From KLM to Corona: A Bird's Eye View of Cultural Ecology and Early Mesopotamian Urbanization

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SETTLEMENT AND SOCIETY

ESSAYS DEDICATED TO ROBERT MCCORMICK ADAMS

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The suggestion, then, is that the relationship between Uruk and its hinterland—and this probably applies to the other Babylonian cities as well—was primarily a political/administrative one that itself governed the economic ties.

Considering the inherent weakness of survey data, this may sound like stretching the evidence but, if nothing else, it makes us aware that the unvoiced assumption of primarily economic relations between the center and periphery needs to be questioned. It is still regrettable how little we know about the details and the organization of the interchange between centers and their hinterlands, but at least the results of archaeological surface surveys help us ask new questions.

As mentioned earlier, to have introduced, propagated, and refined these methods is one of the lasting achievements of Bob Adams. Others may be proud of having added new material to our picture by excavating smaller or larger sites, but it is very rare that a scholar can be attributed with having altered an entire field of study by adding a new dimension to research.

KLM TO CORONA: A BIRD'S-EYE VIEW OF CULTURAL ECOLOGY AND EARLY MESOPOTAMIAN URBANIZATION*

JENNIFER R. POURNELLE

ABSTRACT

A hallmark of nineteenth-century beliefs about non-urban landscapes was that marshes are inherently diseased, sodden wastelands, and that the appropriate effort of good government was to transform them into cultivated agricultural land. This emphasis on the importance of transforming "waste" marshes for "useful" agricultural endeavor was especially operative during the formative period of Mesopotamian archaeology. Through the mid-twentieth century, it was embedded in research paradigms that viewed the birth of Mesopotamian civilization as inherently tied to drying of primordial lands, accompanied by state (or temple, or household) administration of irrigated plow agriculture.

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During the final quarter of the twentieth century, Robert McC. Adams insisted that any characterization of Mesopotamian civil complexity must include due consideration of both cities and their surrounding ruralized zones. He used KLM aerial photographs collected during the late 1950s to address problems of both geographic and temporal scale in mapping and contextualizing data collected during archaeological survey conducted through the 1970s. Adams's definitive 1981 study, entitled Heartland of Cities, quite literally placed rural settlements on the map of urban genesis and decline. In it, he envisioned a complex urban hinterland, comprising grain agriculture, livestock husbandry, and marshland exploitation.

However, geopolitics and war meant that access to the detailed KLM air photos was never guaranteed, and this work halted. During the early 1990s, Adams and others successfully lobbied for public access to high-resolution declassified satellite photographs, code-named CORONA. Relying on Adams's CORONA legacy, this paper revises that map, by showing that the urbanizing/ruralizing heartland was, at its core and urban incept, a deltaic heartland. It outlines with greater precision than was available to mid-twentieth century theorists the paleogeography of the lower Mesopotamian alluvium during the formative Chalcolithic and Early Bronze Age periods. It emphasizes the essential nature of wetlands in supporting and shaping the complex social institutions that underlay urbanization in southern Mesopotamia. It concludes that marshy deposits underlay or surrounded the earliest occupation layers of all early urban sites, suggesting that these settlements were subject to (or bordered) seasonal inundation.

We cannot wrest the origins of alluvial Mesopotamian cities from an irrigated version of the modern landscape. The predecessors of early alluvial Mesopotamian cities were not beads strung along the filaments of rivers and canals. They are better imagined as islands embedded in a marshy plain, situated on the borders and in the heart of vast deltaic marshlands. Many desiccated waterways are ancient transport routes through those wetlands, not relict irrigation canals. The stability of those early urban centers was largely contingent upon the vicissitudes of human interaction with those wetlands during deltaic progradation. The predominance of reeds, reed bundles, and reed structures in the earliest protoliterate texts point to their major role in fourth-millennium tributary economies. It may well yet be shown that a lasting importance of marsh-grown reeds was not only as a commodity per se, but in the way the demands of their production structured the underpinnings of urban-centered labor control.

INTRODUCTION

In a United Nations report based on NASA analyses of LANDSAT satellite images, Hassan Partow documented the demise of the vast marshlands of southeastern Iraq. That demise was the end result of a half-century of systematic flood control, damming, and drainage aimed at asserting centralized political authority and expanding agricultural export production (Cotha Consulting Engineers 1959; Iraq 1956; Koucher 1999; Macfayden 1938; National Aeronautics and Space Administration 2000: 2001; Partow 2001). The LANDSAT multispectral system, released to public access in the early 1970s, was itself produced in response to demands for an accessible aid to landform analysis that could be used in service to regional development schemes. Within the public arena, LANDSAT launched hopes that satellite imagery, when compared with traditional aerial photography, would both expand coverage and lower costs.

But imagery of this kind was barely imaginable to archaeologists and public planners when, in the 1950s, the Iraqi government contracted for a series of engineering studies aimed at harnessing the water and power of the Tigris and Euphrates Rivers. Among its aims, the Iraqi monarchy then in power intended to implement ambitious schemes first proposed by British engineer Sir William Wilcox a half-century earlier. These proposed to systematically drain marshes, lower the saline water table, and rationalize irrigation systems in order to reclaim waste land for high-profit agricultural production.

Thus, both the demise of the marshlands and their documentation were, in a sense, a terminal outcome of nineteenth-century beliefs that marshes are inherently diseased, sodden wastelands, and that the appropriate effort of good government was to transform them into cultivated agricultural land. This emphasis on the importance of transforming "waste" marshes for "useful" agricultural endeavor was especially operative during the formative period of Mesopotamian archaeology. Through the mid-twentieth century, it was embedded in research paradigms that viewed the birth of Mesopotamian civilization as inherently tied to sufficient drying of primordial lands to allow irrigated plow agriculture (for example, Nissen 1988). This was true despite the many clues pointing to the importance of other resources to Mesopotamian culture, such as the remains of burned and unburned fish recovered from Eridu, Ur, Uruk, Tello, and Tell Asmar (van Buren 1948: 102).

Robert McC. Adams was among the first to seriously challenge this paradigm. The Iraqi Crown had contracted KLM Dutch Airlines to conduct systematic aerial photographic mapping of the alluvial areas of Iraq. The Mesopotamian plain was rendered in a series of high-quality photographic mosaics intended to aid geomorphological studies. Adams insisted that any characterization of Mesopotamian civil complexity must include due consideration of both cities and their surrounding ruralized zones. He used the KLM aerial photographs as an interpretive tool for mapping and contextualizing data collected through archaeological survey. He envisioned a complex hinterland, comprising grain agriculture, livestock husbandry, and marshland exploitation. He examined not just the deep past, but its continuous transformation until the onset of the modern age and its drainage efforts, marked by the construction of a massive flood-control barrage at al-Hindiyah at the turn of the twentieth century (Adams and Nissen 1972; Adams 1981).

LANDSAT imagery would never have sufficient ground resolution to identify the fine detail of small site locations and associated ground features that had made Adams's ambitious study possible. However, access to the more detailed KLM photos was never guaranteed, dependent as it was on the variable goodwill of Iraqi officials. During the early 1990s, even as the final drainage installations were emptying Lake Hammar of water, Adams and others successfully lobbied for declassification of, preservation of, and public access to a hoped-for replacement from the United States military sector: satellite photographs, code-named CORONA. Not only were these images of much higher resolution than other imagery commercially available at that time, but they dated to the late 1960s and early 1970s, before modern development and war had transformed earlier landscapes.

Adams did not, of course, invent the use of aerial photography in archaeology or even in the lower Mesopotamian alluvium. Hall, Woolley, and others used British Air Services to scout locations and photograph individual sites as early as 1918. But it was Adams who understood and used the power of aerial mapping to address problems of scale: both geographic scale (in considering a vast region) and temporal scale (in considering the palimpsest of human activity over this terrain). He was also the first to use photography toward a systematic rooting of Mesopotamian societies within their natural environment. This approach—the use of overhead imagery to link regional-scale studies with ground-based point data to produce comprehensive studies—is a powerful one and, for the newest generation of scholarship, one for which Adams's prescience has secured immeasurable opportunity.

Bracketing the half-century from the mid-1950s to the present, the KLM and CORONA bird's-eye views of lower Mesopotamia have twice provided a unique framework within which to reinterpret the cultural ecology underpinning urbanizing landscape transformations (and allow for direct relation of many data sets and scales of analysis). Adams's definitive 1981 study, entitled *Heartland of Cities*, quite literally placed rural settlements on the map of urban genesis and decline.

Relying on Adams's CORONA legacy, I seek to rewrite that map, by showing that the urbanizing/ruralizing heartland was, at its core and urban incept, a deltaic heartland. This work takes a viewpoint at a regional scale inaccessible through single-site excavation. It reconstructs with greater precision than was available to mid-twentieth century theorists the paleogeography of the lower Mesopotamian alluvium during the formative Chalcolithic and Early Bronze Age periods (Pournelle 2003a; 2003b). It emphasizes the essential nature, not merely of water but of wetlands, in supporting and shaping the complex social institutions that underlay urbanization in southern Mesopotamia. I review available ground evidence in light of fundamental geomorphology that is only visible from above the earth. I conclude that marshy deposits underlay or surrounded the earliest occupation layers of all early urban sites, suggesting that these settlements were subject to (or bordered) seasonal inundation. I argue that desiccated waterways cannot be uniformly interpreted as relict irrigation canals; many were more likely transport routes through vast wetlands. We should not conceive of alluvial urban precursors as beads strung along the filaments of rivers and canals. They are better imagined as islands embedded in a marshy plain. The stability of those early urban centers was contingent upon many things, but not the least of these were the vicissitudes of human interaction with the wetlands characteristic of deltaic progradation.

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In a recent article, Guillermo Algaze posits that "geography, environment, and trade can be seen as the most important factors helping shape the initial nature of social complexity in the Mesopotamian alluvium" (Algaze 2001a: 213–214) in that "the unique ecology and geography of the alluvial lowlands . . . gave Mesopotamian societies important advantages in agricultural productivity and subsistence resilience not possessed by contemporary polities on their periphery" (Algaze 2001a: 199), spurring a "synergistic cauldron" that created "high levels of social and economic differentiation, promoted unprecedented population agglomerations and selected for the creation of new forms of social organization and technologies of social control" (Algaze 2001a: 204–205). In this process, first internal, then "inherently asymmetrical external trade" led to import substitution (Algaze 2001a: 199, 208), with concomitant innovations in information management and manufacturing technologies (Algaze 2001a: 207 and passim), at a pace unmatched outside the alluvium (Algaze 2001a: 213, 214, 217).[1] Algaze's work was spurred on by findings of the Mesopotamian Alluvium Project, a CORONA satellite photographic analysis lab run at UC San Diego[2] by myself and Robert McC. Adams between 1998 and 2002 (Pournelle 2001; 2003a; 2003b). Central to Algaze's hypothetical model is a fundamental reconception of the ecology of the southern alluvium during the formative period in question. This radical reconception can be characterized by two words: Tigris marshes.

