The Structure and Dynamics of Dry-Farming States in Upper Mesopotamia [and Comments and Reply]

Author(s): T. J. Wilkinson, John Bintliff, Hans H. Curvers, Paul Halstead, Phillip L. Kohl, Mario Liverani, Joy McCorriston, Joan Oates, Glenn M. Schwartz, Ingolf Thuesen, Harvey Weiss and Marie-Agnes Courty

Source: *Current Anthropology*, Dec., 1994, Vol. 35, No. 5 (Dec., 1994), pp. 483-520

Published by: The University of Chicago Press on behalf of Wenner-Gren Foundation for Anthropological Research

Stable URL: https://www.jstor.org/stable/2744079

Current Anthropology Volume 35, Number 5, December 1994

The Structure and Dynamics of Dry-Farming States in Upper Mesopotamia[1]

by T. J. Wilkinson

A model describing the layout of Early Bronze Age Mesopotamian states is synthesized using a range of off-site and on-site data from Syria, Iraq, and Turkey. These allow the description of the basic settlement patterns, land use, and exchange systems of an early state system. The hypothesis is tested that Bronze Age settlements in this zone of rain-fed farming tended not to exceed 100 hectares, an area which was capable of accommodating between 10,000 and 20,000 people. Detailed off-site surveys and landscape archaeology suggest that these settlements were provisioned by intensively farmed zones of cultivation that surrounded the central settlement and by tributary secondary or satellite communities. This main production zone was just capable of supporting the population of the prime site, but the constraint of labour and the frictional effect of distance meant that food produced farther away than some 10–15 km made only a minor contribution to the main settlement. As a result, settlements tended not to expand beyond a certain size. Even then, the maximizing effect of intensive crop production in such areas of highly variable rainfall and episodic major droughts made these communities very vulnerable to collapse.

T. J. Wilkinson is a Research Associate at the Oriental Institute, University of Chicago (1155 E. 58th St., Chicago, Ill. 60637, U.S.A.) and Assistant Director of the British Archaeological Expedition to Iraq. Initially trained in geography, he has a B.Sc. from Birkbeck College, London University, and an M.Sc. from McMaster University, Hamilton, Ontario. During the past 20 years he has specialized in the reconstruction of ancient landscapes using techniques of off-site survey and geoarchaeology. The present paper was submitted in final form 14 xii 93.

1. This paper grew out of a lecture presented to Northwestern University's Department of Anthropology in January 1993 and a series of seminars on ancient urbanization at the University of Chicago in 1992–93. I thank Gil Stein of the Northwestern University Department of Anthropology, Paul Wheatley of the Committee for Social Thought, University of Chicago, and Donald Whitcomb of the Oriental Institute, University of Chicago, as well as the participants in these seminars for their ideas on this topic, some of which have been incorporated into this paper. I am particularly grateful to Guillermo Algaze, Department of Anthropology, University of California, San Diego, and William Sumner, the Oriental Institute, University of Chicago, for comments on earlier drafts. Thanks also go to the British School of Archaeology in Iraq and to the Oriental Institute, University of Chicago, for enabling me to pursue fieldwork in the Jazira; to Thomas Holland, Richard Zettler, Guillermo Algaze, and Warwick Ball, the directors of excavations at Tell Sweyhat, Titrish Höyük, and Tell al-Hawa respectively, and, for continued financial support, to the various funding bodies of those projects, particularly the National Geographic Society. The final version of this paper has benefited considerably from the comments of two anonymous referees.

With the growth in regional archaeological studies in recent decades and the increased refinement of analytical and field techniques, it is now becoming possible to sketch the overall development of state-size settlement systems through time. Whereas earlier studies, for example, those of Adams (1965, 1981) and Johnson (1975), relied on analysis of sites as point patterns, we now have available a range of spatial data, especially from techniques of off-site archaeology, to enhance our understanding. By the use of these techniques it is possible not only to generate settlement and proxy population distributions but also to suggest zones of agricultural intensification, limits of cultivation, communication routes, and elements of exchange systems as well as demographic trends through time. Because a greater variety of settlement and production systems can be analyzed, the resultant models can be of value to a wider audience of anthropologists, archaeologists, and geographers.

Unlike the massive Bronze Age urban sites of the Mesopotamian plains, which attained areas of 400+ ha, those of Upper Mesopotamia appear to have had a maximum size of some 100 ha (van Liere 1963:114; Weiss 1983). This implies a ceiling beyond which such sites did not or could not grow. Such a notion is not new, and a number of studies have suggested that the size of early cities was limited by the food supplies of their immediate hinterlands (Smailes 1953:21–22; Davis 1955:431; Boserup 1981:82). It remains an interesting avenue to explore because a ceiling could have severely constrained the economic and perhaps the political power of these emerging secondary states. The purpose of this paper is to examine this proposition using selected case studies drawn from recent fieldwork in the Jazira region of Syria, Iraq, and Turkey. The sizes, populations, and patterns of selected Early Bronze Age settlement systems are related to the productivity of the areas that sustained them and to the local exchange systems, and a dynamic model is developed to suggest how such systems may have responded to climatic stress.

Reviews of the study of state formation over the past 15 years have tended to favor systemic models characterized by complex interactions and feedback relationships (Redman 1978*a*, *b*; Rappaport 1978; Butzer 1980) over earlier, more elementary models (notably Childe 1954; see also Redman 1978*b*, Butzer 1982, Zeder 1991). More specifically, Hunt (1987) has generated a model of the likely system of supply and consumption of an early Mesopotamian state, but no wide-ranging field evidence from the Near East has become available to test it. In fact, the complexity of the mechanisms of state formation is such that to develop a sound quantitative base for testing general models is probably beyond any one field project. Nevertheless, given the range of data that can be derived from studies of total landscapes, it is clearly possible to go beyond point-pattern analysis, with its overreliance on geographical models of settlement systems.

Of the systemic models that have become popular in recent years, a particularly appealing one is that which examines the evolution of state societies as systems either fluctuating around a steady state or subject to major changes of state that may result in a new equilibrium at another level (metastable systems [Rappaport 1978, Butzer 1980]). The latter mechanism may well have operated in the southern Andes following the collapse of the Tiwanaku state (for alternative views, see Graffham 1992, Ortloff and Kolata 1993), and a comparable mechanism has been suggested for late 3d millennium B.C. Upper Mesopotamia, where a run of dry years may have precipitated a collapse of urban society (Weiss et al. 1993). One problem raised by metastable or adaptive systems is that the preferred system may be entirely unknown (Whyte 1978). However, by examining the long runs of data that are available to archaeologists, especially for large regions, it may eventually be possible to understand how systems change from one equilibrium state to another and to suggest what factors have precipitated such change.

To address such a broad range of issues and data, it is necessary to restrict the geographical and temporal spread of the data, and here I have chosen the steppe of Upper Mesopotamia during the Early and Middle Bronze Ages (roughly between 3000 and 1500 B.C.). The case studies to be considered here were conducted by me over the past 20 years. By identifying the basic equilibrium state of the settlement and land-use system it is possible to suggest the existence of a state of (metastable) equilibrium that eventually suffered a dramatic change to another state of equilibrium. For this first approximation I will concentrate on the basic structure of the Early Bronze Age settlement system and discuss its potential interaction with prevailing environmental systems.

Fundamental to our understanding of early urban systems is the notion that surplus production enabled early centers to expand and to accommodate specialized economic sectors (Childe 1954:30–31; Hunt 1987:151–53; Halstead 1989:68). In the Near East, although some early centers, such as Susa and Abu Fanduwah in western Iran, may have been self-sufficient in food (see Johnson 1987:112–13 on Susian early Uruk), in other cases outlying settlements probably produced a surplus that could have supported population and institutions at the center (Stein 1987:101). The latter case is illustrated by Ugaritic texts that record the contributions of outlying settlements to the centralized economy (Liverani 1989:143, 152). If outlying settlements were generating a surplus, there would have been a trend toward increasing integration of the system, with the center relying upon satellites for crucial supplies and the satellites being tied to the center by obligation, by force, or by economic factors. Here the problem of surplus will be addressed using field data to determine how surplus or deficit production may have been distributed around major centers.

In contrast to central-place theory (Christaller 1966, Hodder 1972, King 1985), the models proposed here do not rely upon principles of marketing that are more appropriate to modern urban systems and are difficult to demonstrate for many ancient societies (Crumley 1976: 61;1979). Instead they are based upon the productive potential of the surrounding land, taking into account principles of least effort as expressed by the land-use models of von Thünen (Chisholm 1979). Rather than duplicate earlier reviews of location theory and archaeology (Crumley 1976, 1979; Johnson 1980; Evans and Gould 1982), I will examine early states from first principles, using some of the more refined data from landscape archaeology that are now available. Although we are still a long way from fulfilling Wright's (1969:122) requirements for a true input-output model of early states, this paper, in addition to providing a descriptive model of an early dry-farming state, may suggest further hypotheses to be tested.

The Study Area

The Jazira (or Upper Mesopotamia) is an undulating plateau varying between 300 and 450 m above sea level situated between the Tigris and Euphrates Rivers in southeastern Turkey, northern Syria, and northwestern Iraq (fig. 1). The northern part, receiving a mean annual rainfall of 350–500 mm, lies within the moist steppe zone (Guest 1966:71–72), while the southern part, with a mean rainfall of 200–350 mm, lies at or beyond the limits of rain-fed cultivation (Guest 1966:71–72). The original woodland-steppe mosaic or savanna-like steppe has been reduced over much of the region to a severely degraded agricultural desert. Land use is dominated by cereal monoculture (wheat and barley) in the south, but to the north the inclusion of pulses (mainly lentils) and vines makes for a more balanced economy (for details of modern land use see Weiss 1986:72–76; Wilkinson 1990*b*:51–60). Although mean annual rainfall is only a general guide to cropping potential in this area of high interannual variability (De Brichambaut and Wallen 1963:10), the three case studies can be used to exemplify the moist, intermediate, and driest parts of the region: Titrish Höyük (north of Urfa in Turkey) has a mean annual rainfall of 400–470 mm, Tell al-Hawa (northwestern Iraq) a mean of ca. 350 mm, and Tell Sweyhat (on the Syrian Euphrates) a mean of 250–300 mm. Today Tell Sweyhat and sites in equivalent positions are climatically marginal, and although modern cultivation does spread well beyond them, the high risk entailed, acceptable within a modern commercial economy, would hardly have been so in a subsistence economy. Despite references to irrigation in the Rimah texts (Dalley, Walker, and Hawkins 1976:211–15), the dearth of field evidence for irrigation systems in the rain-fed parts of the Jazira suggests that the region was predominantly dry-farmed (Weiss 1986:82). Yields in the Jazira are gen-

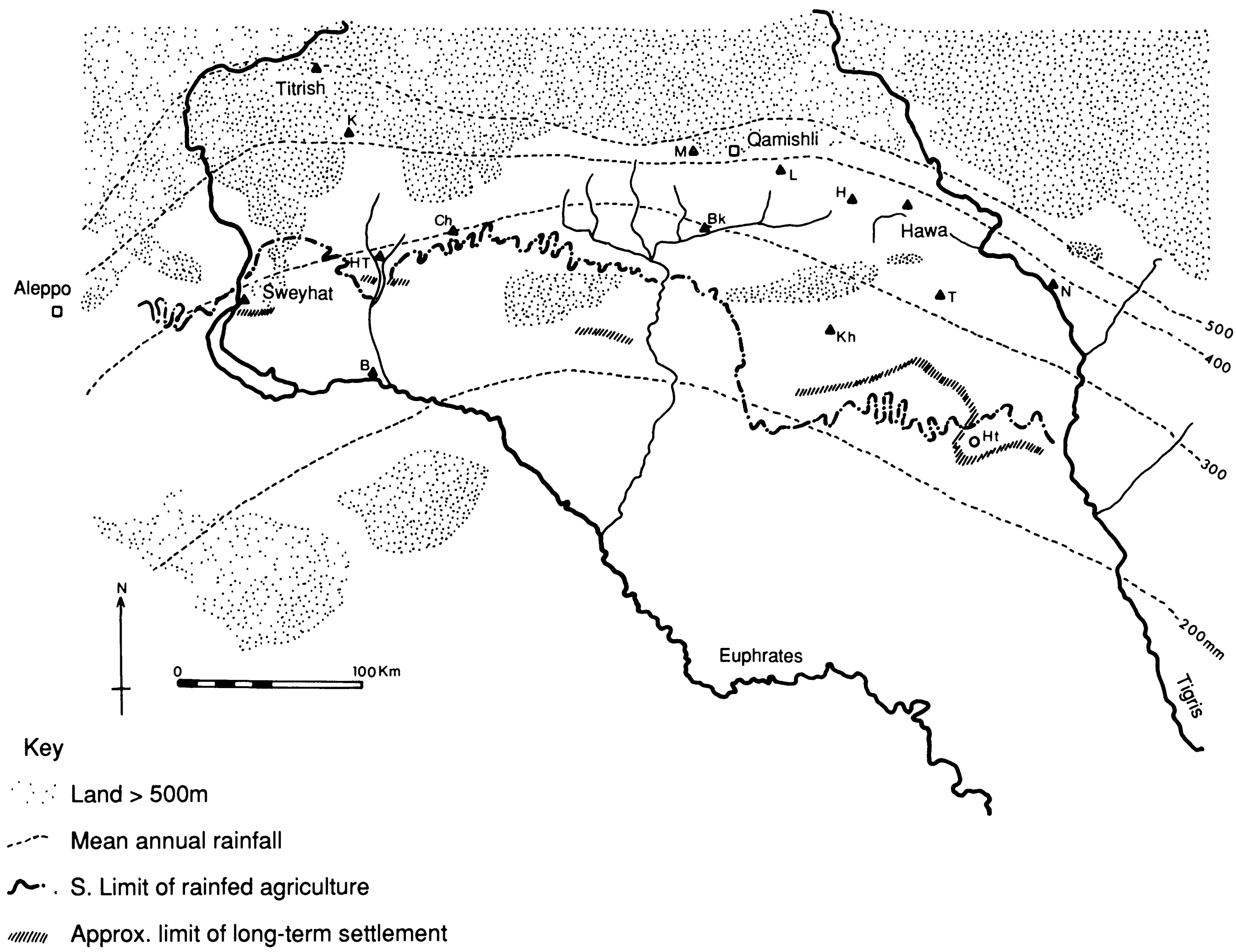

FIG. 1. *The Jazira region of Upper Mesopotamia, showing the southern limits of rain-fed cultivation and the approximate limit of long-term settlement in relation to key rainfall isohyets. Selected Bronze Age sites mentioned in the text are indicated by triangles.* K, *Kazana Höyük;* HT, *Tell Hammam et-Turkman;* B, *Tell B'ia;* Ch, *Tell Chuera;* M, *Tell Mozan;* Bk, *Tell Brak;* L, *Leilan;* H, *Hamoukar;* KH, *Tell Khoshi;* T, *Tell Taya;* N, *Nineveh;* Ht, *Hatra.*

erally low, but because large areas are available for farming gross production may be high (Weiss 1986:72). In contrast, in the lowlands of southern Mesopotamia (Sumer and Akkad), in spite of the significantly higher yields, gross production was limited by the availability of irrigation water at the appropriate season (Adams 1981:6). Thus, the productivity of Upper Mesopotamia may have been equal to or even greater than that of the irrigated lowlands, despite the latter's traditional reputation as the granary of the ancient Near East (Weiss 1986:82).

Site Definition and Settlement Area

Before describing examples of patterns of Bronze Age settlement, one must determine the sizes of the component settlements as a first step toward estimating their populations. This can be difficult because the area actually occupied may exceed by a considerable margin the mounded area. At Tell Taya in northern Iraq, for example, low-density occupation in the form of foundation walls and artifact scatters extends over areas of 70–160 ha; this compares with a 9-m-high tell that covered only 1 ha (Reade 1968:239) and an additional 8-ha outer town with defensive wall and outer enclosure (Reade 1971: pl. 24). Although perhaps an extreme example, Tell Taya demonstrates that single-component occupations may significantly increase the areas of Bronze Age towns. It is therefore essential that field techniques be designed to detect such sites when they occur.

At Titrish Höyük, numerous "suburbs" are scattered around the main mounded site area, which can itself be subdivided into a high mound, a lower town (east and west lobes), and an outer town spreading to the north of these (Algaze, Misir, and Wilkinson 1992:35; fig. 2 and table 1). Although it was not conspicuously walled, the outer town may have been defended by earthen ramparts of substantial size. This outer town, which grew very rapidly from a much smaller and as yet undefined earlier

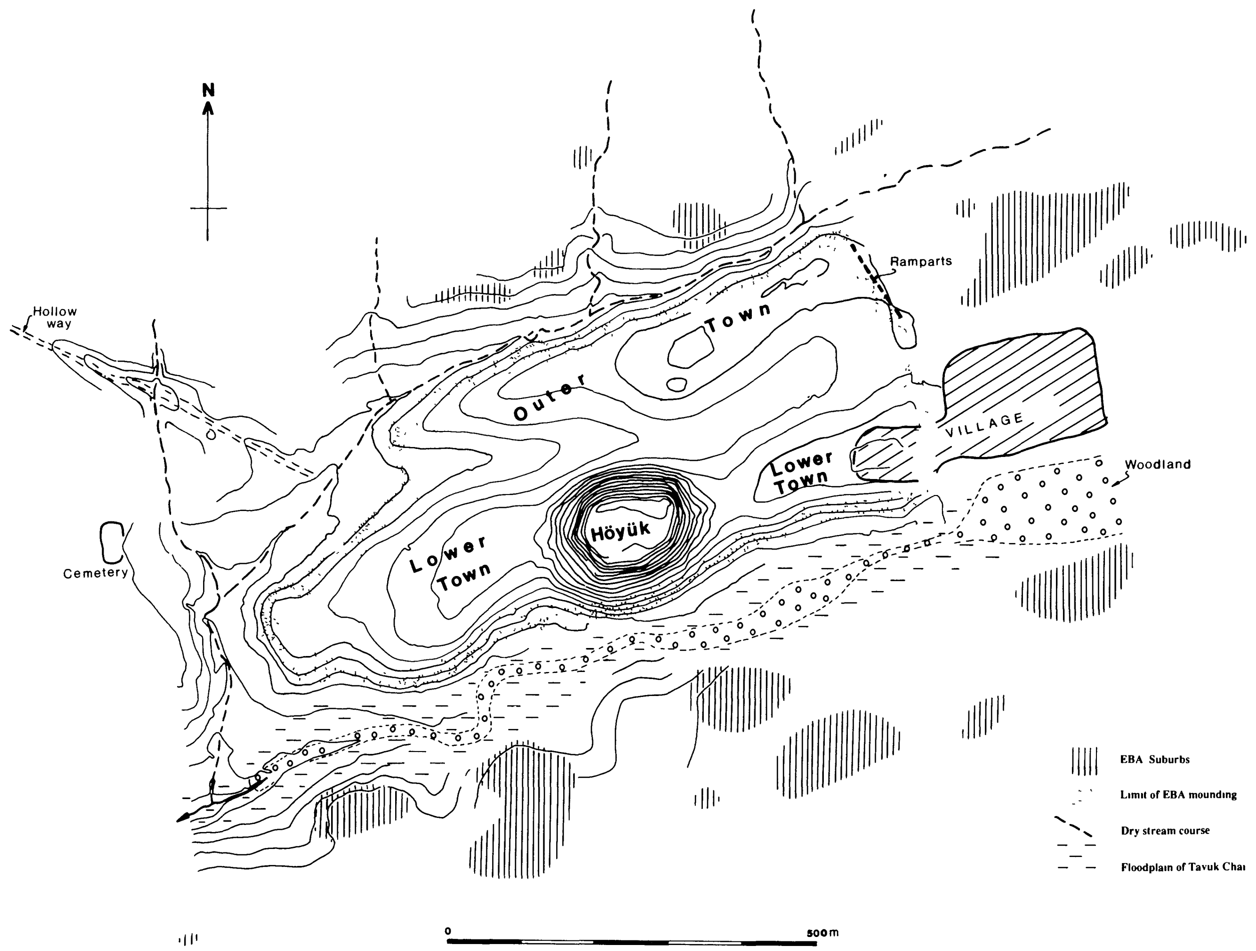

FIG. 2. *Titrish Höyük, with its lower town areas to east and west, the outer town to the north, and suburbs around the site periphery.*

settlement, attained its maximum population around the middle of the 3d millennium B.C. (mid-/late Early Bronze Age, henceforth EBA). The inclusion of the suburbs brings the total occupied area to about 40 ha. The unmounded suburbs were defined by their gray color (in contrast to the surrounding reddish soils), scatters of broken foundation stones, occasional door sockets, large potsherds, and large quernstone fragments. These areas were mapped using an EDM theodolite, and sherd density was estimated by means of a grid of 5 × 5 m sample squares. Sampling was extended several hundred meters beyond obvious habitation in order to distinguish between the in situ occupation and field scatter. The latter, consisting of sparse scatters of small battered sherds without other diagnostic features, could be clearly differentiated from the settlement-related scatters (Algaze, Misir, and Wilkinson 1992: fig. 3). Diagnostic pottery from these areas indicates that the maximum area was occupied for a brief period in the mid-3d millennium B.C., roughly contemporaneous with the Akkadian empire of southern Mesopotamia (Kurban Höyük IV [Algaze 1990]). During the final quarter of the 3d millennium (Kurban Höyük III) settlement shrank to occupy the 3.2-ha high mound and localized areas of the lower and outer towns.

TABLE 1
Area and Depth of Occupation of Subdivisions of Titrish Höyük

Site Subdivision	Area (ha)	Depth of Occupation (m)
High mound	3.2	22.0
Lower town: West lobe	7.5	5.0
Lower town: East lobe	5.0	5.0
Outer town	12.5	1.5–2.5
Suburbs	10.0	negligible
Total	38.2	

Of similar size, Tell Sweyhat consists of a central mound bounded by a wall beyond which spreads the virtually flat outer town, surrounded by a low mudbrick wall on stone foundations (R. L. Zettler, personal communication, 1993) enclosing an area of some 31 ha (Holland 1975, 1976; Holland and Zettler 1991). Surface collection by Lee Horne in 1988 suggested that the outer town was occupied, and 1991 excavations in fact exposed a shallow development of built structures. Further sampling outside the enclosure wall to the south indicated the presence of artifact scatters of a density intermediate between those on the surrounding fields and those in the inner town and occasional fragmentary wall footings (Zettler, personal communication). This scatter lacks the clear attributes of occupation found in the Titrish suburbs, but if habitation can be confirmed it will extend the occupied area by perhaps as much as 10–15 ha to 40–45 ha. (As an interim measure, only the 31-ha walled area is employed in the calculations here.)

In contrast, the northern Jazira of Iraq, with its numerous sections exposed along modern canals and drains, shows no evidence of unmounded outer habitation areas. Therefore EBA occupation was defined by surface mounding, which ranged from 35-m-high tells to subtle undulations of grayish soil (Ball, Tucker, and Wilkinson 1989:26–28). It should be emphasized that at both Titrish Höyük and Tell Sweyhat even the mounded outer towns went unrecognized during initial visits by archaeologists. If these outer towns and suburbs had occurred within modern villages they would have been totally obscured by housing and thereby lost to the archaeological record. In other areas only at Kazana Höyük (P. Wattenmaker, personal communication) and around Leilan have sites been delimited by controlled surface collection (see Lyonnet 1990 for Mohammed Dhiab; Stein and Wattenmaker 1990 for sites around Leilan; see also Meijer 1986:4 for northeastern Syria). Occupied area is often based solely upon overall mounded area rather than the distribution of defined pottery assemblages, with the result that many major sites remain very poorly defined. For example, Hamoukar in northeastern Syria has been delimited only in terms of the areas within the outer and inner "moats," 216 ha and 116 ha respectively. This site, suggested to have been the Mitannian capital of Washukhani (van Liere 1963:120), exhibits major Late Chalcolithic and Middle Bronze Age occupations (4th and early 2d millennium B.C.), but their exact extent remains uncertain. The figure employed here (116 ha) is based on the area of the "lower town" according to van Liere and falls between Weiss's (1983) estimate of 90 ha and Meijer's (1990) estimate of 250 ha (a figure that exceeds the area mapped by van Liere in 1963). Such confusion emphasizes the need for detailed delimitation of major sites before they become disturbed by archaeological excavation, modern development, or agriculture. However, with the exception of this little-understood site and Tell Taya (indicated on fig. 3 by the "zone of uncertainty"), EBA sites in the Jazira apparently attained a maximum size of around 1 km^2 (100 ha) (table 2), and none rivals in scale the sites of the Mesopotamian lowlands (see Adams 1981:85).

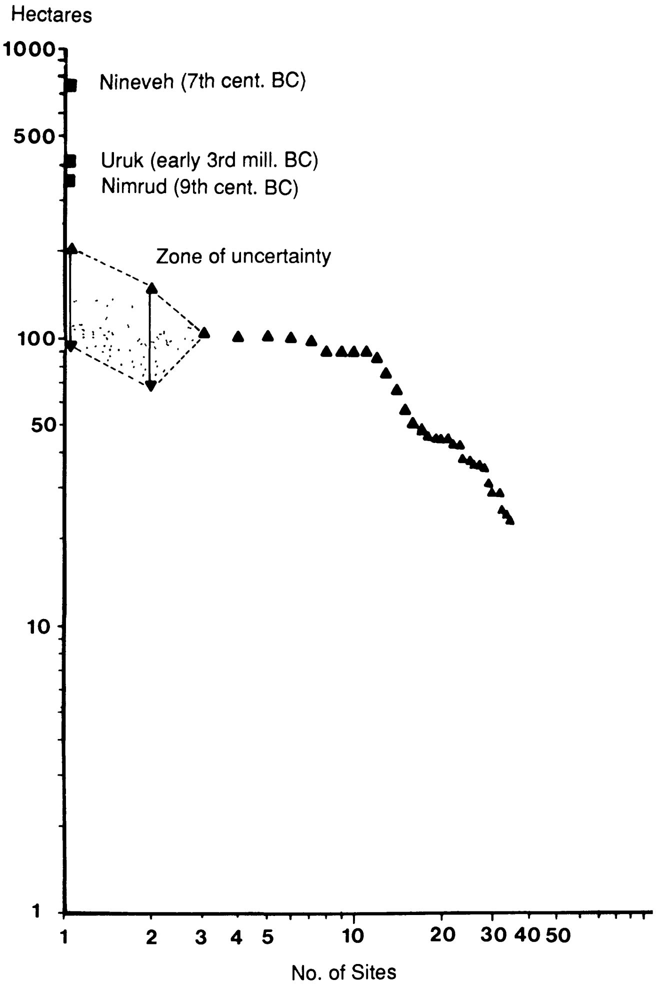

FIG. 3. *Rank-size curve for sites in the rain-fed zone of Upper Mesopotamia, with additional sites from outside the geographical and chronological range indicated by infilled squares.*

Settlement Pattern and Hierarchy

The presentation of a full settlement hierarchy requires a complete or near-complete site survey record ranging from a well-defined prime settlement to the very smallest sites. Because many EBA occupations occur on multiperiod sites, the relevant occupation horizons may be obscured by later levels. Consequently, sample surveys need to be designed to test the distribution and chronological range of artifacts across the site (Whallon 1979; Ball, Tucker, and Wilkinson 1989: fig. 8; Stein and Wattenmaker 1990; Wilkinson 1990*b:* appendix A). If time is limited, qualitative collection and checking should be undertaken, with emphasis on areas where earlier levels are exposed. At minimum the site should be subdivided into topographic or arbitrary areas to provide a breakdown of occupation into smaller units. A particular problem of lower-order "satellite" settlements is that they may be impoverished in certain classes of ceramics. Hence, if a limited range of diagnostics is used for dating surface collections, minor occupations may go unrecognized.

