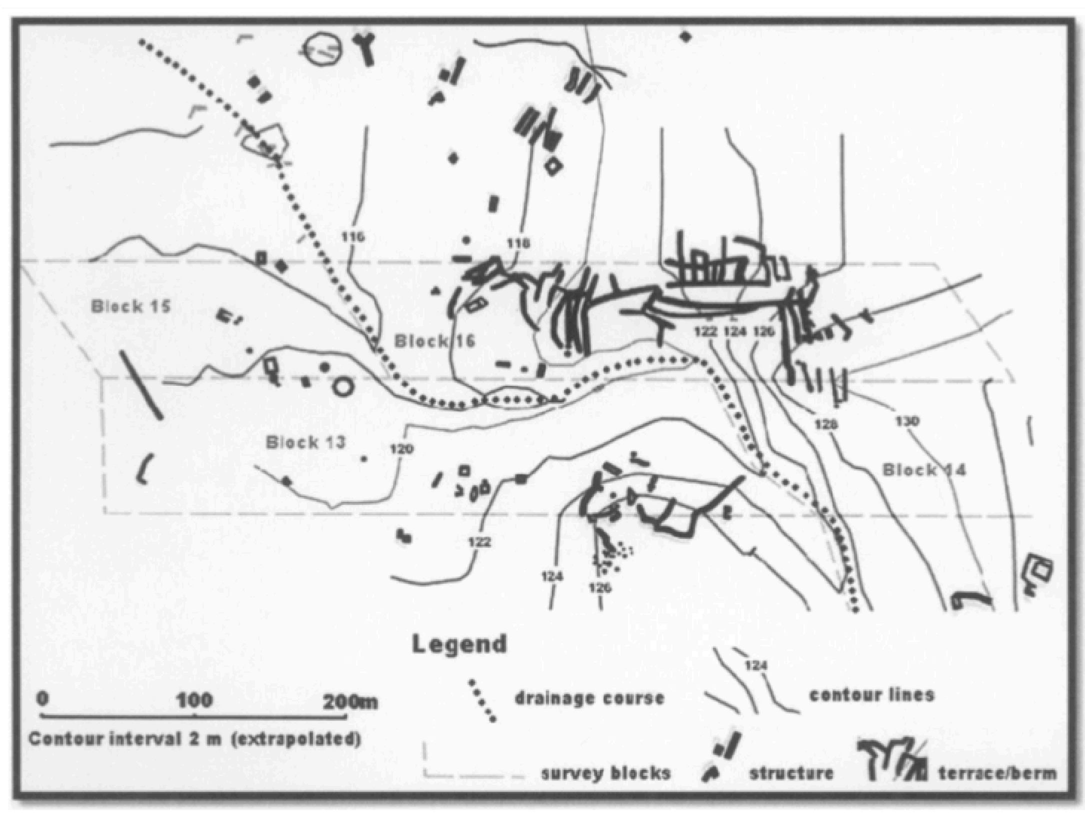


Figure 9. Map of berms and terraces at margins of infilled bajo at La Milpa.

-rather than rely upon labour intensive landscape maintenance, community centres were moved to hillock/ridge summits (minor adaptation) but was also accompanied by political and economic shifts
-catchment water was becoming non-potable in the Late Preclassic
-not only were the catchments filling with sediment restricting their capacity, but a drought at this time exacerbated the situation
-summit reservoirs and directive canals were their adaptations
-this approach may have been based upon Lake Mirador's system whereby a canal-release system from a naturally-elevated lake supported the nearby community
-the 'paving' for nearby community and monumental architecture served to direct seasonal rains towards these raised catchments where it could accumulate and be available for dry periods
-in addition, the grey water run-off was leveraged for additional agriculture at the foot of the ridges
Classic Period Return to Labourtasking: Tikal
-these landscape modifications were refined over time and became widespread
-ongoing occupation and growth where resources were widely dispersed suggests a return to labourtasking with the archetypical site being Tikal (A.D. 250-900)

