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Cooperation, Collective Action, and the Archaeology of Large-Scale Societies

David M. Carballo (corresponding author)

Department of Archaeology, Boston University

675 Commonwealth Avenue

Boston, MA 02215 USA

Phone: 617-358-1660

Fax: 617-353-6800

Email: carballo@bu.edu

Gary M. Feinman

MacArthur Curator of Mesoamerican, Central American, and East Asian Anthropology

Integrative Research Center, Science & Education

Field Museum of Natural History

1400 South Lake Shore Drive

Chicago, IL 60605 USA

Email: gfeinman@fieldmuseum.org

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David M. Carballo is Assistant Professor of Archaeology at Boston University. His interests include urbanism, households, political economy, religion, and the social dynamics of cooperation and conflict. He is the author of *Urbanism and Religion in Ancient Central Mexico* and the editor of *Cooperation and Collective Action: Archaeological Perspectives*.

Gary M. Feinman is MacArthur Curator of Anthropology at the Field Museum (Chicago). His interests include preindustrial economies, urbanism, and human networks of cooperation and collective action. He has conducted extensive, collaborative archaeological field research in Oaxaca, Mexico and Shandong, China.

Archaeologists investigating the emergence of large-scale societies in the past have renewed interest in examining the dynamics of cooperation as a means of understanding societal change over time within human groups and organizational variability among them. Unlike earlier approaches to these issues, designated voluntaristic or managerial models, contemporary research articulates more explicitly with frameworks for cooperation and collective action employed in other fields, thereby facilitating empirical testing through better definition of the costs, benefits, and social mechanisms associated with success or failure in coordinated group action. Current scholarship is nevertheless bifurcated along lines of epistemology and scale, which is understandable but problematic for forging a broader, more transdisciplinary field of cooperation studies. In this paper we point to some areas of potential overlap by reviewing archaeological research that foregrounds the dynamics of social cooperation and competition in the emergence of large-scale societies, which we define as those possessing larger populations, greater concentrations of political power, and higher degrees of social inequality. We focus on key issues involving the communal-resource management of subsistence and other economic goods, as well as the revenue flows that undergird political institutions. Drawing on archaeological cases from across the globe, with greater detail from our area of expertise in Mesoamerica, we offer suggestions for strengthening analytical methods and generating more transdisciplinary research programs that address human societies across scalar and temporal spectra.

In the interests of developing more nuanced theories of human sociality, researchers across the social and behavioral sciences recognize the need to consider both the agency of actors differentiated by power, status, wealth, and other factors, as well as the societal norms and institutions that sustain these divisions and serve to structure action. Archaeologists interested in such pursuits seek to understand broader patterns as well as the contingencies of culture and history.[1,2] We contend that frameworks grounded in the logics of evolutionary cooperation theory and collective action theory offer the best alternative for examining the dynamics of human sociality over the long trajectories that

archaeologists and evolutionary anthropologists study.[3,4] Nevertheless, researchers investigating such issues often talk past one another. **Research following evolutionary cooperation theory relies heavily on the logic of games, mathematical models for how cooperative norms may develop and proliferate within certain social groups, and methods involving surveys or experimental games focused on smaller populations.** In contrast, **research drawing from collective action theory primarily relies on the logic of group resource management** (e.g., public goods or common-pool resource problems)**, consideration of how certain social institutions encourage or discourage cooperation, and methods involving cross-cultural comparison focused on larger populations.** Citation patterns vary accordingly, with researchers who follow evolutionary cooperation theory looking more to the mathematical logic exemplified by works such as Maynerd Smith[5] and Boyd and Richerson[6], while those who follow collective action theory look to the cultural details and comparisons exemplified by works such as Levi[7] and Ostrom.[8]

We do not see this divide as entrenched and find productive lines of archaeological investigation within the evolutionary cooperation literature and the collective action literature. Scholars outside of archaeology have commented on such disciplinary divisions and have begun productive cross-disciplinary dialogs. To cite only one example, Coakley and Nowak[9] explore connections between evolutionary approaches to cooperation and the complex philosophical issues covered in more humanistic disciplines such as religious studies. In this paper we proceed in a similar spirit with the goal of identifying areas of overlap between cooperation theory and the archaeology of large-scale societies, with the hopes of fostering greater complementarity in lines of research.