The extensive loam plains of the northern Jazira provide an excellent example of a three-tiered settlement hierarchy. Here a preexisting pattern of dispersed

TABLE 2
Size Categories for Bronze Age Sites in Upper Mesopotamia and Adjacent Areas

Size Class (ha)	Site	Ancient Name	Area (ha)	Source
>100	Hamoukar (S)	–	116 (216)[a]	van Liere (1963: fig. 3*b*)
	Tell Taya (I)	–	70–160	Reade (1968, 1971)
	Tell Farfara (S)	–	100–106	Meijer (1990: fig. 1)
70–100	Tell Chuera (S)	–	100	Weiss (1983: fig. 11)
	Mishrife (S)	Katna	100	van Liere (1963:118)
	Kazana Höyük (T)	–	100	Wattenmaker (personal communication)
	Tell Sharisi (S)	–	98	Meijer (1990: fig. 1)
	Nisibis (T)	–	90	van Liere (1963:118)
	Leilan (S)	Šubat Enlil, Šehn	90	Weiss (1983: fig. 11)
	Tell Khoshi (I)	–	90	Kepinski (1990)
	Tell Mozan (S)	–	70–100[b]	
	Tell Hadhail (I)	–	90	Weiss (1983: fig. 11)
	Tell Nebi Mend	Qadesh	75	van Liere (1963:118)
30–69	Tell al-Hawa (I)	–	66	Ball, Tucker, and Wilkinson (1989)
	Tell Mardikh (S)	Ebla	56	Weiss (1983: fig. 11)
	Qalat Sherqat (I)	Assur	50	Weiss (1983: fig. 11)
	Mabtouh Charki (S)	–	48	van Liere (1963: fig. 1)
	Tell Humaydi (S)	–	45–47	Meijer (1990: fig. 1)
	Nineveh (I)	Ninewa	45+[c]	
	Rumaylan Kabir (S)	–	45	Meijer (1990:34)
	Mohammed Dhiab (S)	–	43	Lyonnet (1990:74)
	Tell Brak (S)	Nilabshinu?	43	Weiss (1983: fig. 11
	Tell Hadidi (S)	Asu?	40–50	Dornemann (1985)
	Titrish Höyük (T)	–	38	Field survey
	Meskene/Balis (S)	Emar	37	Weiss (1983: fig. 11)
	Tell Bi'a (S)	Tuttul	36	Weiss (1983: fig. 11)
	Tell Cheikhate (S)	–	36	van Liere (1963: fig. 1)
	Melha (S)	–	35	van Liere (1963: fig. 1)
	Tell Sweyhat (S)	–	31	Field survey
20–29	Tell Touqan (S)	Urshu?	28	Weiss (1983: fig. 11)
	Tell Rimah (I)	Karana?	28	Weiss (1983: fig. 11)
	Mouaizar (S)	–	24	van Liere (1963: fig. 1)
	Tell Barri (S)	Kahat	23	Weiss (1983: fig. 11)
	Tell Hammam et-Turkman (S)	Zalpah	20	Field survey

NOTE: *I*, Iraq; *S*, Syria; *T*, Turkey. Because systematic sampling has been undertaken at only a few of these sites, their sizes are approximate. In most cases the area refers to that of Bronze Age occupation, but in the case of Hamoukar it may refer to either late Chalcolithic or early/middle Bronze Age habitation. Weiss and Courty (1993:135–37) have suggested an area of 100 ha for Leilan and 75–100 ha for Tells Mozan, Brak, and Leilan; the 45-ha estimate has been retained for Brak on the basis of a mounded area of 35–45 ha, but the Late Chalcolithic/Uruk settlement may have been significantly larger.
[a]Low tell and (in parentheses) outer moat.
[b]Estimated from Buccellati and Buccellati (1988: fig. 6).
[c]45 ha is the approximate area of Kuyuncuk, but early-3d-millennium Ninevite 5 occupation may have been present to the north of it (Stronach n.d.).

smaller settlements (Wilkinson 1990*a*) developed into a ranked EBA hierarchy dominated by Tell al-Hawa (figs. 4, 5). Detailed sampling at this site allowed David Tucker to delineate a total later-3d-millennium occupied area of some 66 ha (Ball, Tucker, and Wilkinson 1989). At distances of 9–12 km were secondary centers at Tell Samir (site 93: 19 ha), Kharaba Tibn (site 43: 17 ha), and Abu Kula (site 127: 10 ha), below which, occupying the base of the hierarchy, were satellites and other sites with areas of 1–5 ha. Most sites of lowest rank were 3–5 km from their nearest centers, although several smaller sites of uncertain affiliation were recorded. During the early 3d and early 2d millennia B.C. (i.e., during the Ninevite 5 and Khabur periods) a distinctive ring of satellite settlements developed around Tell al-Hawa. These were virtually extinguished during the maximum urbanization of the mid- to late 3d millennium, perhaps as a result of the extension of Tell al-Hawa's land-use zones when most farming was conducted from the center.

At Titrish Höyük, urbanization, dated to Kurban Höyük IV (Algaze 1990), was roughly contemporaneous with the maximum urbanization in the northern Jazira and the Leilan area (fig. 6). Occupying second position was Lidar on the Euphrates 11 km away (Hauptman 1980, 1984), with an estimated area of some 15 ha (Wilkinson 1990*b:* fig. 4.5). Below this were smaller but quite prominent settlements of 5–6 ha (site 15 and Ta-

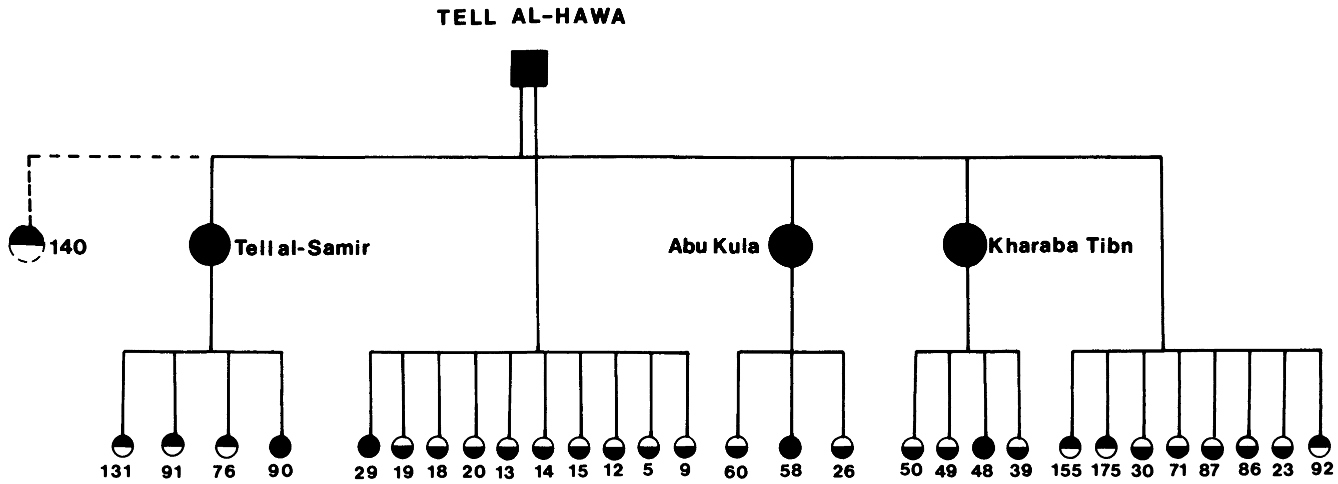

FIG. 4. *The settlement hierarchy of the northern Jazira, Iraq. Tell al Hawa is ca. 66 ha, second-rank sites are 10–20 ha, and third-rank sites are less than 10 ha (with the exception of site 91, the size of which for the EBA remains undetermined).* ◒, *Ninevite 5 site;* ◓, *later-3d-millennium site.*

tarhöyük) and less. In contrast to the situation in the northern Jazira, a distinct hierarchy was lacking, partly because the topographically fragmented terrain, consisting of enclosed lowlands surrounded by limestone hills, restricted the cultivable area.

The small area of available land on the surrounding river terrace restricted the territory of Tell Sweyhat and the development of EBA settlements. Although there were several ca. 1-ha EBA sites, the only sites that may have been contemporaneous with the main expansion of Tell Sweyhat were sites 5 and 20 (Tell Othman) on the dry-farmed steppe to the south and southeast. Tell Hadidi (on the west bank), with an area of 40–50 ha, and Tell Sweyhat (on the east bank) may belong to the same settlement system or be semiautonomous local centers (fig. 7).

On the Khabur plains, albeit for an undifferentiated range of Bronze Age tells, major centers were about 40 km apart, with lesser centers positioned about halfway between (van Liere 1963:112). Although this relatively

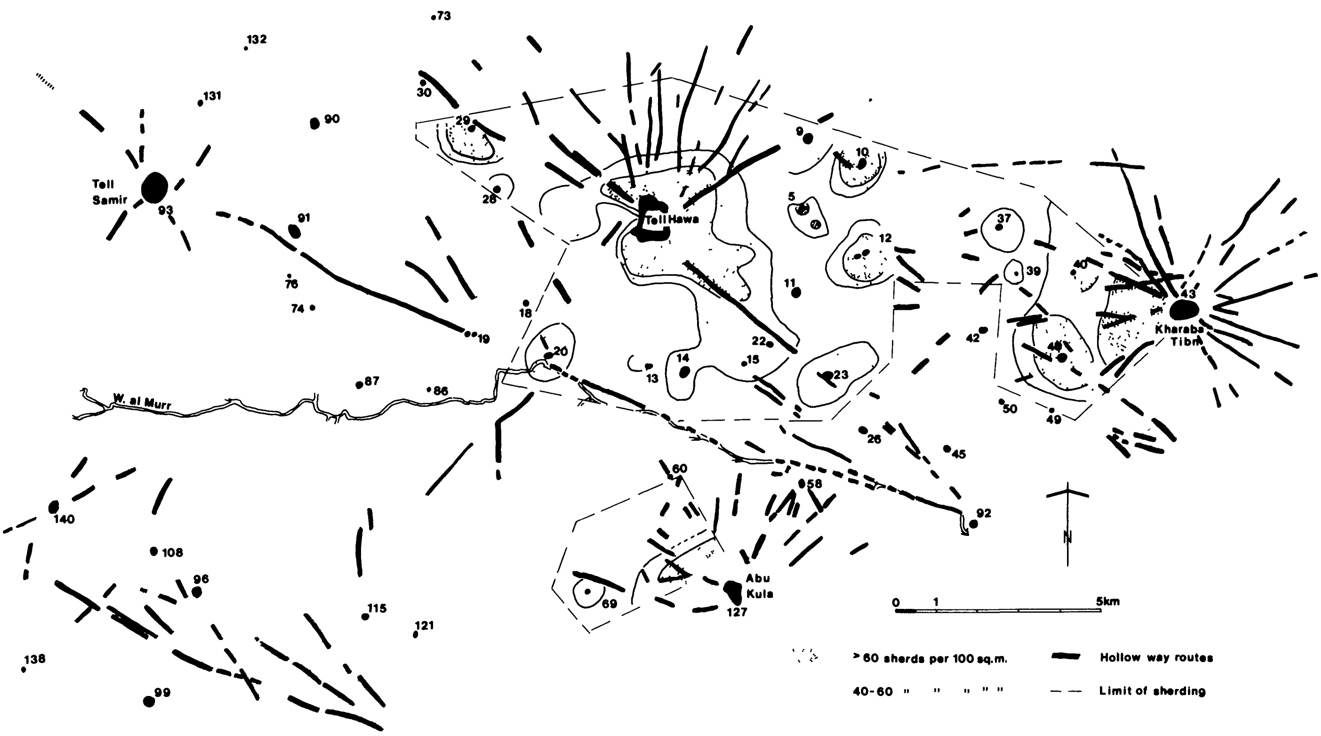

FIG. 5. *Early and Middle Bronze Age sites in the northern Jazira, with* (stippled) *associated off-site sherd scatters.*

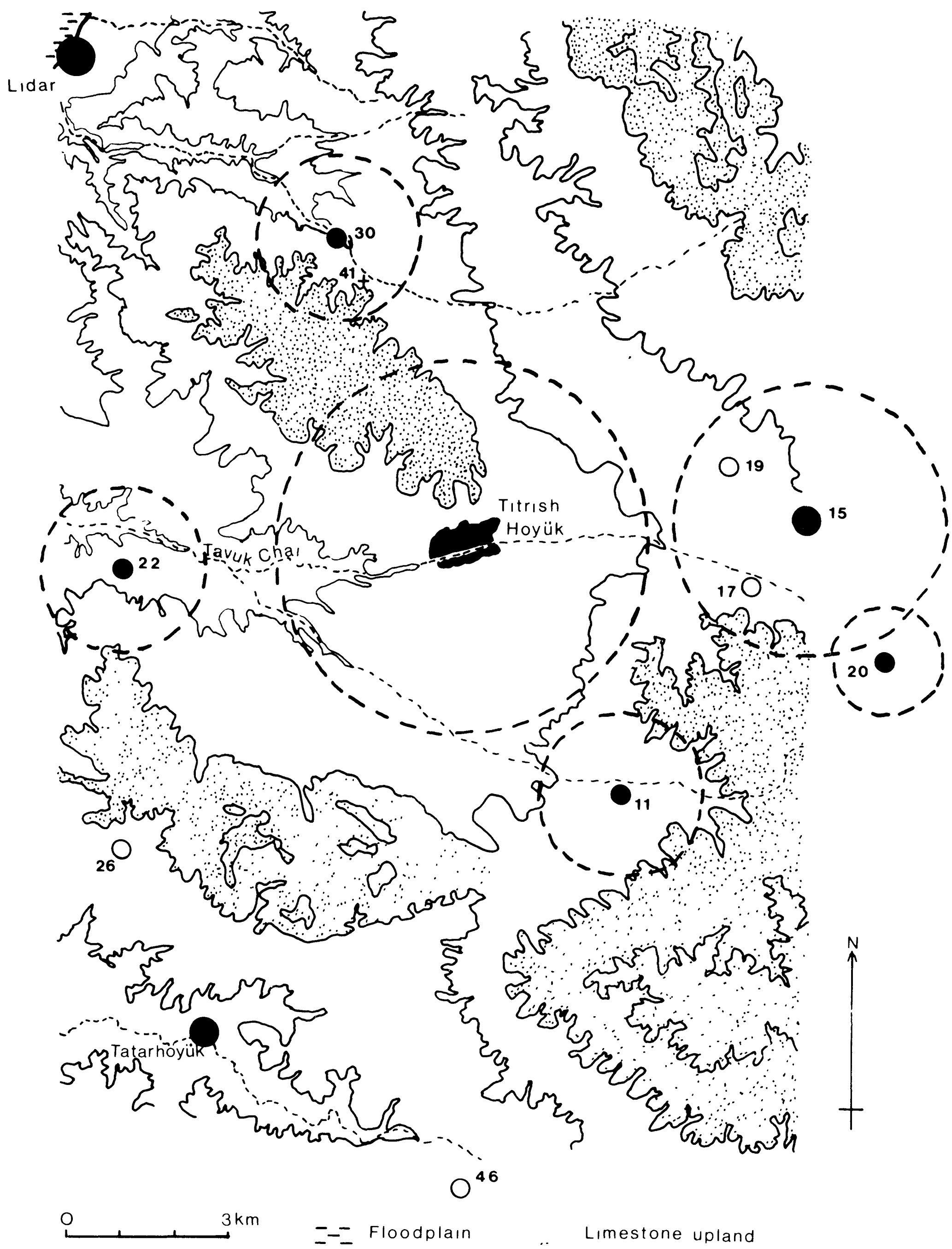

FIG. 6. *Area around Titrish Höyük, showing mid-/late-3d-millennium sites and circular territories employed in crop production calculations.* Solid circles, *major occupations;* open circles, *minor occupations.*

even distribution suggests a moderately even pattern of resource exploitation, concentrations can occur such as those along the Jagh-jagh and Jarreh Rivers, where distances between sites in the 40–100-ha range fall to as little as 8–15 km (Meijer 1990:36). Around the major center of Tell Leilan in northeastern Syria, surveys show how a differentiated system of minor centers and smaller settlements of early-3d-millennium date (i.e., Ninevite 5) had by the mid-3d millennium been transformed into an urbanized population cluster (Stein and Wattenmaker 1990). This included 90–100-ha Tell Leilan at the apex and an expanded 43-ha secondary center of Tell Mohammed Dhiab at a distance of only 5.35 km. Even toward the margins of rain-fed cultivation, large centers such as the 100-ha Tells Hadhail (Lloyd 1938) and Khoshi (Kepinski 1990) on the Sinjar plain are only

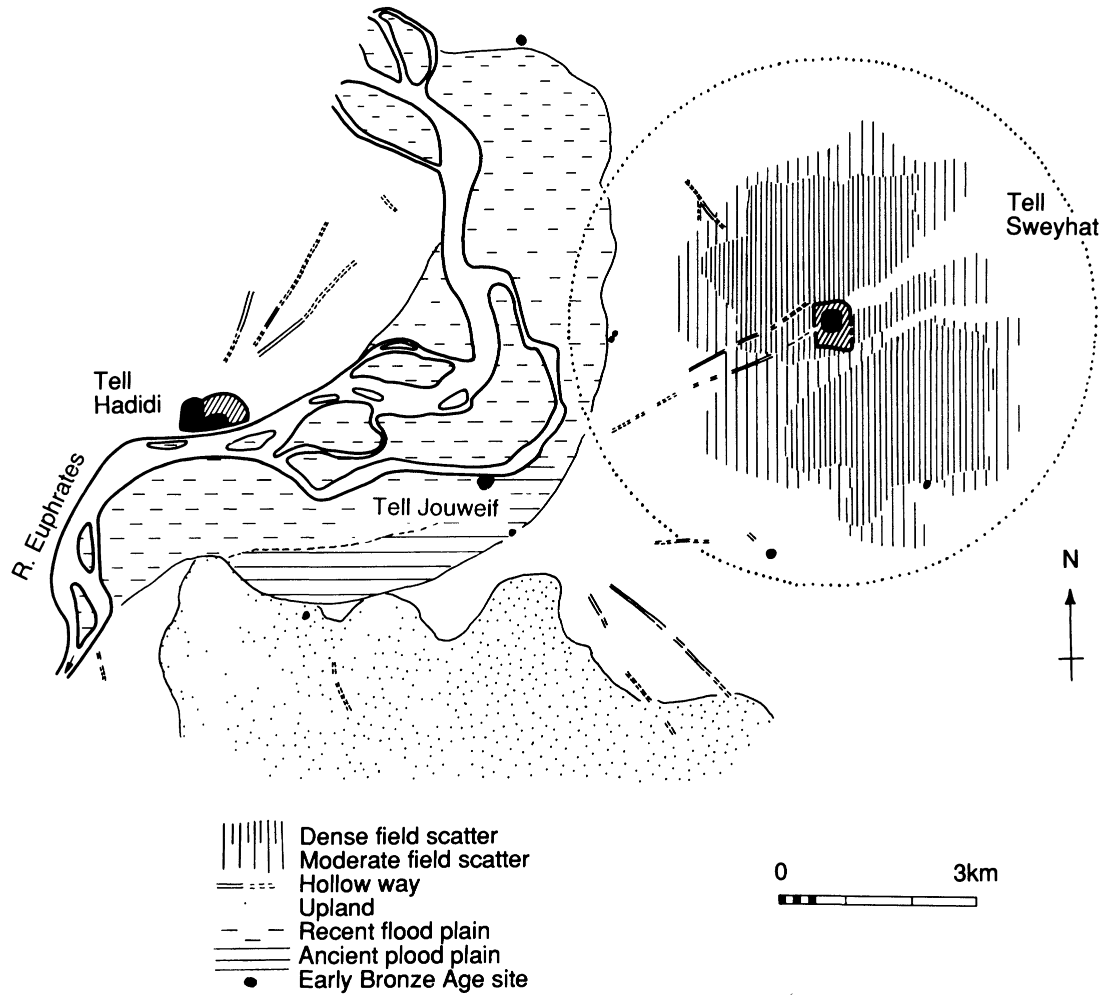

FIG. 7. *Area around Tell Sweyhat showing Early and Middle Bronze Age sites and areas of dense and moderate off-site sherd scatter. Crop production area of 4-km radius assigned on basis of field data.*

20 km apart. Still farther south, where rainfall becomes even less reliable, each tell occupies its own shallow topographic hollow (van Liere 1963:114), which presumably concentrated sufficient soil moisture to generate yields even in dry years.

Although no single pattern of settlement prevails in the Jazira, in each of the above cases a central prime settlement overshadows in size those in the neighborhood. Smaller settlements within 3–6 km of major centers can frequently be recognized as satellites, and in the northern Jazira a well-established three-tier hierarchy with prime center, secondary centers, and satellites had appeared by the mid-3d millennium. Elsewhere the settlement pattern was either restricted by topography (Titrish and Sweyhat) or intensified by urbanization (the Leilan area). Doubtless there are further variations on these patterns, but the examples selected serve to illustrate the fact that, compared with the situation in Early Dynastic lowland Mesopotamia, settlements were relatively evenly dispersed across the landscape and massive urban agglomerations were lacking.

Land-Use Zones

Although the loam plains of the Jazira are not conducive to the preservation of field systems, indirect methods enable us to infer zones of intensive farming that developed at intervals. These methods have been summarized in Wilkinson (1982, 1989), and here only the results that relate directly to the reconstruction of EBA states are discussed.

An important component of the archaeological landscape in the Near East is the extensive low-density scatter of abraded sherds that occurs within and upon the existing topsoil. These form zones of steadily diminishing sherd density away from sites, with larger and denser scatters surrounding major sites. Although occasional small sites may be present within such scatters, the examination of many kilometers of sections cut through the northern Jazira indicates that the scatters are within the topsoil and not associated with in situ occupation. Because artifact scatters on fields can also result from the more recent excavation of tells for fertilizer, it is necessary to ascertain that such contamination is not present (Wilkinson 1989). Where scatters appears to be contemporary with the sites they surround, however, they can be interpreted as resulting from the spreading of settlement-derived refuse on fields to fertilize the soil and thus increase production. Such practices were common throughout the Old World, for example, in Iran (English 1966:116) and China (King 1920:171), and were particularly highly regarded by early Islamic agricultural authorities (El-Samarraie 1972:74–75; see Wilkinson 1982, 1989 for a review). Analysis of sherd scatters suggests that manuring was concurrent with episodes of high population and occurred particularly when the local wood resources had been reduced and it was necessary to use dung as a substitute fuel (Wilkinson 1989). The ensuing competition for fuel resources and the need to increase production to support the growing population made it necessary to secure fertilizer from where it was available, namely, settlements, animal byres, streets, and kilns. The waste not susceptible to decay, consisting of potsherds, vitrified kiln slag, tiny fragments of basalt querns, etc., remained in the topsoil, roughly in proportion to the amount of organic waste applied. Hence, the density of artifacts across the land surface can be used as a proxy indicator of past land-use intensities.

Around Tell al-Hawa, diagnostic ceramics within field scatters, although belonging to numerous phases, are most abundant for the later 3d millennium, thus coinciding with the maximum size and presumably population of the site. Beyond a zone of complex sherd scatters near the site, sherd densities reached a peak between 0.5 and 1.0 km from the site and thereafter declined to very low levels at distances greater than 3–4 km (Wilkinson 1989; Ball, Tucker, and Wilkinson 1989: figs. 4, 5). Similar scatters were defined around secondary centers, and even the small satellite communities appear to have been surrounded by scatter zones of ca. 1 km radius. The predominance of later-3d-millennium diagnostics within the scatters suggests that the peak of land-use intensity was synchronous with the main phase of urbanization, at which time the zone of intensive cultivation extended some 3–4 km from Tell al-Hawa. Beyond this, a background scatter of 1–5 sherds per 100 m^2 extended across at least the remainder of the 115 km^2 mapped. This presumably represents less intensive or intermittent cultivation, which received only very minor additions of settlement-derived manure.

The sherd scatter zone around Tell Sweyhat implies that manured and cultivated land attained a maximum area of 3–4 km radius during the final quarter of the 3d millennium (fig. 7; Wilkinson 1982). Diagnostic sherds from the scatters again indicate that this peak in intensive cultivation coincided approximately with the maximum urban extension of Tell Sweyhat.

Similar scatters around Titrish Höyük included diagnostic sherds of the mid-/late EBA, when urbanization reached a peak, and the Late Roman/Byzantine period, when the area was occupied by a dense scatter of dispersed rural settlements. A noteworthy feature is a very sparse scatter of small mid-/late-EBA fine-ware sherds that extended up and over the nearby high limestone hills, terrain that is virtually uncultivated and uncultivable today (Algaze, Misir, and Wilkinson 1992). These scatters lack the storage-jar sherds that make up the full ceramic inventory of both sites and lowland field scatters, and if they do result from EBA manuring their presence suggests that intensive cultivation, perhaps using special fine-grade composts from which the heavy sherds had been removed, took place even on selected uplands. The presence of scatters on such unfavorable terrain suggests that during maximum urbanization there was considerable pressure on resources so that even marginal land was cultivated. Field scatters spread on lowland soils have not been delimited to their full extent, and for the purpose of computing total cultivated area the entire area of deep cultivable loams (shown as blank in fig. 6), is assumed to have been under agricultural production.