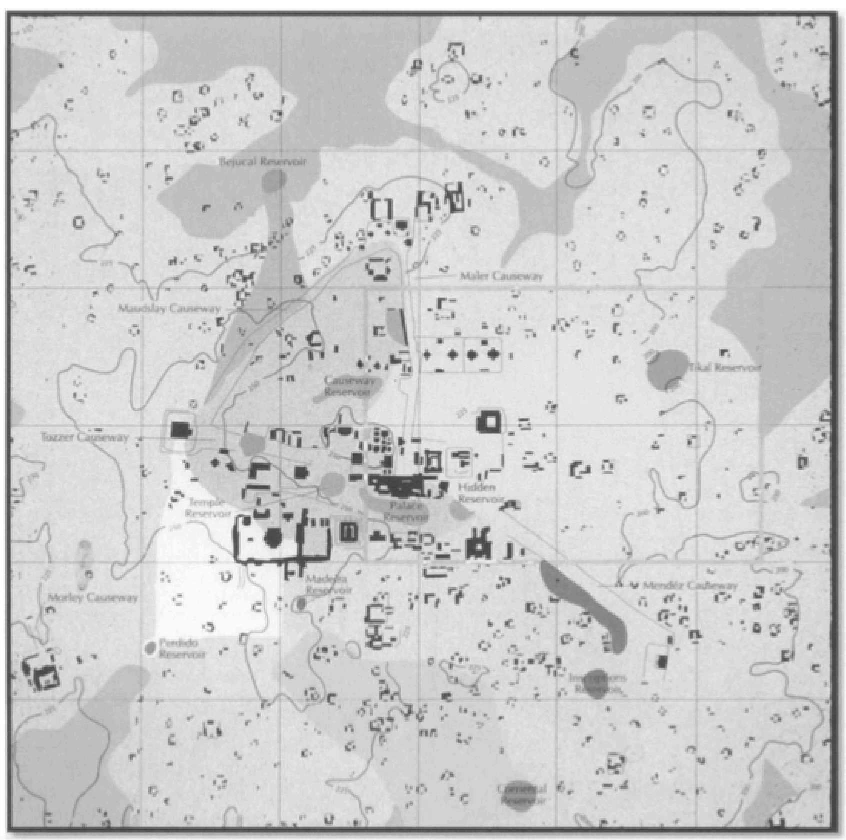


Figure 10. Base map of Tikal with water catchments.

-Tikal appears to have been one of two 'superstate' central locations during the Late Classic; the other being Clalkmul
-the quarrying scars created by Tikal construction were converted to elevated reservoirs, while architecture was built to direct rainfall into them but their capacity is estimated to hold only about 25% of seasonal rains–which would have sufficed when seasonal rains were plentiful