The Archaeological Record of Large-Scale Cooperation

Cooperation is not unique to any set of societies, cultures, or eras, but viewing the dynamics of cooperation cross-culturally and diachronically provides insight into why human groups vary and

change. Extant models for the evolution of cooperation are often highly abstract in depicting unspecified public goods whose procurement individual actors could cooperate towards or defect from.[10] The goal of developing these models is to demonstrate what mechanisms are theoretically plausible. When actual data are considered, the mechanisms can become clouded by problems of correlation and equifinality. Nevertheless, researchers who engage in cross-cultural analysis regularly deal with such problems and have developed methods for parsing the relative weight of certain factors over others.[11,12] When public goods are specified, researchers studying the evolution of cooperation among small groups direct attention primarily to the importance of increasing returns to scale from endeavors such as cooperative hunting or fishing of big game, mutual defense, and resource management.[13] Major research themes tend to deal with subsistence, demographic patterns, and raw material acquisition and exchange. Researchers following collective action frameworks focus more on variability in political organization and the financing of political institutions (the macro-scale).[14] They, in turn, pay less attention to the causal linkages of certain variables, such as calculations on the part of individual actors (the micro-scale) for payoffs in group management of resources or the strength of norms, monitoring, and the effects of sanctions for noncompliance.

Archaeology is the discipline that offers the most varied and chronologically deep material record of human social change relevant to modelers and theorists who study issues such as the development, maintenance, and breakdowns of large-scale cooperation.[15] A promising trend for increased transdisciplinarity is the greater collaboration between theoretical modelers and field archaeologists in examining such issues. Recent examples of such collaboration, drawing only from the archaeology of the pre-Columbian Americas, include the investigation of topics such as village dynamics within the Ancestral Puebloan world, urban organization at the ancient Mexican metropolis of Teotihuacan, relationships between urbanization and water resources in the Maya lowlands, and heterarchical political organization in Colombia.[16-19] In all of these cases the models lose generalizability

in order to accommodate the cultural and historical contingencies of the particular cases, but they gain explanatory power as a result.

In the sections to follow we offer suggestions for how the archaeology of large-scale societies may contribute to broader cooperation research by highlighting certain examples of cross-disciplinary investigations already ongoing. We draw from ecologically and economically focused archaeological research that may not be explicitly grounded in theoretical frameworks on cooperation or collective action, but illustrate how resource problems and revenue streams connect with organizational variability in ways consistent with such frameworks. **We consider archaeological research in three major domains for cooperation and collective action: (1) subsistence dilemmas; (2) economic goods and their production and exchange; and (3) the relationship between political financing and the allocation of public goods.** In Figure 1 we outline how these three domains overlap with respect to the variables of exclusion and subtractability as considered in classic works on cooperation and collective action by Ostrom[20] and others for defining public goods, common-pool resources, toll or club goods, and private goods, as well as the gradations between classes of certain goods depending on how they are organized. The chart thereby provides a means of implementing the models to evaluate material traces of past economic organization commonly found in the archaeological record.

Subsistence Dilemmas

Subsistence issues that impact large groups of people represent focal dilemmas in cooperation research. We follow other theorists in classifying these issues as dilemmas because they contain the possibility that individuals will free-ride or over-exploit resources, but we envision that actual individuals would be behaving logically within their bounded rationality and not necessarily view these as dilemmas themselves. A few examples of such issues that stand out in the archaeological record, spanning variable social scales, are suprahousehold forms of land tenure, food storage, and agricultural intensification.