During historical periods of the later third and second millennia BC, the climatic regime of the southern Mesopotamian alluvium had dried to something approximating its present state, with urban pearls strung along riparian filaments. Direct travel experience spurred by reliance on historical texts led scholars to assume that the alluvial past of Mesopotamia was characterized by a largely flat, uniform, desertic-steppic plain, devoid of the meanest resource save silt and shrub, transited by its two great rivers, the Tigris and the Euphrates (for example, Nissen 1988: 2). But mounting climatic and geomorphological evidence requires a reconsideration of the southern Mesopotamian terrain during the fifth and fourth millennia BC, and thus of the social developments arising from it. At the point of Uruk's dramatic expansion, the rivers-through-the-desert image simply does not adequately characterize reality on the ground as we now understand it (Sanlaville 1989; 1996; Geyer and Sanlaville 1996; Lambeck 1996; Kouchoukos 1998; Aqrawi 1997; 2001, Margarete van Ess, Helmut Brückner, and Jörg Fassbinder, personal communication 2002). In short, we cannot wrest the origins of alluvial Mesopotamian cities from an irrigated version of the modern landscape. They grew instead from their ʿUbaid predecessors, located on the borders and in the heart of vast deltaic marshlands. These wetlands were in part derived from Euphrates overflow, supplemented by rainfall, but the greatest portion of their annual recharge was the result of Tigris discharge. They served as a massive sponge, absorbing water during flood seasons and releasing it to soil moisture and groundwater during the remainder of the year.

Results of geomorphological investigations that relate mid-Holocene Nile Delta paleogeology to fifth-millennium BC site locations (Butzer 2001; van den Brink 1989; 1993) provide a point of departure for interpreting declassified CORONA photography of the southern Mesopotamian alluvium. As an archival data set, this imagery is especially useful now, since the region in question is likely to remain closed to coring operations for the foreseeable future. Landform analysis shows that in alluvial Iraq (roughly south of the 32nd parallel), archaeologically visible early villages were concentrated on river levees at locations bordering swamps and marshes during the Neolithic ʿUbaid 0 periods (6500–900 BC). Many of these early sites continued to be occupied into the Chalcolithic ʿUbaid 4 (4900–350 BC), accounting for half of the sites known in the Warka and Eridu survey areas for that period. Of the newly founded sites, as in the Nile Delta, all but one were situated on exposed surfaces of Pleistocene "turtlebacks" that once overlooked anastomosing distributaries subject to seasonal flooding. These turtlebacks were formed during the Pleistocene, when meandering rivers cut through the alluvium, leaving former surfaces exposed above the newly formed floodplain. The channels between these exposures infilled during subsequent Holocene alluvial aggradation, leaving weathered humps of the older surface protruding slightly above the newer alluvial plain—like a floating turtle's back, protruding above calm water. The Nile data cited above suggest that innumerable smaller, scattered sites may be buried beneath the Holocene deposits, leaving visible only the larger sites, situated on the once-elevated turtlebacks. These archaeologically typical ʿUbaid towns presaged an explosion of new (or newly visible) sites founded during the Early Uruk period, when virtually all identifiable turtlebacks became inhabited (Figure 12).

Placing excavation data within this overarching geomorphological context suggests that a significant component of the resource basis for precocious, large deltaic towns (such as Eridu) was derived from surrounding marshland. Mesopotamian urban civilization could and did flourish only following Chalcolithic specialization and integration of not two, but three productive economies: agricultural/horticultural, pastoral/husbanding, and littoral. By productive economy, I mean a sophisticated organization and level of extraction above and beyond opportunistic hunting/fishing/gathering within riparian, lacustrine, marshland, estuarine, and coastal environments. These activities became sanctified and administered in their own right. They were not merely adjunct, supplemental, or subordinate to agropastoral production.

[1] The argument, made by Algaze, for precocious urbanization (in terms of scale and complexity) in the southern alluvium may or may not be subject to modification on the basis of ongoing excavations at Tell Brak. Algaze and Wilkinson note that the estimates of site size for Brak at the Middle Uruk assume that the totality of the intervening area between the main mound and the ring of satellites surrounding it was occupied (Algaze 2001a: 27). Wilkinson argues that much of this space was in fact dedicated to builders' clay pits (Emberling et al. 1999: 16–17, 25; Wilkinson 2000: 227.

[2] Funded by The Smithsonian Institution, The National Geographic Society, and the University of California, San Diego, Department of Anthropology. I am especially grateful to the National Science Foundation, the University of California Institute on Global Conflict and Cooperation, and the American Schools of Oriental Research for support of my work.

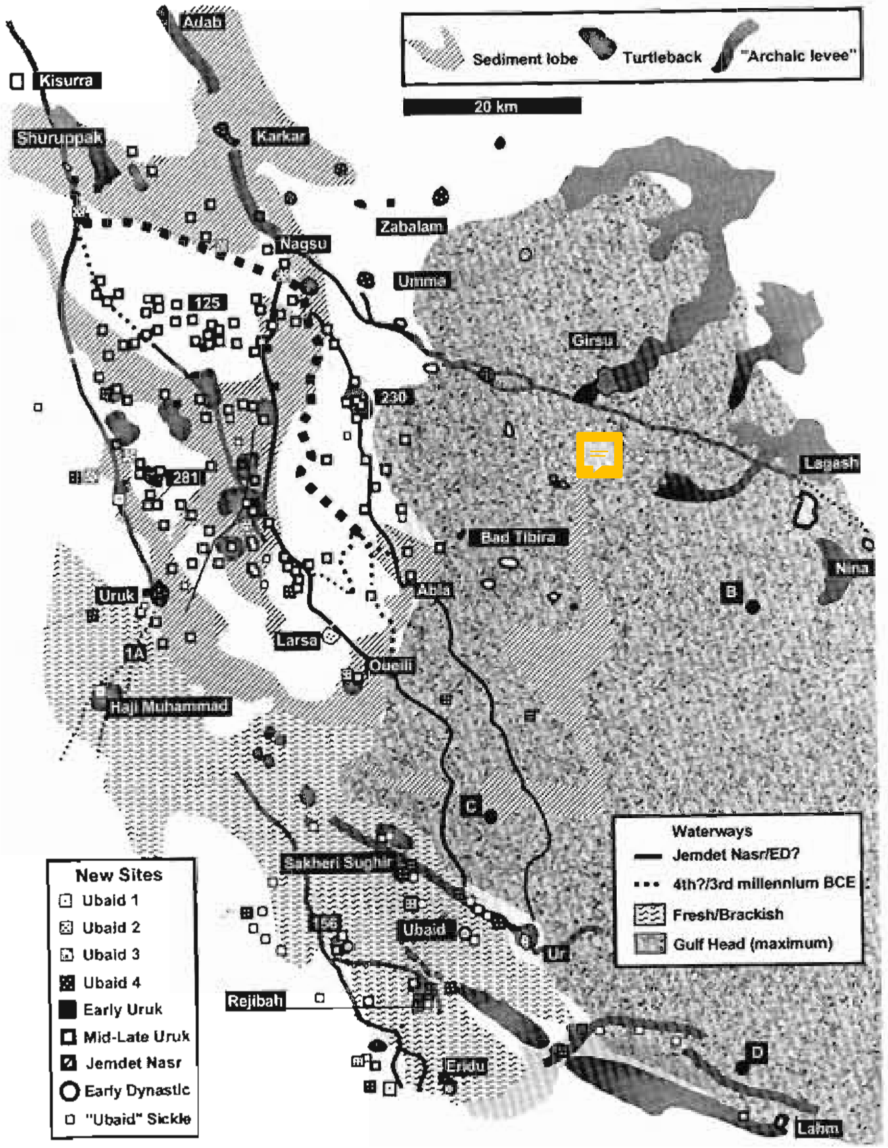

Figure 12. Archaeological sites and relict waterways mentioned in the text, with the approximate extent of the Persian Gulf ca. 3200 BC. Borings show at (B), a transition from fresh marsh to brackish marine conditions, 'Ubaid 1–4; at (C) and (D), brackish marine 'Ubaid 1 Middle Uruk, followed by brackish marsh Late Uruk III and salt panne thereafter.

As for the Mesopotamian heartland, until the latter quarter of the twentieth century, similar arguments regarding the evolution of complex societies in Egypt posited "a swampy Nile delta hostile to all settlement" (Rizkana and Seeher 1987: 21). Challenging this view are careful faunal analyses at deltaic (Maadi, Buto, and Merimde) and lacustrine sites (Brewer 1989: 28; Boessneck, von den Dreish, and Ziegler 1989; Eiwanger 1984). Comparison of these studies to the Mesopotamian case suggests that broad processes were in play; a "third pillar" must be added to the agro-pastoral dyad thought to underpin urban origins. We must reconsider the role of littoral propinquity (in the broad sense including all borderlands between land and water, freshwater and saltwater, and grassland and marsh), not in originating agriculture, but in establishing the territorial precursors to later, enduring social institutions.

THE MESOPOTAMIAN HEARTLAND REVISITED

Four factors are important in assessing the extent and character of surface water and vegetation in the archaic Mesopotamian southern alluvium: (1) Tigris-Euphrates discharge, (2) seasonal rainfall, (3) marine penetration, and (4) river distributary form. The timing, rate, and volume of Tigris and Euphrates water discharge is determined primarily by the quantity and seasonality of precipitation and melting snow packs at their respective Zagros/Taurus headwaters. These are in turn affected by climatic oscillation of the Mediterranean storm track (Mann and Bradley 1998). The amount, extent, and seasonality of rainfall on and east of the alluvium are affected by northwest–southeast displacements of the summer Indian monsoon (el-Moslimany 1994). The extent of saline penetration and related tidal flushing[3] is related to the location and timing of marine transgressions and regressions at the head of the Persian (Arabian) Gulf, as influenced by tectonic uplift, sediment compaction rates, and global sea level variation. Major Tigris and Euphrates distributaries build inner deltas with associated marshlands. Paleoclimatological and sedimentological work regarding the first three

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[3] Diurnal tides twice daily push Gulf waters up the Shatt al-Arab estuary, raising mean sea levels in shipping lanes by up to 2 meters. This tidal action also checks freshwater outflow, similarly raising estuarine freshwater levels ahead of the tidal surge. Palm groves situated in low-lying ground along the Shatt are thus irrigated and drained twice daily by this tidal action, with no need for human intervention beyond occasional clearing of drainage ditches between the stands (Wirth 1962: 150–51, fig. 34). The regions subject to tidal flushing, ideal for date palm gardening, were thus directly influenced by variations in mean sea level and Gulf head progradation.

factors aids interpretation of new evidence derived from satellite photographs.

The degree and extent of inundation, as well as local groundwater levels and soil and water salinity, are obvious considerations critical to the location of specific communities. Taken as a whole, the alluvium is so flat that even small changes in precipitation and sea level markedly affect these. Nevertheless, conclusions regarding the effect of such geologic events on the habitability of the southern alluvium have been driven largely by the embedded notion that the earliest large, permanent settlements were a result of "colonization" under conditions newly, uniquely, or primarily favorable to agro-pastoral production. As argued by Potts, this position becomes increasingly untenable (Potts 1997: 47–55). Joan Oates's early views regarding the attractions of a rich hunting and fishing potential in southernmost Mesopotamia (Oates 1960) would seem, over recent decades, to have been borne out in a number of Middle Eastern locales. Paleobotanical evidence suggests that, in general, the early to middle Holocene (seventh to fourth millennia BC) was considerably wetter than at present, and that, especially during the late fifth millennium, the alluvium may even have experienced summer rains (el-Moslimany 1994; Hole 1998b; Miller 1998; Zarins 1990: 49–50). Even well outside the alluvium, the close association of large, sedentary sites to wetlands has been noted (Agcabay et al. 2001; Bar-Yoseph 1986; Helbaek 1972: 39; Hole 1998b: 45; D. Oates and Oates 1977: 116–117; Oates 1972: 124–127, pl. 23).