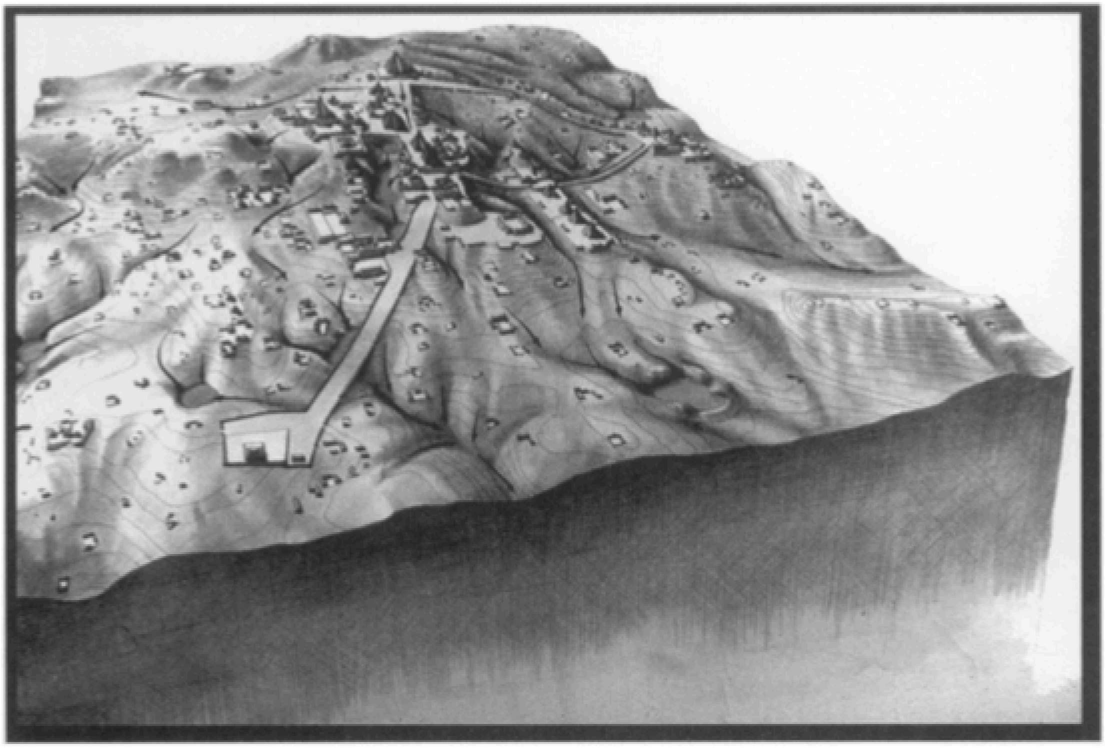


Figure 11. Isometric map of Tikal's watershed.

-causeways, dams, and sluice gates allowed for release of water in a judicious manner during the 3-4 month dry season
-large reservoirs at the foot of these hills captured run-off/grey water, allowing for additional agriculture–including during the dry season
-"This kind of accretionally engineered landscape and its longevity in the content of deranging forces associated with the fragility of a semi-tropical rainforest suggests a classic example of labourtasking economic logic." (p. 343)

Complexity, Tropical Ecosystems, and the Maya 'Collapse'
-despite disagreement regarding the severity of Maya society 'collapse', there is general agreement that the complexity it once displayed was lost in a relatively rapid and irreparable way throughout most of the region
-the population dispersed and much of the built architecture was abandoned
-while most displayed this transition over just a couple of generations, some regions took just a couple of generations, some regions took around two centuries
-"Several generations saw the downward spiral of their quality of life and social values, and they were unable to redirect their ecological and political trajectory." (p. 344)
-the Classic Period was one "of uninterrupted structural solvency and resource abundance characterized by frequent self-correcting adjustments between the society and its environment." (p. 344)

-’small-fast’ adjustments led to relative long-term regional stability so long as the natural environment had not suffered significant losses
-the evidence fits Marcus’s (1993) dynamic cycling model where political and economic changes reflective of a labourtasking pathway were adopted allowing incremental shifts to specialised structures
-while several major centres and their hinterlands experienced ‘collapse’ (especially acute depopulation and the overshoot of local resources), some smaller communities were resilient and avoided the fate of the large ones–mostly by specialising in local resources and establishing trade with nearby populations
-this was a slow process with specific political shifts due to flexible conditions
-the communities mimicked “the dispersed distribution of species abundance through a dispersed settlement design…[with each developing} an economic niche united in the production of one or just a few resources.” (pp. 344-345)