When these involve multiple households they are usually classed as common-pool resource problems and therefore are critical to understanding the dynamics of group behavior in the past. They nevertheless all vary in their degrees of archaeological visibility. Understanding past land tenure usually requires textual evidence, though archaeological studies by Kohler,[21] Oosthuizen,[22] and others also have interpreted them through material remains including the presence of field houses, boundary markers, and the spatial distribution of houses on the landscape. Single houses adjacent to small fields are inferred to represent private landholding, whereas multiple houses with unimpeded access to larger fields are inferred to represent more communal holding and/or management. These relationships may accurately characterize certain contexts, but anthropologists and archaeologists must be more explicit in defining property regimes.[23] Drawing from the work of Ostrom, Acheson[24] suggests definitions with archaeological utility, such as varieties of common-property regimes, cases of *de facto* use rights on otherwise private property, and the difference between rights to access, extract, or manage resources.

Storage facilities often have higher archaeological visibility than do past systems of land tenure and have been modeled as an evolutionary cooperation issue by Angourakis and colleagues.[25] Variability in the economics and cultural norms of storage can nevertheless account for much of the variability in its organization. For instance, archaeologists working in Mesoamerica note that limitations on the transportation of staple goods such as food posed by an environment lacking pack animals resulted in underdeveloped storage infrastructure,[26] but may have simultaneously encouraged the development of markets as a system of distribution, discussed in the section to follow. Still, a Mesoamerican example of suprahousehold food storage that would fit the model proposed by Angourakis and colleagues was recently proposed by Carballo and collegues.[27]

Forms of agricultural intensification that involved the coordinated labor of multiple households are the most archaeologically conspicuous of these subsistence dilemmas since they involve irrigation, terracing, and other means of landscape modification. Irrigation has for centuries been a major

explanation for the emergence of larger populations seen in the archaeological record of various world regions, particularly arid ones. A recent model for the emergence of hierarchical leadership from egalitarianism based on cooperation for a resource analogous to an irrigation system is presented by Powers and Lehman.[28] The model demonstrates a possible path to despotism of a “Wittfogelian” sort, but could be developed further to encompass the variability in levels of collectivity in systems of irrigation and land tenure documented historically. For instance, variability in the scale, organization, and broader societal implications of such systems could be more productively explored by considering variance in maintenance, rule conformance, and water supply discussed for a sample of 47 irrigation systems by Ostrom and colleagues,[20] or the differences between more and less communal agricultural regimes highlighted in a recent study of China by Talhelm and colleagues.[29]

Environmental factors impacting water supply and forms of hydraulic engineering can be defined through archaeology as well, or by evaluating prehistoric cases in the light of comparative historical cases. An example of the latter is work done by Hunt and colleagues[30] who conclude that Hohokam irrigation of the American Southwest is consistent with forms of communal management, rather than with private, acephalous, or state-managed models. Similarly, in reviewing the trajectory of irrigation systems in ancient Iran, an exemplar of earlier despotic models, Wilkinson and colleagues[31] conclude that the smaller networks of the Chalcolithic and Bronze Age are consistent with a model of niche-construction, whereby individuals with lower levels of political integration organize their built environments through more bottom-up mechanisms. They track the spread of larger, Iron Age systems in tandem with imperialistic regimes, but do not find conclusive evidence for their hierarchical imposition. In a study of the similarly arid region of the coastal Andes, Netherly[32] detected no evidence for imperial control of irrigation under the Chimu or Inca, and found management by corporate groups termed *parcialidades* in the ethnohistoric literature instead. **Irrigation in arid and hydraulically circumscribed regions is necessary to expand growing area, whereas the resource-management**

calculus is different in semiarid highlands that receive adequate annual precipitation but on a strongly seasonal cycle, or with the possibility of frost. In such areas, including the highland Andes and Mesoamerica, smaller canal systems that humidify fields early in the growing season or raised-field systems along lakeshores can mitigate the risks posed by marked seasonality.[33-35] The undulating terrain of highland regions creates another set of resource problems since the expansion of fields or mitigation of erosion can involve suprahousehold labor for construction and maintenance. In southern highland Mexico, for example, farmers developed a system of check-dam terraces for cross drainage and erosion control called *lama-bordos*. These strings of small dams required fairly intensive maintenance but labor requirements could be met by households or cooperating groups of them during times of labor bottlenecks.[36,37]

