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Social Transformation and Its Human Costs in the Prehispanic U.S. Southwest

ABSTRACT Change is inevitable, but some changes and transformations are more dramatic and fraught with suffering than others. Resilience theory suggests the concept of a "rigidity trap" as an explanation for these differences. In rigidity traps, a high degree of connectivity and the suppression of innovation prolong an increasingly rigid state, with the result that the eventual transformation is harsh. Three archaeological cases from the U.S. Southwest (Mimbres, Mesa Verde, and Hohokam) and new methods for assessing transformations and rigidity are used to evaluate this concept. They reveal the expected association between the severity of transformation and degree of rigidity, suggesting that a rigidity trap contributed to the Hohokam decline, which included significant human suffering. Possible causes of rigidity, with implications for today's world, are explored. [Keywords: U.S. Southwest, archaeology, social transformation, resilience theory, ecological theory]

THE ARCHAEOLOGICAL and historical record makes clear that societal change is inevitable and (to some extent) desirable. However, some instances of change—major transformations and institutional collapses—are particularly dramatic and often tragic. A huge interdisciplinary literature considers the why and how of collapses (e.g., Diamond 2005; Nelson and Schachner 2002; Tainter 1988; Turchin 2003; Yoffee and Cowgill 1988). In this article, we address a slightly different question: Why are some changes much more dramatic and fraught with suffering than others? Our answer draws on three well-understood archaeological sequences, which allow us to compare transformations in their temporal and ecological contexts. The cases—from the Mimbres, Mesa Verde, and Hohokam regions of the U.S. Southwest (see Figure 1)—involved varying degrees of societal complexity, although none were states or urbanized; thus, this work broadens the kinds of transformations usually studied regarding collapse.

Our research is guided by a body of work known as "resilience theory." Recent summaries describe various aspects of this perspective, including the notion of episodic change in the adaptive cycle and the panarchy concept; the importance of multiple spatial and temporal scales, cross-scale interactions, and nonlinear dynamics; and the recognition of multiple equilibria in contrast to a single stable homeostatic state (Folke 2006; Gunderson and Holling 2002; Redman 2005). Originally developed in ecology (Holling 1973) and linked to concepts of complex adaptive systems, this theory has seen several applications in U.S. Southwest archaeology (e.g., Gumerman and Gell-Mann 1994; Nelson et al. 2006; Upham 1984). Recently, the resilience perspective has directed attention toward social-ecological systems and includes considerable work by anthropologists and other social scientists (Abel and Stepp 2003; Redman and Kinzig 2003; Walker et al. 2006).

Our focus is on one component of resilience theory that is particularly relevant for the study of human-dominated systems with implications for the study of institutions and decision making. Resilience is contrasted with stability (i.e., a fixed unchanging state); a *resilient system* is defined as one that can absorb disturbance and undergo some degree of change while still retaining the same general functions and structure (Walker et al. 2004). In many resilient systems described by ecologists, nonhuman species undergo large population fluctuations, often declining to a fraction of their number and rebounding years later (see summary in Folke

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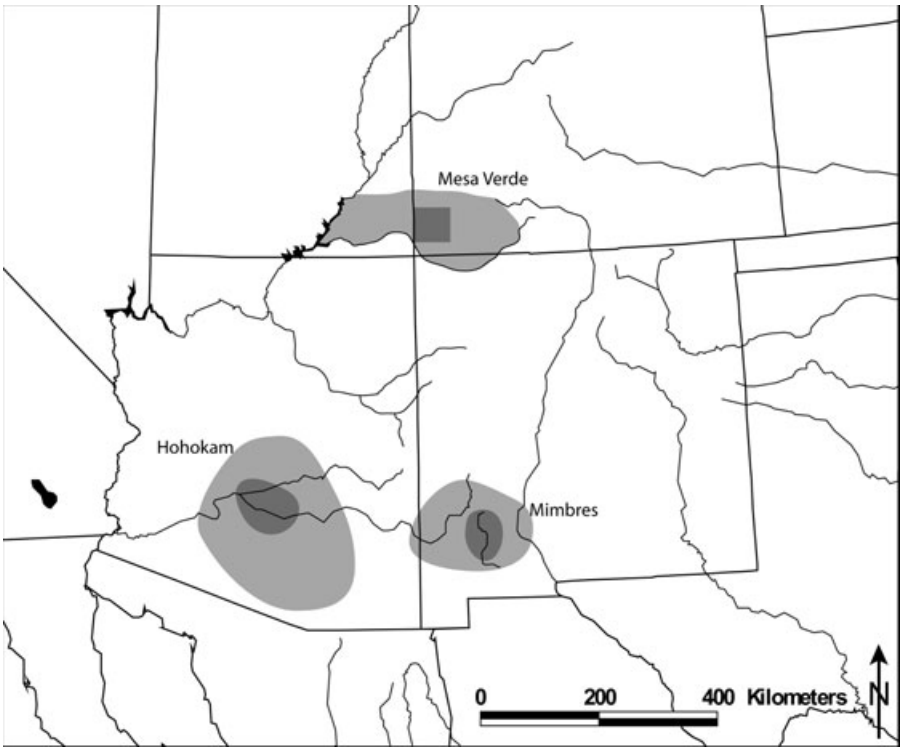