Seeking to understand the origins and development of civilizations in the alluvial lowlands of the Tigris, Euphrates, and Diyala Rivers, Adams, Nissen, Wright, and Gibson conducted broad-scale regional settlement surveys that located, recorded, and dated (based on pottery seriation) thousands of archaeological sites. Then, by means of passive association with archaeological sites located along their courses, Adams dated relict watercourses that intricately lace the region (Adams 1965; 1981; Adams and Nissen 1972; H. T. Wright 1981b; Gibson 1972). From the beginnings of settled towns to the present day, the surveyors were thereby able to provide a broad view of long-term settlement patterns and demographic changes in the Mesopotamian lowlands.

Prior to these studies, it had been generally thought that heavy alluvial deposits over the lower Mesopotamian alluvium would have made it impossible for surveyors to find deeply buried sites. However, the surface surveys showed that this was not necessarily the case. Wind erosion periodically re-exposes long-buried artifacts which, when systematically collected, dated, mapped, and plotted with reference to ancient canal traces, indicated settlement cycling over a period of five millennia (Wilkinson 2003: 71–99, especially fig. 5.5). Thus, the corpus of archaeological survey data for Mesopotamia, although incomplete, succeeded in adding a corrective rural and nonliterate dimension to the predominantly urban, literate, elite focus of excavations and excavated historical texts. On the other hand, the texts lent interpretive dimension to the archaeological data.

Adams's work is especially well known for its clarification of how human engineering interacted with the natural environment. He laid out through deep time the changing strategies Mesopotamian societies used to adapt to shifting hydrology, identifying successive anthropogenic transformations of that environment. He argued that environmental pressures in the region selected for urbanization as an adaptation to social and environmental contingency (Adams 1981).

Overview, Viewed Over

A significant conclusion of Adams's study was that the present-day courses of the Tigris and Euphrates Rivers are, geologically speaking, of recent and anthropogenic origin. He argued that the late mid-Holocene rivers ran down a narrow corridor demarcated by ancient cities strung along now-relict watercourses through the lower alluvium. Following Jacobsen's attempt to reconstruct the main watercourses of ancient southern Mesopotamia from textual sources (Jacobsen 1958), Adams attempted to overcome the inherently speculative problem of attempting to attach precise geographical localities to watercourses attested in early historic itineraries. He undertook to identify actual waterways using extensive ground survey and the KLM air photography, and documented thousands of now-deserted canals in association with these sites. He also hypothesized linear connections between them. The accumulation, argued Adams, of silt carried and deposited by these irrigation activities gradually aggraded the central steppe through which the progressively canalized rivers and canal offtakes ran, ultimately forcing the "wild" rivers respectively westward and eastward (Adams 1981). Once abandoned, aeolian deflation of levees formed dune fields that then scoured their way across the plain. In many cases, this left archaeological features pedestaled above the deflated surface.

Meandering through the Upper Alluvium

While individual channels such as those studied and mapped by Adams from the KLM air photos are suited to localized study supported by ground-based geomorphological assessment, orbital scanners are better suited to detection and analysis of paleochannels at a regional scale. This is especially true for the analysis of adjustments to discharge, sediment load, drainage diversions, and cataclysmic flooding (Baker 1986: 259). Thus, although the original air photos are no longer available,[4] declassification of late 1960s and early 1970s-era satellite photographs enabled me to expand on his original work. Comprehensive mapping of the multiple relict courses of the Tigris and Euphrates, from Samarra in the north to ancient Ur in the south, shows entire, connected systems associated with sites of varying periods. This helps to clarify channel dating and subsequent anthropogenic geomorphology in a way impossible through the analysis of individual localities (Pournelle 2001; 2003a; 2003b; 2004b).

Changes in river regimes related to regional tectonic movements are of particular interest to this study. As the surface slope of alluvial channels levels off en route to the sea, the riverbeds undergo threshold changes, from braided, to meandering, to straight, with the latter in some cases assuming multichannel, anastomosed patterns (Baker 1986: 257–59, figs. 4 and 5 citing Schumm and Khan 1972). River meanders leave fossil traces up to several kilometers in width, characterized by more or less parallel, curvilinear ridges on their crests (Gasche and Tanret 1998: 5–7). Their contours can be preserved for millennia, due in part to their durable function in shaping subsequent agricultural systems as they delineate systems of irrigation dikes and levees that hold recessional silt and demarcate field and crop boundaries. The breadth and periodicity of relict meanders were determined by channel size, sediment load, bank resistance, and volume and flow rate of water discharge (Verhoeven 1998; Baker 1986; Adams 1981: 8). This aids identification of system components and comparison with modern systems (Pournelle 2003a: figs. 19, 21; Pournelle 2003b: fig. 6).

Down the upper Mesopotamian alluvium, meandering systems are visible within the relatively narrow belts of their archaic floodplains. Between Samarra and Adab, Adams posited interconnecting watercourses among hundreds of Late Uruk sites. Others posited riparian connections between ʿUbaid and Early Uruk towns such as Ras Al-Amiya and ʿUqair (Stronach 1961; Adams 1981; Adams and Nissen 1972; Wilkinson 1990b). Careful analysis of imagery and remotely sensed elevation data shows the seemingly interconnected meanders and levees of this zone to be a palimpsest dating primarily to

[4] Three accessible copies of the KLM mosaics are known to have existed. One, held by Hunting Surveys Ltd. and its successors, and utilized for its numerous development contracts in Iraq, was discarded by company librarians in 1989. Multiple frames of this set, along with related geomorphologic assessments, were salvaged and are currently held privately. A partial second set, held for field reference at the Deutches Archälogisches Institut excavation house at Warka, is now presumably held by the Iraqi government. The whereabouts of the original set, made available to Adams for field use by the Director General of Antiquities in the 1960s and 1970s, is unknown.

the Pleistocene, on the one hand, and to the late third/mid-second millennium BC, on the other. Late ʿUbaid through Uruk sites seem instead to have been situated within the aggrading floodplain of anastomosing channels (see Pournelle 2003b: 145–155). This situation certainly allowed for exploitation of littoral biomass (food, construction materials), intensification of intersite boat traffic, and (related to this) exploitation of bitumen seeps for waterproofing. Only after the fourth millennium BC, following the progradation of the Mesopotamian delta, did this Tigris/Euphrates admixture become canalized and subject to the more or less continuous human intervention that has so profoundly affected the hydrologic evolution of lower Mesopotamia.

Studies of toponyms in third- and second-millennium BC cuneiform texts recording shipping and travel itineraries along stretches of the major watercourses largely confirm this view (Nissen 1985; Steinkeller 2001). E. C. Stone (2002b) critiques details of Steinkeller's (2001) argument, but broadly agrees that the watercourse serving Umma and Zabalam was a distributary branch of the Tigris. Areas to the west and south of Uruk *were* significantly augmented by delivery from the Euphrates into fluvial catchments now defined by present-day Euphrates flood zones, the Eridu Basin, and the western portion of Lake Hammar. While details of these interconnecting channels are still being worked out, dated, and confirmed, it is now clear that the later primacy of cities such as Isin, Kish, and Babylon postdate this state of affairs. Progressive channel successions (under conditions of climatic drying and seasonalization) resulted in the view of ancient Mesopotamian cities as pearls strung through the desert, as well as the eventual separation of the Tigris and Euphrates systems. Geomorphological reconstruction of major fluvial systems from Samarra south to Eridu (Northedge, Wilkinson, and Falkner 1989; Gasche and Tanret 1998; Wilkinson 1990a; Adams 1981; E. C. Stone 2002b) paint a revolutionary picture of the Tigris's overall contribution to alluvial settlement and irrigation during the subsequent third and second millennia BC.

Deltaic Changes

In the Tigris-Euphrates alluvium south of Adab, where average surface elevation drops barely 2 meters per 100 kilometers (Cotha Consulting Engineers 1959: fig. 4.1), few relict meanders are visible. Instead, from roughly the 32nd parallel southward to the high desert lands skirting the south rim of the Eridu depression, surface morphology is strewn with relict landforms characteristic of a delta. Orbital imagery is of prime importance to the study of these landforms, as it allows entire deltas to be examined in the context of their surroundings (Coleman, Roberts, and Huh 1986: 317).

Considerable effort has been expended in clarifying alluvial processes and main channel formation during the early historical periods from the third to first millennia BC (Wilkinson 1990b; Gasche, Herman, and Tanret, 1998; E. C. Stone 2002b). South and east of a line between Shuruppak and Jidr, an area where watercourses are from the earliest historical times epigraphically well attested, much of the ground was covered by standing water, drifting dunes, and accumulated alluvial silt. Current understanding of regional climate cycles and mid-Holocene marine transgressions makes clear the need to account in antiquity not only for altered coastlines, but for marsh, estuary, and deltaic conditions such as those now[5] obtaining along, south, and east of the modern Shatt al-Gharraf, the lower Tigris and Euphrates, the Shatt al-Arab, and the delta mouth on the Persian Gulf (Sanlaville 1996; Geyer and Sanlaville 1996; Kouchoukos 1998; Aqrawi 1997).

Within the lower alluvium, two zones of geomorphologic action may be distinguished. The first is the outer delta, where rivers dump their sediment loads into the sea. Northwestward lies the inner delta (the primary focus of this study), a flood-prone region of channel and marsh formation (Wirth 1962). The joint Tigris-Euphrates outer delta, constrained in its outflow westward by the Wadi Batin fluvial cone, and eastward by the Karkheh-Karun Deltas emanating from the Susa plateau, is characterized by a littoral zone transitioning from (1) freshwater marshes at the Tigris-Euphrates confluence at Qurna, through (2) brackish channels south of Basra and the Karun confluence at Mhuhammera, to (3) permanent salt marshes at the Persian Gulf head. North of Basra, annual floodwaters mingled, spread, and slowed as they met the strong action of tidal flushing. Here lies a domain where permanent and seasonal lakes and marshes prevailed until massive agricultural reclamation programs completed in 2001 drained the joint Tigris-Euphrates outflow directly into Gulf waters (National Aeronautics and Space Administration 2000; 2001; Partow 2001; Kouchoukos 1998; Sanlaville 1996).