In more humid regions of the globe, hydraulic works are typically engineered to channel excess water. Scarborough and Lucero[38] evaluate systems in five well-watered regions of the semitropics—Amazonia, Angkor, Bali, the Maya lowlands, and the Niger delta—and identify patterns of self-organization in the creation of low-density urban centers. Hydraulic projects often involved accumulating abundant water in reservoirs or draining inundated areas through raised fields, and the authors illustrate how both might potentially be implemented at the suprahousehold or community level without coercion, operating as heterarchical systems even when part of extremely hierarchical polities such as Angkor. More precise definition along the spectrum of resource problems needs to be made in these cases, as with those from more arid regions, to capture variability in the objectives of and access to such systems. For instance, restricted use reservoirs for temple ritual or palace baths are not common-pool resources, whereas pools at which all neighborhood residents could access drinking water or channel for agriculture are. These issues overlap with those of the section after next, on political financing, but first we turn to other classes of economic goods.

Economic Goods and their Production and Exchange

Because artifacts are a primary set of data for their analyses, archaeologists have spent considerable time attempting to understand the social systems and networks through which their production and exchange was realized. In many cases production and exchange were household undertakings and therefore are envisioned as private goods that pose few cooperation dilemmas for theorists. Yet in others, **divisions of labor for net efficiency create mutual dependencies that enmesh households for the production and distribution of toll goods by corporate groups who cooperate internally and compete externally**, such as with producer or merchant guilds. Freer exchange creates the possibility of more common-pool resources or public goods issues, as with the maintenance of fair marketplaces or open-access roads for transporting goods. Archaeologists have been attuned to such issues in weighing the relative contributions of staple and wealth/prestige goods in early economies[39] and the macroregional changes of exchange networks.[40]

Given the hyper-competitiveness of the corporate takeovers and e-trading of today's global markets, the conclusion by Henrich and colleagues[41,42] that exposure to markets increases cooperation, based on experimental research among small-scale societies, may seem counterintuitive. Yet an important variable in considering markets among traditional societies past and present is that most exchanges are still done through face-to-face interactions and therefore lack the anonymity of an idealized market principle. Marketplace exchange in traditional societies, and also sometimes in industrial ones,[43] is instead shaped by the dilemma of transcending institutions of political and economic power to create more egalitarian settings in which participants can trust that transactions are untethered from dominance hierarchies. In a review of preindustrial markets Blanton[44] draws on collective action theory to examine cross-cultural trends. He notes common strategies of inverting dominant social structures through the construction of marketplaces as liminal spaces. They involve altruistic punishment and the piggybacking of marketplace exchange onto organizational structures that

can uphold a sense of trust and order, such as by positioning them at sites of religious pilgrimage or festivals, or associating them with market deities. These issues of resource types and management of markets leads to the considerations of our final domain: political financing.

Political Financing and the Allocation of Public Goods

The previous two sections demonstrate that cooperation research in archaeology can apply to a range of social scales, as institutions such as irrigation systems and exchange networks are integral to both smaller and larger groups. In its focus on the political economy and public goods, the comparative literature drawing on collective action theory deals mostly with large-scale societies, such as premodern cities, states, and empires—although we see the insights of this research as applicable to smaller-scale societies and, conversely, see how the evolutionary cooperation literature applies to larger formations. In earlier publications Feinman and colleagues[45,46] considered how societies vary in their organization along continua alternatively labeled corporate/network, inclusive/exclusive, and collective/individualizing.[47] Following the comparative analysis by Levi[7] that models historical state tax systems as a cooperative (n-person) dilemma, Blanton and Fargher[14] have expanded significantly on these themes with a survey of 30 premodern states that demonstrates correlations between organizational variability and whether political financing comes from largely internal or external revenues, as this directly impacts the levels of accountability that leaders face from commoners and the likelihood that governance will be shared (oligarchic, democratic) or individualized. In addition to greater accountability for governing authorities, higher levels of internal financing and communal resources also correlates with higher dissemination of public goods and bureaucratization of civic offices.

