

Geoarchaeology, climate change, sustainability: A Mediterranean perspective

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ABSTRACT

Although geological study of Pleistocene cave sites goes back to the nineteenth century, a new paradigm was set in train during the 1920s, when G. Caton-Thompson and E.W. Gardner established a sequence of prehistoric occupations linked to the changing spatial and ecological contours of fluctuating lakes in Egypt's Faiyum Depression. Subsequent collaborations have carried research beyond geochronology and climate stratigraphy to address human settlement within changing environments, which served both as resource and artifact.

Geoarchaeologists, as they were eventually called, worked at multiple scales and with new skills, exploring new ground such as cultural sediments and the taphonomy of site formation, preservation, and destruction. Others, especially in the UK, investigated human modification of particular watersheds. Forty years of work on Mediterranean soil erosion issues saw researchers continue to wrestle with climate or destructive land use as possible prime movers in ecological degradation. The number of geoarchaeologists, full or part time, has increased by an order of magnitude, and the literature continues to explode in quantity and diversity. Perhaps the overarching conceptual framework for most remains a deep interest in landscape histories and the ways in which they co-evolve with human societies.

This paper encourages our confraternity to engage more assertively in the broader academic debates of the day, as empirical scientists open to interdisciplinary exchange and qualified to argue for competent and reasonable positions. We should play a more effective role in environmental history, alongside historians and political ecologists. The popular "new" environmental determinism centered on civilizational collapse in response to "abrupt" climatic change calls for strong voices of caution, on the premise that coincidence, even when true, does not prove causality. We are qualified to monitor the environmental and adaptive changes critical to future projections of global change, and we all have our ideas, even if intuitive, with regard to alternative ways of thinking about sustainability.

EARLY GEOARCHAEOLOGY

Collaboration between geologists and archaeologists in the study of Pleistocene cave sites goes back well into the nineteenth century, when disciplinary lines still were fluid. A watershed was crossed in the 1920s, when geologist Elinor W. Gardner began to work with archaeologist Gertrude Caton-Thompson in the Faiyum Depression of Egypt. A series of high shorelines was traced so as to situate a sequence of Neolithic occupations within the changing spatial and temporal contours of a fluctuating lake. First published in the *Geographical Journal* of 1929, this interdisciplinary framework was only superseded by new expeditions to the Faiyum during the 1960s. By building site clusters into a multidimensional landscape, Caton-Thompson and Gardner (1929) had broken new ground, setting a strategic research direction that anticipated geoarchaeology. Equally so, their model of collaborative research showed what could be done and how.

While surveying for Neolithic and Predynastic sites along the desert margins of the Nile Valley in 1958, the Faiyum investigation served to pose and discuss questions that went beyond stratigraphic placement or environmental reconstruction. The outcome was a complex and explicit strategy to address site selection and preservation, physical versus cultural explanations for apparent settlement gaps, and whether the sites identified were representative of their original density (Butzer, 1960, 1961). Further, a morphostratigraphic map of the desert margins attempted to delineate the geoarchaeological potential of different landscape units (redrawn in Butzer, 1982, figure 14-1). This strategy came together during continuing discussion with archaeologist Werner Kaiser.

Although the term “interdisciplinary” has become a meaningless buzzword for the writers of grant proposals, true cross-disciplinary collaboration is essential for geoarchaeology. There always are people on the other side of the fence who are willing to share their ideas and speculations, or listen to yours, despite the artificial boundaries that continue to divide us. That is the way that *Environment and Archeology* (Butzer, 1964a) came about. An exploratory course on “prehistoric geography,” that I introduced at the University of Wisconsin, combining earth science and archaeology, was supported by colleagues and students in anthropology and biology. Equally critical components for me personally were new fieldwork opportunities, including three seasons at Clark Howell’s Paleolithic excavations in Spain, and almost 7 mo working with an archaeological rescue mission in Nubia and Egypt. Howell generously sponsored my participation at the Wenner-Gren Burg Wartenstein symposia in 1961 and 1963, which included celebrities like Louis Leakey and Desmond Clark. When *Environment and Archeology* appeared in print, it included a half-dozen chapters on archaeological sediments, as well as segments on environmental reconstruction and human-environmental interrelationships in prehistory. Book reviewers from archaeology assured the success of this unorthodox, interdisciplinary presentation, which apparently filled a void. It was this sustained interchange of ideas that led to the conception of

geoarchaeology as an engagement between earth science and archaeology, rather than the application of a battery of techniques in an archaeological context.

This paper first singles out a number of research directions that have become durable themes in geoarchaeology. It then turns to the problematic aspects of Mediterranean landscape history as a prime example of the way in which the field has matured, despite persistent difficulties of synthetic interpretation. It subsequently identifies a less familiar set of cultural and behavioral issues that I believe are critical for more effective diagnosis of cause and effect in transformation and change. This cross-disciplinary excursion concludes with suggestions as to why and how we might enter into a broader academic discourse with regard to the “new” environmentalism, the alleged role of climate or environmental degradation in civilizational collapse, and the linkage of geoarchaeology and sustainability.

A COALESCENCE OF GEOARCHAEOLOGY

Empirical research linked to the discipline that came to be explicitly called *geoarchaeology* has been exploding since the 1970s. The term itself was in informal use well before I applied it to the taphonomy of Acheulian artifacts at the South African site of Amanzi Springs, in *Quaternaria* of 1973 (Butzer, 1973a). Also emphasizing this focus on archaeological sites, Colin Renfrew (1976, p. 2) used the designation to argue that “every archaeological problem starts as a problem in geoarchaeology,” in his keynote address to a symposium on *Sediments in Archaeology* held in 1973. The chronology of the formal term is an unimportant detail, but the creativity within the emerging subdiscipline is noteworthy. The number of full- or part-time geoarchaeologists has increased by an order of magnitude, while the literature continues to expand in quantity and diversity, and in the number of preferred publication outlets.

There now are a number of textbooks (such as Limbrey, 1975; Rapp and Gifford, 1985; Waters, 1992; Brown, 1997; Goldberg and Macphail, 2006; Rapp and Hill, 2006), as well as quite a few volumes of collected papers, dealing with sediments, soils, or sites (for example, Stein and Farrand, 2001; Boardman and Bell, 1992; Lasca and Donahue, 1990; Holliday, 2004; Goldberg et al., 2001). These works suggest that interdisciplinary research between the geosciences and archaeology has come of age, but the diversity of perspectives or positions is striking. The fundamental dichotomy, however, is about the priority given techniques or goals. I would see geoarchaeology as archaeological research using methods and concepts of the earth sciences (Butzer, 1982, p. 35), whereas archaeological geoscience, at least in the United States, tends to apply earth science findings to archaeology, without directly addressing their implications for the interrelationships between the environment and past societies. In the UK, on the other hand, the interactions between earth scientists and archaeologists are closer and more direct. In fact, given a long and complex Pleistocene archaeological record in the Old World, geoarchaeology in Britain, as

documented in the chapters of this volume, typically incorporates archaeology into studies of landscape evolution and environmental history.