The mid-Holocene marine transgression, pushing gradually northward through the deltaic cones during the sixth to fourth millennia BC and subsequently receding, at its maximum pushed the brackish estuary zone inland and further slowed outflow already constrained by the Wadi Batin and Karun-Karkheh Deltas (Potts 1997: 31–42, 47–55; Kouchoukos 1998: 216–231; Sanlaville 1989; 1996; el-Moslimany 1994; Lambeck 1996; Aqrawi 1997; 2001; Pournelle 2003a: 107–129; 2004a). Thus, conditions similar to those obtaining in twentieth-century Tigris-Euphrates marshlands would at that time have been

[5] By 2001, these marshlands ceased to exist (Partow 2001). However, repetition of the phrase "until the close of the past decade," while accurate, is needlessly tedious. Unless otherwise noted, throughout I adopt the convention of a historical present as of 1968–1969, the year documented by the CORONA photographs.

extended along then-extant river distributaries north and west of the present-day Shatt al-Gharraf, into the Warka (Uruk) and Eridu survey areas (Geyer and Sanlaville 1996; Sanlaville 1996; Aqrawi 1997) (Figure 12). The CORONA photographs, imaged before massive irrigation, drainage, and water diversion projects brought an end to millennia-old marsh formation processes, allow us to compare the geomorphology of active Lower Tigris-Euphrates delta, marsh, and alluvium formation with that of the now-desertic Chalcolithic urban heartland. Relict landscapes are photographically revealed especially clearly following the May Euphrates floods that saturate soils, replenish groundwater, and temporarily cover tracts of what is now desert with sheets of water that ultimately drain through a series of seasonal lakes into the Shatt al-Arab. In the Warka and Eridu survey areas, the more comprehensive photographic record may be referenced to the limited, but not insubstantial archaeological record. Ground evidence includes artifacts, botanical and faunal remains, stratigraphic profiles, and other geomorphologic data where it has been recorded.

Levees, "Bird's" Feet, and Dune Deposits

Three relict features help to chart and date the relict fluvial system in its entirety. Over time, flood deposits along riparian distributaries build massive levees. Examination of the putative Chalcolithic alluvial zone in the now-arid Warka survey area revealed a 5-kilometer-wide levee system, extending south–southeast from meander traces recorded by Adams near Warka Survey (WS) site 175, to a series of distributaries dissipating into relict marshland from site WS 427 to WS 447. The width of these eroded natural levees indicates a past discharge capacity equivalent to that of the modern-day Tigris south of Amara (Pournelle 2003a: figs. 20–22; 2003b: fig. 4). Chains of sites situated along and on top of such levees can indicate the dates for the system. Sites located on top of flood season discharge splays, where dramatic annual flooding would make permanent habitation exceedingly hazardous and unlikely, can serve as termini post quem for active inundation from the breach, aiding in dating the system of which they form a part (Pournelle 2003a: fig. 25; 2003b: fig. 5).

Active sediment deposition as rivers abruptly slow on encountering slack water results in the multiple, bifurcating channels of a "bird's-foot" delta, with newly forming sediment deposits creating webs between the toes, such as those surrounding Warka and present-day Amara (Pournelle 2003a: fig. 26; 2003b: fig. 7). In arid coastal climates, alluvial sediments also form similar depositional lobes between dune channels and behind dune dams (Wells 2001). During floods, active channels may scour and rescour, mixing sedimentary layers. The complicated stratigraphy of such structures may be more clearly revealed in overview than by individual core samples (Figure 13).

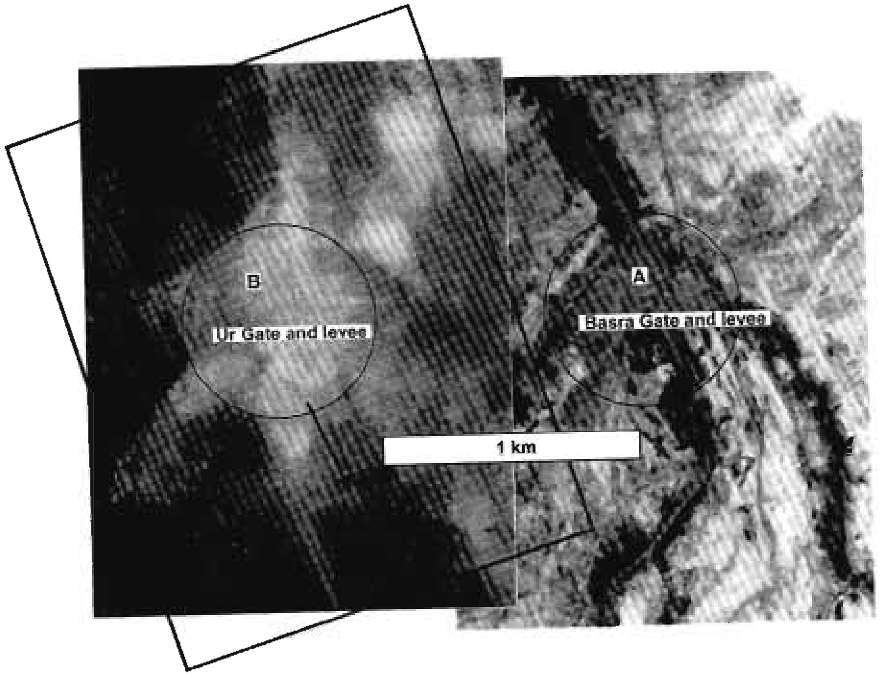

Figure 13. (A) Amara, straddling Tigris distributaries arrayed in a bird's-foot delta rapidly built outward into surrounding marshlands by riverbank rice cultivation (Buringh 1960: 187). Rice cropping is not thought to have been introduced before the late first millennium BC (Ghirshman 1954), although it was practiced in the Indus Valley at least a millennium earlier (Chakrabarti 1994). (B) Warka (ancient Uruk), straddling a relict bird's-foot delta extending into spring Euphrates floodwaters (black). As late summer heat dries surrounding marshes and lowers the water table, lower areas and infilled drainage are marginally wetter, and therefore darker. Less permeable, higher, and drier built-up areas, levees, and consolidated canal beds appear lighter in tone. Source: (A) USGS CORONA KH4B_1103-1A-D041-065 (May 1968); (B) KH4B_1107-2170DA-139 (August 1969).

Turtlebacks Rising

During the pluvial end–late Pleistocene Würm marine regression, rivers scoured channels of up to 40 meters in depth, leaving terraces (at former plain-level) protruding above the water surface and dumping the scoured sediments at delta mouths. Valleys between these terraces were infilled with silts from later alluviation, leaving the impression of a uniform surface. However, during mid-Holocene flood seasons, the tops of these relict terraces and sediment dumps, being of slightly higher elevation, would have remained dry whenever the surrounding plain became inundated by sheets of floodwater, like turtle's ... from a silty tidal flat. In Egypt, systematic coring programs

show that deltaic urban precursors clustered upon these features, safe above seasonal inundation (van den Brink 1993; Butzer 2001).

In the lower Mesopotamian alluvium, relict turtlebacks imaged during the spring spate, when floodwaters saturate lower-lying ground, can be identified by micro-drainage and differential dampening at their bases, making their slight relief above plain level detectable (Pournelle 2003a: figs. 75–66; 2003b: fig. 3).[6] These wind-scoured features are the loci for the oldest-known settlements in southern Mesopotamia (Figure 14).

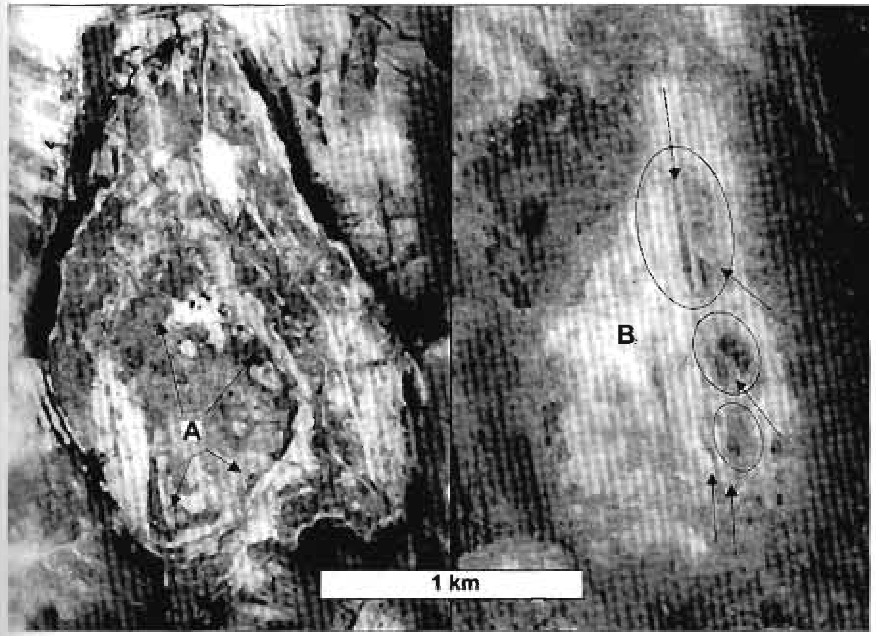

Figure 14. (A) Tello (ancient Girsu) appears to float on an island within irrigated croplands. The archaic city walls encompass one-third of the turtleback land area. (B) WS 230–232, arrayed along internal canals within a turtleback. The high water table following spring floods damps dust and reveals fine details of relief invisible at other seasons. The dark body at the left is a cloud shadow. Source: USGS CORONA KH4B_1103-1A-D041-057 (May 1968).

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[6] Excavations at Tell Oueili (WS 460) confirm that the underlying geomorphology is analogous to similar sites in the Nile Delta. At Oueili, Pleistocene buttes punctuate a Holocene surface incised to several meters deep by the Shatt al-Kar east of the site. Oueili is situated atop one of these earlier surfaces, revealed by excavation as a buried turtleback, where it was most likely located for protection from seasonal flooding. A deep sounding showed 4 meters of alluvial deposition surrounding and eventually burying the channels that would have carried waters past its 'Ubaid 0 foundations (Porada et al. 1992: 86; Geyer and Sanlaville 1996; Plaziat and Sanlaville 1991).

A THIRD ECONOMIC PILLAR

The Holocene paleogeology of the lower alluvium suggests that a larger role must be given to littoral ecotones as a "third pillar" of the formative Mesopotamian economy. Interpretation of surface and excavation finds in light of the photographic evidence summarized above suggests a settlement progression beginning in the Neolithic ʿUbaid with opportunistic dependence on littoral biomass, and ending in the Bronze Age Early Dynastic, with intensive usage of what by then had become agriculturalized marsh zones. For the earlier Neolithic (ʿUbaid 0) periods, as sea levels slowly rose from 15 meters below to within several meters of their current levels (Sanlaville 1989), mid-Holocene (6000/5500–3500 BC) monsoon variations brought increased rainfall to the lower alluvium (el-Moslimany 1994; see Potts 1997: chap. 1, p. 52 passim). Because freshwater outflow to the Gulf is in any case constrained by the twin cones of the Wadi Batin and Karun-Karkeh drainages, even absent the effects of tidal forcing concomitant with later progradation of the Gulf head, these comparatively pluvial conditions would have increased the likelihood of seasonal flooding and marsh formation. Such evidence as exists from coring, excavation stratigraphies, and stratigraphic profiles drawn from regional wells uniformly shows marshy deposits underlying and/or mixed with earliest (ʿUbaid) occupation layers, suggesting that settlements were bordering on and/or subject to seasonal inundation (van Ess and Brückner, personal communication 2002; Nöldeke et al. 1932: 6, table 2; Eichman 1989: 197; Geyer and Sanlaville 1996; Woolley 1933: 328, 334–336, pls. 39, 42; Woolley 1956: pls. 76–78, 82, 83; Safar, Mustafa, and Lloyd 1981: 47, 58; Aqrawi 2001).