Researchers such as Richerson and Boyd[48] and Turchin[49] also apply the logic of evolutionary cooperation to explain the ultrasociality of large-scale societies. Both consider calculations where the

returns of mutual cooperation are higher than defection, and the role of leaders or incipient forms of governance in transforming zero-sum conflicts for individuals into aggregate gains. Blanton and Farger[14] provide a nuanced scheme for classifying revenue streams and assessing their relative weights among diverse cases. Internal revenues include taxes on market transactions, basic agricultural and craft production, and labor; external revenues include state-controlled land, war booty and imperial extraction, state-controlled trade or tax thereof, and direct control of labor or spot resources. Public goods include transportation infrastructure, water supplies, safety, endowments for temples or schools, redistributive economic mechanisms, and an evaluation of how broadly these impact commoners away from capital cities or other elite centers. **The major finding of collective action research on political financing and public goods is that societies with an emphasis on internal revenue streams have a greater tendency to be organized more collectively and to disseminate public goods to a broader populace.**

The archaeological application of these lessons to contexts with few or no textual sources requires their extrapolation to material remains. In Table 1 we outline our logic for evaluating archaeological signatures with respect to these axes of collectivity. Again, we note that considerations such as revenue streams, landholding, indices of social inequality, politically themed iconography, and investments in communal architecture are not exclusive to large-scale societies, though they are all commonly discussed in their archaeological study.

Subsistence, Exchange, and Political Financing: An Application to Pre-Columbian Mesoamerica

In order to provide a more concrete application of the three domains of cooperation and collective action reviewed above we turn to greater detail on cases from pre-Columbian Mesoamerica, where we and our colleagues have been documenting a range of variability along these axes.[50] **Pre-Columbian Mesoamerica presents an example of profound transformations in the scale of societies**

associated with changes in labor relations and cooperative networks, rather than with technology. Major transformations include early interregional interactions focused on the exchange of prestige goods, primarily by elites; the maturation of economies of regional goods associated with the broad participation by commoners and early urbanism; and the creation of a more integrated world system through the proliferation of markets that mobilized staples as well as bulk luxuries—finer goods widely available throughout the socioeconomic spectrum.[51] The regional-goods transformation and development of markets are of greatest interest to cooperation research. In the first case, the potential for exclusion is low but payoffs through suprahousehold cooperation are high.

To provide a quantifiable calculus of economic goods and their exchange, we may consider the potential profits from a craft industry such as fine pressure blades made of obsidian, which are abundant archaeologically and whose market value is attested to through sixteenth-century textual sources. The production and exchange of this artifact class increased dramatically in association with the regional-goods transformation and urbanization of the later Formative period, some two millennia earlier. Based on conservative estimates of the quantity of obsidian a merchant would transport, Hirth[52] concludes that the exchange of a single pack worth of blade-cores could have provided a third more than the annual supply of maize needed to support a household. Using time approximations for blade production,[53] and adding travel times for acquisition and distribution, we extrapolate that this could be met in a maximum of two months, meaning that subsistence yields could be doubled by a single household during the non-agricultural season or even higher returns could be achieved through a cooperative division of labor (e.g., cooperation between quarry workers, producers, and merchants). Exclusionary access to obsidian would have been practically impossible in Mesoamerica, where many flows stretch for tens of kilometers over badlands without resident populations,[54,55] making these production and exchange dynamics a common-pool resource. Mesoamerican obsidian represents only

one example of an array of similar economic goods seen in the world's archaeological record, and that could also be modeled more accurately to meet the specific case.