FIGURE 1. The U.S. Southwest showing the regions (Mesa Verde, Hohokam, and Mimbres) and core areas (Village Project Study Area, Phoenix Basin, and Mimbres Valley) considered in this study.

2006). These smaller-scale fluctuations seem to contribute to the resilience of larger-scale systems (e.g., the communities or ecosystems of which the populations or species are a part; Levin 1999). However, humans often either resist such fluctuations in their own number and in the resources that support them or attempt to maintain an upward trajectory of growth. In resilience theory terms, humans often attempt to remain in the K-phase of the adaptive cycle, a time of growth and accumulation (Redman and Kinzig 2003). As a result of these processes, human-dominated systems sometimes lose resilience. Similarly, the creation of robustness in some realms (e.g., water-control systems that buffer the effects of rainfall fluctuations) results in vulnerabilities in others (Anderies et al. 2004). In both cases, the systems become increasingly unable to absorb disturbances, with the result that they are eventually transformed, often in dramatic and painful ways. A well-known simple example is the suppression of small natural fires, resulting in fuel accumulation and larger conflagrations.

The pathological manifestation of this process is known as a "rigidity trap," which is a key concept in our research. In situations involving a rigidity trap, the potential for growth is high, there is a high degree of connectedness or integration, and the system can (for a while) persist "even beyond the point where it is adaptive and creative . . . [with] efficient methods of social control whereby any novelty is either smothered or sees its inventor ejected" (Holling et al. 2002:96). The rigidity trap concept invokes agency in the sense defined by Anthony Giddens: "Agency refers not to the intentions people have in doing things but to their capability of doing those things in the first place . . . Agency concerns events of which an individual is the perpetrator, in the sense that the individual could, at any phase in a given sequence of conduct, have acted differently" (1984:9). Rigidity traps may be unintended consequences of numerous repetitive acts that reproduce or extend the structure (i.e., a bureaucracy). In other cases, some segments of a society may contribute to the creation of a rigidity trap by intentionally attempting to maintain a situation that they perceive to be beneficial. In either case, the implications for today's world should be obvious.

Here we draw on the deep time of the archaeological record to assess the rigidity trap concept. Specifically, we compare the three cases to evaluate the proposition that there is an association between the degree of rigidity and severity of the transformation. Thus, our focus is on developing and applying methodologies to assess the severity of the transformations (incl. their human costs) and the degree of rigidity that preceded them. We also consider how and why differences in rigidity may have developed. For each component, our methodology involves several steps. First, drawing from general theoretical literature, we propose parameters by which the severity of transformations and degree of rigidity can be assessed, and we translate these into a series of variables that can be operationalized archaeologically. Then, in text and tables, we present relevant data on these variables across the three cases. Finally, we use these data to develop a nominal ranking of the three cases across each variable for comparative purposes.

The primary data for this project derive from our Long-Term Vulnerability and Transformation Project (LTVTP), which synthesizes and compares archaeological sequences from several regions in the U.S. Southwest and northern Mexico. Many of these data are or will be publicly available in an NSF-funded archaeological data archive (http://tdar.org). We also draw on two recent synthetic projects: (1) the Coalescent Communities Database (Hill et al. 2004; Wilcox et al. 2003), which is especially important for our interpretations of Hohokam, and (2) the Village Project (Varien et al. 2007), which provides rich data on the Mesa Verde region. Thus, although the primary contribution of this work is theoretical, it also provides a synthesis of new data and analyses.