Buried Foundations

The little evidence available from excavation indicates a long period of Neolithic ʿUbaid adaptation to littoral conditions. No surface finds can be dated to ʿUbaid 0, but botanical finds from the deep sounding at Tell Oueili, which was situated on a low Pleistocene turtleback surrounded by infilled channels (Huot 1989; 1991; 1996; Forest 1996), suggest that water pooled near the site. These included edible sedge tubers *(Cyperus rotundus)* and giant reed *(Phragmites australis)* (Neef 1989). Near Ur, type site al-ʿUbaid was founded on a low sand knoll (H. R. Hall 1930; Hall and Woolley 1927), and site ES (Eridu Survey) 104 on a Euphrates levee. Comparison of ʿUbaid 1 pottery from al-ʿUbaid (H. R. Hall 1930) with ʿUbaid 0 type ware (Huot 1996) shows clearly the need for reseriation and reconstruction of early occupations, and the possibility of a much earlier origin for the ʿUbaid type site.

Similarly, the early foundations of the third-millennium BC city of Larsa bordered marshes fed by a great Tigris distributary running southward from Jidr. Two additional ʿUbaid 1 sites (Haji Mohammed and W 267) were aligned north to south along a distributary dissipating into marshlands south of Warka. South of the present-day Euphrates, Eridu itself was founded on consolidated dune material, straddling the mouth of a branch of the Euphrates. Beneath later sacred areas were pedestaled mud structures, presaging a succession of temples with burnt offerings of fish (Safar, Mustafa, and Lloyd 1981; Porada et al. 1992), as well as a canoe model and numerous perforated clay ovoids, perhaps net weights (Lloyd and Safar 1948: 118, pl. III).

Four more so-called ʿUbaid 2 sites were also apparent on distributary levee back slopes, one of which, WS 247, overlooked (undated) westerly marshes. WS 242, the first of what would become a complex of sites characterized by surface finds of spools and net weights, was situated at the juncture of the Uruk levee with an anastomosing channel continuing southeastward to join the Tigris system. In marsh districts near al-Hiba (Lagash), characterized by a mixed agro-pastoral-fishing-reed manufacturing economy, similar spools and weights were used during the twentieth century to spin yarn and to weight fishing and fowling nets (Ochsenschlager 1993b). WS 298, a low mound located about 10 kilometers northeast of Uruk, was situated on a turtleback, in this case also facing a levee back slope.

During ʿUbaid 3, although Oueili itself appears to have undergone an occupation hiatus, WS 459 appeared adjacent to it. Surface finds were noted at Jidr, and at another new site, WS 275, located on a turtleback at the back slope of the Uruk levee. South of the modern Euphrates, ES 29, situated on a sand knoll at the Euphrates passage through the Hazim, was first occupied, as was ES 96, on a levee back slope. The Late ʿUbaid 3 site ES 141, 8 kilometers northwest of al-ʿUbaid, was similarly situated and had concentrations of freshwater mollusk on its surface. Wright noted an "expansion of settled areas up and down the developing levee system at this time" (H. T. Wright 1981b: 323). At Eridu, "temple platforms were raised, and clear evidence of mud brick directly associated with adjacent reed domestic construction was exposed" (Safar 1950: 28). This emphasis on levee colonization may have been directly tied to mastery and reliance on water travel as far away as the Persian Gulf, as evidenced by boat fragments and Mesopotamian-manufactured ʿUbaid-period pottery found among deep shell middens bordering Kuwait (Beech, Elders, and Shepherd 2000; R. Carter 2006; R. Carter and Crawford 2001; R. Carter et al. 1999; Frifelt 1989; Roaf 1996; Oates 1976; 1978).

Archaeological evidence from the southern alluvium throughout the later Neolithic is consistent with a riparian distributary system and concomitant marshy zone, shading from seasonal inundation to permanent lakes. At ʿUbaid-period Uruk, Haji Mohammed, al-ʿUbaid, Ur, and Eridu, the deepest soundings all revealed remains of reed platforms, traces of reed structures with plastered reed walls, and reed matting plastered with dung, earth, or bitumen in addition to mud brick (summarized in Moorey 1994: 361). Inhabitants of the southern alluvium had liberal access not only to water supplies and transport, but to littoral biomass. As in later periods, the area probably provided food, including reed and other tubers, fish, shellfish, fowl, and pig (Pollock 1999: 83; Desse 1983; Safar 1950; Safar, Mustafa, and Lloyd 1981); construction material, including reeds and riparian woods (Salim 1962; Thesiger 1964; Ochsenschlager 1993a; Potts 1997: 106–115); fodder and browse, including reeds and sedges (Miller-Rosen and Weiner 1994; Miller-Rosen 1995; Pournelle 2003b), and reeds as fuel for kilns and smoke-houses (Englund 2002; Salim 1962; Thesiger 1964; Ochsenschlager 1993a).

Visible Settlement Trends

Thus far, the oldest period reached beneath the tens of meters of overburden at Uruk dates to ʿUbaid 4/Terminal ʿUbaid. On surfaces exposed to Aeolian scouring, settlement trends become somewhat more visible. Surface finds show five new sites (WS 137, 160, 218, 260, 411) on turtlebacks, three abutting levee back slopes. One, Raidu Sharqi, is added to a delta toe southwest of Uruk. At Oueili, added to the earlier botanical constellation of tubers and reeds are cultivated date palm *(Phoenix dactylifera)*, water-loving poplar *(Populus euphratica)*, and sea club-rush *(Scirpus maritimus)*, while faunal emphasis continues on cattle and pig (Neef 1989). Date cultivation suggests associated gardens and the need for mechanisms to determine access to and control of the turtleback, which was probably surrounded by marshes draining into seasonal lakes. Eridu, 12 hectares in extent, sported a temple on a raised terrace and, for some individuals, substantial brick tombs. Boat models indicate the use of sailing craft. Bales of fried marine fish were recovered in the so-called temple precinct (more likely, administrative storehouses), as well as from the altar, where they were presumably laid as offerings. Botanical remains also included dates (Safar 1950; Gillet 1976; Safar, Mustafa, and Lloyd 1981; H. T. Wright 1981b). Meanwhile, Ur and al-ʿUbaid had grown to about 10 hectares in size (H. R. Hall 1930; Safar, Mustafa, and Lloyd 1981). Two sites (ES 73 and 134) were added to the levee, and one (ES 5) to a large turtleback. Clay sickle distribution indicates extensive harvesting along levee back slopes (H. T. Wright 1981b). Wear pattern and phytolith analyses of similar sickles make intensive reed-harvesting for fodder and construction material likely (Anderson-Gerfaud 1983: 177–191; Benco 1992: 119–134).

As rising sea levels reached (3800 BC) and then exceeded by 1 or 2 meters those of today (3500 BC), during the Early/Middle Uruk period the Gulf head prograded as far north and east as modern Qurna. This marine incursion would have resulted in tidal flushing as far northeast as Ur, and perhaps as far as Uruk itself (Figure 12). This would have been accompanied by at least seasonal marsh formation over all but the highest ground of the

Warka and Eridu survey areas, as the outlets of the combined Tigris and Euphrates discharge became flooded, slowing drainage to the sea. Not surprisingly, during this period, settlement was marked by a continuing colonization of turtlebacks.

Four new sites (WS 20, 22, 23, 24) clustered on the Uruk levee and its back slope in the vicinity of WS 42, all yielding fishing net weights and spools. Site WS 245exploits the same back slope locale as the ʿUbaid 2 site WS 247. In a completely new development, regularized waterways up to 12 kilometers in length may have extended south from the Tigris tributary levee to site WS 107, to site WS 109, and to sites WS 178-201-215. These are aligned respectively toward turtleback sites WS 137, 160, and 218. Similar village distributions are visible today, extending southward from the Euphrates as it wends through the eastern Iraqi marshes—for example, near Kabaish (ech-Chubayish) (Roux 1960; Salim 1962) (Figure 15), indicating that these waterways need not be interpreted as canals extending through arid zones. It is equally likely that they represent permanent boat transport routes between turtlebacks, with villages along their banks, kept clear of reeds during wet seasons and allowing access to the river during dry.

In the Eridu basin, only a few sites were classified as Early Uruk, and this was based on a handful of sherds and the absence of bevel-rim bowls. Assessing whether or not this indicates a hiatus in settlement foundation in the southern marshes depends upon better dating for sickle manufactures, and an assessment of the persistence (or not) of ʿUbaid pottery traditions. More likely, ʿUbaid-style levee exploitation either continues or dates to a somewhat later period. Spot elevations clearly show the Eridu basin (sloping northwest to southeast from 4 to 0.5 meters above mean sea level) separated from present-day Gulf waters to the west and south by the rising Arabian plateau. It is demarcated to the southeast by a 100-kilometer-broad expanse of sandy uplands standing over 24 meters above current sea level. Dune fields blanketing these uplands show no trace of intervening shorelines (General Staff of the Army 1941; Russian National Cartographic Authority 1991a; 1991b). To the east and northeast, the depression is flanked by a sandstone ridge (the Hazim), which *rises* from 3 meters to 46 meters above mean sea level from northwest to southeast (Safar, Mustafa, and Lloyd 1981: 30). Even at this period of maximum marine transgression, Eridu itself could have been situated on an ancient Gulf coastline. Imagery shows no evidence of seawater having either cut or surmounted this feature. Instead, there is much evidence of this depression having formed a closed, marshy basin, characterized by pooling, ponding, and drying of water, derived in part from wadis down-cutting from the Arabian plateau, but mostly from Euphrates flooding. A cut through the Hazim indicates outflow *toward* the Gulf, passing into a well-defined levee system skirting Ur and Tell al-Lahm.