To summarize, sherd scatter analysis suggests that fields around Bronze Age centers were intensively cultivated and that territorial limits fell within the range specified by Chisholm (1979) for Old World traditional economies. However, the existence of a range of site territorial limits from 1 km up to 5–6 km (Wilkinson 1989) shows that there is no single limit; rather, larger settlements tend to be surrounded by territories of larger radius until a maximum figure is reached in the range 5–6 km.

Linear Hollows and Site Catchment Boundaries

Linear shallow hollows or soil marks that either cross the terrain intermittently or radiate from sites are additional features that aid in the definition of site territories (van Liere and Lauffray 1954; Wilkinson 1989, 1990*a*). Although some have been interpreted as ancient canals or runoff channels, they occasionally cross the landscape without regard for topography and even run up and over watersheds (Tsoar and Yekutieli 1993, Wilkinson 1993). This and the absence of evidence for hydraulic installations, tunnels, linear mounds of upcast, or other works make it unlikely that such features were ever dug for water conduction. Here the traditional view is retained that they are the courses of former roads, their hollowed appearance resulting from the continued traffic of humans and animals along them. The resultant concentration of runoff, combined with aeolian removal of dust, produces features equivalent to the hollow ways or sunken lanes of Europe (Jager 1985).

Although linear hollows were in use over many periods, their strong development around major sites with a significant Bronze Age occupation suggests that they were in use at this time. Linear hollows that cross the entire landscape may have been long-distance or interregional routes such as are mentioned in textual itineraries (Wilkinson 1990*a*:61). The presence of major or secondary centers on such routes implies either that ur-

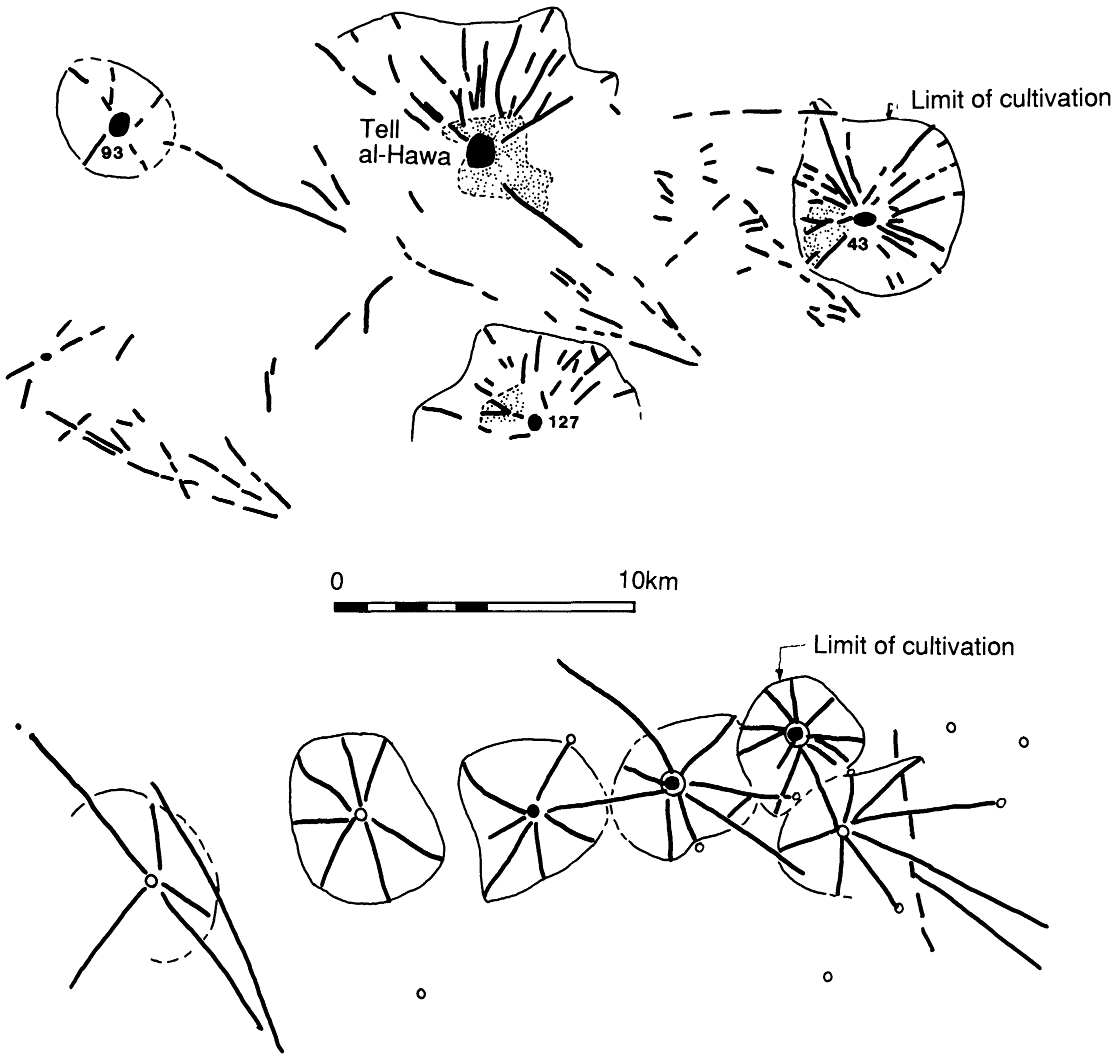

FIG. 8. *The use of radial hollows as proxy indicators of the limits of site territories and/or cultivation.* Top, *northern Jazira (dense sherd scatters stippled);* bottom, *part of the eastern Syrian Jazira, east of Tell Brak (adapted from van Liere and Lauffray 1954).*

banization took place along them or that they developed to link those centers. The shorter hollows that commonly radiate from EBA centers have a mean length of 2–4 km. Because linear hollows may partly develop from the concentration of movements along particular routes as a result of the enclosure of adjacent fields, it follows that where the landscape is less enclosed, the dispersion of people and animals across the landscape will be reflected in an absence of hollows (Crawford and Keiler 1928:154). Consequently, when not linked to satellite sites, the distal limits of hollows can be used as another proxy indicator of the limit of cultivation, in conjunction with or as a cross-check on the field scatters. Similar inferences from paved or rock-cut tracks have allowed the identification of catchment limits around Iron Age, Hellenistic, and Roman sites in the West Bank area of Palestine (Grossman and Safrai 1980:449; Dar 1986: 135). The catchment limits for the northern Jazira inferred from the approximate limits of radial hollows and for part of the Syrian Jazira using the map compiled by van Liere and Lauffray (1954) (fig. 8), when combined with those derived from field scatters, can be used to define the approximate cultivation zones of sites.

Ceramic Distribution and the Movement of Goods

Just as the presence of linear hollows around some sites suggests patterns of communication around early centers, differential distribution of ceramic types suggests the selective movement of goods. For example, in the Titrish survey area, different mid-/late-EBA sites exhibited significantly different proportions of ceramic types. In spite of these variations, the presence of fine wares allowed these sites to be dated with confidence to Kurban Höyük IV (i.e., mid-/late EBA). On sites that yielded large surface collections, the ceramics can be classified

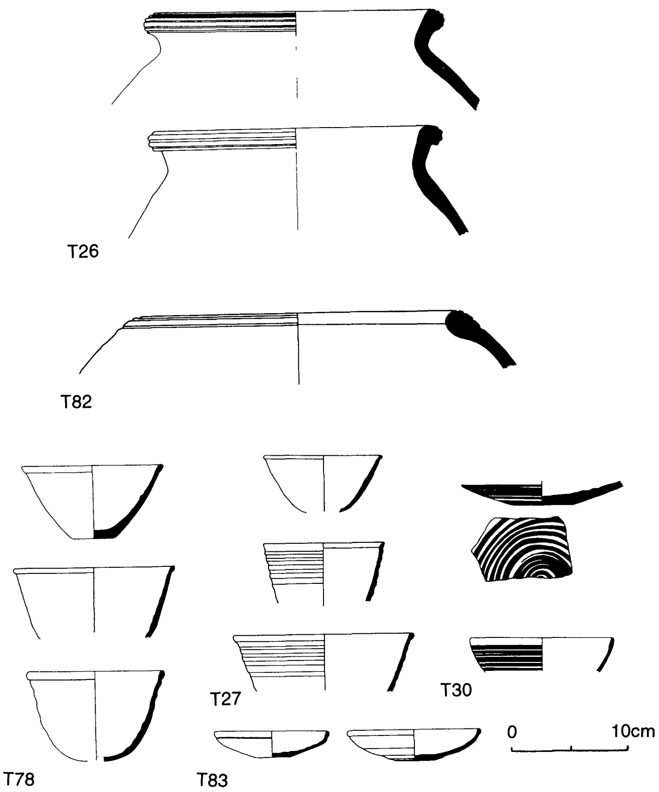

FIG. 9. *Major mid-/late-EBA (=Kurban IV) diagnostic ceramics used for the analysis of movement of products around Titrish Höyük (based on data from Algaze 1990).* T26, T82, *large (storage) jars;* T27, T30, T78, T83, *fine ware.*

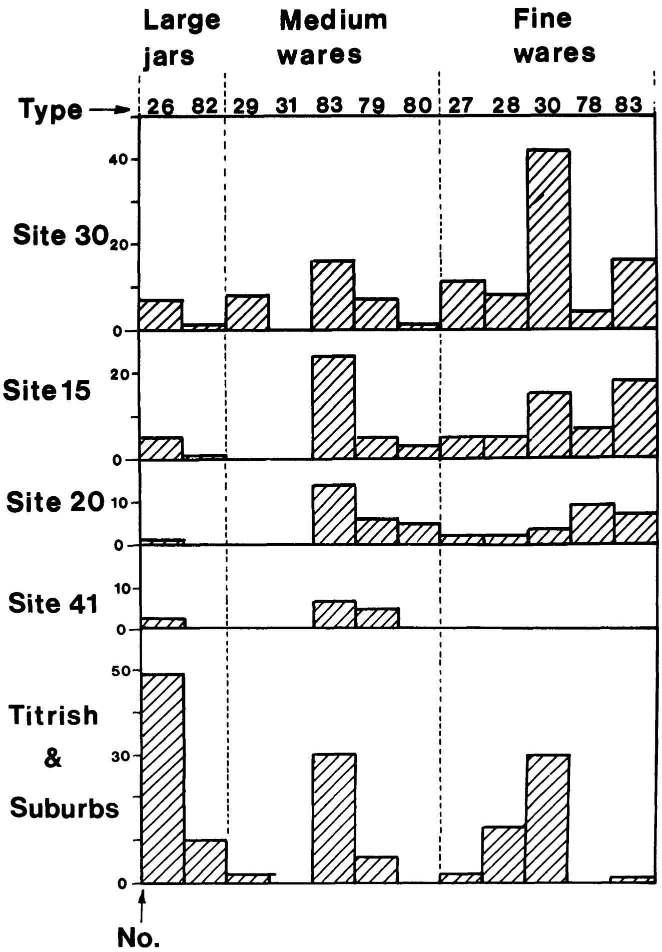

FIG. 10. *Pottery counts for Titrish Höyük and satellites (sites 15, 20, and 30), showing the underrepresentation of large storage jars in the satellites.*

into three broad types: large (storage) jars, medium wares, and fine (or table) wares. Fine-ware survey diagnostics include thin-walled "metallic ware" conical cups (Type 27 = KH Bowls 1 *c-e*) and body sherds (Type 28 = KH ware 02), body sherds of band-painted ware (Type 30 = KH ware 01), plain simple ware conical cups (Type 78 = KH Bowls 1 *c-e*), and small beaded-rim bowls in fine plain simple, metallic, or band-painted ware (Type 83 = KH Bowl 7*a*). The ceramics that show the greatest contrast between sites are type 26 large jars (= KH Jar 18*a* and 18*b* [Algaze 1990:318, pls. 70 and 71]; fig. 9). These were common at Titrish Höyük on all parts of the site including the suburbs (Wilkinson 1990*b:* fig. B.27, *16–21*) but rare on satellite sites 15, 20, and 30 and here only of a smaller variety less suitable for storage of large quantities of food. Medium and fine wares show no significant differences between the center and the satellites (fig. 10). The small site 41 represents a special case because its limited assemblage belongs to a slightly later ceramic phase (Kurban Höyük IVA) that coincided with decline at both Kurban and Titrish Höyüks. It may be significant that the site 41 assemblage includes storage jars, cooking vessels, and other medium wares but no fine wares.

Because care was taken during collection to cover the entire accessible area of all sites, collection bias is unlikely to have caused these differences, and therefore they may reflect functional differences between sites. Type 26 jars, with an estimated height of 70–75 cm and maximum diameter of ca. 52 cm (based on mean rim diameters of 32 cm), would have held some 90,000–100,000 cc of food or liquid. They are similar in volume to an Old Babylonian inscribed jar from Tell Rimah, which according to its inscription was capable of holding "1 homer, 5 sutu, 1/3 qu," some 119–121.3 liters measured volume (Postgate 1978:72). The slightly smaller Titrish example may have contained a little more than 1 homer (a donkey- or mule-load) of grain. Given that 50 liters of grain is a month's ration for an adult male (Liverani 1989:141), the grain contained within a single type 26 jar would have sustained one person for about two months.

The so-called fine wares, rather than being high-status wares, may simply have functioned as table or serving vessels, and therefore there is no reason to endow the satellite communities with particularly high status. Rather, the center may have had a particular need for a certain type of storage. This could be explained in a number of ways: (1) Type 26 storage jars may have been used for valuable commodities, such as oil or wine, that were likely to have been produced closer to the center because of their high labor requirement or value. (2) There may have been less need for storage in jars on the satellite sites because these were occupied only seasonally. (3) Large jars may have been used for everyday storage within the home, with the grain, lentils, cracked wheat, or flour they contained coming from storage facilities outside of the site. Part of the bulk storage at Titrish would have been in storage pits, a group of which was partly excavated in the northwestern area of the outer town (area 63–65 [Algaze, Misir, and Wilkinson 1992:37]). Such medium-term facilities, which are still used in the area, would have complemented built granaries similar to those at, for example, Tellul al-Thalathat (early 3d millennium B.C. [Fukai, Horiuchi, and Matsutani 1974]) and Tell Raq'ai (mid-3d millennium B.C. [Schwartz and Curvers 1992:416]), which were probably for public or institutional storage. Built granaries or pits would have provided the main storage facilities in both center and satellites and could have provisioned most of the town. However, the high demand for food grains within the central town may have made it necessary to import additional supplies from the satellite communities using soft, light containers of reed, cloth, or leather. These would have been transported by pack animal to the town and transferred directly to the homeowners' storage, each jar of which had the capacity of a storage bag. This parallels the pre-grain-elevator situation in the American Midwest, where the sack was the module of transport virtually from field to final destination (Cronon 1991). Such modules were individually owned by the producer until final sale and therefore maintained their unique identity throughout the transport system.

Although the physical evidence for system 3, the explanation favored here, is restricted to the storage jars themselves, a strong case can be made for production surpluses at the satellites and deficits at the center (see below). All three mechanisms may in fact have contributed to the concentration of storage jars at the central site. Each can be tested archaeologically. Stored materials may leave a residue; if no residue traces appear, the jars are more likely to have been used for storage of dry (or nonresinous) goods. Similarly, evidence for seasonal occupation of the satellite sites can be sought by excavation and floral and faunal analysis. Finally, comparative excavation of satellite sites and centers may permit the identification of significant differences in storage practice. Complementary studies of the movement of commodities such as meat from outlying places to the center can also throw light on the question of potential commodity flows (Wattenmaker 1987).

No clear pattern of ceramic distribution was detectable in the northern Jazira, where Tell al-Hawa, secondary centers, and satellite sites all seem to exhibit a full ceramic inventory. Only on the most distant outlying sites beyond the "nuclear" area of urbanization are large jars underrepresented. Three such sites (140, 152, and perhaps 177) exhibit a deficit of large vessels and may therefore have participated in such a supply network. However, without larger samples this case is difficult to sustain.

A Static Model of Production and Territory

In theory, if a settlement is part of a closed system and is surrounded by an agricultural territory of fixed radius, then potential agricultural production and therefore carrying capacity will depend upon (1) the size (radius) of the territory, (2) mean crop yield (or, more likely, the yield in a poor year [Halstead 1989:70]), and (3) available labor (Sumner 1989*a*:143). In accordance with field evidence, the settlement pattern here is considered to consist of a large central settlement, a number of nucleated secondary centers, and surrounding satellite villages. In what follows I will first present a simple theoretical model illustrating the relationship between production, labor supply, settlement, and population. Then I will develop a preliminary empirical model that relates crop production within site territories to the measured sizes of the contained sites for the case-study areas. Both models examine how a given settlement may grow in relationship to the productive potential of its surrounding territory and then as neighboring territories are allowed to become tributary to growing centers.

Territorial radius can be estimated from the spacing of settlements, the distribution of off-site sherd scatters, and the fade-out point of radial hollows. Crop yield[2] depends upon distance from the site, soil type, and rainfall. For the initial model, crop yield is held constant irrespective of distance, soil type is assumed to be uniform, and production is assumed to vary directly with rainfall, high-rainfall years giving high production and low-rainfall years low production.[3] For heuristic purposes, population density is held at 100 persons/ha. Crop production is expressed as the number of persons it can support, assuming that each individual annually consumes 250 kg of cereal products. Hence, an annual production rate of 500 kg/ha is equivalent to 2 persons/ha and with biennial fallowing to only 1 person/ha. Crop production averaged for a 5-km-radius territory is assumed to be equivalent to 2, 1, 0.5, and 0.25 persons/ha.[4] It is further assumed that half the population is engaged in agriculture, a harvest season lasts for two months, each field worker is capable of harvesting 1 ha

2. In this case yield of wheat or barley is assumed. In fact, with increased intensification around growing urban areas it is likely that on some land near the town wheat or barley was replaced by high-value pulses or vegetables (and, in moister areas, vines [Faroqhi 1984:197]). However, grain must have remained the main source of food, and here, for purposes of simplicity, all calculations are based upon grain. This can be viewed as grain per se or the economic wheat equivalent (for a discussion see Hillman 1973).

3. A slight oversimplification of a complex topic—see Hadjichristodoulou (1982) for a discussion.

4. That is, each person requires 0.5, 1, 2, and 4 ha; this compares with 0.5–1.5 ha/person (Kramer 1982:184–87) and 1–9.5 ha/person (Sumner 1989*a:* table 10). For the Leilan area 3 persons/ha was chosen (Stein and Wattenmaker 1990).

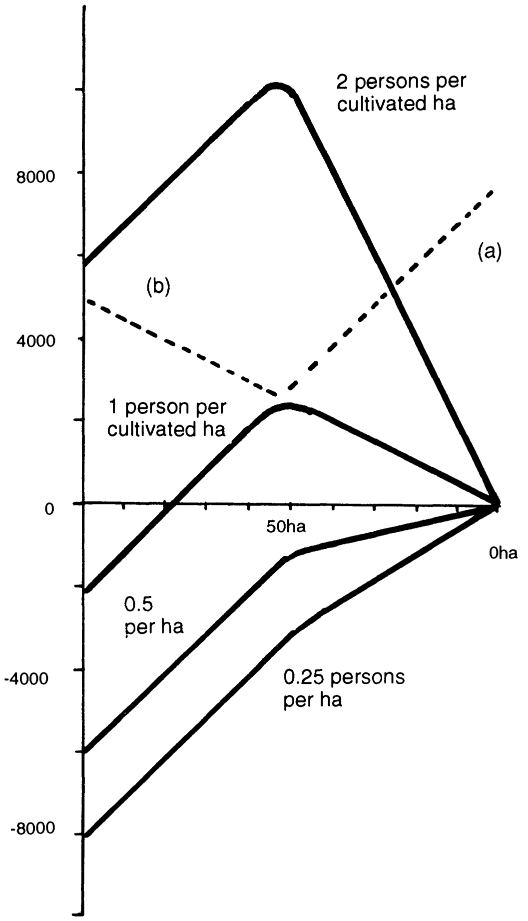

FIG. 11. *Change of surplus or deficit crop production, expressed in terms of the number of persons that the cropped land could support, according to labor supply and size of site for hypothetical 5-km-radius territory. Individual graphs indicate productivity levels employed.*

in 20 days (i.e., 3 ha in a harvest season [see Russell 1988]; cf. 4 ha suggested by Sumner 1989*a*:143), and demand is greater than is required by the population of the contained settlement (i.e., when the settlement is small, an adjacent center could act as a market for the excess grain). When sites are small, production will be limited by available labor (fig. 11). Thus, as the site grows in size and population, its potential productive capacity also increases. However, with growth in population the available labor will eventually exceed the labor required, because, for a finite site catchment of 5-km radius (ca. 7,850 ha), increased population is not matched by a proportional growth in available land. As a result, the labor requirement hits a ceiling of 2,620 persons, at which point total production will peak and surplus production will decline, the resultant labor surplus being available for activities not directly related to primary food production. When production falls below a certain figure, the labor force will harvest only enough to supply itself and the nonagricultural population with food. If half of the population is engaged in agriculture, each field worker will need to support one other person, and at the very least the food requirement for two persons (i.e., 500 kg) must come from the 3 ha harvested for the system to operate without a deficit. In other words, a minimum yield of 500/3 = 167 kg/ha is required to support the population. This figure of 0.66/ha, being the break-even point, would fall on the horizontal axis of figure 11.

Each curve has two components, illustrated here by the 1-person-per-ha curve: (*a*) assuming unlimited labor and (*b*) assuming a labor force amounting to half of the center population where the size of the agricultural territory is unlimited (or, alternatively, crop production is increased per hectare so that greater labor inputs are required per hectare). For the conditions stipulated, however, as the settlement increases in size, surplus production rises until site territory operates to constrain production, at which point it declines. Assuming moderately good production equivalent to 1 person/ha, the site territory is capable of generating sufficient surplus to support 2,500 extra persons, but below the break-even figure of 0.66/ha no surplus is generated. Assuming that production is sufficient to supply the population in a year of poor yields (Halstead 1989:70; in this case 0.66–1 person/ha), with a territorial radius of 5 km the site will suffer a deficit when population exceeds 6,000–8,000, which would be accommodated in an area of 60–80 ha. If the site grows beyond this point, it will have to rely on surplus production from the adjacent sites, which—depending upon their catchment geometry—will be similarly constrained by the interacting forces of production and labor supply.

This model suggests that as population of the central settlement increases beyond a critical point, unless the site territory can be increased in size it will be necessary to increase production by intensification (that is, raising crop yield per hectare) or by importing surplus production from neighboring secondary centers or satellites. These principles can be tested with field data.

The off-site sherd scatter data indicative of intensive cultivation, when combined with a limit for permanent cultivation inferred from the lengths of radial hollows, suggest that territorial boundaries were 2–4 km from most tells (see fig. 8). For the northern Jazira, modular catchments of 5-km radius are suggested by the field scatters, length of hollows, and the distance of secondary centers from Tell al-Hawa (8–12 km). These extended catchments can be subdivided into an inner zone of intensive manuring and cultivation of 1–2 km radius and intermediate and outer zones of lesser intensity of cultivation. Beyond this, either cultivation was low-intensity with long fallow intervals or the land was under steppe-pasture.

Around Tell Sweyhat, where radial hollows are less well developed, the distribution of field scatters suggests that virtually the entire cultivable area around the site was cultivated, again with diminishing intensity toward the margins. Crop production figures are based upon the surrounding field scatters of ca. 4-km radius. Because the small satellite sites were of indeterminate EBA date, they were not used in the computations.

At Titrish, land-use zones can be inferred only from a partial pattern of sherd scatters and the distribution of cultivable soils. A 4-km radius catchment with satellite catchments of 1.5–3.0-km radius has been generated using Thiessen polygons and site distributions and by analogy with the field-scatter distributions around Tells Sweyhat and al-Hawa. Qualitative observations of the limited field-scatter data suggest that large EBA jars extend to at least 3.5 km from Titrish. The rarity of these jars on the satellite sites implies that they probably arrived by manuring from the center rather than from satellites, a datum that provides support for a 4-km agricultural catchment, and the presence of satellite mounds at sites 30, 22, and 11 indicates that for them to have catchments at all the Titrish catchment could not have extended much more than 4 km. Although less satisfactory than the catchment limits derived for Sweyhat and al-Hawa, these boundaries are both plausible and internally consistent. Crop production from these idealized circular catchments has been estimated by diminishing the catchment radius to allow for the area taken up by uncultivable soils.