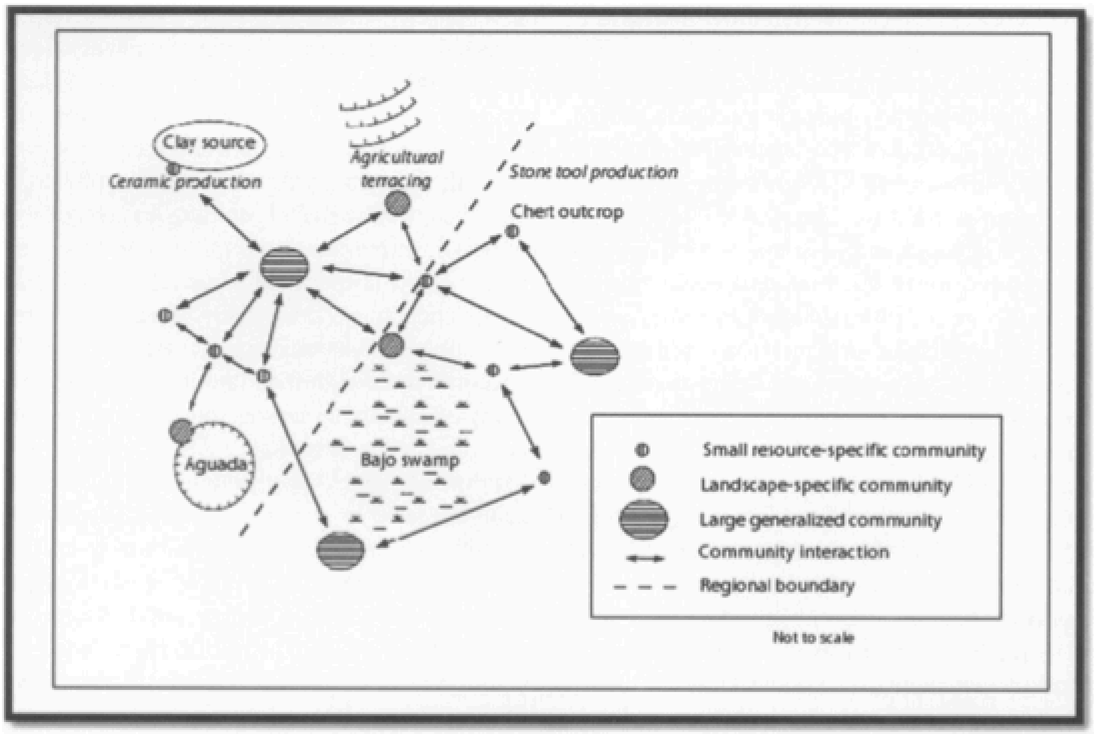


Figure 12. Model of community interaction in the Maya Lowlands.

-this community-level specialisation and subsequent trade resulted in small settlements establishing ties within a larger area
-if one of these small communities ‘collapsed/dissolved’, another one (occasionally further afield) sometimes stepped in to replace its specialised products/resources or a replacement product/resource might be found/developed
-evidence indicates that critical resources (e.g., water) were shared among small communities
-these nodal communities appear to have been highly resilient/stable and grew slowly becoming as dense as the environment and their technology permitted
-larger Mayan ‘cities’ seemed to reflect and represent these dispersed communities

-despite the use of a labourtasking approach to societal adaptations, population growth was rapid and led to geographic expansion with some large-centre growth
-"In sum, the social system of the Ancient Maya involved a highly flexible set of networks conveying information about the conditions and availability of food, fibre, and refined resources in the hinterlands and allowed society to skillfully move and manage these resources." (p. 346)
-Mayan society was based upon local knowledge and local resource limitations
-scheduling provided stability while environmental options led to resilience
-the larger centres and mid-size nodal communities coordinated activity
-its success, however, led to its demise
-it appears that turmoil within large centres disrupted community communication beginning in the west
-information exchange faltered and the elite succumbed to immediate self-interest and became less responsive to other needs investing fewer resources in the many and more to the few; a scramble for hegemonic control between the large centres ensued
-written records suggest a governing council was implemented at Chichen Itza as depopulation hit its southern contemporaries but rather than adjust social networks (i.e.., economic and political) the elite chose to seek greater control
-this top-down approach appears to have worked at Teotihuacan, that in turn influenced a few other centres (e.g., Tikal) but resulted in fragmentation in the hinterlands reversing more than a dozen centuries of growth
-local knowledge was stifled and command structures broke down
-in particular, highly engineered landscapes that required maintenance and monitoring began to breakdown
-in fact, during the Terminal Classic demise phase there is evidence that the cost-complicated landscapes suffered the most from this
-in particular, was the impact upon irrigation channels and reservoirs that show massive sediment/silt buildup
-"We suggest that the Terminal Classic Period Maya (A.D. 800-900) faced a labortasking adaptation with a technotasking solution. They truncated their generations of self-organizing decision-making strategy that was not accommodated by their social structure, the highly evolved and labor-intensive built environment, or semi-tropical setting on a karstic plain." (p. 348)
-some suggest climate changes led the May to 'collapse'
-while it appears that the climate was changing the Maya were and had shown great resilience and it may have been political hubris that was a contributing/complementary factor
-social structures likely became stressed as elite self-interest added to population increases, faltering labour coordination, and climate change (4 short but extreme heat waves between A.D. 760-910)
-a once large and organisationally-complex population dispersed and never returned
-only small aggregates continued to reside the Lowlands
-the erosional damage from the engineered landscape can still be observed
-it would appear that the land and water resources required constant maintenance and without this both the economic and political systems began to breakdown