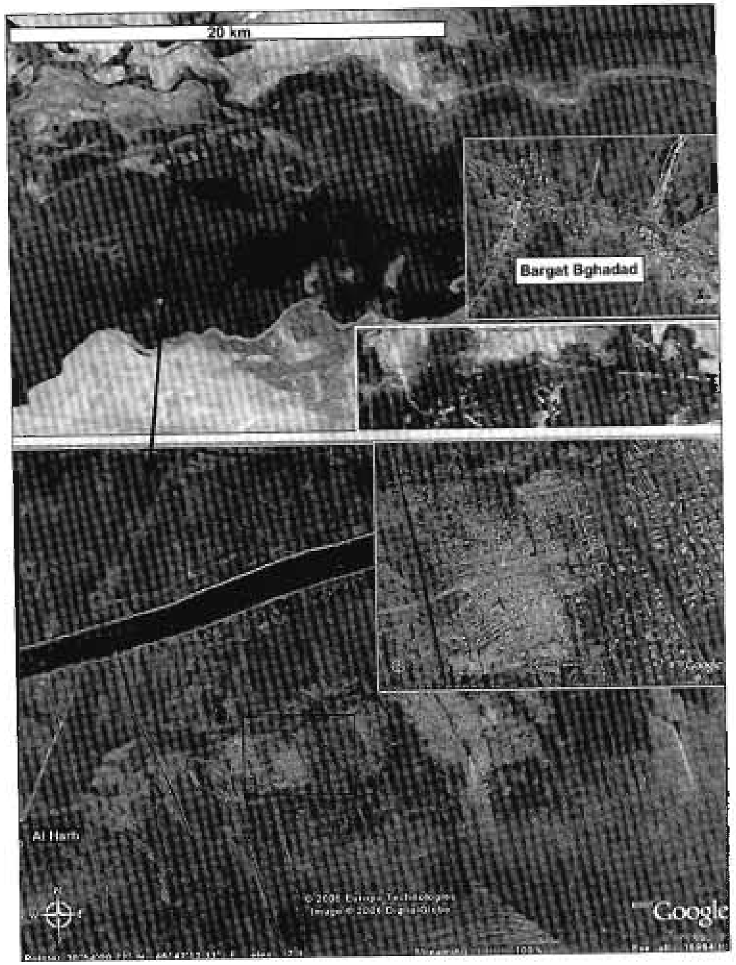

Figure 15. Top: Suwaich (Kabaish; ech-Chubaish), extending several kilometers along a waterway in the Hammar marshes south of Qalat Salih. Only bright white spots are above the water surface. The name means "lace of built islands." In 1959, access was solely by water (black), through thick reed swamps (dark gray). Source: USGS CORONA KH4B_1107-2170DA-139 (August 1969). **Insets:** Bargat Bghadad was situated deep within the permanent marsh northeast of Suwaich. Drains emptied Lake Hammar, leaving the town high and dry. Now desiccated, house groupings appear situated along canals that were in fact waterways through the village. Source: Google Earth Digital Globe 2006. Below this, another example of a former waterway through the reed beds that now (erroneously) appears to be a chain of small settlements strung along a canal. Source: LANDSAT 1994. **Bottom:** East of al-Harb, drainage channels slice through the remains of raised-field gardens once located *within* Lake Hammar. Deprived of its livelihood, the population has fled. There is actually no association between the desiccated village waterways and what appears as a modern canal.

As sea levels and the Gulf shoreline fell back to approximately their present locations, these Early Uruk inroads presaged what at first review appears to be a site explosion during the Late Uruk. Over 100 new sites spread, fan-like, north and east from the emergent city at Warka, south from the levee system tying the Uruk and Tigris channels, and westward from the Tigris levee (no surveys having been conducted to the east). This site distribution has been interpreted as an opening up of land area amenable to grain cultivation. However, it is more an artifact of site visibility, indicating only the vertical limits of aeolian scouring through soft silts in exposing buried sites, and suggests that no *further* inundation occurred *after* the Late Uruk (see Pournelle 2003b: figs. 59, 77).

Until the Gulf head had fully withdrawn, despite a gradual shifting of the permanent marsh zone southward, we must assume that tidal flushing would have influenced cultivation regimes as far inland as Lake Hammar. This would be true even though summer rains were by this late date surely gone, and the climate had become more seasonal (as at present). The riparian regime appears to have been relatively stable until at least the late third millennium BC (Akkadian), when the Euphrates bed appears to have flipped into a southerly channel skirting the Eridu depression (depicted by H. T. Wright 1981b), perhaps obscuring earlier sites. Intensification of cattle production in riparian and littoral habitats would have simultaneously and steadily degraded browse, necessitating intensified fodder gathering and production (Belsky 1999). Contemporary protoliterate economic texts include dozens of ideographs for reeds and reed products, pigs, waterfowl, fish, dried fish, fish traps, dried and processed fish flour, as well as those for cattle and dairy products (Englund 1998). Palms, frogs, livestock emerging from reed byres, and hunting scenes with pigs stalked among reeds all appear on Late Uruk seals, sealings, and tablets recovered from Warka. Many tablets show the clear imprint of the reed mats upon which they lay as they dried (Boehmer 1999: 51–56, 66–67, 71–74, 90–104).

Notable is a match between the geographic clustering of sites around centers on turtlebacks with Adams's hypothetical Jemdet Nasr/ED I territories, based on site sizes and nearest neighbor analysis (Adams 1981: 20, fig. 8) (Figure 16). Among surface evidence, added to net weights, spools, and spindle whorls were a profusion of mace heads (Adams and Nissen 1972: 211–213), which could be indicators of local conflict (although they seem rather light in weight for this purpose) or local office. The profusion of visible Late Uruk small sites could therefore be evidence that, concomitant with intensified agricultural production, reed and other marsh products were becoming intensively harvested and administered to underwrite urbanizing consumption.

While protoliterate economic texts clearly show institutional control of marsh products, three site clusters strongly suggest that Uruk channel

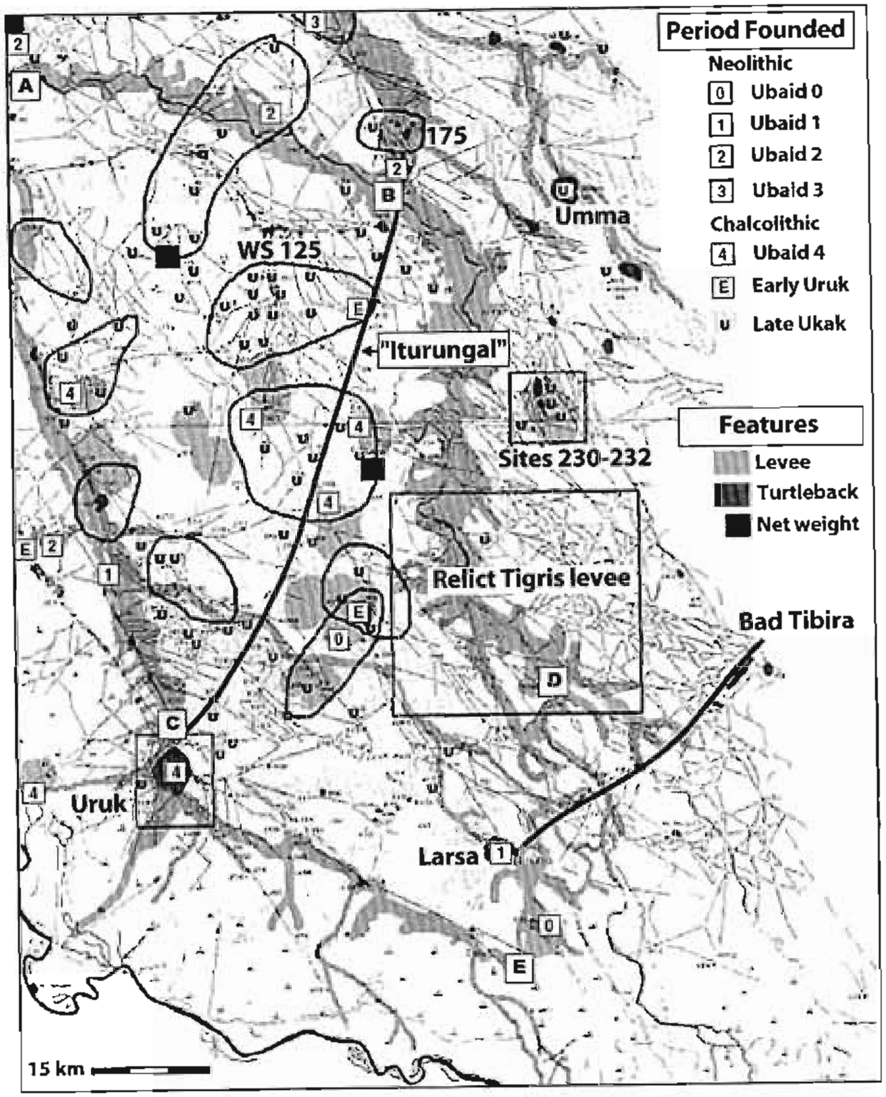

Figure 16. Relict levee systems, Warka survey area, with Iturungal and Bad Tibera waterways. Key indicates the earliest-suspected occupation for sites occupied during the Uruk (fourth millenium BC), with Jemdet Nasr/Early Dynastic nearest neighbor groupings. After Adams 1981; Steinkeller 2001.

management may have become integral to the management of the marshes themselves, as well as being a precursor to later irrigation technologies. Situated on a turtleback, sites WS 230–233 display an internal structure of modest, shallow waterways (Figure 14). These are unlikely to be natural,

bearing a sharp resemblance to waterways ethnographically reported as being cleared during wet seasons and enlarged during dry, in order to extend boat transport through sites and to their surrounding marshes (Salim 1962; Thesiger 1958; 1964; see also Adams and Nissen 1972: 25). Site cluster WS 125 seems placed to control a series of modest offtakes from the west–east distributary, the 2-kilometer-wide fifth- to fourth-millennium BC levee of which underlies the modern trickle of the nearly abandoned Shatt al-Kar. Finally, multiple canal offtakes cut through the relict Euphrates levee abutting site ES 156 clearly directed water flow into the alluvial basin north of the site—but *not* into any apparent field irrigation system. Instead, the water flow seems designed to augment flood season catchment in what is now a desiccated wetland. The surface morphology of the area is directly comparable to desiccated habitation areas on the seasonally inundated edges of massive, permanent marsh reed beds such as those of the Al Khuraib marsh south of Amara (Figure 17).

Investigations of the Nile Delta (van den Brink 1989; 1993; Butzer 2001) and Chad (Holl 2001) suggest that in lacustrine borderlands characterized by seasonal marshes, such sites have long histories and comprise wet-season retreats for cattle herders who, as waters recede, moved animals downslope to graze resulting pastures. Site clusters WS 230 and WS 125 are examples that prefigure two predominant proto-urban locations: turtlebacks (Adab, Girsu, Oueili, Lagash, Nina, Eridu)[7] and levee-straddling cities, often sprawling over bird-foot distributary clusters (Jidr, Larsa, Shuruppak, Umma, Uruk, Ur) (Figure 18). Both site types comprised mid-Holocene "high ground" retreats, accessible by boat at least during the wet season. But, over time, given regional drying, only those along persistent distributaries would have continued to be accessible by water. Wilkinson notes that

> localized cleaning and management of [a] node of avulsion or bifurcation could have maintained flow in both channels . . . thereby substantially increasing the water supply and transportation network. . . . It is not clear which . . . large-scale canal digging or the semi-managed avulsion of anastomosing channels, produced the network that nourished the early cities. . . . Algaze's synergistic cauldron may therefore benefit from the consideration of these two human-environmental interactive systems. (Wilkinson 2001: 255)

[7] The Eridu location is difficult to classify, as it seems to have been situated on paleodunes embraced by distributary arms within an active alluvial basin. The point is that, compared with its surroundings, it embraced the (comparatively) high ground.