Crop yields must have varied in the Bronze Age, as they do today, with the amount and distribution of winter rain and the techniques of land preparation (Hadjichristodoulou 1982, Shepherd et al. 1987). Modern cereal yields averaging 700–900 kg/ha for the northern Jazira and 965 kg/ha for Urfa province seem high compared with estimates of 630 kg/ha at Aşvan near Elaziğ (Hillman 1973:227) but fall within the range of 500–1,500 kg/ha for Palestinian barley and hard wheat (Zohary 1969:56). To allow for this variation in yield, as well as biennial fallowing, a suite of graphs inferred from the decline of field-scatter densities was generated to simulate the decline in land-use intensity and crop yields away from a central site under a range of productivity or rainfall conditions (fig. 12). Although decline in crop production can be expressed as either net or gross (Chisholm 1979:40–45), here only gross decline is considered. Mean annual yield (averaged over a number of years) is assumed to decline as decreasing amounts of manure are applied (Wilkinson 1982) and as the fallowing interval increases with distance from the central settlement (Hillman 1973). As a result, although yields in any one year may be maintained, long-term production decreases with distance. Although biennial fallow is the accepted practice in these regions, with maximum urbanization and population stress this principle may have been violated, part of the area being devoted to annual cropping. Hence, the highest-yield graph could mean either 800 kg/ha production (near site) annually or an average of 800 kg/ha over two years under a biennial fallowing regime. This could entail a very high productivity of 1,600 kg/ha one year being followed by a fallow year of zero production. We can assume that although the actual practice may have included any combination of these two extremes, the average for any one year is as indicated by the curves. To allow for future planting as well as storage losses, 60 kg/ha for seed and 5% wastage have been assumed. The decline in yield from the central site

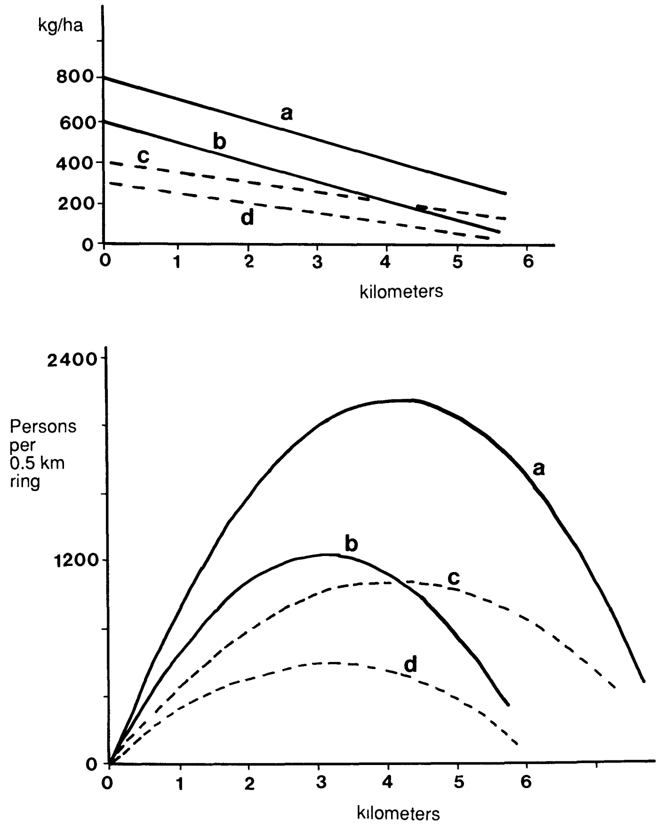

FIG. 12. *Decline in average yield away from a hypothetical center, based upon near-site productions of 800, 600, 400, and 300 kg/ha declining with distance from the center at prescribed rates* (a–d) *and* (below) *total production per 0.5-km land-use ring derived from these yield declines.*

is taken as 100 kg/ha/km for the higher-yield values of 800 kg/ha and 600 kg/ha. Because the straight-line decline for 400 kg/ha would give an unrealistic yield of zero at 3.5–4 km, a lesser decline of 50 kg/ha/km has been adopted for yields of 400 kg/ha and 300 kg/ha. The assumed decline in land-use intensity and therefore crop yield allows the estimation of total production for arbitrary 0.5-km-radius rings around each site, production being crop yield multiplied by the area of the ring in question. Without the constraint of labor, production (expressed as the population the land would support) from each ring would gradually increase with distance, reaching a peak at 3–5 km from the site. Beyond this, peak total production would decline progressively because the low yields would fail to compensate for the progressive increase in the area of the ring. However, owing to the constraint of limited labor, smaller sites would have insufficient labor to harvest such large areas during years of high productivity, and production would be significantly less than predicted by this curve.

From the estimated crop yields for the site territories of the three case-study areas and calculations of surplus or deficit production, we can examine surplus and defi-

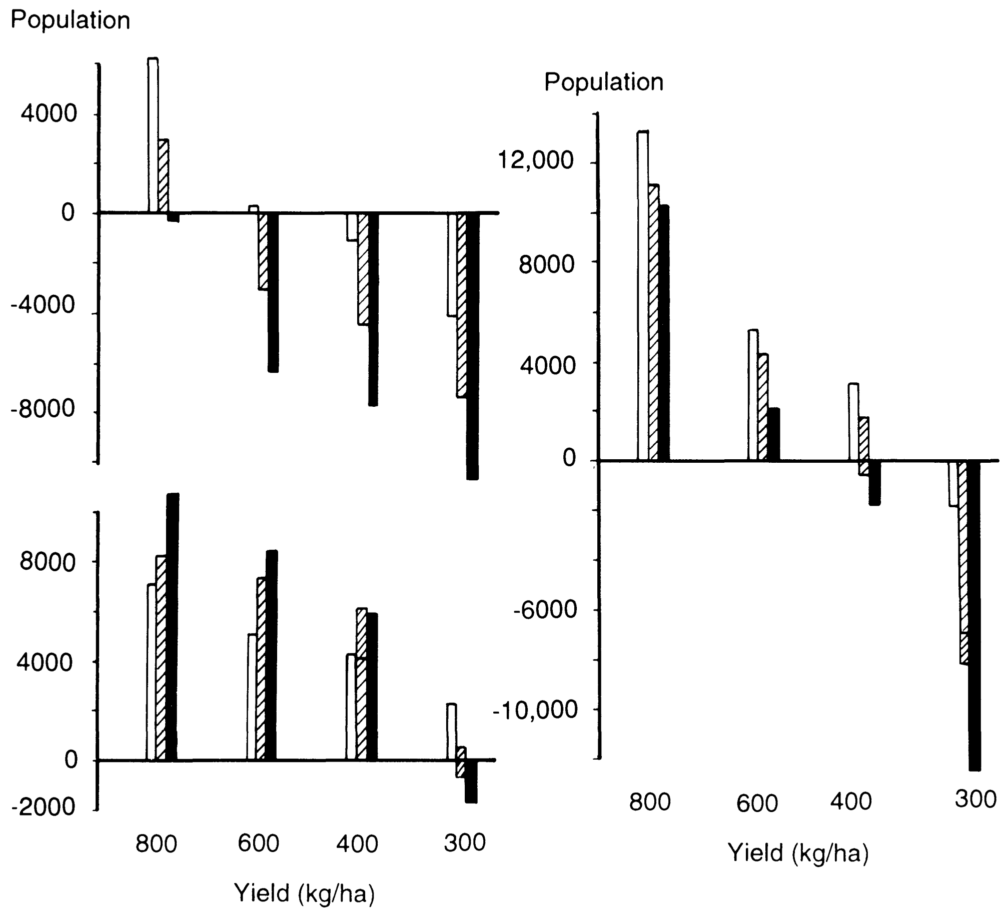

FIG. 13. *Surplus and deficit production (in persons supported per hectare) at different levels of yield generated by* (top left) *Tell al-Hawa,* (bottom left) *its secondary settlements, and* (right) *the settlement system as a whole at various population densities* (white bars, *100/ha;* shaded bars, *150/ha;* solid bars, *200/ha*).

cit production both for centers and satellites separately and for total systems. In high-yield years Tell al-Hawa (fig. 13) would have produced more than it required, but in years of moderate to low yields (often but not necessarily drier years) it would have suffered a deficit. The deficit at the center would have been approximately offset by surplus generated at the three secondary centers (sites 43, 93, and 127), which exhibit substantial surpluses during high-to-moderate-yield years but lower surpluses or even a slight deficit in the worst years. To allow for the uncertainty of settlement population densities, surplus/deficit calculations have been made assuming population densities of 100, 150, and 200 persons/ha, figures that encompass the expected range for traditional communities in the Middle East (see Hassan 1981:66–67; Kramer 1982:163; Sumner 1989*b*). Increasing population would have benefited the secondary centers in high-yield years because with higher site population density more labor would have been available to harvest more crops. In lower-yield years there would have been less food than the inhabitants required, and the secondary centers, especially those with larger populations, would have sustained a deficit. The entire system would have experienced a surplus in high- and moderate-yield years and a deficit in low-yield years. If site population densities reached 200 persons/ha this deficit would have been catastrophic.

A similar pattern emerges for the Titrish area (fig. 14), where deficits at the center are offset by the modest surplus generated by the satellite communities. Again, the effect of labor availability is evident, and high site population densities result in a general deficit during years of low yield.

The pattern is more extreme in the Sweyhat area (fig. 15) either because significant satellite sites (which would have extended the effective radius of cultivation) were lacking or because of shortage of cultivable land on the surrounding terrace. If occupied at the modest population density of 100 persons/ha, the site territory would probably have produced sufficient food except in the lowest-yield years. If site population density had been higher, however, a significant deficit would have been experienced even with yields as high as 600 kg/ha, and these would have been unattainable in such a marginal location.

The catastrophic declines experienced at high site population densities suggest (at the risk of some circularity of argument) that such high densities are unlikely

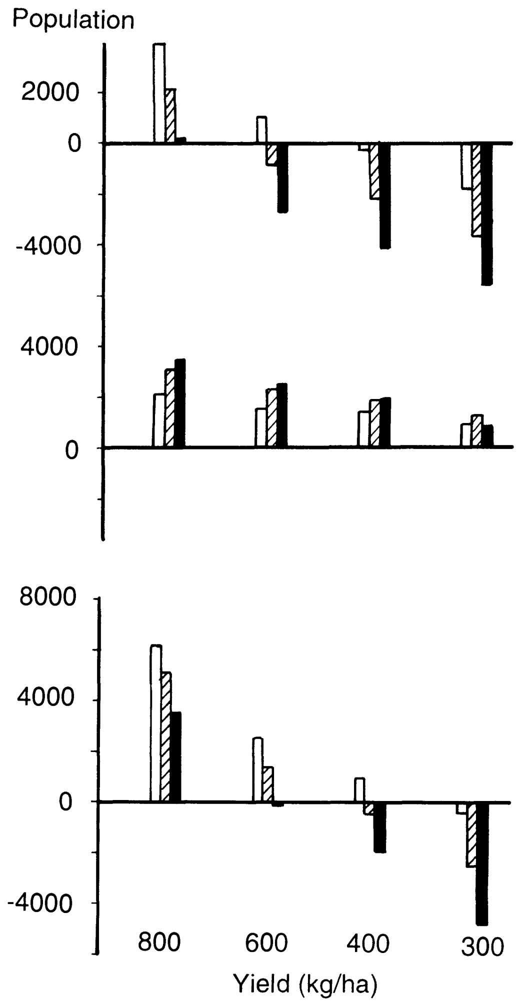

FIG. 14. *Surplus and deficit production (in persons supported per hectare) at different levels of yield generated by* (top) *Titrish Höyük,* (center) *its satellites, and* (bottom) *the settlement system as a whole at various population densities* (white bars, *100/ha;* shaded bars, *150/ha;* solid bars, *200/ha).*

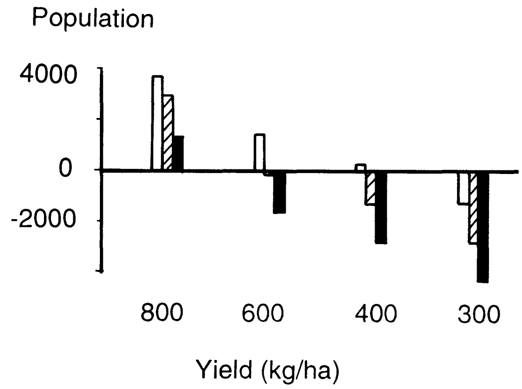

FIG. 15. *Surplus and deficit production (in persons supported per hectare) at different levels of yield generated by Tell Sweyhat at various population densities (*white bars, *100/ha;* shaded bars, *150/ha;* solid bars, *200/ha).*

to have been reached. With site population densities of 100–150 persons/ha, the systems would have been roughly in equilibrium, with deficits at the center being offset by surplus production from the adjacent sites. However, if site population densities were around 200/ha or even greater, then none of the systems would have been in equilibrium in normal to low-yield years and it would have been necessary to import food from beyond the settlement systems defined here. Such a situation would have entailed longer-distance transport of bulk products. Similarly, if the settlements discussed exceeded 50–60 ha, then the system either would have suffered substantial deficits or would have had to import significant quantities of food. If mean crop yields had declined below 400–300 kg/ha for Tell al-Hawa and Titrish Höyük at least, food supply would have been insufficient for the inhabitants.

The considerable overlap of the sustaining areas of Tell Leilan and Mohammed Dhiab in northeastern Syria suggests that these sites too must have been close to maximum production (Stein and Wattenmaker 1990: fig. 9). The fragility of the equilibrium that prevailed around many major centers in the Jazira probably made such settlements very vulnerable to famine precipitated by climatic fluctuations.

Settlement Dynamics and Climatic Fluctuation

In addition to major climatic changes, for which we have little evidence in the Jazira for the past 5,000 years (Bottema 1989, Gremmen and Bottema 1991), the area would probably have experienced a number of prolonged droughts per century which could have had a significant effect on agricultural production (Neumann and Parpola 1987). Although no local tree-ring data are available, a 1,000-year record for Morocco from an area of similar climate suggests that clusters of dry years signifying major droughts have occurred once or twice every century (Stockton and Meko 1990: fig. 1.15). Applying such a frequency to Upper Mesopotamia, it is likely that five to ten significant droughts occurred during the millennium-long Early Bronze Age.

Tell Sweyhat, which experiences a mean annual rainfall of around 250 mm, is climatically marginal for crop production today. This is illustrated by the simulated run of 30 years' annual rainfall (fig. 16) calculated from the mean rainfall of 250 mm increased or decreased for each year in direct proportion to that for the site of the nearest long climatic run, Aleppo. (The justification for this calculation is provided by the high correlation in rainfall between Qamishli and Aleppo, some 370 km apart.) The vulnerability of local production at Sweyhat is apparent from the center curve, which shows 6 years with rainfall less than 200 mm in the 30-year period, a frequency that could result in crop failure perhaps 1 year

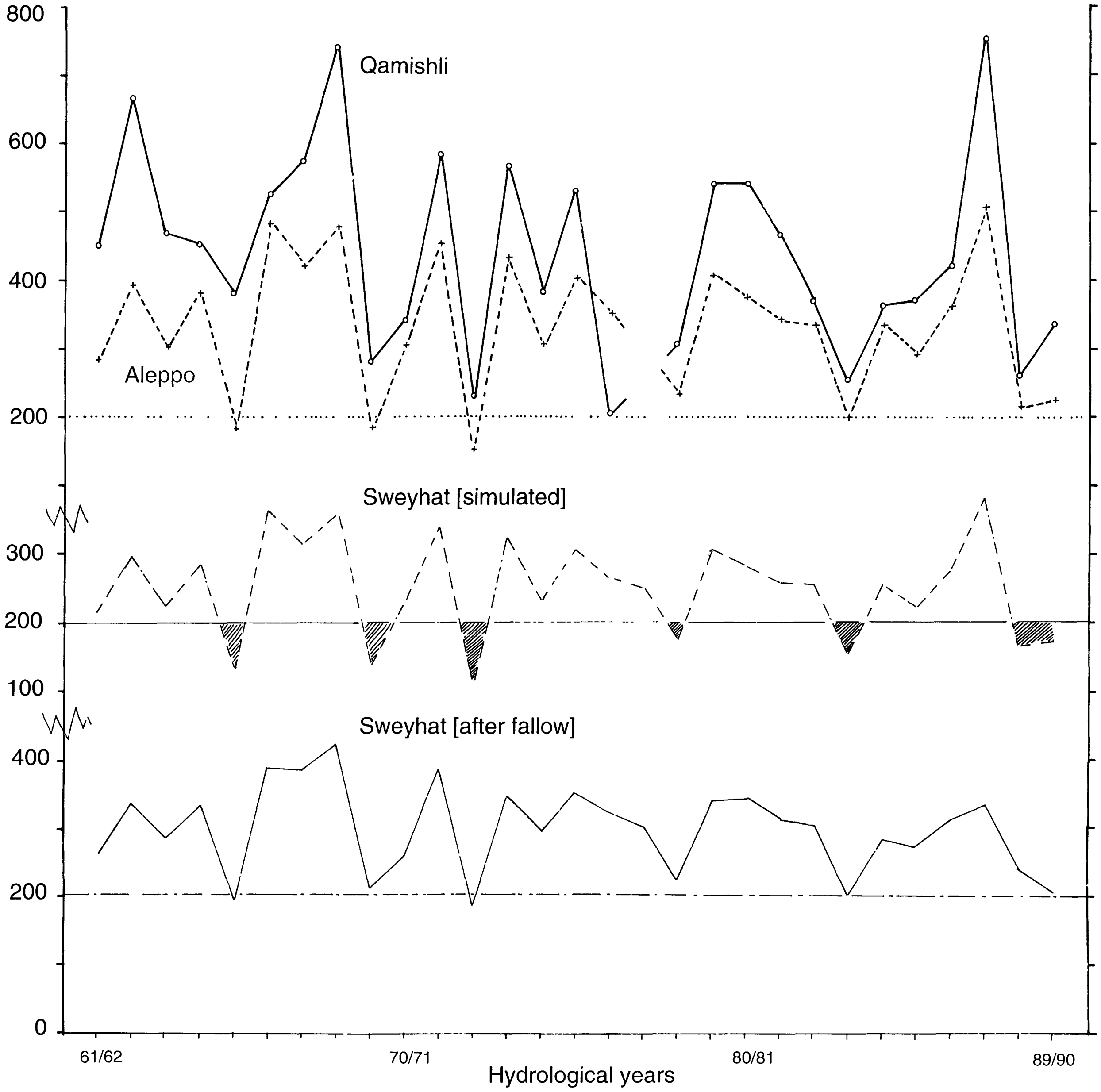

FIG. 16. *Rainfall fluctuation in the Jazira from 1961 to 1990.* Top, *recorded mean annual rainfall for Aleppo and Qamishli;* center, *simulated mean annual rainfall for Tell Sweyhat calculated from mean of 250 mm increased or decreased in proportion to Aleppo curve;* bottom, *Sweyhat curve incorporating a 20% carryover of rainfall from the preceding year. The chronological scale is expressed in hydrological years (September through until September) so that the entire winter's rainfall is expressed in one statistic.*

in 5. Incorporating a fallow year into the annual farming calendar makes it possible not only for soils to recover their fertility but also to carry over some of the rainfall from the fallow year into the year in which the crop is grown (Janssen 1970:22; Andreae 1981). If fallowed fields are maintained free of weeds, the moisture carryover can be 15–20%, thus increasing effective soil moisture (Brengle 1982:73–101). The bottom curve allows for an additional 20% of moisture carried over from the previous year. Because this carryover is high after a wet year and low after a dry one, there is a reduced likelihood of dry years and crop failures. Critical for the inhabitants of early towns is that during periods of maximum urbanization there may have been a temptation to cultivate annually in order to maximize crop yields, especially if manuring was practiced. Violating the fallow regime would have increased the likelihood of crop failures. Yield maximization in this way is characteristic of "brittle economies" and contrasts with the extensive "resilient" economies that have a better long-term chance of survival in semiarid environments (Adams 1978; Halstead 1990:191; for a related example of violation of fallow see Gibson 1974). The effect of fallowing would vary depending upon the propensity of the soils to store soil moisture. For example, rolling upland soils, which exhibit lower moisture retention than lowland soils, would have been more vulnerable to crop failure (Mohammed 1955:147). In the case of Tell Sweyhat, the expansion of cropped area would have entailed cultivation of the marginal rolling steppe, characterized by coarser, more drought-prone soils. Therefore, systems that maximized production would again have been vulnerable to drought. If a significant population collapse did result, cultivation could have been concentrated upon the potentially moister soils that would have benefited from limited overbank flow from wadis or runoff from adjacent slopes.

Rainfall statistics from Aleppo and Qamishli indicate that a dry year in one area would also have been a dry one elsewhere in the Jazira. Consequently, during dry years there would have been little opportunity to import food from adjacent regions even if it had been economically feasible. Instead, as is occasionally noted in the cuneiform texts, there would have been a tendency for starving inhabitants to go in search of food (e.g., Jean 1947:70), perhaps traveling long distances, even outside the region. A run of dry years such as those characteristic of Morocco or the American Great Plains might have induced collapse. Large-scale events such as that suggested for the Leilan area around 2200 B.C. (Weiss et al. 1993) would have been catastrophic given that the systems of agricultural production probably approached maximum capacity. Future work on urban collapse in the rain-fed farming zone will benefit from the large literature on desertification in the African Sahel and adjacent regions that underscores the "combined impact of adverse climatic conditions and the stress created by human activity" (Kemp 1991:54; Verstraete 1986) and the fact that human responses to drought may produce new patterns of behavior and social interaction that absorb the stress (Minnis 1985:32–43).

Early State Modules and Sustaining Areas

We have seen that surplus production from secondary centers and satellite communities can offset the deficit incurred within the catchment of the prime center. The populations of Tell al-Hawa and Titrish Höyük could have been supported in all but the worst years by their immediate territories and those of their neighboring tributary settlements. However, labor availability within satellites and secondary centers would have limited production in good years to the amount that could be harvested. Thus it would have been necessary to offset deficits at the center by storage of production from good years. The situation of communities aiming to be self-sufficient in bad years is consistent with the "normal surplus" of traditional cultivators who aim to cultivate sufficient land to ensure a food supply in seasons of poor yields (Allan 1965:38; Halstead 1989:70). At Tell Sweyhat a deficit would have been incurred even during moderately good years, and given its climatically marginal position this could have been disastrous. However, its location within 4 km of the Euphrates floodplain would have enabled it to import irrigated grains from riverside sites (sites 24, 27, and 8) when necessary. This is supported by recent archaeobotanical work at Tell Jouweif, 4 km southwest of Sweyhat, where six-row barley has been identified among the carbonized plant remains (N. Miller, personal communication, 1992). The frequent association of this crop with irrigation (McCorriston 1992:324–25) suggests that enclaves of irrigated land on the nearby floodplain could have offset shortfalls at Sweyhat.

It is now possible to model cereal production for two idealized settlement systems set within an isotropic plain in which soils and water supply are evenly distributed. Such an environment gives no particular advantage to any one location over others except that of distance from the center. Crop production data are generated first for individual modular catchments of 5-km radius and then for seven catchments[5] of 5-km radius forming a compound region (fig. 17). Catchment production is again calculated on the assumption that site size and settlement population will be in equilibrium with the lowest yield that will enable the settlement's population to survive (i.e., 300 kg/ha). Thus 5-km-radius catchments will support communities of some 2,500, each of which will occupy a site of 12–14 ha (fig. 17, *top*). If a hierarchy develops, each of the six adjacent catchments will be expected to contribute a surplus to the center, as long as there is no labor shortage (it is assumed that symmetrical contributions will occur from all 6 surrounding catchments). These scenarios are displayed in table 3, which requires that equal-sized secondary catchments containing arbitrarily smaller and smaller secondary sites contribute progressively larger surpluses to the center. Surplus production from the secondary sites enables the center to grow, its final size being dependent upon whether the secondary sites are larger (therefore consuming most of their production) or smaller (therefore having more to contribute to the center). The constraint of labor availability requires that only if supplementary labor was made available by the forced transfer of population or as a result of visits by nomadic groups would it have been possible for smaller secondary centers to supply greater production than indicated. It could be argued that the use of animals to work large areas with a limited labor force could raise production per unit of labor (Hunt 1987:148; Halstead 1992:111), but a substantial labor force will still be necessary during harvest time, when the work animals will be of limited use. As before, I have assumed that half of the settlement's population is engaged in the harvest and that site population densities are 100, 150, and 200 persons/ha. Depending upon the percentage of inhabitants involved in the harvest and site population density, secondary sites will have the potential to produce the

5. See Johnston (1980:55–57) for a related geographical model based upon more general assumptions.

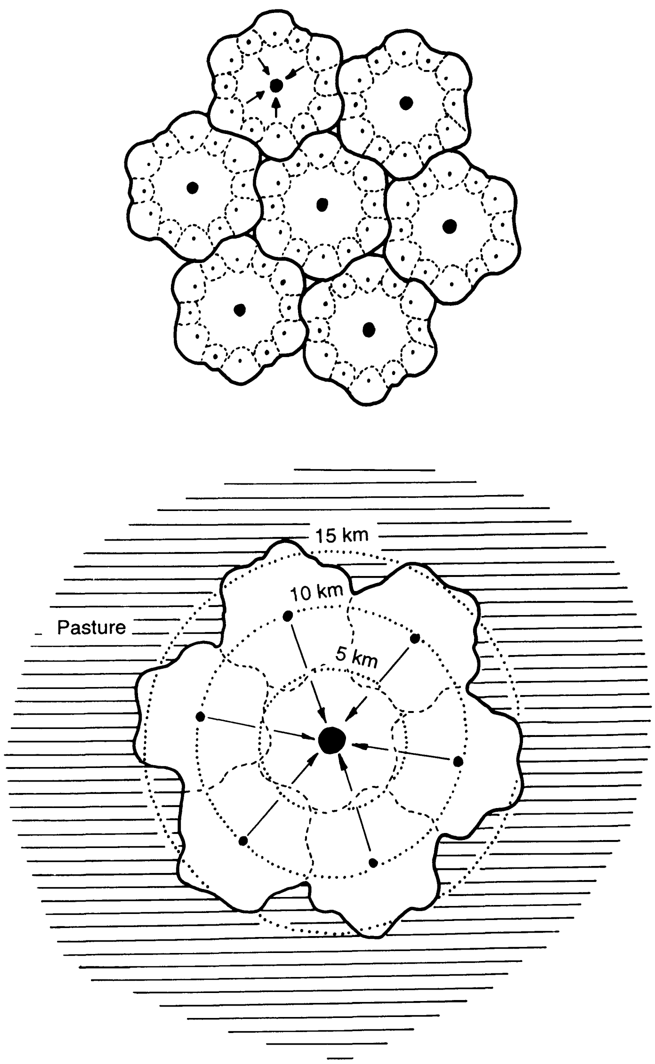

FIG. 17. *Modular catchments illustrating the transformation from seven individual territories each of 5-km radius* (top) *to a compound catchment incorporating the seven individual catchments* (bottom). *Because the lowest-order satellites may be temporary features of the landscape, they have been omitted from the lower diagram. Modified circles have been used to facilitate packing; production figures used in text have been calculated from circular catchments.* Shaded area, *pasture.*

necessary cereals to supply the growing centers. To maintain optimum labor supply, secondary sites of 10–20 ha will be more likely, in which case centers could attain a size of 27 ha (200 persons/ha) to 84 ha (100persons/ha); maximum populations of 11,734–14,374[6] occupying an area of 72–114 ha will be plausible depending upon site population density.

6. In contrast with a total population of 28,000–30,000 for center and six adjacent satellites, Hunt's calculation suggests (albeit for an irrigated economy) that an early state of some 100,000 population could have been supported by a production zone of 12–17-km radius (Hunt 1987:144–46).