NATURE AND SEVERITY OF TRANSFORMATIONS

Many bodies of literature—including applications of resilience theory as well as those of contemporary migrations and refugees (e.g., Castles 2003; Malkki 1995)—are concerned with the nature of transformations and their severity. This literature suggests several parameters by which severity can be assessed and compared: demographic scale, population displacement, degree of cultural change, and physical suffering. *Demographic scale* refers to the number of people affected by a transformation, whereas *population displacement* concerns the extent to which people were disconnected from their homeland. *Degree of cultural change* refers to transformations that would have affected people's lifeways. Finally, *physical suffering* refers to bodily injury or death as a result of malnutrition, disease, and violence. Archaeological variables involving analyses of demography and settlement distributions, ceramic and architectural data, and bioarchaeological studies as well as other information on violence are used to assess these parameters for each of the three cases. For each variable, we assign a severity ranking (1 = mildest, 3 = most severe) to facilitate cross-case comparisons. Where two cases are judged to have the same degree of severity, each gets the same rank (e.g., the 2.5 scores in Table 1).

The selected regions have long histories of settlement and transformations. Our concentration here is on the periods immediately preceding well-documented transformations: the Mimbres Classic (C.E. 1000–1130), which ended with material culture changes and settlement reorganization (Hegmon 2002; Nelson 1999); the Late Pueblo III (C.E.1200–1300) in the Mesa Verde region, which ended with large-scale emigration and depopulation (Glowacki 2006; Varien et al. 2007); and the Hohokam Classic (C.E. 1150–1450), which ended with a long period of poorly understood population decline (Abbott 2003; Hill et al. 2004). We also focus on the most densely populated core areas of each region: the Mimbres Valley, the Village Project study area in the Mesa Verde region, and the Hohokam Phoenix Basin.

Scale and Displacement: Demographic and Settlement Data

All three transformations involved depopulation of villages with different degrees of severity. Demographic scale is assessed by estimating the total number of people involved in each transformation: that is, the regional population prior to the transformation (V1). Population displacement is assessed with a series of variables involving demographic as well as settlement data. What happened to the people during the transformation (V2)? Emigration is more severe than internal resettlement, and emigration that resulted in complete depopulation of the homeland (which would preclude maintaining social ties) is more severe than partial depopulation. The abruptness of the emigration and

TABLE 1. Severity of Transformations: Scale and Displacement.

Variable	Mimbres		Mesa Verde		Hohokam	
Area (km^2) of core and region	Mimbres Valley (MV): 2,000 Region: 19,000		Village Project Study Area (VP): 1,817 Region: 22,000		Phoenix Basin (PB): 4,000 Region: 50,000	
V1) # of people core/region	MV: 2,700 Region[a]: 5,600	**1**	VP: 15,000–19,500 Region[b] : 30,000	**2**	PB: 20000–30000 Region[c]: 40,000+	**3**
V2) What happened to the people?	Some emigration, some reorganization	**1**	Complete depopulation, some emigration, and probably some mortality	**3**	Large but not complete population decline, probably both emigration and mortality	**2**
V3) Abruptness of transformation	Period of change, then abrupt depopulation	**2.5**	Period of change then abrupt depopulation	**2.5**	Gradual	**1**
V4) Eventual resettlement?	Yes; repopulated after ± 50 years	**1**	No	**2.5**	No	**2.5**

[a] Estimated by applying procedures developed by Doelle (1995, 2000) to data collected as part of the LTVTP project (Peeples n.d.).[b] Estimated by Varien et al. (2007:281, Note #6, Method 1) for the Village Project study area and by Ortman (2007) for region (see also Glowacki 2006). [c] Estimated by Hill et al. (2004) and Hill (personal communication, September 15, 2007), drawing on the Coalescent Communities database (Wilcox et al. 2003).

transformation (V3) contributes to severity because rapid change makes adjustment more difficult. Finally, resettlement of the region (V4) shortly following transformation indicates that displacement was not total and, thus, lessens its severity. Results are summarized in Table 1.