These contrasts reflect the distinctive backgrounds of past and present researchers, and the fact that there neither are departments of, nor professorial appointments in geoarchaeology. Despite our individual research trajectories, we all are mainstream practitioners of geography, geology, Quaternary science, or archaeology, as the case may be. It also is a recent subdiscipline, despite its longevity, that only coalesced after the prevailing academic structures had crystallized, a little before or after 1900. However, this very heterodoxy has proven to be healthy, because we all find stimulus, or even excitement, at the various venues we attend, under whatever auspices. There is indeed a close analogy to the spirit of various Quaternary meetings, where everybody does something different, or has a different take on issues or empirical findings, and yet enjoys the opportunity to interact. It is the diversity that is refreshing. Consequently, I think that the big-tent approach to geoarchaeology is a good thing. It brings us together without formal structures, in a way that disciplinary constraints might not have allowed.

The brief discussion that follows attempts to identify some of the salient archaeological subjects being addressed today (also Butzer, 2008), without attempting to do justice to a burgeoning body of literature. Other emphases or interpretations are equally valid, and we should welcome a broader, reflective discussion of what we do and why.

Analysis and Dating of Soils and Sediments

Considerable energy has been and continues to be devoted to the development or application of novel methods to site-specific problems. Relative and quantitative dating has always been a primary concern so that ^{14}C and accelerator mass spectrometry (AMS) remain indispensable. Other, more experimental methods also continue to be tested, and with improving results, for example, optically stimulated luminescence (OSL) (e.g., Fuchs and Wagner, 2005). It need not be emphasized that depositional micro-environments are central to the work of a majority of geoarchaeologists. Interpretative issues of alluvial sites have been discussed by Gladfelter (1981), Abbott and Valastro (1995), and Ferring (2001). Settlement change in response to Holocene fluctuations of sea level in estuarine or deltaic settings has been addressed by Ricklis and Blum (1997), Butzer (2002), and Bell (2007). Soil micromorphology has improved the potential information available from cave sediments (Goldberg and Macphail, 2006, chapter 8). On the other hand, there seems to be a certain reluctance to move from the traditional cave methodologies of Lais (1941) or Laville et al. (1980) toward more sophisticated statistical analyses, which may incorporate analog samples from exterior soils and sediments (Butzer, 1973b, 1981a, 2004; Woodward and Goldberg, 2001). Articles published in various journals illustrate the range of productive examples of geochemical and sediment testing at open-air sites, which has more recently also

turned to the identification of mining residues in alluvial deposits (e.g., Nocete et al., 2005).

Site Patterning and Archaeological Integrity

Of course geoarchaeology is more than the application of a battery of analytical techniques, and we should not lose sight of the wider goal, to address cultural questions directly or indirectly. A prime example of productive collaboration is represented in Pleistocene “open-air” sites that have been sealed and buried by younger sediments. They form a major part of the Old World archaeological record, and significant numbers of such sites have been the subject of elaborate excavations; the early expectation was that sophisticated recovery methods would unearth more or less representative palimpsests of early human cultural behavior.

That illusion has been dispelled by more refined methods (see Behrensmeier and Hill, 1980; Klein, 1987, 1989). Statistical attention to the orientation and disposition of bones and artifacts can show that lithics and long bones in suggestive associations may well have been reworked by streams, while multiple brief occupations of a site can be conflated by erosion of the finer sediments covering them. As a result of such dispersal, some African Acheulian sites may be no more than point bar accumulations or lags left by flood or lake waters. Bone selection and chew marks show that many bone accumulations were not made by humans, but by large carnivores. Even when a few lithic artifacts are present, such a site may prove to be a natural death or carnivore assemblage, scavenged by early humans.

Preburial or postdepositional disturbance has destroyed the cultural integrity of most formerly “open-air” sites (Butzer, 1982, chapter 7; Butzer, 2008), but such problems can also be encountered in cave sites, where multiple occupations and/or mixing during the course of everyday human activities can simulate occupation levels, such as the thick and rich Mousterian horizons in Spain (Butzer, 1981a, 2008). Unfortunately, that problem is not always recognized by archaeologists, who may be inclined to assume that low-energy cave interiors imply cultural integrity. Perhaps the only means to show that associations are representative is by “refitting” the flakes and chips detached from individual artifacts, a technique that can be applied to both cave and open-air sites (see Pope and Roberts, this volume). A high proportion of animal bones with cut-marks can also be helpful.

Merits of “Secondary Sites”

Must then the majority of Pleistocene artifactual concentrations or incidental lithics be rejected as uninformative “nonsites”? By no means, as several presentations, from the “Geoarchaeology 2006” conference (held at the University of Exeter, UK, in September 2006) that now appear as chapters in this volume have shown. Artifacts, like human fossils, record a human presence and identify a changing biophysical context for human activities (cf. Helgren, 1997). When found in small numbers within a high-energy sedimentary sequence, artifact frequency and depositional

structures may allow identification of the original location of the site in a paleolandscape. Bell (2007) suggested that human activity may even have been concentrated during periods of maximum environmental dynamism.

Surface surveys of promising landform elements with the aid of geographic information systems (GIS) can identify sensitive archaeological landscapes for management purposes, as well as provide understanding of the spatial activities of Paleolithic to Early Bronze Age people with respect to their contemporary landscape (Passmore et al., this volume). This is more reasonable than using gridded, random squares, as has been done in many formal archaeological surveys. Dense regional concentrations of abraded surface artifacts can also be systematically studied in a spatial perspective. They may be most common in areas with a particular lithology, or at contacts between different lithologies (quarry sites), and equally so at river channel confluences, where stream gradients can change abruptly (Hosfield, 2005, this volume). The gaps in such “nonsite” distributions raise interesting questions, not just in terms of past spatial behavior, settlement expansion or retraction, and lithic provenance, but also for landscape dynamics, such as river entrenchment.

Interpretation of the UK archaeological landscape has been greatly enhanced in recent years by support from the Aggregates Levy Sustainability Fund (see Brown, 2008). This complements the once-introverted focus on site excavation with fresh spatial perspectives.

Urban Geoarchaeology

Much attention has been focused on settlement sites with architectural components, which are informative for both environmental and sociohistorical questions (Butzer, 1982, p. 83–94; Butzer, 2008; Rosen, 1986; Beach and Luzzadder-Beach, 2008). With its mix of cultural and environmental sediments, urban geoarchaeology may record natural hazards or disasters, site growth and decline, or deliberate destruction. Such deposits are sensitive to human disturbance as well as to social change. Occupation residues, artifactual fills, mudbrick residues, collapse rubbles, flood silts, or intrusive slope-soil wash can be found on house floors, in roadways or alleyside dumps, or in civic precincts (Butzer, 1981b). These may elucidate continuing or changing human activities. On the other hand, environmental insights are particularly promising in floodplain sites prone to destructive floods or channel shifts (Butzer et al., 1983), while footslope sites may be susceptible to repeated waves of soil influx (Butzer, 1981b). Larger questions of urban site formation, preservation, or erosion raise geomorphological issues of sediment accumulation, or modification and removal (Kirkby and Kirkby, 1976; Butzer, 1982, chapter 7; Rosen, 1986; Schuldenrein et al., 2004; Beach and Luzzadder-Beach, 2008), which have important implications for archaeological survey and excavation.