It appears that a threshold is crossed when the system changes from individual 5-km-radius catchments to compound catchments, and with the crossing of this threshold, population at the center can rise from ca. 2,500 to between three and five times this figure. Similar jumps can be observed in the archaeological record. For example, at Leilan there was an explosive expansion in the area of the center from ca. 15 ha during the early 3d millennium to between 75 and 100 ha around the middle of the millennium (Weiss 1989, Stein and Wattenmaker 1990), and Titrish Höyük probably expanded from between 3 and 15 ha to some 38 ha. In the former case this increase occurred when a number of semiautonomous small centers became integrated into a larger system as the result of the growth of Tell Leilan at the center (Stein and Wattenmaker 1990:12–16). Although it is not clear whether this change was caused by endogenous or exogenous factors, the change in catchment geometry would have allowed growth up to a ceiling of 70–120 ha. Allowing for the presence of large public building complexes that require large areas but have few inhabitants, the ceiling could have risen to close to the combined areas of Leilan and Mohammed Dhiab (i.e., 140–150 ha). To exceed this it would have been necessary to incorporate further 5-km-radius catchments, in which case not only would further thresholds have been crossed but also the frictional effect of increased distance from the center would have reduced the efficiency of transport of goods. This would have been particularly marked if the adjacent catchment was also a compound catchment housing a small center. Although the nearest small center would have been only some 10 km distant (say, a five-hour return trip at 4 km per hour), the next tier of centers would have been about 20 km distant, and it would have been inconvenient from this distance to visit (or supply) the main center, transact business, and return home within the same day.

Being based upon the concept of the isotropic plain, this urban/territorial model may be more appropriate to the northern Jazira around Tell al-Hawa and areas of similar topography elsewhere in the Jazira than to the region as a whole. The boundary between the main cultivated area and the next modular system would have been about a day's round-trip from the center. Equivalent "early state modules" recognized elsewhere in the Old World include the Susiana plain, where during the Middle Uruk period a 20-km radial distance may have been the maximum limit of direct control from any given center (Johnson 1987:115). This one-day round-trip distance from the center may be related to the ability of rural inhabitants to avail themselves of center services. Similar modules have been hypothesized to cover an area averaging 1,500 km^2, with perhaps 40 km between adjacent centers, but varying in size depending upon social and physical factors (Renfrew 1975:14). The compound-catchment model would result in regional modules of ca. 15-km radius with adjacent centers about 28–30 km apart. Such tight packing would have severely constrained the pastoral sector that was a crucial component of the Bronze Age economy (Gelb 1986, Zeder 1991)

TABLE 3
Sizes and Populations of Centers and Secondary Centers

Population Density	Area (ha)/ Population of Secondary Site	Surplus Production (Center/Total)	Area (ha)/ Population of Prime Center
100 persons/ha	25/2,482	0	24/2,482
	20/2,000	482/2,892	48/4,892
	15/1,500	982/5,892	84/8,374
	10/1,000	1,482/8,892	114/11,374
150 persons/ha	17/2,482	0	17/2,482
	15/2,250	232/1,392	26/3,874
	10/1,500	952/5,712	55/8,194
	5/750	1,732/10,392	86/12,874
200 persons/ha	12/2,482	0	12/2,482
	10/2,000	482/2,892	27/5,374
	5/1,000	1,482/8,892	57/11,374
	25/500	1,982/11,892	72/14,374

NOTE: Potential population, calculated from a base yield of 300 kg/ha per annum less 50 kg/ha for seed, for a 5-km radius catchment = 2,482; labor requirement, based on Russell's (1988:131, table 41) report of 20–23 hours for cultivating 1 dunum (0.1 ha) using animal traction and early metal technology = 500–1,000 hours, assuming half the population engaged in cultivation. Surplus production expressed as number of persons that could be supported by it.

and perhaps instead can be regarded as an absolute minimum for settlement spacing. Because fallow fields within the main cultivated zone would probably have been insufficient for the large flocks emanating from such centers, it is more likely that the periphery of many catchments consisted of extensive areas of pasture or steppe inhabited by nomadic pastoralists or settlements that had looser ties with the center.

Discussion

The proposed models are all powered by the combined surplus production of growing centers and their satellites and secondary centers. If land-use intensity increased in proportion to population, the system must have become more brittle and prone to collapse, especially as centers approached 100 ha. This is not to suggest a rigid ceiling on site size; if prevailing conditions allowed a center to increase in size still further, a higher threshold would have been crossed and the system would have expanded, probably again rather abruptly. Owing to the constraining effects of land transport cost and the convenience of being within one day's round trip of the center, such higher-level transformations were probably rather uncommon. In recognizing the existence of thresholds, this construct suggests that there should be specific reasons for settlements significantly exceeding 100 ha. These may be factors inherent in the developing economy or the result of political, defensive, or geographical conditions. For example, near rivers, as in southern Mesopotamia, the use of boats would have allowed bulk food items to be transported relatively cheaply, thus nullifying the frictional effect of distance (see Greene 1986:39–43; Weiss 1986). As a result, sites like Uruk/Warka (Early Dynastic I = early 3d millennium B.C.) appear to have expanded to cover some 400 ha and were capable of housing 40,000–80,000 people (Adams 1981:85; see also Boehmer 1991:468). Textual evidence even suggests that grain movements by boat from southern Mesopotamia were probably sufficient to contribute significantly to the provisioning of some towns on the shores of the Gulf (Leemans 1960:20–22; Edens 1992:127). Although opportunities for boat transport were limited in Upper Mesopotamia, it would have been possible on canals along the Khabur (Ergenzinger et al. 1988) and Balikh Rivers and might have permitted the occasional growth of towns beyond the limits suggested here. Alternatively, monopoly of a particular resource or the existence of an irrigation system might have allowed higher and more dependable yields, thus enabling towns to increase above the normal limits. In general, though, the proposed mechanisms may have operated over much of the rain-fed steppe of Upper Mesopotamia, and the opportunities for growth beyond the stated figures would have been limited. Whatever the cause of urbanization, the social/administrative entity, be it a chiefdom, state bureaucrats, or a semiprivate system, would have had to deal with the problems of production and supply described here.

Labor surplus at the growing center would have contrasted with labor deficiencies in the outlying territories, but whether this imbalance was ever redressed by seasonal migration is unclear. Although the scale of the system may have been adjusted to low-yield years, during high-yield years the entire available population of the center may have been occupied during the harvest period. This underscores the dynamic nature of economic systems in climatically marginal dry-farming zones, where high-yield fluctuations would necessitate high labor mobility or episodic seasonal unemployment—a situation that could have been turned to the advantage of the administrative elite.

Insufficient emphasis has been placed upon the role of animal production or nomadic pastoralism here, partly because of the type of field evidence employed: field scatters, radial hollows, and movement of cereals all relate to cultivation. However, by defining both the intensity and the limits of the "sown" lands it should be possible to sketch, albeit by default, the important pastoral component of early states. For example, in the northern Jazira, a conspicuous gap in the EBA settlement pattern may have represented new pastoral land developed at the expense of former late Chalcolithic settlements in order to supply the growing centers (Wilkinson 1990*a*:61 and fig. 6). A pattern of peripheral areas' contributing livestock to the central economy, thus saving on the transport of products over long distances, can also be suggested for the Aegean (Halstead 1992:109) and makes an attractive case for the development of specialized regional economies. In turn, such pastoral areas could also have provided the occasionally needed reservoir of seasonal labor.

An additional inadequacy of the present data base is that it does not distinguish between, for example, a private or diversified farming system and a large-scale state-sponsored one (see Halstead 1992:115). Nevertheless, a strong case can be made from the sherd scatters for intensified food production with increased manuring around centers. This situation would thus contrast with the "extensification" model suggested for the Aegean by Halstead (1992)—a contrast which should not be too troublesome given the different physical geography and demographic histories of the Aegean lands and Upper Mesopotamia.

If system integration is taken to be proportional to the degree of interdependence between centers and sites in the hinterland (Stein 1987, Zeder 1991), then as the system moved from individual 5-km-radius catchments to compound catchments linkage would necessarily have increased as more supplies were needed at the center. With the increased scale of the system, system integration would have followed (Whyte 1977:76), especially if transfer of labor was also involved. Although the bulk of movement of cereals is assumed to have been within 15 km of major centers, the evidence from cuneiform texts (e.g., Dalley, Walker, and Hawkins 1976:119) indicates that not *all* movement necessarily occurred within this area. When long-distance transport of bulk commodities did take place by the inefficient means of overland transport that were available it was probably not the normal procedure, instead reflecting stress at the center, the possibility of exceptional profits, or a specific request to supply a growing capital. That such "out of state" transactions were unusual is suggested by the Ottoman records indicating that permission from the central administration was required to trade grain from one administrative district to another (Faroqhi 1984:191). The exceptional nature of such transactions is underscored, for lowland Mesopotamia, by the Babylonian Talmud; according to Rabbi Nakhman, when food has to be transported "from canal to canal it means drought, from a city to a city it means famine" (Israel Eph'al, personal communication, 1993).

If a climatically induced collapse had taken place, it would have resulted in a decline in both system scale and integration but would also have shifted the economy toward greater resilience. Thus the later "adaptive" state might have attained metastable equilibrium (Butzer 1980: fig. 1). Smaller populations would have put less pressure on available soil resources, which would also have benefited from longer fallowing. The gradual decline in scale toward smaller, less integrated settlements is reminiscent of Yoffee's (1988:67) notion of the collapse of regional states. In areas such as the northern Jazira, collapse was toward the smaller but still viable Middle Assyrian settlements, whereas in marginal areas such as that of Tell Sweyhat collapse initially resulted in a much smaller Middle Bronze Age center which itself was eventually abandoned, along with all other sites on the adjacent terrace plain, in favor of more resilient niches along the river. Inevitably a local population decline and redistribution would be expected, but to what extent this population change can be accounted for by climatically induced famine, political changes, increased nomadism, out-migration, or settlement growth elsewhere remains to be determined.

Summary and Conclusions

I have suggested that the apparent ceiling on the area of Early Bronze Age sites in the Jazira may be related to the productive potential of site territories and the limited distance across which bulk food products could be transported. Each settlement system under consideration expanded rapidly during the mid- or late 3d millennium B.C., and in each case the main surge in town growth may be ascribed to the integration of a series of smaller catchments into a larger, compound catchment. The proposed model represents growth at the center as having been supported by surplus production generated by secondary centers or satellite communities. Of the case studies treated here, the systems around Titrish Höyük and Tell al-Hawa appear to have been approximately in balance, with the outlying secondary centers apparently providing sufficient produce to compensate for deficits at the center. Tell Sweyhat, in contrast, was probably supplied with sufficient production only in the moister years and in dry years may have experienced a deficit that could be remedied only by bringing supplies from the adjacent floodplain.

In contrast to the Tell al-Hawa region, Leilan was probably barely able to supply its requirements owing to the proximity of 50-ha Mohammed Dhiab (Stein and Wattenmaker 1990: fig. 9). Together these two sites may be considered as an urban complex covering some 140–150 ha. This approaches or exceeds the limit supportable by the compound catchments, and it may therefore have been necessary to expand the supply base either by means of irrigation or by the import of food from beyond a radius of 15 km. Tell Taya's outer town also exceeded the proposed ceiling, but the dispersed pattern of buildings may have housed only a relatively small population. Furthermore, the site may have had a specialized function, perhaps being positioned near a localized high-value resource (bitumen?) that would have generated sufficient wealth to allow the import of food not normally justifiable within an agricultural economy.

It appears, therefore, that, as in the real world, the fit between models and reality is rather fuzzy. However, there is sufficient field evidence in support of the proposed ceiling for site area to suggest that the area of Early Bronze Age towns in Upper Mesopotamia is related not only to population density but also to the capacity of the surrounding territory to sustain it. Further research should therefore be aimed at testing the idea of such spatial limits to the sizes of centers, more accurately identifying territorial limits, and providing further evidence for archaeologically demonstrable links between centers and outlying sites.

Comments

JOHN BINTLIFF
Department of Archaeology, University of Durham, Durham DH1 3NV, England. 15 V 94

A new study by Wilkinson can always be expected to challenge us with innovative approaches to impressive bodies of carefully assembled data, and this paper is no exception. I see important initiatives in regional analysis that will prompt applications elsewhere and insights into older models and approaches that take their discussion a stage further.

It is refreshing to see renewed attention to site territories, with empirical data from separate indicators (manuring haloes, fossil field tracks, intersite spacing) supporting the long-standing generalisations of Chisholm on farming constraints imposed by distance. Particularly intriguing are the calculations presented to explore the logical thesis that a territorial threshold imposed by time-to-fields creates a threshold of sustainable population for a small town essentially fed from a catchment of 5 km or less in radius. One can of course reasonably question how testable any of Wilkinson's yield figures and site population densities currently are for particular periods of the past, but I am impressed by the fact that the suggested self-sustaining town reaches a cut-off at some 60–80 ha or 6,000–8,000 people, not least because urban hierarchies for ancient Greek cities seem to show a divide at around this point between catchment-based hinterlands and larger cities drawing on those of satellite towns and villages (Bintliff 1991). These Greek settlement networks had the advantage of iron technology, and it is commonly argued that agricultural productivity could have increased substantially as a result (Bintliff 1984:157 with references). Nonetheless, I consider Wilkinson's overall approach to urban sustainability exciting and ultimately testable even if the exact figures remain speculative.

I am also excited by Wilkinson's model of emergent networks of central places supported by "feeder" dependent towns and villages, all constrained by a day-return access threshold of some 15 km radius from the core town to the farthest satellite community. Systems of central places of similar scale operating under comparable constraints were long ago identified for rural market centres in traditional England and America, fortified central places in Saxon southern England, and lesser walled towns in Roman Britain. I would have liked to hear more about the flow of goods and services from the central towns to satellites in the northern Mesopotamian case.

Wilkinson's further obervation that these replicating "solar systems" may be inherently unstable in a semi-arid climate, not just for the large town that has been thereby enabled to outgrow its own hinterland but also for the supportive satellites, seems appealing for several reasons. Empirically we often observe highly developed networks of farming communities "collapsing" into more fragmentary and less sophisticated patterns of settlement. Furthermore, the removal of buffering mechanisms through relations of heightened production in all members of each local system means, as Wilkinson points out, that crop failure in one district is unlikely to be compensated for by normal or surplus production in neighbouring local systems—and of course the small satellites suffer economic crisis along with their swollen central place. Interregional climatic fluctuations can even bring otherwise little-related settlement networks into collapse at approximately the same time—a possibility mooted here in the light of recent work by Weiss et al. (1993) that has very wide implications for late-3d-millennium-B.C. settlement disjunction, beyond Mesopotamia, in Anatolia and the Aegean. I find such models rather satisfying in that they remind us that the prominent recent advocates of purely anthropogenic causes of landscape degradation (Van Andel and students in the forefront!) have unreasonably written off climatic effects (Bintliff 1992).

A final comment: Wilkinson's semi-simulation of the emergence of "solar-system" networks of major and minor towns and villages in dry-farming northern Mesopotamia accords rather poorly with his comments on equilibrium-seeking mechanisms. If anything, the impetus for the breakdown of settlement self-sufficiency that results in the 15-km-radius local "polity" arises rather quickly and seems an unstable pathway for social and economic evolution. I would suggest that a far closer general model would be recent thinking on the science of complexity (Lewin 1993), where it is being argued that complex self-organizing systems (and I would see these local systems as such) thrive on the edge of disorder or breakdown ("chaos").

HANS H. CURVERS
Instituut voor Prae- en Protohistorie, University of Amsterdam, Nieuwe Prinsengracht 130, 1018 VZ Amsterdam, The Netherlands. 22 IV 94

Wilkinson's fieldwork has offered us a better view of the off-site aspects of the rural hinterland throughout Mesopotamia. He makes a persuasive argument for the intensification of agriculture in relationship to the productive potential of its environment. In the tradition of Adams (1965, 1981) and Childe (1954), he links the growth of urban centers in Upper Mesopotamia to a surplus generated from their hinterland. Adams and Childe, however, based their ideas on the evidence from Lower Mesopotamia, where irrigation played an important role. With the data collected by Wilkinson we come closer to the particular landscapes and agroecologies of Mesopotamia. The closer we get, however, the less clear it is whether the intensification is incremental or crosses important thresholds or both. Throughout antiquity the most important question has been whether any configuration was sustainable.

The agroecology of Upper Mesopotamia has been described as predominantly based on goat/sheep breeding (Gelb 1986) and dry farming (Weiss 1983), resulting in a dimorphic society of "petty dynasties residing in small towns, with a blend of rule and influence over a countryside inhabited by tribal and non-tribal elements, nomads, sedentary tribesmen and peasants" (Rowton 1973). This basic configuration dates back to the Neolithic mixed strategies of hunting and gathering but sharply defines agrarian society in the period of the first urban centers dominating their hinterland. Textual evidence from a later center, Mari on the Syrian Euphrates (ca. 1800 B.C.), reflects in detail the urban concerns about the peasants and nomads in the hinterland (Luke 1965). Besides agricultural growth, intensification of political relations and religious involvement configured ancient Upper Mesopotamian society.

Wilkinson widens the focus from sites to larger regions and their landscapes. The landscape is at the center of his model of the urban growth in the second half of the 3d millennium B.C.; his promise to deal with data from the 2d millennium is still pending. This narrow view overlooks the fact that the interdependence between regions represented by their dominant urban nodes may have varied in its economic, social, and political aspects through time. A successful petty dynasty may have become attractive to peasants but was more likely to be so to mobile pastoralists. Population growth and intensification were the key to short-term success but long-term decline of the dynasty's hegemony. Therefore, I disagree with the predominant role assigned to arable lands in the model that describes the "growth of a given settlement in relationship to the productive potential of its surrounding territory" and suggests that "neighboring territories . . . become tributary to growing centers." Wilkinson adapts the view of Adams (1981), who suggests that specialized herdsmen lived in communities beyond the limits of the arable lands. Pastoralists are demoted to a source of supplementary labor during the harvest period. Sherd-scatters could alternatively be interpreted as the remnants of (temporary) dwellings close to the fields, whereas yet another interpretation could relate them to the presence of pastoralists living in tents.

Furthermore, viewing the villages as mere suppliers of grain surplus is a simplification that allows for no functional variation. Textual evidence from Lower Mesopotamia indicates the wide variety in function of the smaller settlements (Carroué 1983). The evidence obtained from an urban hinterland in the Middle Khabur Valley (Syria) shows that small-scale storage facilities of a rural population of peasants and herdsmen were transformed into larger units. The reconstruction of one of the larger buildings at Tell al-Raqa'i into a central rounded building with silos and an area for processing grain and, subsequently, the construction of a sanctuary in the village indicate urban influence (Curvers and Schwartz 1990). This urban involvement fits Wilkinson's model, in which the neighboring territory becomes tributary to a growing center (Fortin 1991, Margueron 1991, Schwartz and Curvers 1992). The period of intensive occupation throughout the region, however, is followed by the decline of the small sites previously specialized in grain storage. In this period (ca. 2500 B.C.) Tell Leilan increased in size from 15 ha to 90 ha (Weiss 1989), and two larger towns dominated the Middle Khabur Valley (Pfälzner 1989, LeBeau et al. 1989). The regional economy oscillated between cultivation and pastoralism, sedentism and mobility (Adams 1974). The economy of the Middle Khabur region shifted from a local agrarian subsistence economy to an economy producing grain surplus and back; pastoralism may have been stable throughout the period.

Despite my reservations, I appreciate Wilkinson's fieldwork and its implications for the understanding of ancient Mesopotamian society. His view and my comment express the difference between the ecological and the sociological approach in archaeology. These differences should be more openly discussed.

PAUL HALSTEAD
Department of Archaeology and Prehistory, University of Sheffield, Sheffield S10 2TN, England. 16 V 94

On-site bioarchaeological evidence for past economy is essentially qualitative: it sheds light on which plants and animals were raised and how, but estimates of scale largely depend on off-site archaeology. One of the strengths of intensive survey is attention to off-site "middening" scatters, which offer a measure of the actual as well as the potential scale of cultivation. Wilkinson uses such evidence to explore "the notion that surplus production enabled early centers to expand and to accommodate specialized economic sectors." He considers whether large aggregations of population were sustained by (1) agricultural intensification or (2) extracting surplus from satellite settlements. Broader bands of dense middening scatters around larger settlements suggest intensification, although Wilkinson notes that such settlements may exhaust local wood supplies, forcing the use of dung as fuel and so of domestic refuse as a substitute fertiliser. Thus in semi-arid areas middening scatters may be a very indirect reflection of the scale and intensity of cultivation. Wilkinson bases a plausible case for the second alternative on off-site evidence for the scale of intensive cultivation coupled with estimates of population size and crop yields. He concludes that some centres were too large to be self-sustaining but had satellites small enough to leave land for surplus production and large enough to muster the necessary labour. These conclusions and the assumptions which underpin them are reasonable but not unassailable. The largest centres covered up to 100 ha, and, adopting Wilkinson's preferred, lower estimate of habitation density (100 persons/ha), this implies a population not exceeding 10,000—less if much space was devoted to public buildings. Taking Wilkinson's 5-km (7,850-ha) catchment and his figures for grain consumption (250 kg/head), seed corn (60 kg/ha), and wastage (5%), this would require an average yield of 397 kg/ha. This is by no means inconceivable, especially if husbandry was more intensive (e.g., in manuring and weeding) than modern extensive agriculture and if surpluses from good years were effectively stored for bad years. With alternate fallowing, the target yield of 795 kg/ha is more daunting, but fallowing is arguably a labour-saving tactic of extensive agriculture rather than a necessary adaptation to the environment (cf. Halstead 1987), at least in the wetter north of Upper Mesopotamia. To the south, alternate fallowing is more probable, but even here 795 kg/ha is not so high, given the inaccuracy of the modelling, that regular grain imports are a safe inference. Finally, as Wilkinson emphasises, bad harvests must be reckoned with, but these may have been buffered by measures (release of central stores, slaughter of livestock, export of population, irregular import of grain from satellites or other centres) invisible in the evidence under review. Wilkinson dismisses the possibility of extending cultivation or adopting more extensive methods: "the use of animals to work large areas with a limited labor force could raise production per unit of labor . . . , but a substantial labor force will still be necessary during harvest time." Around the larger centres, however, land rather than labour may have been the limiting resource, and, because this third possibility is not explored, Wilkinson's assertion that centres were supported by intensification, in "contrast with the 'extensification' model suggested for the Aegean by Halstead (1992)," is unsubstantiated. It may be fruitful to distinguish two slightly different problems posed by the 3d-millennium B.C. centres of Upper Mesopotamia: (1) How did the largest aggregations of people feed themselves from the limited arable land accessible to them? This is the subject of Wilkinson's paper. (2) How did the elites implied by the existence of such centres mobilise sufficient surplus to feed large numbers of non-producers (retainers, craftsmen, et al.)? Non-producers might have been maintained through central redistribution of "normal surplus" (Halstead 1989), but this is likely to have been at best a partial solution for the largest centres. In the Aegean, recent urban populations were sustained by overproduction on agricultural estates, in which oxen and extensive methods of husbandry were substituted for human labour—except at harvest time, when thousands of "non-producers" were employed temporarily. This extensification model is consistent with textual and archival evidence from the 2d-millennium-B.C. Aegean "palaces" (Halstead 1992) and perhaps also from 3d-millennium-B.C. southern Mesopotamia (Halstead 1990). The extensification model raises the possibility that the key to maintenance of Upper Mesopotamian centres lies not only in the intensive middening scatters which surround them but also in the areas of sparse scatters and, presumably, more extensive cultivation. Wilkinson's paper represents a stimulating attempt to harness valuable fieldwork to an important issue but is not entirely convincing.

PHILIP L. KOHL
Department of Anthropology, Wellesley College, Wellesley, Mass. 02181, U.S.A. 13 V 94

Wilkinson's review of regional data in three areas of Upper Mesopotamia which are now located in the three separate nation-states of Iraq, Syria, and Turkey (and the compilation of data across these international boundaries itself is no mean feat!) represents a major contribution to our understanding of settlement patterns in Western Asia during the crucial formative Early Bronze period. Wilkinson's work builds on that of Weiss and his coworkers in the Khabur region around Tell Leilan and documents the contrast in productive potential between northern Mesopotamia and the southern alluvium. He teases considerable economic information from the surveys he has conducted and argues persuasively that a ceiling or limit of ca. 100 ha was reached by the early cities in the north, a pattern that contrasts with the substantially larger urban and catchment areas encompassed by the major Sumerian city-states in the south.

I find his documentation impressive and his basic interpretation convincing and important for our understanding of the culture history of the ancient Near East and even of larger evolutionary issues such as secondary-state formation. My only regret is that he did not compare this early urban pattern in the Jazira with that which later emerged under the Assyrians, especially in Late Bronze and Iron Age times. Had he done so he would surely have documented the attainment of another level or equilibrium characterized by the emergence of much larger urban centers. The ability to sustain the latter, in turn, would have required explanation, and it would have been interesting to see whether Wilkinson's "natural" or environmentally based interpretation would have remained convincing. His tendency to see settlement patterns as largely determined by the agricultural potential or carrying capacity of the catchment area surrounding the settlements is more persuasive when there is no later or, for that matter, earlier pattern with which to compare it; the environment is never just a given but an area capable of being differentially exploited by peoples with different technological and social skills at different times. Adams's interpretations of his settlement data in the south, while obviously tied to irrigation agriculture and the local ecology of the alluvium, always stressed social and political factors that skewed these patterns and at times made them, in his own word, "artificial" (i.e., not directly attuned to the environment). Does "a relatively even distribution" of sites on the Khabur plains simply reflect "a moderately even pattern of resource exploitation," or does it also suggest, in some still not clearly perceived fashion, relatively peaceful political conditions? What else can be teased out of these data?

Some reconstructions are problematic or, at least to me, not entirely clear. The claim that the absence of large storage jars in smaller settlements means that these sites supplied the urban centers with their surplus cereal production is, of course, an *argumentum ex silentio* and not the only or even the most parsimonious explanation for this distribution (fewer people, fewer large storage jars). How will one document "the movement of commodities such as meat from outlying places to the center"? Finally, if the surge in town growth is due to the integration of smaller catchments into a larger, compound catchment, what, in turn, explains this latter process? Are we dealing with an explanation or just a description in this instance?