The end of the Mimbres Classic, once considered a collapse of Mimbres culture, is now widely interpreted as a regional reorganization (Hegmon et al. 1998; Nelson 1999; Nelson and Hegmon 2001; Nelson et al. 2006). Some people left the region, others simply moved from villages into smaller dispersed hamlets, and the reorganization took various forms. In the western Upper Gila, villages were empty by C.E. 1100; in the northern Mimbres Valley, most villages were abruptly depopulated in the mid-1100s C.E. In the central and southern Mimbres Valley and the eastern Mimbres area, some villages were not completely depopulated. At many villages, depopulation was temporary, indicated by Postclassic reoccupations within 50 to 100 years.

The Mesa Verde region, which had been home to tens of thousands, was almost totally depopulated by C.E. 1290. Recent research (Glowacki 2006; Varien et al. 2007) provides a detailed understanding of the process. Some emigration occurred throughout the 13th century (Duff and Wilshusen 2000), and people increasingly aggregated into the central part of the region. The Village Project estimates that 10,000 people remained in their study area at C.E. 1260, and by 1280 it was virtually empty (Varien et al. 2007:284). Many people probably emigrated to the northern Rio Grande and other areas (Cameron 1995; Cordell 1995) while others may have died.

The Hohokam region had been integrated into a vast regional economy, which dissolved in the late 11th century (Abbott et al. 2007). The Hohokam Classic was a time of coalescence, beginning by C.E. 1100, peaking around C.E. 1300, and then declining. Different processes characterize different areas, with the largest population concentration around the massive Phoenix Basin irrigation systems (Abbott 2003). By C.E. 1450, the system was no longer in existence, although some people remained in the region. Overall, the population decline appears to have been gradual, primarily a result of increased mortality (Hill et al. 2004:697); however, in some areas, including the Phoenix Basin, the final decline may have been precipitated by unfavorable environmental and social conditions.

Degree of Change: Ceramic and Architectural Data

Transformations in the archaeological record are often recognized by stylistic and organizational changes in material culture. Here, we focus on assessing the change in four realms, which can be compared across the cases (see Table 2): ceramic style and technology (V5), household organization (V6), ritual architecture and organization (V7), and village layout and organization (V8). We consider changes to be more severe if they would have involved shifts in how people or activities were organized: for example, a change in the form of ritual architecture gets a lower severity ranking than a change in religious or ritual organization.

The end of the Mimbres Classic had been equated with the decline of spectacularly painted Mimbres pottery. There no doubt were changes in pottery style and technology, but recent research shows that Mimbres types continued to be used (if not made) in Postclassic hamlets (Nelson and Hegmon 2001). Other realms exhibit starker changes. Household mobility increased, and there was an organizational shift from residence in suites to single rooms (Nelson et al. 2006). Various ritual structures that had been prevalent in Classic Mimbres villages were no longer made, and both site layout and settlement pattern changed as people moved from village-centered communities to dispersed hamlets (Nelson 1999).

Thousands of people moved from the Mesa Verde region to the northern Rio Grande in the 13th century, although there was little material continuity (Cordell 1995). People left their unit pueblo (household-oriented) architecture in the Mesa Verde region and established very different modular and plaza-oriented villages in the Rio Grande. This shift involved a change in ritual organization (incl. the disappearance of household-scale kivas), and it correlates with the adoption of new religious forms (Crown 1994). Some characteristics of Mesa Verde ceramic style and technology (carbon-painted black-on-white pottery) were continued in the Rio Grande, and local variants developed rapidly (Habicht-Mauche 1993:91–92).

TABLE 2. Severity of Transformations: Degree of Change.

Variable	Mimbres		Mesa Verde		Hohokam	
V5) Ceramic style and technology	Fades away	**1.5**	Fades away	**1.5**	Disappears	**3**
V6) Household organization	Changes in organization and mobility	**1.5**	Change from unit pueblo to modular	**1.5**	N/A	
V7) Ritual architecture and organization	Change in architecture	**1**	New organization and religion	**2**	N/A	
V8) Village layout/ organization	Major change	**1.5**	Major change	**1.5**	N/A	

TABLE 3. Severity of Transformations: Physical Suffering.