Unfortunately, geoarchaeological investigations carried out in urban “heritage projects,” such as in York (UK) or Valencia (Spain), do not always find publication in readily visible outlets.

On the other hand, systematic urban excavations by academic teams may lack a geoarchaeological component, with some notable exceptions, such as Catalhüyük or Giza. Even today, one can see backhoes in the Mediterranean Basin removing so-called site overburden. A great deal of information is being lost or left inaccessible, suggesting the need for a special symposium on urban geoarchaeology.

Landscape Geoarchaeology and Watershed Transformation

At a larger scale, geoarchaeologists have been active in studying the Holocene evolution of small or large watersheds, in partial response to human intervention (see Needham and Macklin, 1992; Lewin et al., 1995; Brown, 1997, 2008; Howard et al., 2003). Such work is marked by a fresh attention to detail, modeling, and paleohydrology, which incorporates historical and archaeological data, and draws on palynology or tree-ring results. The result is a better understanding of the temporal and spatial parameters of climatic change or of human impacts on environmental equilibrium. However, it remains a formidable task to separate climatic and human factors, and this need is being met by increasing attention to archival chronologies and patient contextual examination (Brown, 2008; Dotterweich, 2005; Macklin et al., 2005; Benito et al., 2008). This has contemporary relevance going well beyond management issues. A diachronic approach that monitors the processes and feedbacks of “historical” change is critical to understanding contemporary, synchronic patterning, or to anticipate future contingencies. In other words, alluvial histories pose questions and provide insights in regard to global change or that elusive matter of sustainability (Butzer, 2005).

These micro- and macrothemes of site versus watershed can now facilitate a more focused analytical discussion, emphasizing the Mediterranean world with its large corpus of data. It has also attracted the interest of many international researchers.

MEDITERRANEAN LANDSCAPE HISTORY

The Debate

With the aura of Classical and earlier civilizations, the Mediterranean world has long attracted visitors from northern climes, whether scholars or travelers, barbarians or sun-worshippers. Echoing Plato and Pausanias, George Perkins Marsh (1864) fired off the opening diatribe, blaming Mediterranean people for destructive land use, whereas Ellsworth Huntington (1910) waxed nostalgic over Arcadian forests fallen victim to progressive desiccation. With the benefit of hindsight, Marsh and Huntington positioned human impact and climatic change as the polar coordinates of an environmental dialectic, even before the emergence of contemporary concerns about long-term ecology.

A new round of discourse began with publication of *The Mediterranean Valleys* by Claudio Vita-Finzi (1969; also review by Butzer, 1969). That author claimed a single phase of Holocene

alluviation, a “Younger Fill,” which he considered to be of post-Roman age. It was believed to be synchronous throughout the Mediterranean world, in response to a climatic anomaly. Vita-Finzi also identified an “Older Fill” pertaining to the late Pleistocene. The ensuing debate is ably covered by the extended review of Horden and Purcell (2000, chapter 8).

The substantial corpus of research in Greece by Tjeerd Van Andel and his associates provided a more refined database. Not one, but several phases of substantial alluviation have been identified for Neolithic and Bronze Age times (Van Andel et al., 1990; Wells et al., 1990; Zangger, 1993; Jameson et al., 1994). Some of these episodes were linked to debris flows, reflecting slope failure, a more “catastrophic” process (Pope and Van Andel, 1984). Soil erosion did take place during the Classical, Roman, and later periods, but it was less dramatic and more variable. These authors favored an anthropogenic interpretation, suggesting that accelerated valley alluviation may have been preferentially linked to initial occupancy or abandonment, rather than periods of agricultural intensification. While these interpretations require more documentation, especially a local pollen record, they do not warrant identification of Van Andel as a “narrowly-culturalist” determinist (Bintliff, 2000, p. 57), whatever that may be. The issue is no longer whether human impact can have repercussions for the soil landscape, but to distinguish between the impacts of climatic perturbations and changing land use.

Sediment Facies Are Complex

During the course of intensive Quaternary and geoarchaeological studies in a half-dozen different environments of Spain and Mallorca, it has been my experience that landform evolution, and the development of alluvial and slope deposits are different in each. Key variables are elevation, relief and slope, different equilibrium thresholds, and the complexities of Cenozoic geological evolution.

Some mountain ranges were initially shaped within a medium of deep tropical soils, such as in southern Galicia (Butzer, 1967). Others were opened through the expansion of extensive erosional surfaces, endowing them with repeated knickpoints and changes of gradients, e.g., the central sierras of Spain (Gladfelter, 1971). In other cases, topographies were greatly roughed up by Pleistocene cold-climate processes or glaciers. In the Cantabrian ranges of northern Spain, alluvial formations include glaciofluvial terraces, with or without periglacial modification, that progressively change character downstream (Butzer, 1986). Cobble-bed channels may be recycled from Pleistocene units by the undercutting of older fills or reactivation of deeper channel floors (Butzer and Mateu, 1999). Massive silt/clay accumulations are derived from poorly consolidated Miocene–Pliocene basin deposits, while karstic terrain favors carbonate-impregnated fills, marls, and spring tufas (Gladfelter, 1971). Mixed-caliber valley fills may be interdigitated with Quaternary slope screes, with rubble set in a matrix of reddish soil-derived sediment (Butzer, 1964b; Butzer and Mateu, 1999). Clayey alluvia characterize limestone terrain

where weathering has dissolved clasts and sands, in contrast to the prominent bed-load alluvia and slope screes of watersheds with silicate rocks (Butzer and Mateu, 1999).

Such cases underscore the fact that one cannot lump mid- or late Holocene fills and colluvia into a single facies model, regardless of age. Geological antecedents and complex three-dimensional landscapes, coupled with Quaternary history, strongly affect facies development and variability, channel gradients, and the overarching hydraulic parameters. The architecture of sedimentary fills is correspondingly complex.

Dissimilar Patterns of Landscape Evolution

These Spanish examples are not exceptional. The mountainous northwestern half of Greece is dominated by Pleistocene features that reflect cold-climate denudation, with late Holocene detail imprinted around major historical sites. By contrast, in the southeastern half of Greece, mountain crests are bare, slope soils are thin, and the lowlands support both Holocene and Pleistocene depositional sequences. Often buried, mid-Holocene sediments on the piedmonts typically record high-energy depositional environments. Alluvium and colluvium mantling Early Roman-age urban sites may attain remarkable thicknesses of 5 m or more in places such as Eleusis or ancient Corinth, but mainly reflect low-energy transfer.