Such minor quibbles aside, Wilkinson is to be congratulated for compiling an impressive body of primary data and interpreting it in a manner that emphasizes the different potentials of the dry-farming region of northern Mesopotamia and the irrigated alluvium of the south. In so doing he has substantially increased our understanding of the differently paced and contrastive processes of historical development in these critical areas.

MARIO LIVERANI
Dipartimento di Scienze dell'Antichità, via Palestro 63, 00185 Rome, Italy. 8 v 94

Wilkinson's fieldwork in Upper Mesopotamia and his theoretical model for "dry-farming states" constitute a fundamental step toward a historically framed and archaeologically tested reconstruction of the early political, economic, and demographic processes which shaped the Near East in the Early Bronze Age and more generally during all the proto-historical periods. His model is certainly worthy of an attentive evaluation from various perspectives, and my contribution thereon will be based on texts rather than on archaeology. From the archaeological point of view I can only advance a warning: off-site sherd scatter can result not only from manuring practices but from burials disturbed by modern agricultural activities. This could easily explain why storage jars are underrepresented (sometimes absent altogether) in the off-site sample without recourse to sophisticated economic analyses.

Although the textual evidence properly stemming from Upper Mesopotamia in the Early Bronze Age is still quite scanty, the structural picture and dynamic trends here discussed are general enough to be enlightened by textual data from adjacent areas or from subsequent periods—certainly much more pertinent than modern data of purely "comparative" value. In particular, the Ebla texts pertain to the period under study and provide information on the Upper Mesopotamian area. (By the way, I take this opportunity to venture the hypothesis that one of the sites discussed by Wilkinson, Kazana Höyük, could be ancient Abarsal, an important center [of the same rank as Ebla] of the western Jezira in the third quarter of the 3d millennium and completely absent thereafter.)

Wilkinson's model is mainly based (for obvious reasons connected with the archaeological and geographical nature of his evidence) on the evaluation of land. Now, in ancient periods land is generally an overabundant resource, labor and seed being the scarce resources which are carefully evaluated and recorded in the administrative archives of the early states. For example, the Late Assyrian "Harran census" (Fales 1973) provides a picture of the western Jazira in which only part of the available land is actually cultivated and the cultivated percentage seems to decrease in proceeding from towns and rivers to the open countryside.

It is significant that ancient administrative texts are generally more attentive in calculating the ratio of seed to harvest than in evaluating the yield per area. From this point of view, it is worth remembering that the rain-fed cereal agriculture of Upper Mesopotamia had rates of 1:8 to 1:10 (Zaccagnini 1975, based on the similar Nuzi area), about half the Lower Mesopotamian rates of 1:15 to 1:20 (Liverani 1990–91) and about double the Mediterranean rates of 1:3 to 1:5 (Liverani 1979). Of course, apart from cereals, other resources have to be included in the overall picture. Horticulture and arboriculture were probably more important both in Lower Mesopotamia (onion and garlic, pulses and lettuce, date palms) and in the Mediterranean area (vines and olives) than in Upper Mesopotamia, while animal husbandry, a major resource in all three areas, may have been especially important in the semiarid lands (such as Ebla, although some of the high estimates provided by Butz 1981 and Renger 1987 are in need of a reappraisal).

My earlier model for the Ugaritic economy (Liverani 1982), based on texts rather than archaeological data, was entirely built on labor and seed, with the land playing no major role. This is probably too extreme a position, as open to criticism as that of Wilkinson; a mixed model would certainly be more in accord with historical reality. Also, within the "land" resource a more marked differentiation should be considered between rain-fed areas and irrigated fields, which were certainly an important feature in the case of Tell Sweyhat on the Euphrates. The Emar texts provide an important set of data on the rural landscape along the Middle Euphrates (I am working on this subject; for the moment, see Buccellati 1990 on an area farther downstream).

Wilkinson's estimate of 50% of the population as engaged in agriculture is nothing more than an educated guess, but a more precise and detailed estimate would have important consequences. Among the non-agriculturalists, I think we have to distinguish other people engaged in food production (basically, the pastoralists) from people engaged in nonproductive activities, above all those who made up the "palace," the political and administrative complex. We could grossly estimate, for the Near East in the Bronze Age in general, that ca. 80% of the active population was engaged in food production and 20% in nonproductive activities, but the variations over time and space could have been quite significant and should be the subject of specific research. The Alalakh lists are a good example of data on the size of villages and on the percentages of socioeconomic classes within them (Liverani 1975, Serangeli 1978).

Once the general model of a "fragile" equilibrium has been delineated, the problem of its collapse does indeed seem to have no other answer than climatic change; this can be inescapable if we consider land the main (or unique) resource and are unable to distinguish types within the labor (or people) resource. But another explanation for the collapse, a sociopolitical one, can in fact be sought in the changing proportions of productive and nonproductive people. The presence of a palace is effective in organizing the flow of food from the villages (entirely inhabited by food producers), where a surplus can be gathered, to the town (whose population is largely made up of nonproducers). But if the burden of the "palace" sector—the number of nonproducers to be maintained by food producers—becomes excessive, it can disturb the equilibrium and even return the area to a preurban condition with villages only and no urban (or palace) superstructure. It is clear that in such a scenario many different factors, from the properly economic and demographic to the social (class relationships) and political (in the realm of consensus and ideology), must be considered. The connection between "complexity" and "collapse" has been pointed to in recent studies (Yoffee 1979, Tainter 1988).

This sociopolitical explanation can be proposed as a very reasonable one for the Upper Mesopotamian crisis towards the end of the Middle Bronze period because of the abundant data provided by the Mari archives. For the end of the Early Bronze period we have no such wealth of textual data, but the hypothesis could be advanced that the Akkadian conquest in the north resulted in an attempt at overexploitation. Be that as it may, it is a matter of fact that large urban settlements centered around a palace are denser and especially more continuous in irrigated Lower Mesopotamia than in rain-fed Upper Mesopotamia, and this is a structural feature, imperial intervention or climatic change merely acting as catalysts (on climate, see Wright 1993). Upper Mesopotamian resources (or, better, the relationships of resources with demography and sociopolitical structure) are such that a large-centered town can endure only for a few generations, to be followed by a longer period of "resilient economy."

JOY MCCORRISTON
Archaeobiology Program, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A. 5 V 94

Wilkinson's model showing how EBA site and population sizes reflect the ecological and economic constraints of their sustaining hinterlands is a perceptive contribution to our understanding of urban process in northern and also by implication in southern Mesopotamia. His argument substantially augments efforts to assess the productivity of sustaining lands around cities. The dry-farming potential of extensive land area has been noted as a significant contrast to the constraints imposed by irrigation farming in southern Mesopotamia (Weiss 1986:70). Wilkinson's model suggests, however, that the extensive nature of the dry-farming system operated as a constraint on site growth rather than encouraging it. This elegant model further serves to remind us of the fragility of systems operating at or close to maximum productive capacity. In such circumstances, minor climatic fluctuations or instability in interannual rainfall could have dramatic effects, including collapse of centers.

Wilkinson's analysis has important implications for reconstructing the development of economic systems in the Jazira. In particular, intensive archaeological survey and excavations prior to modern dam construction have established that a dramatic increase in settlement size and decrease in distance between settlements occurred in the *early* 3d millennium (Röllig and Kühne 1977–78, Schwartz 1994) in the marginal steppic zone of the Middle Habur River (Syrian Jazira). In this area an average annual rainfall below 250 mm precludes dependable yields from dry farming. Considerable collaboration among archaeologists and archaeobiologists has led to a systematic collection of faunal and botanical materials that complement and supplement archaeological indications of economic activities in the dry steppe and river floodplain. While the bulk of these materials remains unanalyzed, preliminary studies point to a significant shift from predominantly hunting to predominantly herding strategies in the 3d millennium (Zeder 1994). Both crops and weed assemblages from this period indicate dry farming with no evidence of irrigation.

This material is relevant here because it may well represent an agricultural "extensification" (*sensu* Halstead 1992) predating the manuring and short or no fallowing documented by Wilkinson for the late 3d millennium. Wilkinson suggests that "the peak of land-use intensity was synchronous with the main phase of urbanization" during the *later* 3d millennium. Most Middle Habur 3d-millennium occupation—in some cases nearly the entire sequence, as at Tell Raqa'i, Tell 'Atij, Tell Melebiya, and Tell Kerma North—predates the earliest firmly established date for urban growth in the dry-farming plains to the north (G. Schwartz, personal communication, 1994; Fortin 1991; LeBeau 1989; Oates 1986; Saghieh 1991; Weiss 1990*a, b*). The impetus for population expansion in the steppe in the *early* 3d millennium therefore cannot be linked to urban growth in the north, but perhaps it can be attributed in part to increasing population and land use, especially if Ninevite 5 villagers remained committed to fallow cycles and crop rotation. Land availability for pastoral use remains an important consideration, particularly as demand grew for dung fuel and fertilizer.

The methods Wilkinson employs to reconstruct agricultural production during the latter part of the 3d millennium represent an impressive contribution to archaeological survey in the Near East, and there is little doubt that this work will be widely emulated in regional research designs. Botanical evidence—usually indicative of *production* rather than *consumption* of crops—should further complement ceramic evidence of links between centers and outlying sites. A simple caveat against using sherds from tertiary contexts (broken pots, discarded in middens, scattered on fields) to date agricultural use of fields: these cannot demonstrate contemporaneity of fields and occupation unequivocally, generally providing a terminus post quem at best. Wilkinson's caution in restricting such interpretations of contemporaneity to sites at which the greatest occupational extent of any period corresponds to the date of the sherds on the fields deserves emphasis. There is a straightforward energy: yield ratio implied in this assumption that would preclude, for example, the mining by subsequent settlers at a site of previous deposits in order to maintain interannual yields on the same land in marginal zones.

JOAN OATES
Faculty of Oriental Studies, University of Cambridge, Cambridge CB3 9DA, U.K. 3 v 94

Wilkinson's admirable article clearly demonstrates the potential of the models generated by the analytical and field techniques he employs. Of particular interest to those of us working at Brak are the comments on the limitations and potential of the ancient economies of the Khabur triangle, especially theoretical site ceilings which, interestingly, closely approximate the indigenous 4th-millennium urban centres of Brak and Hamoukar (Oates and Oates 1993), an urbanization which has received relatively little attention by comparison with the secondary 3d-millennium floruit which has formed the major focus of recent studies.

Of our major areas of (amicable) disagreement, perhaps the most important relates to the interpretation of sherd distributions, especially on multi-period sites. At Brak, for example, a single thunderstorm has been observed to carry sherds from the uppermost levels of the site some 15–20 m into the adjacent plough. The interpretation of off-site sherd scatters presents other problems, and here I believe there are plausible alternatives to manuring, a practice attested neither in ancient texts nor in contemporary farming. (Roman and medieval references to manuring do occur [White 1970:178].) My reservations reflect the fact that despite the existence of a number of cuneiform texts that provide detailed descriptions of "proper" agricultural practice (in particular the "Farmer's Almanac" [Kramer 1963:340–42; Civil 1987]) and of a number of letters and other "daily life" records, no ancient documentation exists. Site soil is today sometimes removed for small garden cultivation—the classic example comes from 19th-century Egypt with the discovery of the Amarna letters—but not large field areas. The fact that sherd scatters are of consistent date does not identify their date of transfer, if indeed that is how they originate. Ancient land surfaces can be ploughed away, with sherds surviving, while sherds of consistent date can easily reflect non-contemporary soil transfer. At Brak, for example, major late 3d- and early 2d-millennium building operations involved the use of very large quantities of occupation soil which contained, *consistently,* Mid- to Late Uruk ceramics. Such ancient deposits must have been extensive and easily accessible a millennium or more later—perhaps *because* they represent a site maximum. Site soil can be removed for other purposes: our local village has been responsible for the (illegal) removal of much occupation debris from the Eye Temple site at Brak "because it makes the best ovens." Perhaps more important in the context of Wilkinson's observations is that grey bricks made from occupation soil are of better quality than those (red) manufactured from clean soil. Brick-making activities take place today anywhere where rainwater has pooled; they occupy extensive space, and the removal of site soil for such a purpose could account for at least some of the sherd scatters observed by Wilkinson. Large mud-bricks are fragile, and many break in the course of manufacture and removal. We have inadvertently deposited large numbers of Roman sherds on the tell at Brak, where no Roman occupation exists, by virtue of making bricks for the dig house at the nearest water source, an artesian well some 500 m northwest of the tell where there was a Roman settlement (Oates and Oates 1993:fig. 39).

There has been some debate as to the efficacy of manure as soil fertilizer in the hot sun of the Near East. It seems generally agreed that no benefit accrues unless such manure is immediately ploughed into the soil. Buringh (1970:253) goes so far as to assert that "in arid and hot climates the organic manure disappears in a short time, due to rapid oxidation, and therefore the soils obtain no benefit from it." This observation has been somewhat modified in more recent publications (Charles 1990), but the fact remains that dung is more profitably employed as fuel, a practice well-attested at least as early as 6000 B.C. (Hole, Flannery, and Neely 1969:396; Miller 1984). A feature of Near Eastern ecology that has not, I believe, been previously noted is the presence of the dung beetle. As most Mesopotamian archaeologists will know, dung beetles are highly efficient at removing dung pads from land surfaces. They are, moreover, remarkably clever at calculating the exact amount of dung required by their larvae.[1] Thus, although the dung is buried, little nutrient value accrues to the soil itself, although there is considerable benefit in soil aeration and improved structure (Crosson 1981, Waterhouse 1974).

One further comment: theories of late-3d-millennium urban collapse must in the Khabur accommodate the well-attested post-Akkadian kingdom of Urkish and Nagar (see, most recently, Matthews and Eidem 1993). Moreover, the whole of the large tell area at Brak continued to be occupied until well into the 20th century B.C., and in the Khabur the implication of post-collapse deterioration and "decline in scale toward smaller, less integrated settlements" hardly accommodates the Shamshi-Adad and Mitanni empires. These are, of course, relatively minor comments on a thought-provoking article.

GLENN M. SCHWARTZ
Department of Near Eastern Studies, The Johns Hopkins University, Baltimore, Md. 21218, U.S.A.
29 IV 94

Wilkinson's work in off-site archaeology has, in one fell swoop, provided an extremely promising new body of evidence for the study of emerging complex societies in the Near East. In this paper he examines the idea that the size of early Upper Mesopotamian and Syrian cities was constrained by their carrying capacities to no more than 100 hectares and discusses how climatic stress may have affected these early urban systems.

Central to Wilkinson's ideas and very much on the minds of Near Eastern prehistorians as well as historic-period archaeologists is the propensity for agricultural overintensification in pre- and early state societies. This tendency, combined with such stresses as climatic change, is thought to result in system collapse (Tainter 1988). Wilkinson gathers evidence for such overintensification from his data on sherd scatters, which he interprets as the remains of ancient field manuring. In apparent support of this premise are the results from the northern Jazira, where cuts and ditches showed no evidence of habitation outside the mounded tells.

If this interpretation is correct, it will help ease the guilty conscience that Near Eastern archaeologists may have about neglecting a significant proportion of the ancient settled population by concentrating solely on mound excavation. Indeed, an Egyptological colleague of mine once went so far as to accuse Near Eastern archaeology of elitism because of its exclusive focus on tell excavation even when it is conducted on the smallest of mounds, as in the case of my own research (Schwartz and Curvers 1992). Much as I would like to refute this charge of elitism with Wilkinson's northern Jazira data, however, I wonder whether the sherd scatters that he interprets as remnants of field manuring might be construed in other ways, among them as the remains of temporary dwellings in the fields around the major communities such as the field huts of the Maya (Freter 1994). If manuring was the cause of the sherd scatters, one would presumably expect only small potsherds in the fields, yet large storage-jar sherds are also attested.

Another issue that deserves clarification is the discrepancy between Wilkinson's results in the Kurban survey area (Wilkinson 1990) and those from the Titrish, Sweyhat, and Tell al-Hawa regions reported here. In the latter cases, field sherd scatters were associated with periods of peak urbanization, but in the Kurban area the field scatters were predominant in the late 3d millennium, a period of "ruralization" *subsequent* to the major episode of 3d-millennium centralization and system integration. At Kurban, evidence of manuring from sherds was interpreted as a consequence of environmental degradation; after the sources of wood fuel were depleted, the livestock herds' dung would be reserved for fuel, forcing the farmers to scour village streets and dumps for manure. If sherd scatters are to be associated with the decline of wood fuel, therefore, sherd scatters that coincide with urban peaks at Titrish, Sweyhat, and Tell al-Hawa are symptomatic of environmental degradation, not the introduction of manuring.

As an aside, I would like to remark that, given the scarcity of historical evidence, we should be careful about assuming, as Wilkinson does, a synchronism between the floruit of early Upper Mesopotamian cities such as Titrish and the Akkadian empire of southern Mesopotamia. This is important because one could interpret the development of societal complexity in Upper Mesopotamia as a reaction to Akkadian imperialism. In the case of Titrish, the date is based on the unprovenienced find of an Akkadian-period inscribed weight, an extremely uncertain datum point from which to determine the chronology of an entire site.

While there are predictable questions of method and interpretation, Wilkinson's model of urban development and fragility in the context of agricultural intensification should prove a highly useful tool for future testing. In the case of Syria and Upper Mesopotamia, one should note that the "collapse" of urban systems at the end of the 3d millennium was by no means uniform chronologically, regionally, or substantively. For example, areas such as the upper Khabur seem to have been almost completely deserted (Weiss et al. 1993), while others merely saw a reduction in the size of their urban centers. Nor was their "recovery" a uniform process: Upper Mesopotamia and Syria experienced a vigorous reurbanization in the early 2d millennium, but the Kurban and Titrish area was virtually abandoned. Wilkinson's model should prove most useful in future attempts to account for this intriguing variability.

1. I am very much indebted to Janet Harker, Department of Zoology, Cambridge University, for much fascinating information on dung beetles.

INGOLF THUESEN
Carsten Niebuhr Institute, University of Copenhagen, Copenhagen 5 DK-2300, Denmark. 24 V 94

Wilkinson's paper brings forward a set of important new data and calculations, following the pioneering studies of ancient settlement patterns in Mesopotamia initiated by, for example, Adams, Nissen, Gibson, Johnson, and Wright in the sixties and seventies. I am not sure that their work should be labelled point-pattern analysis, as they were basically dealing with regional subsistence strategies with emphasis on the socioeconomic dimension of urban development. It is tempting to see this new contribution, which emphasizes agricultural (read crop) production, as a natural and relevant refinement of these earlier works.

A major part of the conclusion is based on the detailed examination of field scatters of sherds and waste products. Therefore, it is appropriate to ask questions dealing with the interpretation of the field scatters. A field scatter is explained as the result of intensified agriculture in connection with fertilization with settlement-derived manure. The field scatter decreases gradually from the urban centers to the periphery of an assumed land use zone within a 5-kilometer radius (limit of field scatter and hollows). Accepting this explanation, the next step is to look for archaeological indications of technologies invented in order to meet the increasing demand for field productivity—ways of producing, collecting, and distributing fertilizing material or manure. Was the intensification of field use during the mid-/late 3d millennium a response to restricted yields caused by climatic, ecological, or demographic deterioration after the stable favorable conditions of the 4th and early 3d millennia?

Since the occurrence of sherds in the fields must be classified as a tertiary context, great caution should be exercised in using their dating values. Can it be excluded that the scatter on the high limestone hills near Titrish Höyük is not a result of the use of the debris of an ancient mid-/late-EBA satellite site as fertilizing material? Apparently, the satellites did not use large jars, which would explain the absence of this type among the field scatters. The concentrations on the hills therefore do not necessarily mean differentiated use of manure. Could these field scatters not also date to a post-3d-millennium context? After all, a sherd scatter only provides us with a terminus post quem for manuring the fields. In order to clarify these important assumptions, future excavation strategies should pay attention to facilities or technologies in the urban centers or suburbs that are associated with field-fertilizing technologies.

Another issue which may be raised as a consequence of the demographic dynamics reconstructed here is how much we actually know about town planning or use of domestic space in 3d-millennium urban centres. In a sense, important and innovative work such as Wilkinson's leaves us with an uncomfortable feeling of the insufficiency of traditional archaeological strategies in the Near East. Despite decades of intensive excavation activities in the Jazira, we still do not have much documentation of subsistence strategies, land use, agricultural techniques—data on the basic daily activities of the majority of the population.

Finally, the recognition and analysis of field scatter makes another and perhaps even more important contribution to archaeological research; it saves data which are seriously threatened because of recent cultivation. Remains located in the topsoil/plough zone—and this is a global problem—are endangered by the rapidly increasing human exploitation of the environment. Therefore, this kind of surface sampling should become an integral part of all salvage activities in regions with increasing human activity.

HARVEY WEISS AND MARIE-AGNÈS COURTY
Departments of Anthropology and Near Eastern Languages and Civilizations, Yale University, New Haven, Conn. 06520-8236, U.S.A./L.A. 7520, C.R.A., C.N.R.S. Laboratoire de Science des Sols et Hydrologie INA P-G, 78850 Grignon, France. 28 VI 94

Wilkinson argues that an equilibrium between elastic urban systems and inelastic productive resources (cultivated land) developed in late-3d-millennium dry-farming northern Mesopotamia. In his reconstruction, systemic and recurrent drought, characteristic of today's climate, upset this equilibrium in some regions that were, inexplicably, hyperurbanized, and one of these droughts generated the collapse of a portion of northern Mesopotamia at the end of the 3d millennium B.C. Discussion is limited here to the verisimilitude of his argument.

"Ploughzone archaeology," pioneered by Bowen (1961) and developed intensively by English archaeologists (see, most recently, Schofield 1991), is used in part for determining the extent of agricultural fields around ancient, especially Roman-period sites. For instance, sherd distributions outside of ancient sites can be tested as remnant distributions of urban-derived, potsherd-filled fertilizers. Wilkinson uses this method to delimit the cultivated land around mid–late-3d-millennium B.C. northern Mesopotamian cities and thereby to ground his argument that efficiency constraints on cultivable land determined both the limits and the collapse of 3d-millennium urbanization in northern Mesopotamia.

Are there reasons to believe that ancient Mesopotamian cities fertilized their fields with sherd-filled urban-derived fertilizers and that sherd distributions around 3d-millennium urban sites delimit those fields? Wilkinson presents four arguments to support his assumptions: (1) Citing el-Samarraie (1972), he suggests that medieval Mesopotamian cities were agriculturally dependent upon intensive manuring in which night soils, dung, street sweepings, ash, and other organic wastes were carried out of cities and spread on fields. Contemporary potsherds would have been included within these fertilizers, according to Wilkinson. (2) There are no 3d-millennium epigraphic data from southern Mesopotamia that describe field practices; hence no data negate his assumption that 3d-millennium cities' field practices were the same as those of the medieval period (Wilkinson 1982, 1989). (3) The time and effort efficiencies of field distributions around urban sites, as described by Chorley (1962), correspond to the distribution of 3d-millennium B.C. potsherds around 3d-millennium-B.C. urban sites. (4) Manuring was necessary to sustain and increase northern Mespotamian soil productivity in the 3d millennium B.C.. Each of these arguments is, however, erroneous.

1. Wilkinson's source for medieval Mesopotamian cities' use of intensive manuring is el-Samarraie (1972), a summary of agricultural handbooks for 9th-century "Iraq" or "the Sawad"—irrigation-agriculture southern Mesopotamia; the "Jezira," dry-farming northern Mesopotamia, is explicitly not treated in this volume (el-Samarraie 1972:2). The section of el-Samarraie cited by Wilkinson (here and in Wilkinson 1989:41) is a summary of ibn Waḥšiya's *al-Filāḥa an-nabaṭīya* (Nabatean Agriculture) handbook. The utility of this manuscript as a source for 9th-century agriculture in southern Mesopotamia has been the subject of much debate: the authorship of the text, its date, the date of the practices described in it, and the relationship between the practices described and agricultural practice in any period are all doubtful (Ullman 1972:440–42; Fahd 1974, 1977; Adams 1981:216; Watson 1983; Endress 1993). To the degree to which it has been edited and translated, it provides only an annual calendar of intensive fertilization for specialized gardens, vines, vegetables, and fruit trees (Fahd 1974, 1977). The 6th–9th-century Arab transformation of southern Mesopotamia from single-cropping cereal monoculture to multiple-cropping including newly introduced cotton, sugarcane, fruit trees, and vegetables required garden and orchard fertilization and may, therefore, be reflected in *Nabatean Agriculture* (Watson 1983). Similarly, manure and town refuse are used in modern Iraqi gardens but not cereal fields (Buringh 1960:252; Charles 1990:53).

2. The considerable data on 3d-millennium southern Mesopotamian cereal agriculture describe neither multicropping nor intensive manuring. In 3d-millennium southern Mesopotamia fields were prepared for sowing with enclosed sheep foddering and postharvest "green-fertilizing" (Butz 1983). In spite of large numbers of grain-fed stalled sheep (e.g., 52,533 at Lagash [Schneider 1927]), sheep and cow dung was deposited upon cultivated and fallow fields during enclosed grazing (Postgate 1992:159; Michalowski 1989:ll. 44, 48, 333; van de Mieroop 1993:172 *contra* Butz 1979 and Butz and Schröder 1985). Manuring of fields through such landowner and herd owner arrangements was widespread in southern Mesopotamia through the Sassanian period, that is, for at least 3,000 years (Newman 1932; Adams 1981:204). Similarly, in early 2d-millennium northern Mesopotamia the sheep herds of pastoralists grazed upon both cultivated and fallow fields (Matthews 1978:52, 90–92). The roles of animal production and pastoral nomadism within ancient Mesopotamian agriculture are not treated by Wilkinson.

3. On the Habur Plains, Leilan data suggested von Thünen–like 3d-millennium land use with settlements extending to 18 km and territoriality up to 25 km from urban centers (Weiss 1992). But precollapse imperialization and its labor deployment, administration, and production within the Leilan-Mozan-Brak triangle do not support Wilkinson's arguments for the delimitation of 15-km bands of cereal cultivation due to the constraining effects of land transport cost and the convenience of being within one day's round trip of the center. Stoddart and Whitehead (1991:141) have already criticized Wilkinson (1982) for following Chisholm (1962) in assuming a simple, "efficient" relationship between land-use intensity and distance from settlements. Such relationships did not obtain in the ration-labor agroproduction system of 3d-millennium Mesopotamia, north and south, where workers were moved long distances between their cities of origin and regionwide harvest areas (Goetze 1963; Adams 1981:144–47; Weiss 1986:93; Catagnoti and Bonechi 1992; Weiss 1992).