Variable	Mimbres		Mesa Verde		Hohokam	
V9) Health problems	Sporadic	**1.5**	Sporadic	**1.5**	Endemic	**3**
V10) Violence	Slight	**1**	Yes, massacre	**3**	Threat	**2**

The end of the Hohokam Classic represents a virtual disappearance of the material culture that archaeologists associate with Hohokam, including pottery, formal architecture, and the irrigation system. Some people did remain in the region, and there are continuities with historic and contemporary populations, but these are difficult to trace archaeologically because of the lack of material continuity.

Physical Suffering

Some of the stylistic changes that form the basis of archaeological chronologies were probably of minor importance to the people involved. But some transformations involved severe human costs, including malnutrition, disease, and warfare. These forms of physical suffering are relevant both to this discussion of the severity of transformations and to the following discussion of rigidity, in that endurance of pretransformation difficulties can be taken as an indicator of rigidity. Rather than comparing kinds of suffering, we rank the cases in terms of degrees of two general variables—health problems (V9) and violence (V10)—in Table 3.

The Mimbres case has little evidence of either health problems or violence. Ethnobotanical data indicate possible food stress prior to the Classic Mimbres village depopulation (Minnis 1985), but there is no definitive skeletal evidence of disease or malnutrition either before or after the transition (Lippmeier 1991). Similarly, an apparent absence of weaponry, defensive site locations, and burning suggests the Mimbres Classic was a fairly nonviolent period (LeBlanc 1999). An increase in the number of burned houses in the Postclassic is possible evidence of a slight increase in violence (LeBlanc 1999:197–276; Nelson 1999), although the burning could have resulted from other causes such as ritual closure.

In the Mesa Verde region, there is considerable and widespread evidence for warfare in the 13th century (Kuckelman 2002; Kuckelman et al. 2002; LeBlanc 1999), indicated by defensive architecture, weapons, artistic representations, and definitive skeletal evidence. The most clear-cut evidence is from the central part of the region, including a massacre of at least 41 people at Castle Rock Pueblo; at the very least, the threat of warfare seems to have been felt region wide. In contrast, there is little evidence of other health problems (Martin 1994) beyond those that persisted through the prehistory of agricultural life in the U.S. Southwest.

In the Hohokam Classic, there is some evidence for violence and stark evidence for severe health problems, especially in the Phoenix Basin. Both Steven LeBlanc (1999) and Glen Rice (2001) argue that warfare was prevalent at various times, including in the later Hohokam Classic. Others (e.g., Wallace and Doelle 2001) take a more moderate position, and there is no definitive skeletal evidence. In contrast, health problems—including iron-deficiency anemia, bone mass lost from nutritional and reproductive stresses, and shortened life spans—were definitely present at the large site of Pueblo Grande in the Phoenix Basin (Van Gerven and Sheridan 1994). Susan Sheridan argues that the occupation was "marginal at best [and] doomed to eventual failure" (2003:106). Different demographic patterns (Hill et al. 2004) suggest that other parts of the region did not experience such severe health problems. However, the emergence of buffer zones and defensive sites in many parts of the region—including the San Pedro Valley and Tucson Basin (Wallace and Doelle 2001), and the high mesa country of central Arizona (Wilcox et al. 2001)—suggest that at least the threat of violence was region wide.

Comparison

The numerical severity rankings in Tables 1–3 involve the reduction of complex phenomena to a few states and, thus, provide another means of expressing what was presented verbally. We calculate means for each case to facilitate comparison. The Mimbres region (mean severity = 1.4) experienced a less dramatic and painful transformation than either Mesa Verde (mean severity = 2.1) or Hohokam (mean severity = 2.4). Mimbres pottery and settlement changed and people reorganized, but many stayed in the region; the continuity indicates that in some ways the Mimbres reorganization exemplifies resilience (Nelson et al. 2006). In contrast, in the other two cases enormous populations declined or emigrated and long-established cultural traditions virtually disappeared. By our ratings, the Hohokam transition was slightly more severe, in that much of the population may have died and health problems in some areas were horrific. But the Mesa Verde transformation was severe in different ways, including the deadly warfare and the rapid depopulation.

Below we draw on this comparison to evaluate our proposition regarding the relationship between rigidity and the severity of the transformation. We expect the least rigidity in the Mimbres case and the most in the Hohokam case. We also investigate whether different forms of rigidity explain differences between the Mesa Verde and Hohokam transformations.