Initial observations on Cyprus suggest both differences and similarities with mainland Greece. In the mountains, the picture is comparable, but without glaciers; in the lowlands, Holocene sediment supply and volume have been small, with erosion concentrated during Late Roman times, with earlier equilibrium maintenance, despite Archaic and Classical copper-smelting and shipbuilding. However, there is evidence of renewed pedogenesis, flood silt accretion, or bed-load aggradation during the Medieval period (Butzer and Harris, 2007).

In effect, the development of alluvia and colluvia varies from one region or district to another, suggesting different progressions of slope evolution. Topography, sediment supply, climate, and land cover set distinctive equilibrium conditions in most watersheds. Feedbacks are dampened or enhanced accordingly, so that outcomes are difficult to anticipate. As a result, *no single model can be proposed for Mediterranean landscape history*. Premature regional or global teleconnections introduce unproven assumptions and ignore complexity (also Schumm, 1991). Local landscape histories, based on intensive local studies, should first be properly understood and allowed to reveal their own stories.

Difficulties of Establishing Causality

The Mediterranean world represents a nonequilibrium environment, affected by both high-magnitude climatic impulses and longer-term change. At the same time, sporadic, sustained, or intensified land use can reinforce “natural” change, or create a soil environment vulnerable to climatic perturbation. Two practical examples may illustrate the scope of the problem.

Hypothetical Case A

Assume some 4 m of soil sediment burying a former Early Roman site in a watershed with gently rolling hillsides. Scale and disproportionality of change would point to a basic land-use problem, but did colluviation actually begin before abandonment (in which case high-intensity use may have been the main culprit)? Did it only begin after desertion (in response to deteriorating terrace systems or a switch to an improvident form of pastoralism)? Was it multiphased (in part responding to renewed but nonurban cultivation two centuries later)? Did extreme precipitation events trigger one or more postabandonment events in a stressed landscape? The importance of a biological record, sufficient test trenches, tight dating controls, and comprehension of land-use histories is evident.

Hypothetical Case B

Assume 2 m of colluvium at the foot of a long, stony slope with “natural” shrub and bush cover, next to a once heavily settled valley bottom, but not in visible contact with settlement residues. Do potsherds of that occupation found in the colluvium actually date its accumulation? Did the colluvium perhaps accumulate in pulses across several millennia, both before and after occupation, in response to climatic events? Can we suppose that pastoral use of the slope before, during, or after valley settlement facilitated or “forced” soil erosion? Basic questions might be resolved by uncovering cultural interdigitations during extensive valley margin trenching (if permitted by the directing archaeologist). However, uncertainties will remain, particularly if we do not know which human actors were doing what, where, and when.

Synthesis

It is challenging to isolate climatic and land-use histories as prime suspects for waves of soil erosion in the Mediterranean world. Experimental erosion plots with different land-use types are not readily converted to watersheds, because of complex patterns of sediment storage—on slopes, floodplains, or channelways (see Butzer and Helgren, 2005; Houben, 2008). It is therefore difficult to quantify the appealing notion that climatic triggering will release the latent instability of use-stressed landscapes. Holocene stream disequilibria in mid-latitude European rivers suggest that such triggering can also be quite subtle, with cut-and-fill cycles and channel changes sometimes linked by historical evidence to high-magnitude events (Dotterweich, 2005), or amenable to tree-ring “identification” via buried timbers (Spurk et al., 2002; Zolitschka et al., 2003), and yet not apparent from coarser-grained and less-sensitive pollen diagrams.

Given such contingencies, I continue to be ambivalent about how best to interpret the interplay of climatic and human impacts in Mediterranean alluvial history. On the one hand, the higher-energy processes recorded by many mid-Holocene deposits appear to suggest climatic anomalies—commonly but not necessarily playing out on a fragile cultural landscape. On the other, late Holocene counterparts are best developed in and around

major sites, where colluvial components are prominent. That would imply a response to landscape intervention, but even in heavily stressed landscapes, climatic perturbations may be necessary to trigger erosion (Butzer and Harris, 2007). Given a context of local equilibrium thresholds and vegetation change, particular settlement histories and disjunctions may therefore only influence, rather than control, the timing of erosional bursts. *No generalizing criteria have yet been devised to identify Mediterranean response to climatic inputs versus human intervention.*

This reflective discussion of Mediterranean landscape history highlights the fact that there are many ambiguities, but few certainties. Climatic pulses or anomalies, in combination with exploitative land use, may accelerate change or force an equilibrium shift, unless social adaptability and resilience dampen or arrest such processes. Long-term environmental outcomes therefore become unpredictable (see Fig. 1).

The debate that began in 1969 has been salutary, and not only because it stimulated a great deal of fresh fieldwork. With the benefit of hindsight and a more dispassionate stance, it now obliges us to (1) reexamine flawed assumptions about equilibrium ecology; (2) investigate problems at multiple scales of site, valley, and district; (3) better integrate a fine-grained geoarchaeology with a proper expertise in Quaternary studies; and (4) abandon the premise that there is a simple, deductive model for Mediterranean alluviation, slope evolution, and chronology, or for the diagnosis of climate versus anthropogenic factors.

The future of geoarchaeology lies in accepting our diversity and building on the complementary nature of researchers with unlike training and experience, whether it be in geomorphology, soils, paleobiology, archaeology, or management. We might also engage in real conversations and interact in the field, including like-minded bioscience specialists, historians, and ethnographers or cultural anthropologists. Such a cross-disciplinary discourse would facilitate a better formulation of problems and an exchange of ideas as to how to resolve them, as part of the common goal of constructing an effective environmental history.

CULTURAL AND BEHAVIORAL PERSPECTIVES ON CAUSE AND EFFECT

Human perceptions and behavior are integral to understanding cause-and-effect relationships and the impact of people on environmental history. They offer alternative readings on what is, and what is not, degradation, so as to require another look at ecological equilibrium and resilience. They clarify that sound ecological behavior has been culturally embedded since at least late prehistoric times, defined by community values, economics, and the obligations of transgenerational continuity (Butzer, 2005; herein). Such behavior is a secular ideal, rather than a theological imperative, but excessive demands on a rural population, social repression, insecurity, or the ravages of war can break community spirit and lead to ecological damage as long-term strategies are abandoned in favor of short-term survival. A grasp of the rationale behind successful or failed communities is essential for an