Following this intensification in the economic networks associated with regional goods, the urban revolution in the southern Mexican state of Oaxaca saw the creation of hundreds of fortified hill-towns, designed for mutual defense as community architectural projects.[56] It is clear from excavations at sites such as El Palmillo that networks of residential terraces required suprahousehold labor for interconnecting and maintaining terrace walls.[57] Here, a town of some 5000 occupants constructed 1400 terraces tightly packed in one km^2 of occupation (Figure 2). Such architectural features represent common-pool resources because they required suprahousehold level coordination to construct, and failure in any portion adversely impacted multiple households. The occupation of El Palmillo lasted five centuries, but episodes of construction and remodeling probably occurred quickly in a coordinated manner for large sectors, possibly over one dry season. If we employ common labor calculations used in archaeology to estimate 50-140 person days per terrace, we find that El Palmillo's network of terraces represents approximately 52,000 person days of construction, while smaller sites in the region would total the low thousands.[36]

This example relates to a general trend seen in Mesoamerica and in other cases of premodern urbanism whereby neighborhoods in settlements with denser populations appear to have fostered more collective action than low-density urbanism.[57-59] The proposal can also be evaluated quantitatively by comparing houses or their associated holdings, as has been done recently by Smith and colleagues[60] using a sample from central Mexico. The study calculates the Gini index, used commonly for contemporary social science research on inequality, based on variability in archaeological house and room size and, when available, textual accounts of landholding. Consistent with the suggested trend of urban density and collectivity, Teotihuacan—one of the largest, most nucleated cities of the ancient Americas—ranked as the lowest Gini score, meaning more muted inequality. The city also aligns with

most of the collective side of the axis in Table 1. As proposed in a recent model by Froese and colleagues,[17] some of this collectivity may have been driven by self-organization at the neighborhood level.[61]

Early cases of urbanization in Mesoamerica generally appear to have followed more collective lines, but the disintegration of these systems led to balkanized political landscapes and power vacuums that in many cases were filled initially by smaller kingdoms. The leaders of these smaller polities, in contrast to their predecessors, frequently drew power more from external or spot resources, coercive military practices, and interpersonal networks, expressing the trappings of nobility without returning many public goods. It is possible that this trend applies to many, although clearly not all, sequences in other parts of the world, since early urban centers such as Uruk, Harappa and Mojenjo-Daro, late Neolithic northern China, and Initial Period coastal Peru also seem to have modest burials and wealth accumulation, and an emphasis on temples or other monumental public architecture rather than on palaces.

We speculate that early urbanization frequently could have followed more self-organizing, non-coercive principles as cities offered mutualistic benefits;[61,62] in contrast, political expansionism was an inherently more competitive process since force or the threat of it often is associated with marked growth in the spatial extent of political control or dominion.[63,64]

Conclusions and Future Prospects

In this overview, we have illustrated potential intersections and synergies between research drawing from evolutionary cooperation theory and collective action theory, and where the archaeology of large-scale societies can facilitate connections. Explanation of the development and organizational variability of large human agglomerations of the past requires consideration of the micro-scale of individual or small-group strategies, exemplified by studies drawing on evolutionary cooperation theory,

but they cannot be accounted for by these foundations alone. In this paper we propose an approach drawing on frameworks for cooperation and collective action that considers the relations between individuals and the macro-scale of institutions and structures that are the product of individuals and their interrelations, but cannot simply be reduced exclusively to them.

Archaeological findings, sometimes supplemented by documentary records, offer comparative trajectories of cooperation in large-scale societies in realms such as subsistence, production and exchange, and the relationship between political financing and public goods. We have provided frameworks that more explicitly connect types of resource-management issues, based on their subtractibility and exclusion, and indices of the collectivity in institutions to remains commonly encountered in the archaeological record. These provide empirical referents that can be employed to actualize the cost/benefit calculations of many cooperation models, as do calculations of labor in construction or craft production longstanding to archaeological analyses, and newer applications such as Gini indices for evaluating inequality. Such grounding is critical because it provides a basis to realistically consider culture and the fluidity in composition of large-scale societies seen in comparative historical cases, and can more productively account for the marked degrees of regional and temporal variation in the ways that humans have and have not cooperated.[65] In turn, such models provide archaeologists with means to give greater consideration to individual agency and motivations in the assessment of past processes that they tend to observe at more macro-scales over time and space. Increased collaboration between modelers and field archaeologists holds promise for a more transdisciplinary field of cooperation research unhindered by the artificial divide often constructed between the distant past and the present, and focused to account for both the cross-regional parallels and the diversities that characterize humanity's global career.