-"Generally speaking, the more long-term time and energy invested in the system, the greater the degree of collapse if the fields or related surfaces are neglected or abandoned for even a short period." (p. 349)
-this can be seen in specific regions of Mexico with the arrival of the Spanish with the consequential disruption of labour schedules due to disease and population dislocations
-any altering of societal structures can impact the built environment
-a disruption in maintenance led to an acceleration of sediment accretion in basins that eventually resulted in food production 'collapse'
-even modern technotasking approaches have been unable to achieve former productivity levels
-it seems past populations so altered their environments to make them significantly more productive and stable than prior to such engineering
-degradation appears to be a result of a change in economic logic
-moving to a top-down, technotasking structure left the environment collapse-vulnerable
-once erosion and sediment filled the engineered landscape, reclamation was impossible
-surpluses during 'good times' had been diverted to massive monumental architecture, leaving little for landscape maintenance
-much of the altered landscape remains hidden and there is only the beginning of an understanding of how much labour was required to change and then maintain the environment

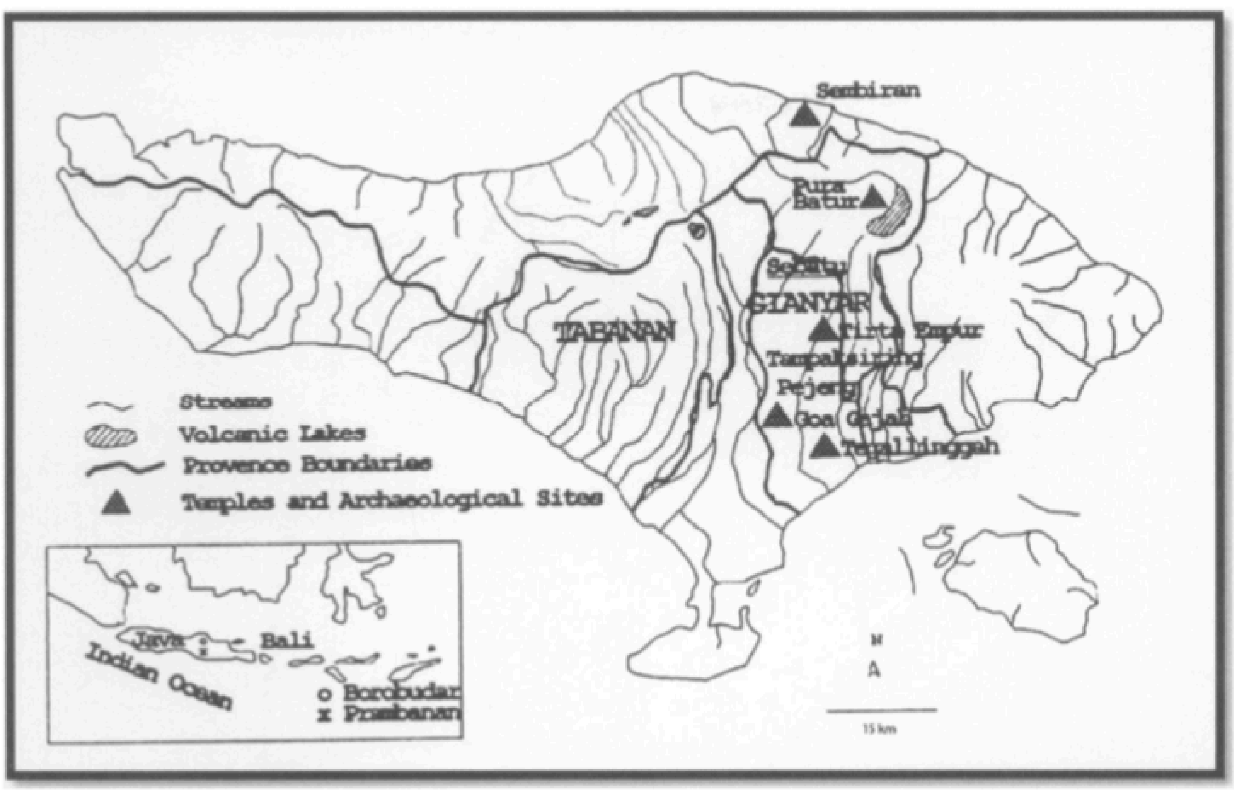


Figure 13. Map of Bali. Illustration by John Schoenfelder.

Bali

-modern ethnographic research on Bali provides a glimpse of labourtasking demands and social complexity of a semi-tropical society similar to the Maya; while not a state-level society, it displays a chiefdom-like social structure allowing for comparison
-the island was recolonised from Java by the 11th century
-initial attempts to recreate Java's complexities failed, likely due to the vastly different geographies: Java is relatively flat with fertile soil; Bali consists of
-instead, societal complexity arose out a more decentralised structure