EQUILIBRIUM RESPONSE TO ENVIRONMENTAL VARIABILITY

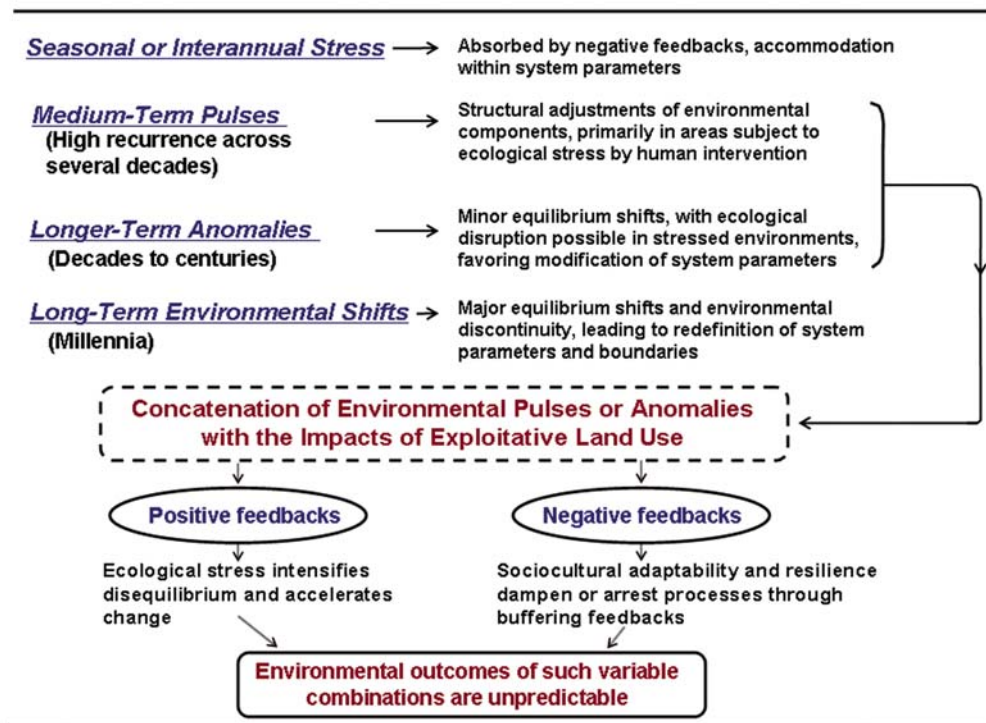


Figure 1. Equilibrium response to the recurrence, persistence, and amplitude of environmental variability. Precipitation is the major dynamic variable. The co-agency of exploitative land use will affect the feedbacks and the environmental outcome as well.

effective environmental history, and will require a deeper appreciation of human behavior, experience, and social resilience.

Cultural Preconceptions

“Degradation,” as a professional evaluation, comes out of the conceptual perspective of French and British Colonial officers working in the Mediterranean during the late 1800s (for similar views to those expressed here, see Grove and Rackham, 2001). It was predicated on an incomplete appreciation of dry-land ecology and a limited comprehension of traditional land-use systems. Observers were troubled by old-growth forests because they were open-spaced, and they saw mixed land-cover of woody shrubs and interspersed bushy trees as degraded (Butzer and Harris, 2007). Cultivated fields with olive groves did not match John Constable’s (11 June 1776–31 March 1837) paintings of rustic harmony and were reluctantly accepted as a compromised form of nature. Indigenous farmers, alien pastoralists, or voracious goats were held responsible for the destruction of a mythical, primeval forest.

People, biota, and climate have been co-evolving for millennia (Birks et al., 1988), particularly in the Mediterranean world, so that trying to define a pre-agricultural, early or mid-Holocene datum of what is “natural” seems futile. Long pollen

profiles in various countries offer proxy records of partial woodland recovery, partial reconstitution, or cultural replacement by a new array of economic hardwoods. Large-scale experimental observations show that “degraded” health of woody shrubs favors dispersal of native legumes and provides an equivalent ground cover compared to woodland (González Bernáldez, 1995). The open agropastoral landscapes of eighteenth-century Tuscany are now extensively wooded, with little or no evidence of damage. Vegetation adapts itself to the exigencies of a terrain, responding to climatic and anthropogenic pressures, and reaccommodating itself to improving conditions. Mediterranean land cover is zoned according to elevation and slope, molded to local details of roughness and substrate, within a patchwork of biotic mosaics.

These features define biotic resilience. Unless the soil mantle has been swept away, woodlands can recover, sooner rather than later, and the environment does not qualify as “destroyed.” In contrast to the dichotomy of “arable” and “waste” in north-western Europe, a typical municipal territory in the Mediterranean world embeds a threefold distinction of woodland (*monte alto*), pastoral (*monte bajo*), and cultivated domains. Depending on the changing demand for land, pastoral shrub and bush can be converted to carob and olive groves or vineyards, if not in fact dry-farm land. In the indigenous cultural perception, pastoral tracts are therefore not “degraded,” but in a sort of natural

fallow, which remains a productive part of a changing landscape mosaic (Butzer and Harris, 2007). This should invite “outsiders” to appreciate that there are different cultural readings of what is or is not degradation.

Furthermore, degradation and soil erosion respond to both biophysical and cultural-behavioral inputs. Since the processes and criteria will differ, this requires either cross-disciplinary experience or interactive collaboration across the disciplinary divides. What, for example, is encompassed by a concept such as land-use stress? Several social or humanistic perspectives may illustrate the explanatory possibilities of a more behavioral and inductive form of historical ecology (Butzer, 2005); they represent an extension of what Kevin Walsh (2004) has called a *cultural* geoarchaeology.

Elite Agronomic Writings

A number of legal sources, including the laws of Hammurabi, the Visigothic law code, and the Medieval Mesta, show that agropastoral activities in the wider Mediterranean world were long articulated in common law, which specified mutual agropastoral responsibilities, conflict, and cooperation (Butzer, 1988, 1994, 2005). The Roman author Varro first explained the details of small-scale, village-based transhumance of sheep, versus the long-distance, seasonal movements of animals that crossed ecozones and were controlled by squads of shepherds, working for wealthy owners of the flocks. The ecological behavior of the long-distance pastoralists was not necessarily consonant with that of the villagers engaged in local transhumance. This fact has potential applications in areas such as the Peloponnese, where uncontrolled pastoralists often represented different ethnic groups (Forbes, 2000). Yet, the seasonal presence of outside flocks has invariably had major economic significance as a source of manure. For the most part, cultivation and pastoralism have been complementary, but uncontrolled pastoralism could be destructive.

An alternative source is given by elite agronomic writings that represent early ecological perspectives and understanding (Butzer, 1993, 1994). There is a Sumerian agricultural calendar that outlines the sequential activities of the annual cycle, and probably represents a transgenerational transmission of information. Beyond some evocative images of familiar agricultural activities in the *Iliad*, Hesiod presented the annual cycle in a framework of behavioral precepts. Xenophon wrote a work for a nephew that emphasizes rational estate management, and favors improved agricultural productivity so as to stimulate general economic expansion. Theophrastus elucidated a high level of ecological comprehension and hinted at the role of common farmers in advancing cultivation practices (through crop rotation), as a matter of trial and error. Cato stands out because of his emphasis on the “good” farmer as a repository of traditional values and civic probity. The most complete treatise was written by Columella, who described soil erosion, and recommended hillside terracing and manuring, but he also supported commercial agri-

culture on large estates, which forced out small freehold farmers, as lamented by Varro and Pliny. There evidently was a protracted Roman discourse on rural problems and their underlying social and economic issues.