4. The main limitation on the sustaining capacity of northern Mesopotamian soils is neither phosphorus nor nitrogen—both of which are restored easily, if temporarily, through postharvest flock pasturing, fallow, and fallow with legumes (Buringh 1960:253–54; Loizides 1980: table 16; Hagin and Tucker 1982)—but soil workability and water reserves. Experimental data indicate that nitrogen fertilization lowers wheat yields on semiarid soils with insufficient soil moisture (Hagin and Tucker 1982). For these reasons, therefore, the traditional high-efficiency farming system that does not use fertilizers but incorporates fallow with nitrogen-fixing plants, green mulching, and animal grazing (Leroux 1951) was apparently the system used in 3d-millennium Mesopotamia.

These arguments indicate that Wilkinson's sherd scatters do not delimit manured 3d-millennium cereal fields because 3d-millennium cities did not manure their cereal fields. Furthermore, the characteristics of the sherd distributions do not correspond to intensive cultivation/manuring 4,000–5,000 years ago. Third-millennium land use is hardly visible today on the Habur Plains but lies buried by recent flood and aeolian deposits reworked by water or wind erosion and homogenized by biological activity. Third-millennium evidence usually occurs at a minimum of 40 cm below the present surface and extends down to 4 m below it. Incorporation of sherd-filled manures into the 3d-millennium soil by plowing and mixing would not have left a 3d-millennium accumulation of sherds at the modern surface. Wilkinson's model assumes landscapes unchanged for 4,000 years, an assumption refuted by detailed soil investigation (Courty n.d., Weiss et al. 1993). Detailed examination of the sedimentary characteristics associated with scattered sherds is required to provide diagnostic evidence for their origin (see Courty, Goldberg, and Macphail 1991). The interpretation of linear hollows as 3d-millennium road systems is also based upon the assumption that these landscapes have not suffered significant modification over the past 4,000 years.

Wilkinson understands the regionwide collapse of settlement beginning at ca. 2200 B.C. (calibrated Leilan radiocarbon dates) to have been the collapse of an indigenous northern politicoeconomic system by ignoring the extraregional force, Akkadian imperialism, that had been imposed upon northern Mesopotamia 100 years earlier. He attempts to make the Leilan region a special case of unexplained hyperurbanization leading to collapse. He admits the circularity of his argument, but the frame for his argument is also mistaken because he has misunderstood the relevant archaeological data. The precollapse occupation of Tell Leilan was not synchronous with the 50-ha occupation of nearby Mohammed Diyab: the Leilan IIb expansion of settlement to the city walls was synchronous with the 80% reduction in the size of Mohammed Diyab to 10 ha (Lyonnet 1990:75; Weiss 1990*b*, 1991, 1994), and Stein and Wattenmaker's (1990) Leilan period II "integration" probably reflects Akkadian imperialization rather than the indigenous state formation that occurred 300 years earlier (Weiss 1990*a*, *b*). The imperializing Akkadian administrative control removed secondary regional centers, intensified agro-production, imposed Akkadian standard ration-wages, and appropriated agricultural surpluses across Sumer and the five dry-farming plains adjacent to southern Mesopotamia (Senior and Weiss 1992, Weiss and Courty 1993, Weiss et al. 1993).

The nature of the regionwide collapse is also misunderstood by Wilkinson. The abrupt climate change at ca. 2200 B.C. was not a brief drought incident within the regular, systemic drought series typical of North Africa or southwestern Asia. The pedosedimentary record for the abrupt climate change at 2200 B.C. indicates extreme aridity and violent winds for a lengthy period and therefore differs substantially from the systemic, short-term climate variability well-documented in the region (Weiss et al. 1993). Synchronous climate change and collapse occurred in adjacent regions with different socioeconomic systems, for example, Egypt (Butzer 1976:33; Butzer 1982:317), but never with the frequency of brief systemic droughts. In this case, the present is not a guide to the past; as recent climatological research has demonstrated, many aspects of previous climate change cannot be understood by present-day analogs (Stine 1994). Adaptive stress-absorbing responses to the abrupt climate change modified social and natural constraints, but these responses varied regionally across the late-3d-millennium landscape and along the vectors of settlement resource dependence and politicoeconomic organization. Certainly the predictions of Wilkinson's model did not obtain, as city-sized settlements did not fragment into smaller units during this period; small towns and villages disappeared, while a few very large cities, for example, Urkish, Nagar, and Nineveh, continued to be occupied. Responses to the climate change included previously unexplained phenomena documented in both the archaeological and the epigraphic record: (1) large-scale abandonment of the region by both sedentary and transhumant populations, (2) new regional political organization, and (3) interregional migration from drought-affected dry-farming areas in northern Mesopotamia to riverine and sustainable-irrigation-agriculture settings in the south ((Weiss 1992; Weiss et al. 1993; Weiss and Courty 1993; Matthews and Eidem 1993:206). Hence Wilkinson's use of Butzer's (1980, 1982) amplification of Chorley and Kennedy's (1971) equilibrium types misidentifies the chronology, causes, and long-term trend of 3d-millennium events, processes, and adaptations. A new "metastable equilibrium" was established briefly with the Akkadian imperialization of adjacent northern Mesopotamian dry-farming economies; 100 years later the abrupt climate change induced both the collapse of regional dry farming and the irrigation-agriculture imperial core that was dependent, in part, upon it (Weiss et al. 1993).

Lastly, Wilkinson ignores the long-term history of this region, jumbling data to conclude that "in areas such as the northern Jazira, collapse was toward the smaller but still viable Middle Assyrian settlements." The 1,000-year period following the Akkadian collapse witnessed the creation of the Leilan-based empire of Shamshi-Adad, the northern Mesopotamian kingdoms of the Leilan/Apum dynasts and their contemporaries, and the Mitanni, Kassite, and Middle Assyrian empires, all urban-based polities that imperialized Mesopotamian agro-production, in some cases for centuries. These and the subsequent Neo-Assyrian (Postgate 1977), Achaemenid (Olmstead 1948), Seleucid and Roman (Jones 1971), Sassanian (Altheim and Stiehl 1954), and Islamic (Kennedy 1981, Morony 1984) agro-empires demonstrate that the long-term trend was toward increasingly larger and more efficient imperial economies. This trend began in the mid-3d millennium, was truncated briefly with the Akkadian collapse, and then quickly resumed its long-term trajectory, in spite of significant "hiatuses." Ignoring the archaeological record and available historical contexts, Wilkinson misreads the region's developmental history and thereby replaces the perduring interaction between determinate and stochastic forces with static definitions of efficiency and "optimality" that lack empirical and theoretical support.

Reply

T. J. WILKINSON
Chicago, Ill., U.S.A. 5 VII 94

My article attempts to bring together a number of themes relating settlement to land use, communications, and other aspects of off-site archaeology in the rain-fed farming zone of the Near East. It is evident, however, that manuring and off-site sherd scatters have taken the attention of many, to the point that the commentaries should perhaps have been entitled "No Turd

Unstoned." Consequently I shall respond first to manuring and associated issues and then to other topics.

The paper builds upon numerous detailed surveys conducted throughout the Middle East but is deliberately restricted to the rain-fed zone and, within that area, to my own areas of field experience (with only minor comments upon other areas), with the result that the models presented here are primarily founded upon field data. In my initial surveys around Tell Sweyhat (Wilkinson in Holland 1976) I expected to find numerous minor sites that had been missed by earlier archaeologists; instead, away from conventional mounded sites (some admittedly very small and almost flat) a virtually continuous scatter of sherds and other debris was present across the surface. Rather than revealing the peaks and troughs in the scatters that one would expect from settlements, the early surveys consistently demonstrated continuity. Initial fieldwork therefore resulted in the rejection of the hypothesis that the scatters were formed by the presence of temporary dwellings and other sites. This conclusion was supported by further work using continuous sampling techniques as well as sample intervals of 100 m or less. The absence of foundation stones, post-holes, and lenses of occupation debris in the many kilometers of sections exposed during later work in the northern Jazira consistently argued that the scatters were not primarily caused by small temporary structures or sites. Furthermore, the presence in some survey areas of a sparse but relatively even scatter of kiln waste (not the concentrations that one would expect from in situ kilns) suggested that waste products had also made their way onto fields. More recent work by others in Britain and Greece, which refined my original rudimentary sampling techniques, revealed the presence of sites within manuring-related sherd scatters (see papers by Bintliff, Gaffney, and others cited in Wilkinson 1989). As I have reported here for the Titrish area and elsewhere for the area around Kurban Höyük (Wilkinson 1990*b*), the methods described have proved essential for the recognition and definition of minor sites and suburbs. My conclusion therefore remains that where intensive off-site surveys have been conducted in Upper Mesopotamia field scatters exist, and although temporary dwellings or minor sites may be present within the scatters they do not explain literally hundreds of square kilometers of sherds dispersed continuously across the surface and evenly throughout the plow soil. Although I continue to favor an intepretation of the scatters primarily in terms of manuring or soil conditioning in antiquity, I nevertheless remain an off-site (as well as an onsite) archaeologist and therefore continue to record every type of landscape and cultural and geomorphological feature in the landscape.

Two commentators (Oates and Weiss) correctly point out that there is no evidence for 3d- or early 2d-millennium refuse manuring in southern Mesopotamia, which I hasten to add I did not suggest. My limited and admittedly negative data support texts such as the Farmer's Instructions (18th-century B.C. [Civil 1994]), which, as the commentators point out, describe the pasturing of cattle and sheep on fields, thus enriching the fields with their manure. Recent fieldwork in southern Mesopotamia around Abu Duwari, Abu Salabikh, and Zibliyat has demonstrated no obvious early field scatters, large areas of later sherd scatters being recorded instead across many square kilometers of land. The dates of the contained sherds coincide with the phase of maximum population density in the lowlands between the Parthian and early Islamic periods (Adams 1981 [for a population curve based upon Adams's work see Whitmore et al. 1990 fig. 2.4]). Thus for the irrigated lowlands of Lower Mesopotamia the field evidence suggests that from before 4000 B.C. until about 500 B.C., when population densities were modest (perhaps up to 11.4 persons/km^2 [Whitmore et al. 1990: table 2.1]), irrigation with supplementary animal manuring was practiced. Following this, in Partho-Sasanian times (in the area surveyed by Adams), when population densities were approximately double those of the previous phase, field scatters appear, and I would suggest that it then became necessary to raise yields by using settlement-derived refuse. The resultant Parthian-to-Early-Islamic field scatters observed during my small sample surveys are associated with remains of major and minor canals and are virtually indistinguishable from those associated with Sasanian/Islamic irrigated cultivation around Siraf and Sohar in the Gulf (Costa and Wilkinson 1987).

Weiss and Courty's pungent and enthusiastic dismissal for manuring not only fails to account for the field evidence of the field scatters but also may be premature in terms of the agronomic value of the practice. According to a recent discussion of the practice of fallowing as a means of soil moisture conservation and stabilizing crop yields (Stewart, Jones, and Unger 1993: 71),

> The nutrients released as a result of tillage are readily available to growing plants and increased yields are generally obtained. Therefore, in addition to increasing water storage, summer fallowing also increases available soil nutrients. However, unless the organic matter supply is replenished by plant residues or manures, the system is not sustainable. This is the situation for many soils of the world located in arid and semiarid regions and increased attention to the problem is critical. It is also the underlying principle that resulted in the infamous "Dust Bowl." . . .

The sparse textual references to manuring from Upper Mesopotamia may simply mean that manuring was not deemed worthy of official correspondence. Nevertheless, a text from Nuzi does refer to manure for one *im r* and five *aweḫaru* of land being taken away and given to another[1] (Pfeiffer and Speiser 1936:67; Fales 1990:128), and there are at least two references in Neo-Assyrian texts

1. *Ziblu, zibli,* although given as "meaning uncertain" in the 1961 University of Chicago *Assyrian Dictionary,* is taken by Pfeiffer and Speiser and, more recently, by the editors of the State Archives of Assyria to mean "manure, manure house."

from Nineveh to what are interpreted as manure houses (Kwasman and Parpola 1991:27 [text 28] and 216 [text 271]). The Nuzi text suggests that manure was perceived as being applied to a certain area of land, whereas those from Nineveh imply that manure was stored, presumably, I would suggest, prior to use.

Although, as Oates suggests, manure may be ineffective in semiarid or arid climates, to avoid desiccation the compost or manure may be added to a moist soil, which of course presents no problems, as anyone who has conducted field surveys in the damp and cool winters of Upper Mesopotamia will attest. The use of household refuse on fields today in the Middle East also suggests that it is effective, and on a recent visit to part of the rain-fed farming zone of highland Yemen we were rewarded with the sight of numerous small piles of household refuse, containing ash and occasional potsherds, on the terraced fields. I agree that part of the beneficial effect of dung is the improvement of soil structure and aeration (Wilkinson 1982:323, 330), and this is partly why the addition of manures may be important in producing a favorable medium for plant growth and one which may help counteract soil deterioration. An additional factor worthy of examination is the role of manuring in the maintenance of mycorrhizal fungi, which, by contributing to soil aggregate development, are a major factor governing the ability of a system to handle intensive farming (Miller and Jastrow 1992).

The explosive growth of Late Assyrian cities is a topic that would require another paper, at least, to do it justice. However, I agree with Kohl that those cities must have benefited from a higher-level supply zone. It is clear from detailed surveys around Tell al-Hawa that the Early Bronze Age centers had dwindled to a fraction of their former size by the Late Assyrian period, just as the royal cities were increasing in size. My own feeling is that many of the small dispersed farmsteads and villages that developed in northern Iraq were deliberate foundations, perhaps of deported captives (Wilkinson and Tucker n.d.). Such settlements may then have been part of a broad supply zone for the growing capitals of Nineveh and Nimrud, which could have been most readily supplied by goods transported downriver. Areas such as the Cizre Plain, where Algaze has recorded a peak in Late Assyrian settlement (Algaze et al. 1991), would have been obvious supply areas for Nineveh and Nimrud. The advent of a more flexible quasi-monetary system (Saggs 1984:172), combined with the sheer economic power of the Late Assyrian royal economy, may have enabled Nimrud/Nineveh to develop a much larger supply zone than had existed during the Early Bronze Age. Significantly, variations in the price of grain between the "desert," intermediate areas of the Jazira and Nineveh itself (Saggs 1959; Fales 1990:113) suggest that by this time a more flexible economy existed, and this may have allowed a larger supply zone to develop.

Another of Kohl's points relates to the movement of goods from satellites to centers. Although the data supplied on vessel class are not unassailable, the underrepresentation of certain classes of vessels is conspicuous on some sites and requires explanation. I feel that the interpretation provided, although provisional, remains valid and also accords with Wattenmaker's (1987) faunal analyses suggesting the export of animals from producing to consuming sites.

The issue of whether the chosen values for crop yield and other parameters are correct can, I feel, be addressed by generating models for a range of values as I have attempted with figures 13–15. In this way it should be possible to develop a dynamic view of the economic behavior of early communities which should avoid arguments over the details of production figures or population densities.

Although the models may contribute to an understanding of the framework of collapse, I was not attempting to tackle specifically the suggested post-Akkadian collapse. My point that collapse was towards (not directly into) the Middle Assyrian ceramics remains valid. If it is necessary to elaborate, in the Tell al-Hawa area the later 3d-millennium (or Akkadian) site hierarchy was followed by an early-2d-millennium phase of Khabur-period settlement, but whether there was a genuine collapse of settlement between these two phases is simply not known from excavation in that area. In a more extended discussion of the settlement history (which I deliberately avoided in this paper [see Wilkinson and Tucker n.d.]) we provide data for the gradual thinning of the settlement pattern and dwindling of the centers throughout the 2d millennium.

My adherence to intensification as a prime factor in production rather than Halstead's extensification model is again driven by the evidence of the field scatters. However, McCorriston's point regarding the possibility that extensification may have been important during the Ninevite 5 period is well taken and reinforces the notion that settlement/land-use systems of the 4th to 1st millennia B.C. were dynamic and fluctuated between a range of states. I fully accept the point that pastoral systems loom less large than they might, and I apologize to sheep and goats around the world for underrepresenting them. This was, as I pointed out, because of the nature of the field data. I will, however, take pains to include more ovicaprids in future fieldwork.

References Cited

ADAMS, R. MCC. 1965. *Land behind Baghdad.* Chicago: University of Chicago Press.

———. 1974. "The Mesopotamian social landscape: A view from the frontier," in *Reconstructing complex societies.* Edited by C. B. Moore, pp. 1–20. Supplement to the Bulletin of the American Schools of Oriental Research 20. [HHC]

———. 1978. Strategies of maximisation, stability, and resilience in Mesopotamian society, settlement, and agriculture. *Proceedings of the American Philosophical Society* 122:329–35.

———. 1981. *Heartland of cities.* Chicago: University of Chicago Press.

ALGAZE, G. Editor. 1990. *Town and country in southeastern Anatolia.* Vol. 2. *The stratigraphic sequence at Kurban Höyük.* Oriental Institute Publications 110.

ALGAZE, G., R. BREUNINGER, C. LIGHTFOOT, AND M. RO-

SENBERG. 1991. The Tigris-Euphrates archaeological reconnaissance project: A preliminary report of the 1989–1990 seasons. *Anatolica* 17:175–240.

ALGAZE, G., A. MISIR, AND T. J. WILKINSON. 1992. Şanliurfa Museum/University of California excavations and surveys at Titrish Höyük, 1991: A preliminary report. *Anatolica* 18:33–60.

ALLAN, W. 1965. *The African husbandman.* Edinburgh: Oliver and Boyd.

ALTHEIM, F., AND R. STIEHL. 1954. *Ein asiatischer Staat: Feudalismus unter den Sasaniden und ihren Nachbarn.* Wiesbaden: Limes-Verlag. [HW, MC]

ANDREAE, BERND. 1981. *Farming, development, and space.* Berlin and New York: de Gruyter.

BALL, W., D. TUCKER, AND T. J. WILKINSON. 1989. The Tell al-Hawa Project: Archaeological investigations in the North Jazira 1986–1987. *Iraq* 51:1–66.

BINTLIFF, J. L. 1984. "Iron Age Europe," in *European social evolution: Archaeological perspectives.* Edited by J. L. Bintliff, pp. 157–225. Bradford: Bradford University Press. [JLB]

———. 1991. "Die Polis-Landschaften Griechenlands: Probleme und Aussichten der Bevolkerungsgeschichte," in *Stuttgarter Kolloquium zur historischen Geographie des Altertums 2–3.* Edited by E. Olshausen and H. Sonnabend, pp. 149–202. Bonn: Habelt Verlag. [JLB]

———. 1992. "Erosion in the Mediterranean lands," in *Past and present soil erosion.* Edited by M. Bell and J. Boardman, pp. 125–31. Oxbow Monograph 22. [JLB]

BOEHMER, R. M. 1991. Uruk 1980–1990: A progress report. *Antiquity* 65:465–78.

BOSERUP, E. 1981. *Population and technology.* Oxford: Blackwell.

BOTTEMA, S. 1989. "Notes on the prehistoric environment of the Syrian Djezireh," in *To the Euphrates and beyond: Archaeological studies in honour of Maurits Van Loon.* Edited by O. M. C. Haex, H. H. Curvers, P. M. M. G. Akkermans, pp. 1–16. Rotterdam: Balkema.

BOWEN, H. C. 1961. *Ancient fields.* London: British Association for the Advancement of Science. [HW, MC]

BRENGLE, K. G. 1982. *Principles and practices of dryland farming.* Boulder: Associated Universities Press.

BUCCELLATI, G. 1990. "The rural landscape of the ancient Zor: The Terqa evidence," in *Techniqes et pratiques hydro-agricoles traditionnelles en domain irrigué.* Edited by B. Geyer, pp. 155–67. Paris: Paul Geuthner. [ML]

BUCCELLATI, G., AND M. K. BUCCELLATI. 1988. *Mozan I: The soundings of the first two seasons.* Malibu: Undena.

BURINGH, P. 1960. *Soils and soil conditions in Iraq.* Baghdad: Iraq Directorate-General of Agricultural Research and Projects. [JO, HW, MC]

BUTZ, K. 1979. "Ur in altbabylonischer Zeit als Wirtschaftsfaktor," in *State and temple economy in the ancient Near East.* Edited by E. Lipinski, pp. 257–409. Orientalia Lovaniensia Analecta 5. [HW, MC]

———. 1981. "Terminologie der Viehwirtschaft in den Texten aus Ebla," in *La lingua di Ebla.* Edited by L. Cagni, pp. 321–53. Napoli: Istituto Universitario Orientale. [ML]

———. 1983. "Landwirtschaft," in *Reallexikon der Assyriologie,* vol. 6. pp. 407–86. Berlin: de Gruyter. [HW, MC]

BUTZ, K., AND P. SCHRÖDER. 1985. Zu Getreideertragen in Mesopotamien und dem Mittlemeergebiet. *Baghdader Mitteilungen* 16:165–208. [HW, MC]

BUTZER, K. W. 1976. *Early hydraulic civilization in Egypt.* Chicago: University of Chicago Press. [HW, MC]

———. 1980. Civilizations: Organisms or systems? *American Scientist* 68:517–23.

———. 1982. *Archaeology as human ecology.* Cambridge: Cambridge University Press.

CARROUÉ, FRANÇOIS. 1983. "Les villes de l'état de Lagash au 3e millénaire," in *La ville dans le Proche-Orient ancient: Actes de Colloque de Cartigny 1979.* Edited by F. Brushweiler, pp. 97–112. Leuven: Éditions Peeters. [HHC]

CATAGNOTI, A., AND M. BONECHI. 1992. Le volcan Kawkab, Nagar, et problèmes connexes. *NABU* no. 2, pp. 50–53. [HW, MC]

CHARLES , M. 1990. Traditional crop husbandry in southern Iraq. *Bulletin on Sumerian Agriculture* 5:47–64. [JO, HW, MC]

CHILDE, V. G. 1954. *What happened in history.* London: Penguin Books.

CHISHOLM, M. 1979. *Rural settlement and land use.* London: Hutchinson.

CHORLEY, R. J., AND B. A. KENNEDY. 1971. *Physical geography: A systems approach.* Englewood Cliffs: Prentice-Hall. [HW, MC]

CHRISTALLER, W. 1966. *Central places in southern Germany.* Translated by C. W. Baskin. Englewood Cliffs: Prentice-Hall.

CIVIL, M. 1987. Critical edition of *The farmer's instructions.* MS.

———. 1994. *The farmer's instructions.* Barcelona.

COSTA, P. M., AND T. J. WILKINSON. 1987. The hinterland of Sohar: Archaeological surveys and excavations within the region of an Omani seafaring city. *Journal of Oman Studies* 9:1–238.

COURTY, M.-A. n.d. Le cadre paléogeographique des occupations humaines dans le bassin du Haut-Khabour (Syrie du Nord-est): Premiers résultats. *Paléorient.* In press. [HW, MC]

COURTY, M.-A., P. GOLDBERG, AND R. MACPHAIL. 1991. *Soils and micromorphology in archaeology.* Cambridge: Cambridge University Press. [HW, MC]

CRAWFORD, O. G. S., AND A. KEILLER. 1928. *Wessex from the air.* Oxford: Clarendon Press.

CRONON, W. 1991. *Nature's metropolis: Chicago and the Great West.* New York: Norton.

CROWSON, R. A. 1981. *Biology of* Coleoptera. London: Academic Press. [JO]

CRUMLEY, CAROLE. 1976. Towards a locational definition of state systems of settlement. *American Anthropologist* 78:59–73.

———. 1979. Three locational models: An epistemological assessment for anthropology and archaeology. *Advances in Archaeological Method and Theory* 2:143–74.

CURVERS, HANS H., AND GLENN M. SCHWARTZ. 1990. Excavations at Tell al-Raqa'i: A small rural site of early urban northern Mesopotamia. *American Journal of Archaeology* 94(1):3–23. [HHC]

DALLEY, S., C. B. F. WALKER, AND J. D. HAWKINS. 1976. *The Old Babylonian tablets from Tell al-Rimah.* London: British School of Archaeology in Iraq.

DAR, S. 1986. *Landscape and pattern: An archaeological survey of agroclimatology in the Near East.* World Meteorological Organisation Technical Note 56.

DAVIS, KINGSLEY. 1955. The origin and growth of urbanization in the world. *American Journal of Sociology* 60:429–37.

DE BRICHAMBAUT, G. P., AND C. C. WALLEN. 1963. *A study of agroclimatology in the Near East.* World Meteorological Organisation Technical Note 56.

DORNEMANN, R. H. 1985. Salvage excavations at Tell Hadidi in the Euphrates River valley. *Biblical Archaeologist* 48:49–59.

EDENS, CHRISTOPHER. 1992. Dynamics of trade in the ancient Mesopotamian world system. *American Anthropologist* 94:118–39.

EL-SAMARRAIE, H. Q. 1972. *Agriculture in Iraq during the 3rd century A.H.* Beirut: Librairie du Liban.

ENDRESS, G. 1993. "Die wissenschaftliche Literatur," in *Grundriss der Arabischen Philologie,* vol. 3, suppl. Edited by W. Fisher, pp. 149–98. Wiesbaden: Reichert. [HW, MC]

ENGLISH, P. W. 1966. *City and village in Iran.* Madison: University of Wisconsin Press.

ERGENZINGER, P. J., W. FREY, H. KUHNE, AND H. KURSCHNER. 1988. "The reconstruction of environment, irrigation, and the development of settlement on the Habur in north-east Syria," in *Conceptual issues in environmental archaeology.* Edited by J. L. Bintliff, D. A. Davidson, and E. G. Grant, pp. 108–28. Edinburgh: Edinburgh University Press.

EVANS, S., AND P. GOULD. 1982. Settlement models in archaeology. *Journal of Anthropological Archaeology* 1:275–304.

FAHD, T. 1974. "Le calendrier des travaux agricoles d'aprés al-Filaha al-Nabatiyya," in *Orientalia hispanica F. M. Pareja octogenario dicata,* pp. 245–72. Leiden: Brill. [HW, MC]

———. 1977. "Matériaux pour l'histoire de l'agriculture en Iraq: *al-Filaha n-Nabatiyya*," in *Handbuch der Orientalistik,* vol. 1. Edited by B. Spuler, pp. 276–378. Wirtschaftsgeschichte des vorderen Orients in Islamischer Zeit 1. [HW, MC]

FALES, F. M. 1973. *Censimenti e catasti di epoca neo-assira.* Roma: Centro per le Antichità e la Storia dell'Arte del Vicino Oriente. [ML]

———. 1990. The rural landscape of the Neo-Assyrian empire: A survey. *State Archives of Assyria Bulletin* 4(2):81–142.