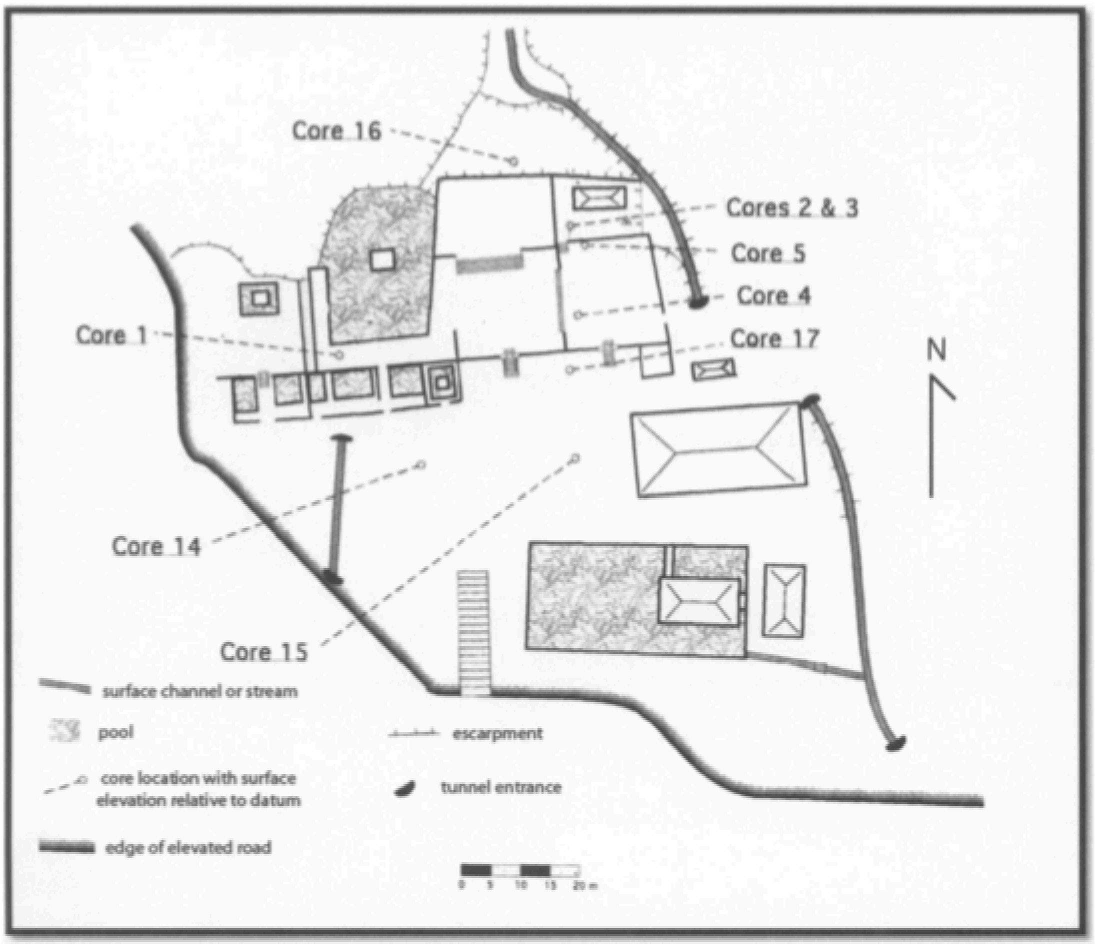


Figure 14. Map of Water Temple, showing features and soil core sample locations. Illustration by John Schoenfelder.

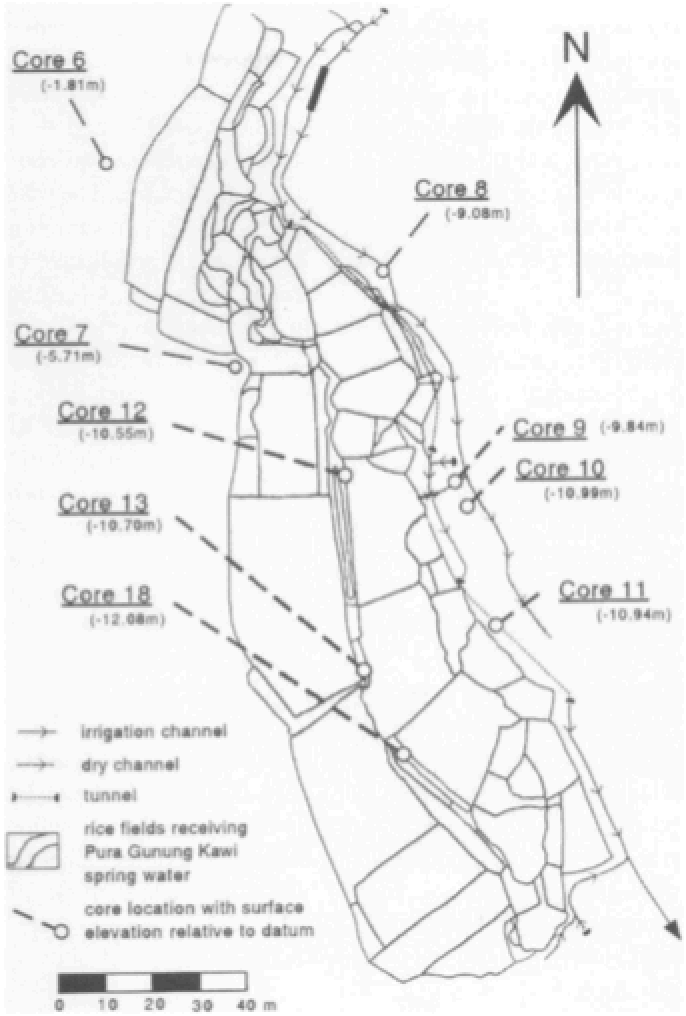


Figure 15. Adjacent Rice Paddy Map, showing soil core sample locations. Illustration by John Schoenfelder.

-the site of Sebatu contained some of the island's most fertile soil
-core samples indicate that early inhabitants took up residence on the margins of a steep valley with peat-like soil deposits
-the site's water temple appears about the same time occupants moved from the forests to rice production (circa A.D. 1450)
-inscriptions suggest gradient-controlled tunnels were introduced sometime in the 11th century allowing summit water to be moved throughout the Balinese landscape and decentralising agriculture
-slopes could be terraced into rice paddies using water from elsewhere as a result
-this breakthrough innovation required skillful engineering and local management
-massive infilling by sediment raised the natural bottom of the valley, helping to create large paddies
-farmers adopted methods from neighbour that proved useful
-this water management and its built systems required community cooperation and fostered interdependencies
-this heterarchical systems evolved incrementally from a top-down centralised one