Islamic traditions of agronomy (ca. 930–1160 CE) can also be identified, especially in Mesopotamia and Spain. In part, its authors built on Roman and Greek experience, but went well beyond these prototypes, particularly in their comprehension of agricultural soils (Butzer, 1994). They were also engaged in agricultural expansion, in the service of a progressive elite.

These Greek, Roman, and Islamic writings were not designed to educate illiterate country people, but to explicate the intricacies of agriculture as ideally practiced in their day. In so doing, they open a window on the incremental and cumulative understanding of agroecology among rural people. The writers were cognizant of technological change as well as the human implications of intensification. A basic inference from this elite Greco-Roman discourse is that “good farming” was culturally embedded, as a civic responsibility and economic concern, rather than a philosophical or theological tenet.

Ecological Ethnohistory

In 1609, most of the residual Muslim population of Spain was expelled and their villages resettled by Christian farmers, such as in the Sierra de Espadán, north of Valencia. In this setting, Elisabeth Butzer, Juan Mateu, and I across seven seasons studied the village of Aín and some of its neighbors, based on archival history and ethnographic observation (Butzer et al., 1986). The underlying focus was on rural ecoscience, to grasp the fine grain of community decision-making and its impact on ecological behavior and the environment.

The main thrust of our findings was that sound ecological behavior is implicitly expected of each individual, and is understood to be imperative for social continuity. This can be rationalized by the strong sense of community, attachment to home, and a pride of place (Butzer, 1990, 2005). Land-use changes are made in the light of extended community discussion and with reference to community integrity, the market economy, and the responsibility to pass an undamaged resource on to future generations. Growth has been regulated by population curtailment, with out-migration considered an alternative of last resort. Trees have been explicitly cut down at a rate consonant with natural replacement. Thorny Mediterranean shrubs and brush were once burned under carefully controlled conditions; since burning is prohibited today, orchards and former pasturage are being overgrown by thorny macchia. The manure of transhumant sheep was preferred over chemical fertilizer because there were fewer pests. Slopes were terraced, and our excavations within such terraces, as well as study of valley alluvia, revealed no discernible soil erosion across four centuries; significantly, the primary stream has incised its bed because of sediment starvation.

This indigenous, rural narrative elucidates a constantly shifting repertoire of agricultural strategies in response to market

opportunities, demographic growth, finite resources, and environmental problems. These in turn are predicated on values, prescribed social behavior, cumulative experience, and ongoing information exchange. This may not be an ecology palatable for idealistic modern environmentalists, but it explicates a traditional, practicable sustainability, closely tailored to a fragile Mediterranean environment.

“Good” and “Bad” Farming

As our research in Aín continued, it became clear that we were privy to an idealizing discourse that was reflective, rather than directed to us as outsiders; it sought to articulate the proper ecological behavior that was expected of the members of the community. We began to hear echoes of Cato, on the stereotypic “good farmer” and his common sense approach to ecology. That model of traditional harmony with the environment has explanatory value in its own right, and yet poor farming practices have been common in many areas for at least part of the time. Can they too be explained?

Here the Muslim experience in Aín (Butzer et al., 1986) provides a counterpoint. The district was forested and unsettled prior to the founding toward 1100 CE of a network of villages that were soon paired with small refuge castles. During the Christian (re)conquest of the Sierra de Espadán in 1242, the Muslim villagers accepted generous terms and remained in place until 1609. After a rough start with “coexistence,” the area experienced population growth during the 1300s, when a number of satellite hamlets came into being.

Our record of changing ecological behavior in part derives from excavation in two pre-conquest castles, a post-conquest hamlet (Beniali), rescue archaeology of a Muslim cemetery, and survey of a dozen other castles and abandoned hamlets. Analysis included macrobotanical remains, animal bone, snails, and soil sediments (Butzer, 2005), as well as the changing alluvial contexts of irrigation works (Butzer et al., 1986). Interpretation of the archaeology was made possible by a wealth of fragmentary and scattered archival records in Valencia and Barcelona, covering more than three centuries prior to 1609. These documents included administrative rulings, household registries, marketplace litigation, criminal cases, and general reports (Butzer et al., 1986). The resulting data composite is varied, detailed, and informative, and allows some generalizing interpretations to be made about patterns of subsistence and changing ecological behavior.

The biotic environment had not been transformed before 1363 CE. At that point, the first hamlet at Beniali was destroyed during a civil war, which was followed by a wave of soil erosion, probably as terrace walls were ruined. Reoccupation of Beniali ca. 1410 CE coincided with a decline of hardwood trees, the presence of large numbers of goats, and periodic washing of small amounts of laminated soil-derived sediment through Beniali after excessive rains. There also was torrential alluviation in the channel of the axial stream. Yet, until destruction of Beniali during a bloody uprising in 1526, the Muslim farmers planted a full

array of Mediterranean crops in the valley bottom. Thereafter, the ecology deteriorated dramatically, and the uplands were treeless by 1570.

Destruction by warfare in 1363 and 1526 marked a progression to degradation, without recovery until after the expulsion in 1609. Why did these sierra villagers not bounce back? After the 1420s, there is evidence of food stress, exorbitant special taxes, increasing insecurity, and population decline. After the slaughter of 1526, the Muslims were forcibly “converted.” Since forced labor was already being met with passive resistance during the mid-1400s, we infer that after 1526, the bailiffs were unable to enforce customary law in a hostile countryside, leaving the surviving woodland unprotected (Butzer, 2005).

The “captive” Muslim population then had no incentive to pursue conservationist strategies, concentrating instead on the short-term survival of their families. Community spirit and solidarity had been broken, with some adopting Christian names and surnames, others not. Socially adrift and drawn into a vicious circle of disintensification, the pace and scope of ecological damage increased. The “good farmers” of the 1340s now simply hung on and were eventually expelled without offering resistance. Conservationist land use had been rendered infeasible by extraordinary structural and economic constraints.

Ecological behavior is contextual, as the contrasting Muslim and Christian faces of Aín show. It is grounded in community experience, will, and accepted or rejected principles of common behavior. Ruinous economic demands on a rural population are counterproductive. When coupled with social repression, violence, and insecurity, they become disastrous for both economy and ecology (Fig. 2). Given such an antithesis to a “moral” economy, insecurity and warfare offer a recipe for degradation (Butzer, 2005).

Cause and effect in environmental history are ultimately about real people and living communities (Fig. 3), rather than deductive generalization. Effective study of successful or failed communities requires a certain amount of “insider” understanding of human behavior, experience, and insights, which is indispensable to evaluating ecological problems in the historical or prehistoric record. A more integrative and cross-disciplinary methodology or collaborative engagement is called for in order to better understand the cause-and-effect relationships of ecological change. This is a difficult but important charge for geoarchaeologists.