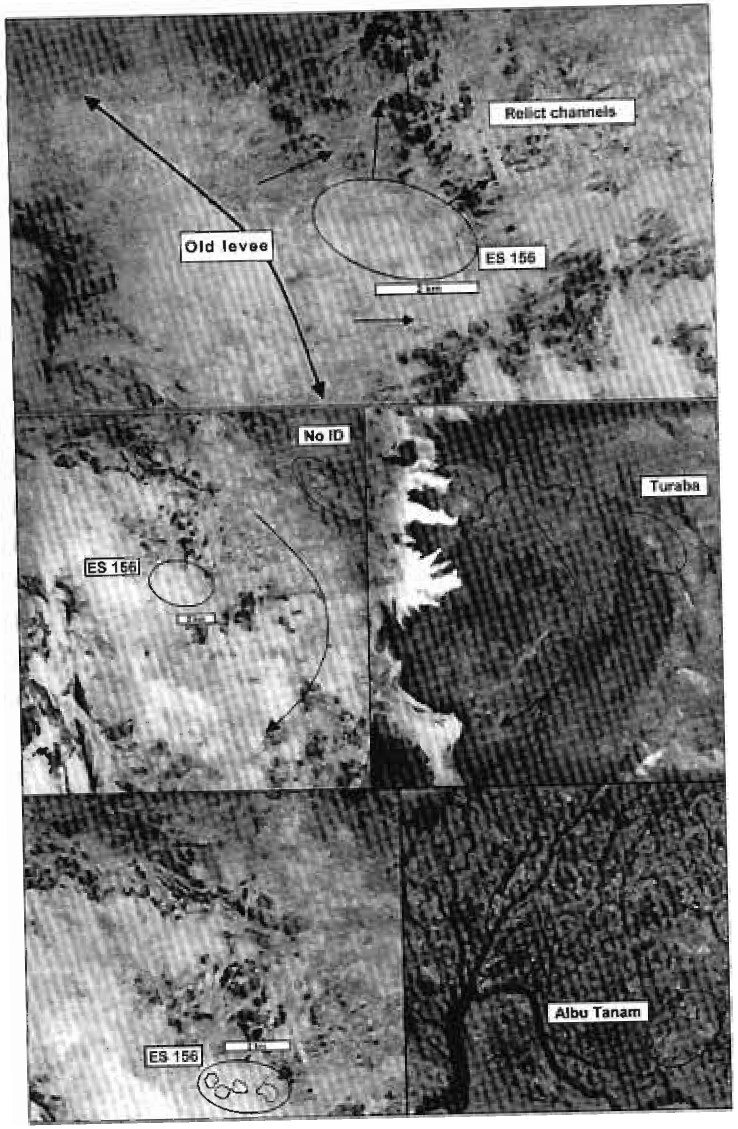

Figure 17. Marshland hinterlands. **Top:** ES 156 in the Eridu Basin. Hundreds of thread-like channels, 1.5–10 meters wide, extend between ES 156 and surrounding desiccated wetlands, suggesting levee cultivation combined with intensive marshland exploitation. **Middle:** (L) ES 156 (R) Turaba in the al-Khuraib (Tigris) marshes south of Amara. Water overtops banks and leaks through weak levees, draining slowly to eventually rejoin the fluvial system (arrows). **Bottom:** (L) Desiccated (white) water channels infilled with dry sand skirt ES 156. (R) Dendritic water channels (black) through reed beds skirt Abu Tanam. Source: (L) KH4B_1103-1A-D041-067 (May 1968); (R) KH4B_1107-2170DA-140 (August 1969).

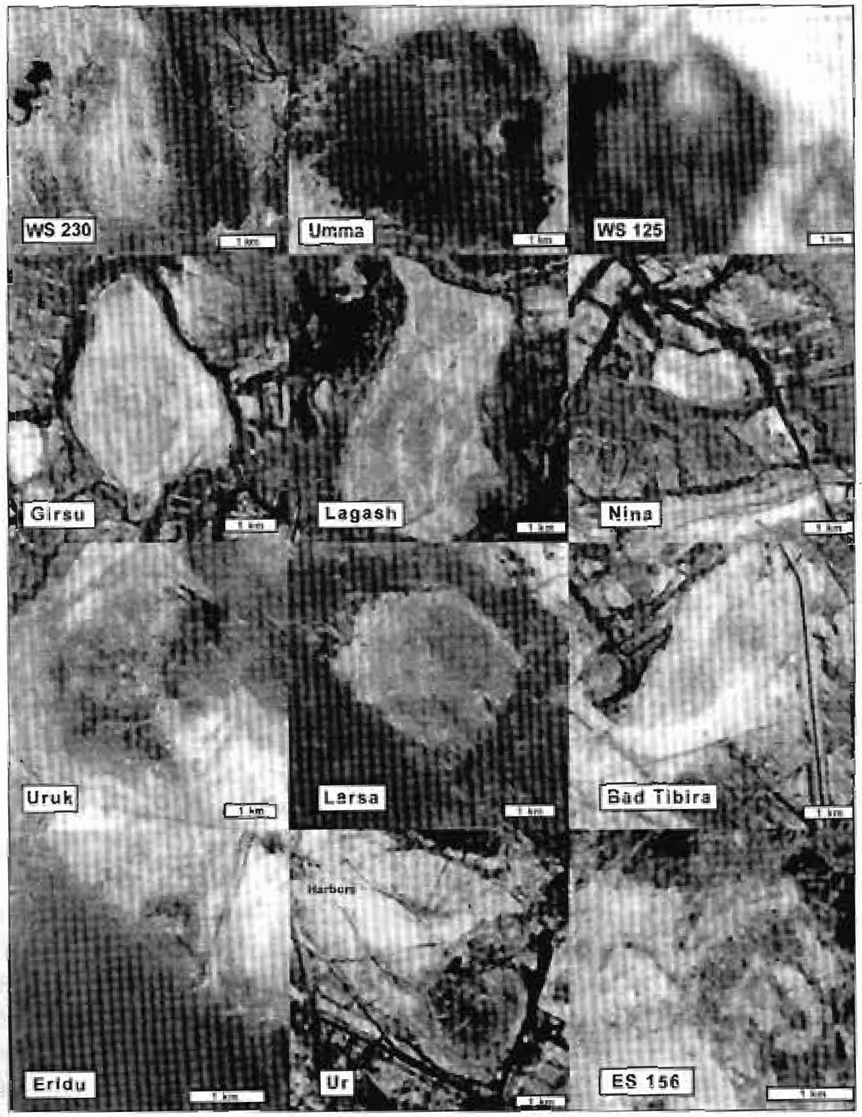

Figure 18. Deltaic Mesopotamian cities and surrounding wetlands, past and present. WS 125, Umma, WS 230, ES 156: USGS CORONA May 1968. All others: NIMA SPOT 1991. Scales approximate.

For example, the remarkably straight line of a posited route for the "Iturungal" connecting Uruk with the levee junction near site WS 175 (Steinkeller 2001) suggests an executed canal that also captured the water traffic and produce of earlier, smaller-scale catchments dominated by turtleback settlements. The situation of a sweeping arc from Larsa to Bad Tibira (Steinkeller 2001) suggests that this "canal" should be understood as a transport waterway kept cleared for boat traffic through, and along the edge of, marshy zones (Figures 15, 17).

Enduring Wetlands Capital

During the historical Early Dynastic III period (2600–2350 BC), sea levels once again rose to 1 meter above present (Sanlaville 1989; Potts 1997: 33), and thus in areas not yet transformed by state irrigation and drainage schemes, a similar hydrologic regime to that of the late Chalcolithic probably prevailed. All known third-second millennium BC (land) itineraries from Sumer to Susa run first northwest to the Diyala region, and then southeast to their destination, suggesting a requirement to circumnavigate a marine incursion. East of the Warka survey area, a relict levee, cut by modern canals, extends into a seasonal flood zone. Ancient Lagash surmounts another levee remnant, appearing as an island to the south surmounted by multiple occupation mounds (Pournelle 2003b: fig. 9). There, ED III faunal remains included not only seven species of marine mollusk shell (which could merely have been imported for bead manufacture; E. Carter 1990; Kenoyer 1990), but two of marine fish, as well as duck, coot, cormorant, flamingo, gull, and spoonbill. Spoonbill particularly prefer open marshes, shallow lagoons, and estuarine mud flats (Mudar 1982: 29–30, 33–34).[8] Analysis of faunal remains from the 1970–1971 excavations of distinct temple and administrative/residential precincts showed a decided separation in their distribution. All fish, fowl, and mollusk (shell) were found in the administrative/residential zone; none in the temple area. This marked differentiation in consumption was also noted for mammalian finds. In the temple precinct, as compared with the residential/administrative precinct, ovicaprids represented a proportionally higher, cattle a slightly higher, and pig a significantly lower percentage of finds (Mudar 1982). It is tempting to conclude that (elite) mutton and beef had become appropriate as temple offerings and priestly food, while pork had become less so, and fish inappropriate. If so, this reversal from the ʿUbaid precincts at Eridu demarcates a transition from a time of Neolithic social integration served by fish as everyman's food, to one of Bronze Age social hierarchy marked by fish as poor man's food.

[8] Of note is the lack of ʿUbaid or Uruk finds, indicating that in Chalcolithic times the Gulf transgression either precluded permanent habitation altogether or confined it to relatively small areas, not subject to seasonal inundation, now deeply buried beneath subsequent occupation debris. That the earlier periods are represented at nearby Tello (Girsu) and Shurgal (Nina) supports the latter probability.

Although probably well above the mean, al-Hiba was hardly unique in its littoral reliance. Robert Englund has treated at length the regulation and management of late third-millennium Ur III fisheries (Englund 1990). Cylinder sealings from the ED III Seal Impression Strata at Ur depict reed structures (Amiet 1961: 333–344), cattle fed in and led from reed byres (Amiet 1961: 337, 342, 344), personages poled along fish-filled watercourses in high-prowed boats (Amiet 1961: 300), fishing from small watercraft (Amiet 1961: 310), and persons carrying tribute of fish and waterfowl (Amiet 1961: 302, 303). Umma texts record quotas for the production of reed, bitumen, boats mats, and standardized fish baskets (de Genouillac 1920: 603). Proto-Elamite lexical lists record 58 terms relating to wild and domestic pigs. "Professions lists" record offices including "fisheries governor" and "fisheries accountant" that endure one and one-half millennia to the Old Babylonian period (Englund 1998).

This administration of marshland resources was not a mere addendum to a better-studied agro-pastoral irrigation economy. Just as excavation overly focused on massive temple and administrative architecture has skewed attention to and perception of the scope and scale of Mesopotamian domestic settlement, osteological analysis overly focused on large mammalian fauna has skewed attention to and perception of the littoral component of the domestic diet. "For the vast majority of the working population, the primary dietary protein source was dried fish" (Englund, personal communication 2000). Its managerial origins in earlier hydrostrategies were *a priori* dependent upon a wetland landscape that endured in various forms for seven millennia, and one that only during the twentieth century AD finally was dammed, diked distributed, drained, and managed to extinction (Iraq 1956; Koucher 1999; Partow 2001). Early Dynastic foundations were, from a geographic perspective, well laid during the ʿUbaid 4 and were apparently predicated and dependent upon littoral communications with their hinterlands. During the Chalcolithic, ʿUbaid, and Early Uruk, palm groves, gardens, temples, kilns, and other institutions, long consolidated on turtlebacks and levees away from seasonal inundation by peoples accustomed to thorough exploitation of wetlands, became loci for Uruk political and economic transformations. These in turn laid the institutional foundations for subsequent Early Dynastic management, replication, and intensification of marshland production.