-indigenous farming populations managed their own affairs avoiding centralised bureaucracies and their demands
-groups self organised within their unique ecological circumstances
-this approach proved productive and shaped the social system
-the modern *subak* system reflects its roots with risk being mitigated through associations with neighbouring communities via water temples and their priesthood that serve as information nodes sharing field conditions and other important knowledge (e.g., pest infestations, water availability)
-"Balinese social institutions remain responsive to the complex adaptive system they have spawned, providing the flexibility to accommodate and locally manage accretional landscape change." (p. 353)--see Figure 1b

Discussion
-two significant shifts occurred during the Mayan growth/expansion
-first was the change from a concave to a convex microwatershed system
-social systems complemented this by a partial concentration of populations upon hillocks, and significant incorporation of specific material properties (e.g., formalised writing, monumental architecture)
-the new landscape alteration and material changes suggests information flow was significantly improved, particularly regarding their built environment and greatly promoted self organisation throughout the region
-the Lowland fragmentation of the 8-9th century appears to have resulted from a 'perfect storm' of circumstances that suppressed institutional resilience
-an overstressed societal structure succumbed to forces impacting the labour pool and natural resources, resulting in localised agricultural systems faltering in their production capacity beginning on the margins of the bajo system
-an interruption in/abandonment of the scheduled field maintenance was likely the culprit (similar to the explanation proposed for the Cambodian site of Angkor Wat)
-the Balinese, with their labourtasking approach that focuses upon decentralisation (as opposed to the hypercentralisaiton characterised by the Late Classic Maya), have so far avoided collapse and suggests a path forward for sustainability
-resilience and long-lived stability would appear to be the result of small, incremental adjustments in a labourtasking approach as opposed to the frequent and rapid shifts that result from a technotasking one
-however, near the end of an extended run, labourtasking systems may still result in extreme social 'collapse'

Conclusions
-for the purposes of this discussion complexity is viewed as: "(1) a step-wise, nonlinear escalation of costs as societies concentrate power and organization; and (2) the ordered structure that emerges with such increasing political, economic, and energetic intensification." (p. 354)
-it is both a societal path and the associated structural condition involving institutions (e.g., economic, political, ideological) ad group relationships (i.e., within and between groups, and including with the biophysical environment)

-a ‘state-level’ society has been used as an indicator of complexity but the definition for a state varies greatly
-most include the idea of stratification, large populations, elaborate information networks, and large concentrations of refined resources
-each follows a different path to complexity but almost all by either a technotasking or labourtasking approach
-most view complexity as dependent upon high energy levels, exchanged materials, and socioeconomic costs
-while true, a technotasking approach tends to move entire social systems through a break with traditional institutional orders
-in spite of its high social costs, technotasking endures as innovations aid in generating abundant natural and refined resources that helps to sustain new levels of complexity
-once established, costs to maintain the new level can fall and be directed towards social routines and structural behaviours that help support complexity
-with societal growth, however, a disenfranchised population evolves that tends towards non-technological ways of making a living; this also results in societal stress that Marx termed alienation
-the same forces are present in labourtasking but its smaller and less periodic changes are more responsive to society and its interdependencies on the biophysical environment
-abrupt changes are reduced due to constant monitoring and self-organisation using small, frequent adjustments
-“A key difference between the two systems is the expectations for grand collapse…Because of the ever-changing, nonlinear interdependencies within and between groups and their environments, labortasking leads to a set of ‘phase transitions’ that produce adaptive forms of social organization and built environments. This process is long-lasting, resilient, and generally well-adjusted to resource limitations, making it relatively sustainable. However, acute vulnerability or collapse can occur if drastic external and/or social structural change is unleashed.” (pp. 355-356)
-technological innovations that tend to buffer humans from the environment but negatively impact it are often chosen because they accommodate rapid growth and the consolidation of social/economic power without much thought or concern about sustainability
-while improvements in human health and welfare can be attributed to technotasking these need to be evaluated in terms of the costs, especially upon the environment whose ‘health’ human societies depend on