TABLE 4. Measures of Rigidity: Integration (Calculated for the Core Areas).

Variable	Mimbres		Mesa Verde[a]		Hohokam[a]	
V11) % of population in aggregated sites	~50	**2**	~30	**1**	~90+	**3**
V12) Average # of people per aggregated site	80	**1**	130	**2**	250	**3**
V13) People per public structure	N/A	**1**	250	**2**	450+	**3**
V14) Average # public structures per aggregated site	N/A	**1**	~1.6	**2**	~0.5	**3**

[a]Calculated using Village Project and Coalescent Communities data.

MEASURES OF RIGIDITY

Discussions in the resilience literature describe various aspects of rigidity. C. S. Holling and colleagues emphasize "connectedness" and "efficient methods of social control" (2002:96). Building on this discussion, rigidity traps are described as resulting from situations that (consciously or not) "squeezed out diversity" (Allison and Hobbs 2004) or created "explicit rules and regulations about who is in the network and how the members interact" (Gunderson et al. 2006). Although these discussions concern contemporary social-ecological systems, the general concepts are broadly applicable.

We translate these concepts into three parameters—integration, hierarchy, and conformity—that can be assessed archaeologically. These parameters concern characteristics (such as social control) that contribute to rigidity, as well as those (such as a lack of innovation) that might result from rigidity. We do not attempt to parse causes and effects because separation would be impractical archaeologically and because the concepts are intertwined conceptually.

Integration

We use integration—the extent to which units are in some way interdependent—as a proxy for the resilience theory concept of "connectedness." Integration is not necessarily a negative state, in that it may contribute to a sense of community and facilitate cooperation or specialization, although its extreme form may involve hypercoherence. But even in less extreme forms, integration fosters rigidity by reducing the flexibility of individual units and what ecologists call "modularity" (Levin 1999). We assess integration in terms of four variables of architecture and settlement (see Table 4). The first two consider aggregation as a general measure of overall integration, whereas the latter two consider the distribution of public architecture—possible loci of integrative activities—as more specific indicators regarding the scale of inter- and intrasite integration.

Southwestern populations may have aggregated for many reasons, ranging from defense to the organization of subsistence or ceremonial activities. The extent to which such aggregates constituted unified social or economic units clearly varied, as is suggested by the variation in the distribution of public architecture discussed below. Here, we simply assume that degree of settlement aggregation is a general indicator of integration and, thus, of rigidity. Aggregation is measured as the percentage of the population living in relatively large sites (V11) and the average population in aggregated sites (V12). *Aggregated sites* are defined as those with 50 or more people; they are considered to be communities (Hill et al. 2004) and community centers (Varien 1999). By both measures, the Hohokam core area, within which nearly the entire population was living in large aggregated sites, is the most integrated.

The relationship between architecture and social integration has long been of interest to Southwest archaeologists (e.g., Lipe and Hegmon 1989). Public architecture—structures made and used by groups larger than household units—may be indicative of interhousehold integration but may also have been used for competitive activities (Potter 2000). Furthermore, integration at one scale may involve competition at other scales, and there are possible links between religious integration and warfare (Plog and Solometo 1997). Thus, we consider public architecture to be most useful as an indicator of the possible scale of integration. Given our focus on integration as a component of rigidity, the linkage of integration to competition or conflict is not problematic analytically.

Public architecture takes different forms in the three regions. Classic Mimbres sites have (mostly informal) plazas, small kivas, and special large rooms but little or no architecture clearly constructed for use by large groups (Clayton 2006). Mesa Verde region public architecture took various forms, including great kivas and multiwalled structures (see Glowacki 2006). In the Hohokam Classic, platform mounds were the primary form of public architecture. The number of people per public structure in the core areas (V13, total population divided by the number of public architectural structures) indicates the possible scale of architecturally organized integration: the higher the number, the higher the rigidity ranking. The number of such structures per aggregated site (V14) indicates the degree of intrasite integration. The rigidity rankings for V14 are based on the interpretation that the absence of such structures is indicative of a low degree of integration but that when structures are present, fewer indicates stronger integration. Again, by both measures, the Hohokam region shows the most integration: it had the most people per ritual structure, and these structures were concentrated on a few sites.