FAROQHI, SURAIYA. 1984. *Towns and townsmen of Ottoman Anatolia: Trade crafts and food production in an urban setting, 1520–1650.* Cambridge: Cambridge University Press.

FORTIN, MICHEL. 1991. Récentes recherches archéologiques dans la Moyenne Vallée du Khabur (Syrie). *Bullétin de la Société Canadienne des Études Mésopotamiennes* 21:5–16. [HHC, JM]

FRETER, ANN CORINNE. 1994. "The Classic Maya collapse at Copan, Honduras: An analysis of Maya rural settlement trends," in *Archaeological views from the countryside: Village communities in early complex societies.* Edited by G. Schwartz and S. Falconer, pp. 160–76. Washington, D.C.: Smithsonian Institution Press. [GMS]

FUKAI, S., K. HORIUCHI, AND T. MATSUTANI. 1974. *Telul eth-Thalathat 3: The excavation of Tell V.* Tokyo: University of Tokyo.

GELB, I. J. 1986. "Ebla and Lagash: Environmental contrast," in *The origins of cities in dry-farming Syria.* Edited by H. Weiss, pp. 157–67. Guilford, Conn.: Four Quarters.

GIBSON, MC GUIRE. 1974. "Violation of fallow and engineered disaster in Mesopotamian civilization," in *Irrigation's impact on society.* Edited by T. E. Downing and Gibson McGuire, pp. 7–19. Tucson: University of Arizona Press.

GOETZE, A. 1963. Šakkanakkus of the Ur III empire. *Journal of Cuneiform Studies* 17:1–31. [HW, MC]

GRAFFAM, GRAY. 1992. Beyond state collapse: Rural history, raised fields, and pastoralism in the south Andes. *American Anthropologist* 94:882–904.

GREENE, K. 1986. *The archaeology of the Roman economy.* Berkeley and Los Angeles: University of California Press.

GREMMEN, W. H. E., AND S. BOTTEMA. 1991. "Palynolological investigations in the Syrian Gazira," in *Die Rezente Umwelt von Tall Seh Hamad und Daten zur Umweltrekonstruktion der Assyrischen Stadt Dur-Katlimmu.* Edited by H. Kuhne, pp. 105–16. Berlin: Dietrich Reimer Verlag.

GROSSMAN, D., AND Z. SAFFRAI. 1980. Satellite settlement in Western Samaria. *Geographical Review* 70:446–61.

GUEST, E. 1966. *The flora of Iraq.* Baghdad: Republic of Iraq, Ministry of Agriculture.

HADJICHRISTODOULOU, A. 1982. The effects of annual precipitation and its distribution on grain yield of dryland cereals. *Journal of Agricultural Science* 99:261–70.

HAGIN, J., AND B. TUCKER. 1982. *Fertilization of dryland and irrigated soils.* Berlin: Springer. [HW, MC]

HALSTEAD, PAUL. 1987. Traditional and ancient rural economy in Mediterranean Europe: *plus ça change? Journal of Hellenic Studies* 107:77–87. [PH]

———. 1989. "The economy has a normal surplus: Economic stability and social change among early farming communities of Thessaly, Greece," in *Bad year economics.* Edited by Paul Halstead and John O'Shea, pp. 68–80. Cambridge: Cambridge University Press.

———. 1990. Quantifying Sumerian agriculture: Some seeds of doubt and hope. *Bulletin on Sumerian Agriculture* 5:187–95.

———. 1992. "Agriculture in the Bronze Age Aegean: Towards a model of palatial economy," in *Agriculture in ancient Greece.* Edited by Berit Wells, pp. 105–17. Skrifter Utgivna av Svenska i Athen 42.

HASSAN, FEKRI A. 1981. *Demographic archaeology.* New York: Academic Press.

HAUPTMAN, H. 1980. "Lidar Hoyuk 1978," in Recent archaeological research in Turkey. *Anatolian Studies* 30:225–26.

———. 1984. "Lidar Hoyuk 1983," in Recent archaeological research in Turkey. *Anatolian Studies* 34:226–28.

HILLMAN, G. 1973. Agricultural productivity and past population potential at Aşvan. *Anatolian Studies* 232:225–40.

HODDER, I. R. 1972. "Locational analysis and the study of Romano-British settlement," in *Models in archaeology.* Edited by D. L. Clarke, pp. 887–909. London: Academic Press.

HOLE, F., K. V. FLANNERY, AND J. A. NEELY. 1969. *Prehistory and human ecology of the Deh Luran Plain.* Ann Arbor: Museum of Anthropology. [JO]

HOLLAND, T. A. 1976. Preliminary report on excavations at Tell Sweyhat, Syria, 1973–74. *Levant* 8:36–70.

———. 1977. Preliminary report on excavations at Tell Sweyhat, Syria, 1975. *Levant* 9:36–65.

HOLLAND, T. A., AND R. L. ZETTLER. 1991. "Sweyhat," in *Archaeology in Syria.* Edited by H. Weiss, pp. 717–19. American Journal of Archaeology 95.

HUNT, R. C. 1987. "The role of bureaucracy in the provisioning of cities: A framework for analysis of the ancient Near East," in *The organization of power: Aspects of bureaucracy in the ancient Near East.* Edited by McGuire Gibson and Robert Biggs, pp. 141–68. (Studies in Ancient Oriental Civilization 46.) Chicago: Oriental Institute.

JAGER, S. W. 1985. A prehistoric route and ancient cart-tracks in the *Gemeente* of Anloo (Province of Drenthe). *PalaeoHistoria* 27:185–202.

JANSSEN, B. H. 1970. *Soil fertility in the Great Konya Basin, Turkey.* Wageningen: Center for Agricultural Publication and Documentation.

JEAN, CHARLES-F. 1947. Lettres de Mari IV, transcrites and traduites. *Revue d'Assyriologie* 42:53–78.

———. 1975. "Locational analysis and the investigation of Uruk locational exchange systems," in *Ancient civilization and trade.* Edited by J. A. Sabloff and C. C. Lamberg-Karlovsky, pp. 285–339. Albuquerque: University of New Mexico Press.

———. 1980. Rank-size convexity and system integration: A view from archaeology. *Economic Geography* 5:234–47.

———. 1987. "The changing organisation of Uruk administration on the Susiana plain," in *The archaeology of western Iran.* Edited by F. Hole, pp. 107–39. Washington, D.C.: Smithsonian Institution Press.

JOHNSTON, R. J. 1984. *An outline for urban geography.* London: Hutchinson.

JONES, H. M. 1971. 2d edition. *Cities of the eastern Roman provinces.* Oxford: Oxford University Press. [HW, MC]

KEMP, D. D. 1990. *Global environmental issues: A climatological approach.* London: Routledge.

KENNEDY, H. 1981. *The early Abassid caliphate.* London: Croom Helm. [HW, MC]

KEPINSKI, C. 1990. "Tell Khoshi," in *Archaeology in Iraq.* Edited by Khaled Nashef, pp. 275–77. American Journal of Archaeology 94.

KING, F. H. 1920. *Farmers of forty centuries: Permanent agriculture in China, Korea, and Japan.* Emmaus, Pa.: Rodale.

KING, L. J. 1985. *Central place theory.* Beverley Hills: Sage.

KRAMER, CAROL. 1982. *Village ethnoarchaeology.* New York: Academic Press.

KRAMER, S. N. 1963. *The Sumerians.* Chicago: University of Chicago Press. [JO]

KWASMAN, T., AND S. PARPOLA. Editors. 1991. *Legal transactions of the court of Nineveh.* Pt. 1. (State Archives of Assyria 6.) Helsinki: University of Helsinki Press.

LEBEAU, MARC. 1989. Rapport preliminaire sur la quatrième campagne de fouilles à Tel Melebiya (Moyen-Khabur–printemps 1987). *Akkadica* 61:1–31. [HHC, JM]

LEEMANS, W. F. 1960. *Foreign trade in the Old Babylonian period.* Leiden: Brill.

LEROUX, D. 1951. *Engrais, amendements, produits pour la protection des cultures: Étude et analyse.* Paris: Gauthier-Villars. [HW, MC]

LEWIN, R. 1993. *Complexity: Life at the edge of chaos.* London: J. M. Dent. [JLB]

LIVERANI, M. 1975. Communautés de village et palais royal dans la Syrie du II^ème^ millénaire. *Journal of the Economic and Social History of the Orient* 18:146–64. [ML]

———. 1979. Economia delle fattorie palatine ugaritiche. *Dialoghi di Archeologia* 1/2:57–72. (English translation in *Production and consumption.* Edited by C. Zaccagnini, pp. 127–88. Budapest, 1989.) [ML]

———. 1982. "Ville et campagne dans le royaume d'Ugarit: Essai d'analyse économique," in *Societies and languages of the ancient Near East: Studies in honour of I. M. Diakonoff*, pp. 250–58. Warminster: Aris and Phillips. [ML]

———. 1989. "Economy of Ugaritic royal farms," in *Production and consumption in the ancient Near East.* Edited by C. Zaccagnini, pp. 127–68. Budapest.

———. 1990–91. Il rendimento dei cereali durante la III dinastia di Ur: Contributo ad un approccio realistico. *Origini* 15:359–68. [ML]

LLOYD, S. 1938. Some ancient sites in the Sinjar district. *Iraq* 5:123–42.

LOIZIDES, P. 1980. "Crop rotations under rainfed conditions in a Mediterranean climate in relation to soil moisture and fertilizer requirements," in *Rainfed agriculture in the Near East and North Africa.* Edited by V. D. Krontos. Rome: FAO. [HW, MC]

LUKE, JOHN T. 1965. *Pastoralism and politics in the Mari period: A reexamination of the character and political significance of the major West Semitic tribal groups on the Middle Euphrates, ca. 1828–1758 B.C.* Ann Arbor: University Microfilms. [HHC]

LYONNET, B. 1990. "Prospection archéologique du site de Mohammed Diyab," in *Tell Mohammed Diyab (Campagnes 1987 et 1988).* Edited by J.-M. Durand, pp. 71–115. Paris: S.E.P.O.A.

MCCORRISTON, J. 1992. The Halaf environment and human activities in the Khabur drainage, Syria. *Journal of Field Archaeology* 19:315–33.

MARGUERON, JEAN-CLAUDE. 1991. Mari, l'Euphrate, et le Khabur au milieu du IIIe millénaire. *Bulletin of the Canadian Society for Mesopotamian Studies* 21:79–100. [HHC]

MATTHEWS, V. H. 1978. *Pastoral nomadism in the Mari Kingdom.* American Schools of Oriental Research Series 3. [HW, MC]

MATTHEWS, D., AND J. EIDEM. 1993. Tell Brak and Nagar. *Iraq* 55:201–7. [JO, HW, MC]

MEIJER, D. J. W. 1986. *A survey in northeastern Syria.* Nederlands Historisch-Archaeologisch Instituut te Istanbul.

———. 1990. "An archaeological surface survey: Some assumptions and ideas," in *Tall al-Hamidiya 2.* Edited by S. Eichlar, M. Wafler, and D. Warburton, pp. 31–45. Orbis Biblius Orientalis 6.

MICHALOWSKI, P. 1989. *The lamentation over the destruction of Sumer and Ur.* Winona Lake: Eisenbraun's. [HW, MC]

MILLER, N. 1984. The interpretation of some carbonised cereal remains as remnants of dung cake fuel. *Bulletin of Sumerian Agriculture* 1:45–47. [JO]

MILLER, R. M., AND J. D. JASTROW. 1992. "The role of mycorrhizal fungi in soil conservation," in Mycorrhizae *in sustainable agriculture*, pp. 29–44. American Society of Agronomy Special Publication 54.

MINNIS, P. E. 1985. *Social adaptation to food stress: A prehistoric Southwestern example.* Chicago: University of Chicago Press.

MOHAMMED, ALI HASSAN. 1955. *Land reclamation and settlement in Iraq.* Baghdad: Baghdad Printing Press.

MORONY, M. 1984. *Iraq after the Muslim conquest.* Princeton: Princeton University Press. [HW, MC]

NEUMANN, J., AND S. PARPOLA. 1987. Climatic change and the 11th–10th century eclipse of Assyria and Babylonia. *Journal of Near Eastern Studies* 6:161–82.

NEWMAN, J. 1932. *The agricultural life of the Jews in Babylon.* London: Oxford University Press.

OATES, JOAN. 1986. "Tell Brak: The Uruk/Early Dynastic sequence," in *Gamdat Nasr: Period or regional style?* Edited by U. Finkbeiner and W. Röllig. Wiebaden: Dr. Ludwig Reichert Verlag. [JM]

OATES, D., AND J. OATES. 1993. Excavations at Tell Brak 1992–93. *Iraq* 55:155–99. [JO]

OLMSTEAD, A. T. 1948. *History of the Persian Empire.* Chicago: University of Chicago Press. [HW, MC]

ORTLOFF, C., AND A. KOLATA. 1993. Climate and collapse: Agri-ecological perspectives on the decline of the Tiwanaku state. *Journal of Archaeological Science* 20:195–221.

PFÄLZNER, PETER. 1990. "Tell Bderi: The development of a Bronze Age town," in *The Near East in antiquity*, vol. 1, *German contributions to the archaeology of Jordan, Palestine, Syria, Lebanon, and Egypt.* Edited by S. Kerner, pp. 63–79. Amman: Goethe-Institut. [HCC]

POSTGATE, J. N. 1977. "The economic structure of the Assyrian empire," in *Power and propaganda.* Edited by M. T. Larsen, pp. 193–221. Copenhagen: Akademisk. [HW, MC]

———. 1978. An inscribed jar from Tell al-Rimah. *Iraq* 40:71–75.

———. 1992. *Early Mesopotamia.* New York: Routledge. [HW, MC]

RAPPAPORT, R. A. 1978. "Maladaption in social systems," in *The evolution of social systems.* Edited by J. Friedman and M. J. Rowlands, pp. 49–71, 79–87.. Pittsburgh: University of Pittsburgh Press.

READE, J. E. 1968. Tell Taya (1967): A summary report. *Iraq* 30:234–64.

———. 1971. Tell Taya (1968–69): A summary report. *Iraq* 33:87–100.

REDMAN, C. L. 1978*a*. "Mesopotamian urban ecology: The systemic context of the emergence of urbanism," in *Social archaeology: Beyond subsistence and dating.* Edited by C. L. Redman , W. T. Langhorne Jr., M. J. Berman, N. M. Versaggi, E. V. Curtis, and J. C. Wanser, 329–47. New York: Academic Press.

———. 1978*b*. *The rise of civilization.* San Francisco: Freeman.

RENFREW, C. 1975. "Trade as action at a distance: Questions of integration and communication," in *Ancient trade and civilization.* Edited by Jeremy Sabloff and C. C. Lamberg-Karlovsky, pp. 3–59. Albuquerque: University of New Mexico Press.

RENGER, J. 1987. "Überlegungen zur räumlichen Ausdehnung des Staates von Ebla an Hand der agrarischen und viehwiertschaftlichen Gegebenheiten," in *Ebla 1975–1985.* Edited by L. Cagni, pp. 293–311. Napoli: Istituto Universitario Orientale. [ML]

RÖLLIG, W., AND HARMUT KÜHNE. 1977–78. Preliminary report on a survey conducted by the Tübinger Atlas des Vorderen Orients in 1975. *Annales Archéologiques Arabes Syriennes* 7–8:115–40. [JM]

ROWTON, MICHAEL B. 1973. Urban autonomy in a nomadic environment. *Journal of Near Eastern Studies* 32:201–15. [HHC]

RUSSELL, K. W. 1988. *After Eden: The behavioural ecology of early food production in the Near East and North Africa.* British Archaeological Reports International Series 391.

SAGGS, H. W. F. 1959. The Nimrud letters. Pt. 5. *Iraq* 21:162.

———. 1984. *The might that was Assyria.* London: Sidgwick and Jackson.

SAGHIEH, MUNTAHA. 1991. "The Lebanese University recent excavations at Tell Kerma: A salvage operation on the Middle Khabur, N.E. Syria." *Actes de la XXXVIe Rencontre Assyriologique Internationale.* Gand. [JM]

SCHNEIDER, N. 1927. Der Viehbestand des é-gal in Lagash. *Archiv für Orientforschung* 4:206–8. [HW MC]

SCHOFIELD, A. J. Editor. 1991. *Interpreting artefact scatters: Contributions to ploughzone archaeology.* Oxford: Oxbow. [HW MC]

SCHWARTZ, GLENN. 1994. "Rural economic specialization and early urbanization in the Khabur Valley, Syria," in *Village communities in early complex societies.* Edited by G. Schwartz and S. Falconer. Washington, D.C.: Smithsonian Institution Press. [JM]

SCHWARTZ, G. M., AND H. H. CURVERS. 1992. Tell al-Raqa'i 1989 and 1990: Further investigations at a small rural site of early urban northern Mesopotamia. *American Journal of Archaeology* 96:397–419.

SENIOR, L., AND H. WEISS. 1992. Tell Leilan *sila*-bowls and the Akkadian reorganization of Subarian agricultural production. *Orient-Express*, no. 2, pp. 16–23. [HW MC]

SERANGELI. F. 1978. Le liste di censo di Alalakh IV. *Vicino Oriente* 1:99–131. [ML]

SHEPHERD, K. D., P. J. M. COOPER, A. Y. ALLAN, D. S. H. DRENNAN, AND J. D. H. KEATINGE. 1987. Growth, water use, and yield of barley in Mediterranean-type environments. *Journal of Agricultural Science* 109:365–78.

SMAILES, A. E. 1953. *The geography of towns.* London: Hutchinson.

STEIN, G. 1987. Regional economic integration in early state societies: Third millennium B.C. pastoral production at Gritille, southeast Turkey. *Paléorient* 13(2):101–11.

STEIN, G., AND P. WATTENMAKER. 1990. "The 1987 Tell Leilan regional survey: A preliminary report," in *Economy and settlement in the Near East.* Edited by Naomi Miller, pp. 9–18. MASCA Research Papers in Archaeology 7.

STEWART, B. A., O. R. JONES, AND P. W. UNGER. 1993. "Moisture management in semiarid temperate regions." *Agricultural and environmental challenges: Proceedings of the 13th Agricultural Sector Symposium.* Edited by J. P. Srivastava and H. Alderman, pp. 67–80. Washington, D.C.: World Bank.

STINE, S. 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. *Nature* 369:546–49.

STOCKTON, CHARLES W., AND DAVID M. MEKO. 1990. "Some aspects of the hydroclimatology of arid and semi-arid lands," in *Human intervention in the climatology of arid lands.* Edited by Donald R. Haragan, pp. 1–26. Albuquerque: University of New Mexico Press.

STODDART, S. K. F., AND N. WHITEHEAD. 1991. Cleaning the Iguvine stables: Site and off-site analysis from a central Mediterranean perspective," in *Interpreting artefact scatters.* Edited by A. J. Schofield, pp. 141–48. Oxford: Oxbow. [HW, MC]

STRONACH, D. n.d. "Village to metropolis: Nineveh and the beginnings of urbanism in north Mesopotamia," in *Egitto e vicino orienti.* Edited by S. Mazzoni. Rome.

SUMNER, W. M. 1989*a*. "Anshan in the Kaftari phase: Patterns of settlement and land use," in *Archaeologia Iranica et Orientalis.* Edited by L. de Meyer and E. Haerink, pp. 135–61. Ghent.

———. 1989*b*. Population and settlement area: An example from Iran. *American Anthropologist* 91:631–41.

TAINTER, JOSEPH A. 1988. *The collapse of complex societies.* Cambridge: Cambridge University Press. [ML, GMS]

TSOAR, H., AND Y. YEKUTLIELI. 1993. Geomorphological identification of ancient roads and paths on the loess of the northern Negev. *Israel Journal of Earth Sciences* 41:209–16.

ULLMANN, M. 1972. *Die Natur- und Geheimwissenschaften im Islam.* Leiden: Brill. [HW, MC]

VAN DE MIEROOP, M. 1993. Sheep and goat herding according to the Old Babylonian texts from Ur. *Bulletin on Sumerian Agriculture* 7:161–72. [HW, MC]

VAN LIERE, W. J. 1963. Capitals and citadels of Bronze–Iron Age Syria in their relationship to land and water. *Les Annales Archéologiques de Syrie* 13:109–22.

VAN LIERE, W. J., AND J. LAUFFRAY. 1954. Nouvelle prospection archéologique dans la Haute Jezireh Syrienne. *Les Annales Archéologiques de Syrie* 4–5:129–48.

VERSTRAETE, M. M. 1986. Defining desertification: A review. *Climatic Change* 9:5–18.

WATERHOUSE, D. F. 1974. The biological control of dung. *Scientific American* 230:100–109. [JO]

WATSON, A. M. 1983. *Agricultural innovation in the early Islamic world.* Cambridge: Cambridge University Press. [HW MC]

WATSON, P. J. 1979. *Archaeological ethnography in Western Iran.* Viking Fund Publications in Anthropology 57.

WATTENMAKER, P. 1987. Town and village economies in an early state society. *Paléorient* 13(2):113–22.

WEISS, H. 1983. Excavations at Tell Leilan and the origin of north Mesopotamian cities in the third millennium B.C. *Paléorient* 9(2):39–52.

———. 1986. "The origins of Tell Leilan and the conquest of space in 3rd millennium Mesopotamia," in *The origins of cities in dry-farming Syria.* Edited by Harvey Weiss, pp. 71–108. Guilford, Conn.: Four Quarters Press.

———. 1989. Tell Leilan 1989: New data for mid-third-millennium urbanization and state formation. *Mitteilungen der Deutschen Orient-Gesellschaft zu Berlin* 122:193–218.

———. 1990*a*. "'Civilizing' the Habur Plains: Mid-third millennium state formation at Tell Leilan," in *Resurrecting the past.* Edited by P. Matthiae, M. van Loon, and H. Weiss. Istanbul: Nederlands Historisch-Archeologisch Instituut. [JM]

———. 1990*b*. Tell Leilan 1989: Leilan IIID-IIB urbanization and state formation. *Mar-Sipri* 3:1–3. [JM]

———. 1991. Chronique de fouilles: Tell Leilan. *Orient-Express,* no. 2, pp. 3–5. [HW, MC]

———. 1992. Habur triangles: Third-millennium urban settlement in Subir. *Nouvelles Assyriologiques Brèves et Utilitaires,* no. 4, pp. 91–94. [HW, MC]

———. 1994. "Tell Leilan," in *Archaeology in Syria.* Edited by H. Weiss, pp. 125–27. American Journal of Archaeology 98(1). [HW, MC]

WEISS, H.., AND M.-A. COURTY. 1993. "The genesis and collapse of the Akkadian empire: The accidental refraction of historical law," in *Akkad: The first world empire.* Edited by Mario Liverani, pp. 131–55. Padua: Sargon.

WEISS, H., M.-A. COURTY, W. WETTERSTROM, F. GUICHARD, L. SENIOR, R. MEADOW, AND A. CURNOW. 1993. The genesis and collapse of third millennium north Mesopotamian civilization. *Science* 261:995–1004.

WHALLON, R. 1979. *An archaeological survey of the Keban Reservoir area of east-central Turkey.* University of Michigan Museum of Anthropology Memoir 11.

WHITE, K. D. 1970. *Roman farming.* London: Thames and Hudson. [JO]

WHITMORE, T. M., B. L. TURNER II, D. L. JOHNSON, R. W. KATES, AND T. R. GOTTSCHANG. 1990. "Long-term population change," in *The earth as transformed by human action: Global and regional change in the biosphere over the past 300 years.* Edited by B. L. Turner II, pp. 25–39. Cambridge: Cambridge University Press.

WHYTE, A. 1977. "Systems as perceived: A discussion of 'maladaptation in social systems,'" in *The evolution of social systems.* Edited by J. Friedman and M. J. Rowlands, pp. 73–78. London: Duckworth.

WILKINSON, T. J. 1982. The definition of ancient manured zones by extensive sherd-sampling techniques. *Journal of Field Archaeology* 9:323–33.

———. 1989. Extensive sherd scatters and land-use intensity: Some recent results. *Journal of Field Archaeology* 16:31–46.

———. 1990*a*. The development of settlement in the north Jazira between the 7th and 1st millennia B.C. *Iraq* 52:49–62.

———. 1990*b*. *Town and country in southeastern Anatolia.* Vol. 1. *Settlement and land-use at Kurban Höyük and other sites in the Lower Karaba Basin.* Oriental Institute Publications 109.

———. 1993. Linear hollows in the Jazira, Upper Mesopotamia. *Antiquity* 67:548–62.

WILKINSON, T. J., AND D. TUCKER. n.d. *Settlement development in the North Jazira, Iraq: A study of the archaeological landscape.* Warminster: Aris and Phillips. In press.

WRIGHT, H. E. JR. 1993. Environmental determinism in Near Eastern prehistory. CURRENT ANTHROPOLOGY 34:458–69. [ML]

WRIGHT, H. T. 1969. *The administration of rural production in an early Mesopotamian town.* University of Michigan Museum of Anthropology Anthropological Papers 38.

YOFFEE, N. 1979. The decline and rise of Mesopotamian civilization: An ethnoarchaeological perspective on the evolution of social complexity. *American Antiquity* 44:5–35. [ML]

———. 1988. "The collapse of ancient Mesopotamian states and civilizations," in *The collapse of ancient states and civilizations.* Edited by N. Yoffee and G. L. Cowgill, pp. 44–66. Tucson: University of Arizona Press.

ZACCAGNINI, C. 1975. The yield of the fields at Nuzi. *Oriens Antiquus* 14:181–225. [ML]

ZEDER, M. A. 1991. *Feeding cities: Specialized animal economy in the ancient Near East.* Washington, D.C.: Smithsonian Institution Press.

———. 1994. After the revolution: Post-Neolithic subsistence in northern Mesopotamia. *American Anthropologist* 96:97–126. [JM]

ZOHARY, D. 1969. "The progenitors of wheat and barley in relation to agricultural dispersal in the Old World," in *The domestication of plants and animals.* Edited by P. J. Ucko and G. W. Dimbleby, pp. 47–66. London: Duckworth.