ENGAGING IN CURRENT DEBATES

A primary goal of geoarchaeology will remain an inductive and high-resolution investigation of multiscale landscape change, but more deliberate attention to cross-disciplinary issues would clarify the role of the incremental, cumulative, or “catastrophic” change that is of particular interest to environmental historians.

A host of articles and books currently proclaims “abrupt climatic change” as a prime mover of sociocultural or historical change. This new environmentalism draws from archaeological sequences on all continents to support theories for civilizational

RURAL DECISION-MAKING AND ECOLOGICAL BEHAVIOR

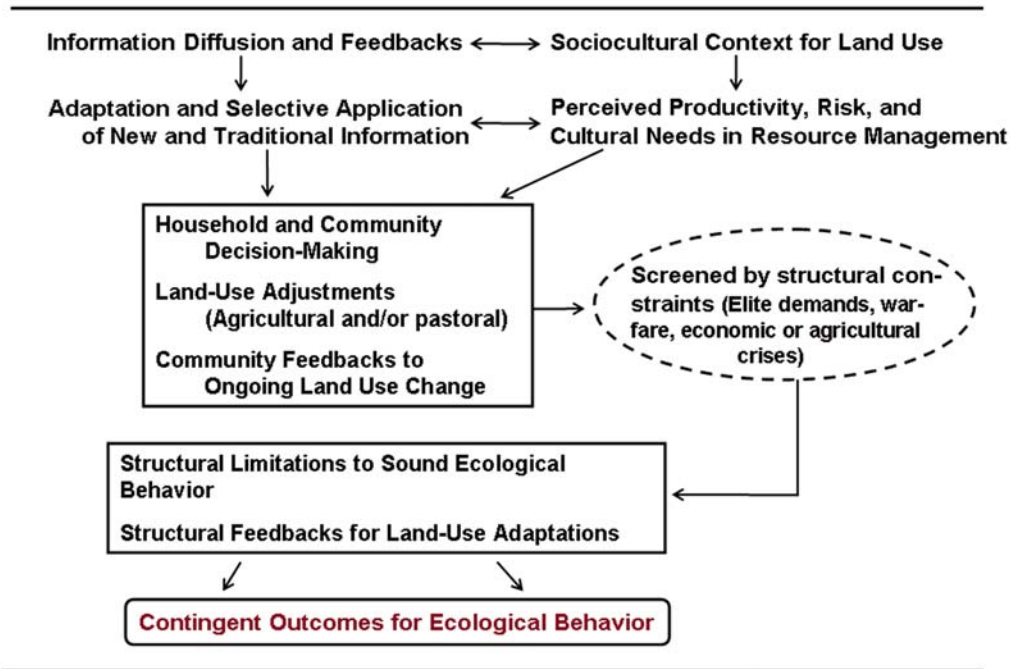


Figure 2. Rural decision-making is central to socioecological behavior. The sociocultural context includes dietary preferences, social values, intracommunity dialectics, cultural screening of priorities, as well as ritual and social restraints to innovation. In turn, local decision-making is constrained by the demands of land-owning elites and tax collectors, by warfare or insecurity, and by the growth or decline of market integration or political control.

A MODEL FOR CAUSE AND EFFECT IN ENVIRONMENTAL HISTORY

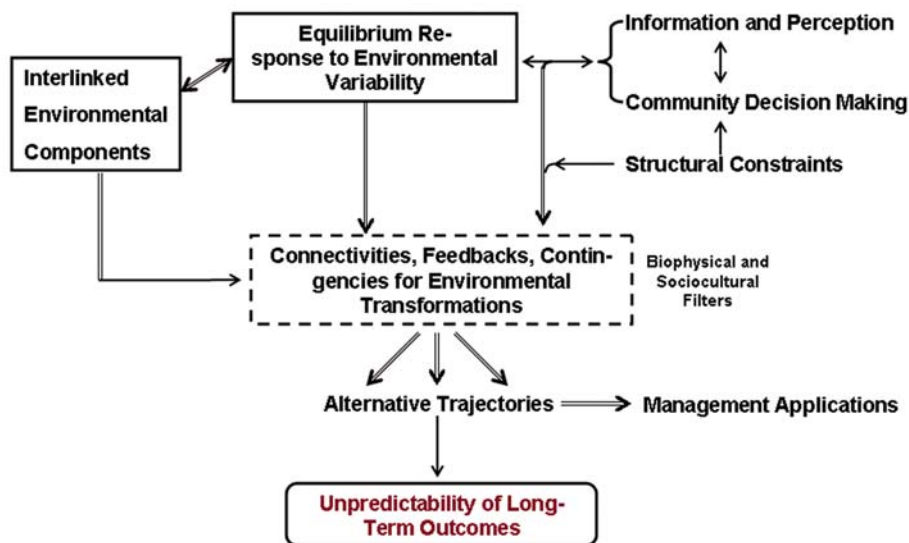


Figure 3. A simple, composite model for cause and effect in environmental history.

collapse. It can also be found as concluding applications of hard-science journal articles.

For example, the astounding title “Late Holocene drought responsible for the collapse of Old World civilizations is recorded in an Italian cave flowstone” appeared in *Geology* (Drysdale et al., 2006). Also, a deep-sea core from the Arabian Sea was claimed to identify aridification of the Near East after 2350 BCE, leading to “the formation of hierarchical societies in the overpopulated Nile Valley and Mesopotamia” (Sirocko et al., 1993, p. 324), which is incorrect on several counts. A different core from the Gulf of Oman was used to posit an abrupt climatic change ca. 2200 BCE that forced Akkadian abandonment of rain-fed agriculture in northern Mesopotamia (Cullen et al., 2000, their figure 3); this was inferred from high calcium carbonate levels as evidence of eolian dust, but it thereby reversed the criteria of Sirocko et al. (1993), and featured imprecise dating control. The common feature in these cases is the Tell Leilan “collapse” bandwagon, which itself is burdened by beginning as a story about thick volcanic ash promoting a “nuclear winter,” before the tephra hypothesis was abandoned in favor of sheer aridity (see Butzer, 1997). It took science writer A. Lawler (2008) to puncture another such hypothesis, about a failure of the Indian monsoon as responsible for Indus Valley collapse (Staubwasser et al., 2003), a civilizational disaster that did not really happen. We appear to have a serious problem of reckless teleconnection, perhaps for publicity purposes, and one that seems to suggest that the peer-review system is failing repeatedly.

A different form of environmental determinism is collapse by “ecocide,” when a society destroys itself by overexploiting its own resources (Diamond, 2005, p. 118). However, the arguments that support this prospect are centered on four island ecosystems. One of these is Easter Island, where Hunt (2007) showed that biotic invasion and genocide were responsible for the despoliation of Easter Island, so demolishing the case made by Diamond (2005). This pattern becomes alarming when one of the authors engaged in such “explorations” announces that “study of past cultural adaptations to persistent climate change may provide valuable perspective on possible responses of modern societies to future climate change” (deMenocal, 2001, abstract, p. 667).