TABLE 5. Measures of Rigidity: Social Power.

Variable	Mimbres		Mesa Verde		Hohokam	
V15) Household differences	Possible differential access to ceremonial spaces	**1**	Differential access to special structures/stores	**2**	Clear differences in form and placement	**3**
V16) Restricted access to public architecture	N/A	**1**	Yes, new more restricted forms in last few decades	**2**	Yes, surrounded by walls	**3**
V17) Differential burial treatment	No	**1.5**	No evidence	**1.5**	Yes, goods and treatment	**3**

Hierarchy

There are many issues regarding hierarchy—including how it and related concepts such as inequality, complexity, and stratification—can be assessed. Focus here (following Lipe 2002) is on differences in social power: the degree to which some people have more power (over people or resources) than others. Power differentials may contribute to rigidity in that those in power are often insulated from difficult conditions and, thus, have little motivation for change or have reason to resist change. Power differentials fit well with descriptions of the rigidity trap as involving "efficient means of social control" (Holling et al. 2002:96). Although hierarchical organizations may be capable of efficient and rapid responses, a large literature on the study of institutions argues for a strong link between hierarchy and rigidity (e.g., Ouchi and Price 1978; Staw et al. 1981). In Table 5, we assess hierarchy in terms of three variables—household differences (V15), restricted access to public architecture (V16), and differential burial treatment (V17)—although not all are applicable to all three cases.

In Mimbres, there are only tentative indications of social differentiation, including more elaborately constructed room blocks at the NAN Ranch Ruin and suggestions that households who occupied core rooms had ancestral ties to prime land (Shafer 2003). The distribution of household or room block–scale ceremonial structures is also uneven (Clayton 2006). However, there is minimal evidence of a social hierarchy, no strong differentiation in mortuary treatment (Gilman 1990), and no clear indication that some people exercised more power than others.

In the Mesa Verde region, there are indications that social power differentials increased in the last decades of the occupation, such that some may have had power over the activities of others (Lipe 2002:224). Evidence includes the change from relatively open great kivas to more restricted forms of public architecture; this architecture is often associated with more or special food storage (Glowacki 2006:63), to which some households had more access than others. This change in social power may be linked to the violence at this time; thus, it can be understood as both a cause and an effect of rigidity.

Finally, in the Hohokam case, there is strong evidence of differential access to social power as well as wealth and status, although there was intraregional variation. Restricted access to public architecture, one of the key indicators of power differentials in the Mesa Verde region, is characteristic of Hohokam platform mounds, which were often surrounded by substantial walls. Furthermore, households' access to the restricted architecture clearly varied. Some households were located within the walls or even on the mounds, whereas many others were outside the walls, and the latter arrangement is often interpreted as exclusionary (Gregory 1987; Harry and Bayman 2002; Wilcox 1991). Differences in status—as well as power inequalities—are also indicated by burial treatment; these differences intensified over time, especially after C.E. 1300. Some individuals were buried in specially prepared graves, on or near special places (the platform mounds), and with more or different goods than others (Loendorf 2001; Mitchell and Brunson-Hadley 2001).

Conformity

The parameter of conformity corresponds closely to the definitions of rigidity cited above, including the squeezing out of diversity and the suppression of innovation. Conformity—indicated archaeologically by material homogeneity—has also been the subject of recent archaeological discussion. For example, Timothy Kohler and colleagues (2004) argue that conformity, resulting in part from conformist transmission, is characteristic of early population aggregates and would have fostered integration and cooperation. These kinds of social processes, especially if they are self-amplifying, could suppress diversity and contribute to rigidity.

We assess conformity (see Table 6) in terms of the diversity of ceramic wares and types (V18 and 19) and household architecture (V20). These measures are complementary: ceramic diversity is (relatively) easily measured, but its relationship to behavioral diversity—and, thus, to conformity—is less straightforward. Diversity in household architecture is more complicated to assess, but it is more likely to have a direct relationship to behavioral diversity.

Ceramic diversity is tabulated simply on the basis of the number of types and wares. In each case, there was only one locally made decorated ware and one (or a few closely related and sequential) locally available decorated types in the period prior to the transformation (V18). Decorated imports were also scarce in all three areas (V19). Thus, despite the differences among the cases, they all have similarly low ceramic diversity.