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Table 1

More Collective	Less Collective
Internal revenues: regularized taxation, a focus on staple finance and regional goods	External revenues: long-distance trade, importance of portable wealth, spoils of war, control of spot resources
More communally owned or managed land	Less communally owned or managed land
Fewer disparities of wealth in life and death	Greater disparities of wealth in life and death
Greater potential for shared power	Greater potential for individualized power
Political ideology emphasizes abstract principles of offices and strength of the polity, cosmology and fertility	Political ideology emphasizes lineal descent systems for succession and legitimation, divine kingship and royal patron deities
Not centered on palaces	Centrality of palaces
Monumental architecture fosters access (e.g., open plazas, wide access-ways, community temples)	Monumental architecture fosters exclusivity (e.g., elite tombs and memorials, dynastic temples)
Higher expenditures on public goods	Lower expenditures on public goods

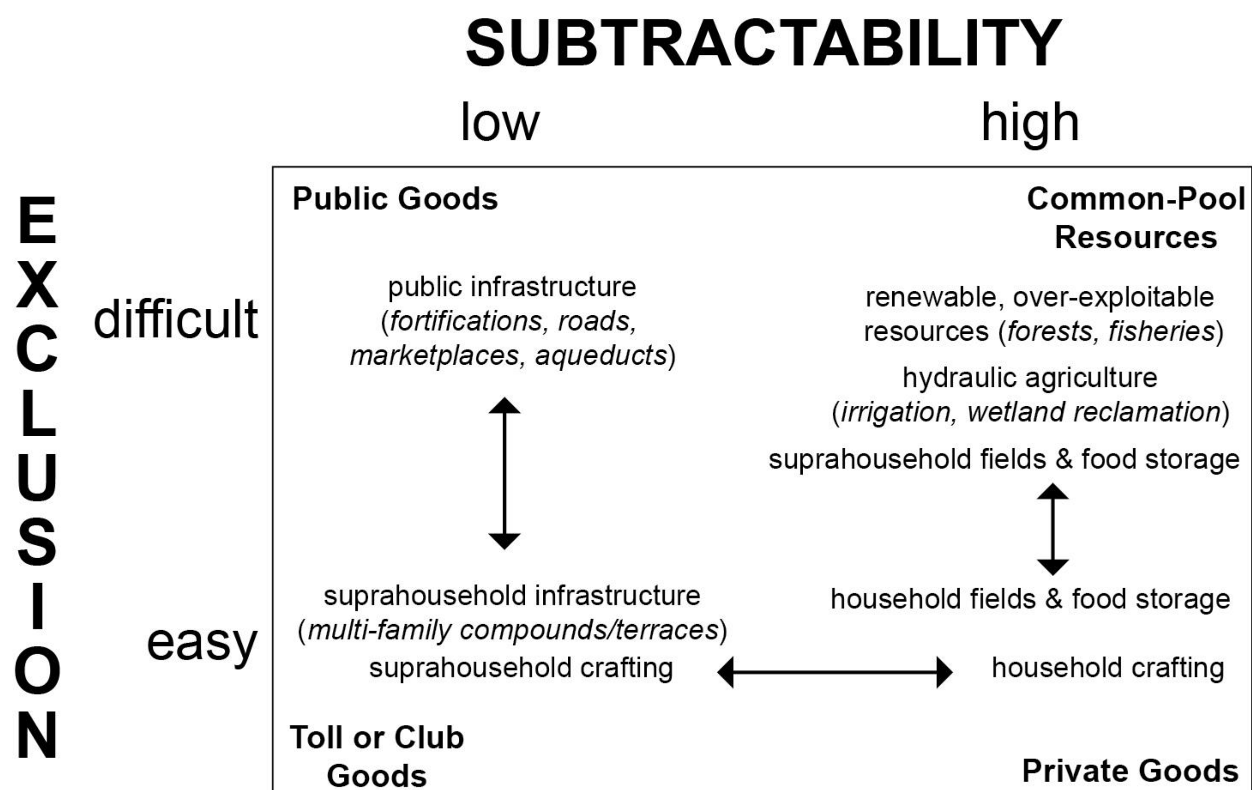

Figure 1

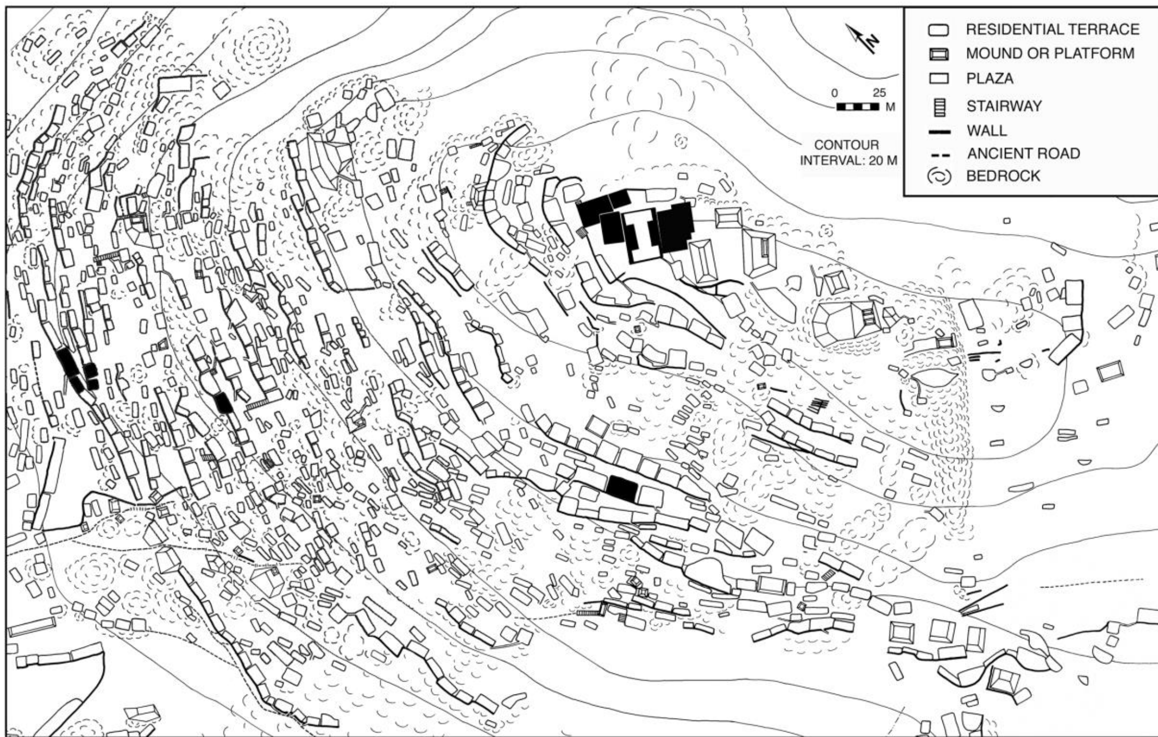

Figure 2

Table 1. Axes of collectivity for premodern complex societies.

Figure 1. Classification of types of goods with examples of variable axes used in the archaeology of complex societies.

Figure 2. Map and photograph illustrating the western, heavily terraced face of El Palmillo (Oaxaca, Mexico). Arrows on the photo correspond to the blackened spaces on the map, where excavations confirmed pre-Columbian occupation and residential terrace construction and maintenance that were carried out over centuries during the first millennium A.D. The map also provides a record of areas with dense terrace construction that were not excavated.