Most of the more popular claims that climate has impacted history are deductive and based on data that are inadequate or misrepresented. Social resilience and adaptation are not considered, ignoring case studies of the ways in which people have confronted short- or long-term crises in the past. Such a methodology “by assertion” goes against the very grain of what anthropology stands for, and yet too few anthropological archaeologists have taken an explicit stand. Geoarchaeologists have the regional expertise to critically examine the weak factual underpinnings on which this environmentalist parade runs (Butzer, 1997; Hunt, 2007). At the very least, either local or global chronological controls are faulty, and *coincidence, even when true, does not prove causality*.

In a similar vein, anthropogenic destruction has been used to explain historical disjunction. Certainly, there is room here for serious discussion, and I am open to the possibility (e.g., Butzer,

1981b), but most diagnoses of large-scale degradation are based on incomplete, debatable, or even antiquated sources. Geoarchaeologists are among the most qualified researchers to set the record straight, but that is not always easy. The more prestigious science journals appear to prefer exuberant reviewers for best-selling books, so that there is little opportunity for effective balance.

“World-system” historians represent a special case. There are occasional claims or assumptions about degradation and its contributions to the cyclic “rise and demise” of civilizations (e.g., Chew, 2001). However, their historical interpretations may also be projected into a sober analysis of contemporary environmental issues and potential future scenarios (e.g., Chase-Dunn and Hall, 1997; Turchin, 2003). There is then reason for geoarchaeologists to engage actively with open-minded system-historians in order to communicate a more accurate and explicit environmental history, with appropriate sensitivity to system resilience. In this spirit, Figure 4 suggests a model for the systemic context of sociopolitical decline, involving both climate and degradation as potential inputs. It is unlikely that such interrelationships can be operationalized in the near future, but object-oriented simulation is now being applied to concurrently examine socioecological interactions over a broad range of such issues at various social, spatial, and temporal scales (Altaweel, 2008). Applied to Mesopotamia, the initial, stepwise results are promising.

Last but not least, there is the problem of sustainability and a sustainable global future. There is no adequate definition for this cognitive and empirical concept, which itself is being degraded by opportunistic overuse. Most of us intuitively know what is at stake, but the concept raises some uncomfortable questions. For example, can one approve of ecological modification that substitutes some of the original components and yet allows a similar or improved productivity? Are invasive taxa always bad, or can they be judged by more flexible criteria? Other issues are less ambiguous. For example, a number of well-placed individuals have claimed impending “desertification” of the Mediterranean world, leading to a generously funded European Union enterprise to assess the problem. When geoarchaeology was drawn into the effort, Grove and Rackham (2001, chapter 20) convincingly rejected the case for such desertification.

The link between geoarchaeology and sustainability is not fortuitous. Together with paleobiologists, we have the expertise to document and evaluate ten millennia of agropastoral land use or urbanism in the Mediterranean world. Nonetheless, regional productivity has not been diminished, and its coasts and cultural landscapes continue to draw artists, writers, and millions of tourists. While far from pristine, it remains uplifting. It is an endangered environment, but it has not been “destroyed” (Butzer, 2005). The Mediterranean geoarchaeological issues outlined here have become much more than an “internal debate.” They are about an effective interpretation of the health of a major world ecosystem. In addition, the trajectory of Mediterranean environmental history offers a rich record of diachronic experience for reflection and prognosis. It gives testimony to both human and ecological resilience.

A SYSTEMIC CONTEXT FOR SOCIOPOLITICAL DECLINE

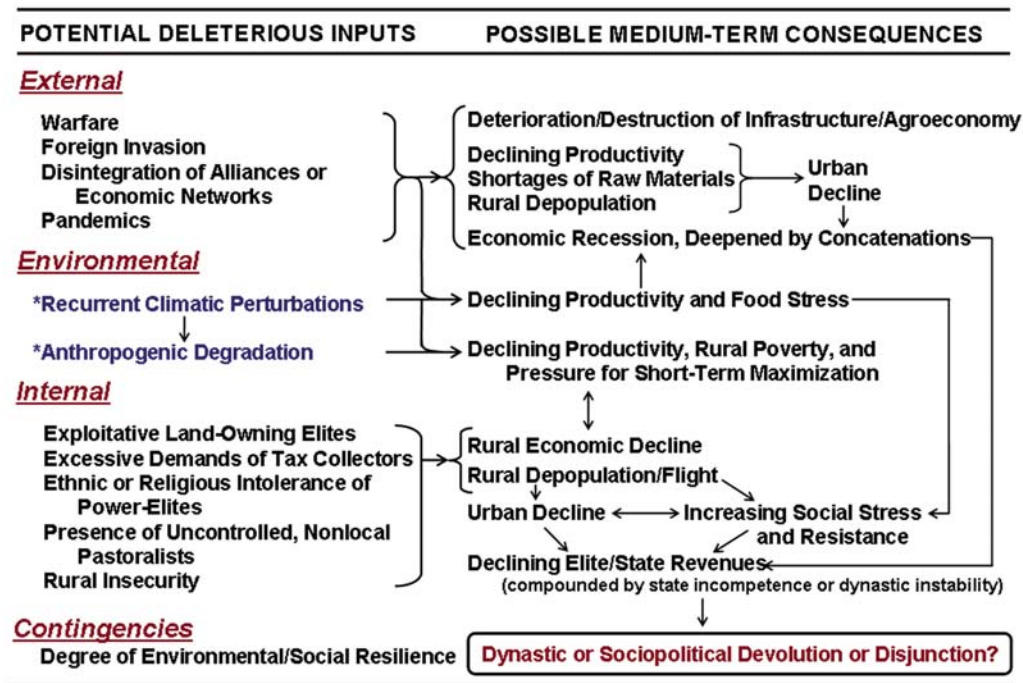


Figure 4. Sociopolitical decline can be caused by many inputs other than climatic perturbations or anthropogenic degradation (marked by *). These variables are interlinked by multiple feedbacks, as are their medium-range changes, which in this graphic representation emphasize socioeconomic problems rather than environmental history. The category of “contingencies” spans a wide range of socioecological feedbacks that help to define different forms of resilience critical to long-term outcomes.

In conclusion, this review may serve to encourage geoarchaeologists to engage more assertively in the broader academic debates of the day, not as cutters of wood for the generalizing mediators of science, but as empirical scientists, open to interdisciplinary exchange, and qualified to argue for competent and reasonable positions. We could and should play a more visible role in the emerging, multidisciplinary arena of environmental history, alongside historians and political ecologists. The popular, “new” environmental determinism about civilizational collapse in response to climatic or environmental change calls for strong voices of caution. We are qualified to monitor the ecological impacts and at least to discuss the adaptive changes central to future projections of global change and sustainability.

Those of us comfortable with the human dimensions of these issues should participate more freely in such engagements, to stake out an unimpeachable middle ground, for the benefit of upcoming generations in our academic and applied science.

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