CONCLUSION: RESOURCES AND (SOCIAL) ENGINEERING

Exploitation of marshland resources made agricultural colonization of the southern Mesopotamian alluvium enduringly possible. Specialized communities harvested marsh fowl, fish, bitumen, shell, and reeds; grazed herds on and cut fodder from pastures watered by receding floodwaters; and traded boat cargoes with near-neighbors. Sixth- and fifth-millennium BC settlements initially took localized advantage of productive littoral ecotones. By practicing local, small-scale damming and diking to build up permanently habitable platforms and to control the rate and progression of flooding and runoff, they accumulated "hydrologic capital" that gave them possession of the most suitable landscapes, led to the invention of technologies for flood and irrigation control, and developed institutions for labor mobilization.

Resource complementarities would, of course, have provided local resiliency. But just as important would have been the replicability of these small, bounded, human-maintained ecosystems at each meander loop, on each turtleback, and at each levee junction. In such locales, locally shifting land usage brought minimal acreage into well-drained cultivation. Such specializations and complementarities thus could have been maintained beyond the reach of any locally destructive flood or drought. Communities sustained by marshland biomass and fed by the combination of farming, fishing, and husbandry could produce sufficiently consistent agricultural surpluses and sufficiently robust trade networks to tilt the balance toward consolidation of local management structures. This preceded the work of straightening and regularizing channels and building new canals that came to characterize and fuel urban growth during the third millennium.

Insightful Mesopotamian scholars have long considered the contribution of wetlands and water transport to pre-urban southern Mesopotamian material culture (Woolley 1929; 1955; 1956; Oates 1960; 1969; Potts 1997; Pollock 1999). However, only over the past decade has sufficient data accumulated to support the proposition that alluvial Mesopotamian cities grew from 'Ubaid precursors heavily participant in and reliant upon littoral subsistence and trade. Algaze's import substitution model (Algaze 2001a and this volume) must in this context be understood as a first delineation of the regional economic ramifications of this fundamental reassessment: a twofold "southern advantage" that may have overwhelmed the stability of supra-regional uniformity (or even advantages) in other social institutions. The first is the inexorable advantage of the riparian: it is simply easier to move bulky cargoes downstream than up, opening the possibility (from the southern Mesopotamian perspective) of downstream imports of bulk commodities in exchange for upstream exports of manufactured goods. The second is the inexorable advantage of the marsh, and not just in terms of its compounding the transportation advantage by opening pathways across the southern alluvium.[9] To be sure, Uruk's (and its sister cities') location would have conferred significant transportation advantages. But more importantly, in littoral ecotones, intensification of natural resource collection, hydrologic management, and cultiva-

tion are the primary mechanisms *both* for generating agronomic surplus *and* for buffering against its failure. By comparison, rain-fed grain farming is inherently more dependent on transportation advantages to overcome local or regional crop failures than wetlands exploitation and cultivation. In rain-fed zones, given comparable agricultural inputs, farmers can only increase production by enlarging the area under cultivation. During early urbanization and state formation, these marshlands—by 2001 almost fully destroyed, and therefore difficult to imagine in their former extent—would have acted as a nearly inexhaustible agro-pastoral buffer. Therefore, the greater resiliency here described is not merely a result of more varied resources (Wilkinson 2001), but of *more* resources.[10] To return to my opening comments, it is in this sense that one should understand Algaze's reference to greater fertility (Algaze 2001a: 200).

It was precisely at the time of increased local precipitation variability and during the general drying of the fourth millennium BC that the alluvial "Mesopotamian advantage" of higher resilience became crucial. This is true whether or not generally wetter mid-Holocene climate (Weiss and Bradley 2001; Cullen et al 2000; Bar-Matthews, Ayalon, and Kaufman 1997; Lemcke and Sturm 1997) or a summer monsoon effect deduced from paleobotanical data for the Arabian Peninsula (el-Moslimany 1994) positively affected Syro-Anatolia. In the south, the marsh littoral provided both a sustainable resource base and a model for hydrologic management, sustaining experiments in intensification that may well have sought to recreate and preserve previous natural conditions. These compounded geographic advantages fueled Algaze's "synergistic cauldron" and favored accelerated urbanizing processes.

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9 During the earlier Chalcolithic period, evidence for the movement of bulk goods is limited and (given the richness and perishability of available resources, unsurprisingly) local (H. T. Wright 1998). By the Late Uruk, when such evidence increases dramatically, routinized navigable routes would have been well established and, in a drying climatic regime, of heightened importance.

10 Area-specific marsh resource productivity estimates for southern Iraq are at best fragmentary and will not be forthcoming, now that the marshes themselves have been consigned to oblivion (Partow 2001). A detailed demonstration of how productive the Mesopotamian marshlands might have been, given available technologies, will thus depend upon comparative proxies, for example, to the Ganges Delta or the (equally threatened) Florida Everglades. There, economic impact assessments show a dramatic decline in economic output following field drainage and the introduction of sugarcane monocropping (Hartmann 1994; McCalley 1999).

I do not mean to imply by this a crude environmental determinism. The situation of 'Ubaid towns, villages, temples, and associated temple economies on levees, turtlebacks, and marsh rims within the vast littoral created a kind of geographic circumscription-within-plenty. The high, dry ground itself, as well as associated permanent structures (temples, docks, ferries, kilns, and dwellings), could have become contested, but the resource base supporting them remained readily accessible. In considering early urbanization and the concomitant emergence of state-level institutions, this situation has profound scalar implications. "Northern 'Ubaid temples had the organizational technology to extract large-scale surpluses, but lacked the necessary resource base. Temples were thus a . . . critical factor in the development of Mesopotamian urbanism, but only when planted in the rich and diverse alluvium of the south" (G. Stein, personal communication to Algaze, 2001, emphasis added.)

Fish, shellfish, turtle, waterfowl, and pigs sustained human populations. Reeds, sedges, tubers, and seasonal grasses provided animal fodder and massive quantities of handicraft and construction material. Littoral ecotones constrained habitation. Annual floods replenished marshes and recessional gardens. The watery environment provided lines of communication that ensured rapid transmission of technologies, trade goods, and peoples themselves. All these factors concentrated resources, produce, institutions, and know-how into the hands of the few, setting the stage for hierarchy and heterarchy.

If adaptive flexibility explains the long history of cycling between urban agglomeration and ruralization in the southern alluvium, now that a voluminous body of investigations into the pastoral component of Sumerian agropastoral relationships have been undertaken (following Rowton 1973 and Adams 1981), the "third leg" of littoral resources must be carefully considered. Adams has long noted the role of marshlands as a place of flight from predatory rulership, and he never discounted their supplemental subsistence importance (Adams 1981; 2002). However, for the southern alluvium during the crucial sixth through fourth millennia BC, marshlands must be at the center stage of any nuanced discussion of adaptability and constraint. Proxies for specific "processes" of social organization and control are open to reinterpretation.

It could be charged that "ecological approaches . . . express an overriding concern for the adaptive features of societies" (Pollock 1992: 314), but emphasis on human ecology must be clearly distinguished from environmental determinism. Were marshlands sufficiently extensive to create a safe "inside passage" for primitive boat traffic eastward toward Susa? Is the cyclical history of Mesopotamian incursion along the Persian Gulf related to the same monsoonal cycle that alternatively encourages and discourages fishing and sailing?

It is precisely answers to these and similar questions that create "room for conscious manipulation and advantage-seeking behavior" (Pollock 1992: 314) that, at the close of the second millennium AD, obliterated the final vestiges of that ancient heartland of cities.

In this regard, in closing this short piece, I wish to lay down a marker toward further work on this bird's-eye view of cities like Uruk astride their bird's-foot deltas. As compared with rain-fed grain farming, which requires extensive landholdings, even absent any other (irrigated or otherwise) agricultural endeavor, exploitation of wetlands capital is especially dependent upon associated control of human capital. While reed crops have the advantage of virtually unlimited regenerative capacity, that capacity is dependent on hand-harvesting. Reed beds subjected to mechanical plowing, chopping below the waterline, or desiccation to allow easier access quickly die (Westlake, Kvet, and Szczepanski 1998). Wetland successor crops such as rice and sugarcane are notorious for their dependency on slave labor to establish and maintain profitability (Carney 2001; Galloway 1989; Rehder 1999; Seavoy 1998). As 'Ubaid towns grew, burgeoning demands for reed as food, animal fodder, fuel, and construction material would have, from a political-economic perspective, created selective pressure for labor intensification, with concomitant labor control by ideological, administrative, or other means. Indeed, administrative texts for the later Ur III period show that reed harvesting constituted a significant component of labor debt (Englund 2003); that reed transport constituted a significant component of boat cargoes (Sharlach 2004); that reed, along with fish and sheep, was an integral component of the bala exchange system (Sharlach 2004); and that, as for other foodstuffs (cereals and containers of fish), reed was probably a designator of an archaic metrological system (Chambon 2003).

While beyond the scope of this paper to fully explore, only a small intellectual leap is required to hypothesize that burgeoning reed-cutting sickle scatters are material evidence of such labor intensification in the hinterlands as early as the 'Ubaid period. The predominance of reeds, reed bundles, and reed structures as components of the very ideograms of Uruk protoliterate texts point to their major role in fourth-millennium tributary economies. It may well yet be proven that the lasting importance of those marsh-grown reeds was not only as a commodity per se, but in the way the demands of their production structured the political-economic underpinnings of urban-centered labor control. In short, when assessing labor requirements, along with the work involved in producing the barley that presumably filled the bevel-rim bowl, one must add that required to deliver the reeds to fire the kiln. In addition to the labor behind every woven wool textile, one must consider that behind the harvesting of the reeds that fed the sheep. In addition to the work that went into building every mud-brick wall, one must picture the productive effort that delivered the supports between the courses, the filler within the roof, and the matting that lined the walls and floors. From a bird's-eye view, that picture becomes compelling.

CYCLES OF SETTLEMENT IN THE KHORRAMABAD VALLEY IN LURISTAN, IRAN*

FRANK HOLE

ABSTRACT

This paper reports on an archaeological survey carried out in the Khorramabad Valley in the Luristan province of western Iran in the 1960s. The rugged topography of this region, with parallel mountain ridges, narrow valleys, and few passes, created small isolated pockets of favorable land for settlement with little potential for internal growth, but extensive forests and pastures. Until the nineteenth century, Luristan remained largely beyond the reach of history, despite its proximity to the literate civilizations of Mesopotamia and Iran. Lacking either unique resources or good routes, Luristan was isolated from the outside world as well as internally from one valley to the next. For long stretches of time, it is likely that the predominant mode of occupation was transhumant pastoralism.

Although relatively good archaeological sequences are known from adjoining regions, there is no single sequence of occupation for Luristan. Indeed, it appears that most sites were small and short-term, and for long stretches of time, Luristan may have lacked permanent settlements. When sites were

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