TABLE 6. Measures of Rigidity: Conformity.

Variable	Mimbres		Mesa Verde		Hohokam	
V18a) # of locally made decorated ceramic wares	1 (Mimbres B/W)	**2**	1 (Mesa Verde White Ware)	**2**	1 (Salado Polychrome)	**2**
V18b) # of locally made decorated ceramic types	1 or 2 closely related (Style II and III)	**2.5**	2 closely related (Mesa Verde and McElmo B/W)	**2.5**	3 closely related (Pinto, Tonto, Gila Polychrome)	**1**
V19) % of locally made types in decorated assemblages	97%[a]	**2**	99%[b]	**2**	95%[a]	**2**
V20) Household architecture	Many forms and configurations	**1**	Redundant unit pueblos	**3**	Redundant courtyard groups, some variability at larger scale	**2**

[a]Calculated from the LTVTP database. [b]Based on data from Castle Rock Pueblo (Ortman 2000), Woods Canyon Pueblo (Ortman 2002), Yellowjacket Pueblo (Ortman 2003), and the Sand Canyon small-site testing program (Varien 1999).

We argue elsewhere that diversity in household organization and architecture is indicative of household autonomy (Hegmon et al. 2000). By extension, diversity in household architecture may indicate a lack of rigidity. Here, we summarize analyses presented elsewhere (Hegmon et al. 1998). Classic Mimbres household architecture is extremely variable: some residential units shared a single residential room (with a hearth) and a few storage rooms, others shared two residential rooms, and others occupied large (probably multihousehold) suites (Hegmon et al. 2006). In contrast, both Mesa Verde and Hohokam household architecture was organized quite uniformly. The Mesa Verde region residential unit was the unit pueblo, consisting of several room suites that shared a kiva; this configuration is seen in sites of all sizes. Similarly, the basic Hohokam residential unit was a courtyard group consisting of several houses that opened into and shared an open area, a configuration seen in various architectural forms and locales. Typically, several courtyard groups shared other facilities including a cemetery, midden, and *horno* (earth oven).

Comparison

These three parameters of rigidity summarize (and simplify) an enormous range of phenomena and data, but they allow us to draw comparisons among the cases and, thus, to evaluate our general proposition. Overall, the average rigidity rankings (Mimbres = 1.5, Mesa Verde = 2.0, Hohokam = 2.5) correlate well with the severity rankings derived in the previous section. The least rigid case (Mimbres) also experienced the least dramatic transformation; the most rigid case (Hohokam) was characterized by the most dramatic transformation, including a long period of human suffering and the decline of both the population and the cultural tradition. The biggest surprise in this assessment of rigidity is the lack of variability in ceramic diversity; all three cases had very homogeneous decorated ceramic assemblages, indicative of rigidity in this realm. It may be that more detailed analyses of ceramic design style would reveal relevant differences.

CONCLUSIONS

In a broad sweep of Southwestern prehistory, we consider in this article the relationship between rigidity and social transformation through a comparison of the changes that constitute the ends of the Mimbres and Hohokam Classic periods and the end of the occupation of the Mesa Verde region. We developed methods to assess and compare parameters of transformation (demographic scale and displacement, degree of cultural change, and physical suffering) and rigidity (integration, hierarchy, and conformity). Our measures of these parameters, with a series of 20 archaeologically measurable variables, support the proposition, suggested by resilience theory and the rigidity trap concept, that there is an association between the degree of rigidity and the severity of transformations.

The Mimbres transformation was clearly the least severe: it was the smallest in scale and involved no obvious (corporeal) human suffering. It also was associated with the least pretransformation rigidity. People in the Mimbres Classic period apparently did not hold onto their old ways very tenaciously; when faced with climatic, subsistence, and social stresses of the early 12th century, they reorganized their settlements and changed their material culture, and many stayed in the region or returned after a generation or two.

The other two cases, Mesa Verde and Hohokam, evidenced much harsher conditions prior to their more severe transformations. Much of the 13th-century occupation of the Mesa Verde region can be seen as an attempt to continue in the face of growing difficulties (Glowacki 2006). Some people probably left, whereas others packed into the central part of the region and began developing increasingly rigid forms of organization, including aggregation and social power differentials. However, they do not appear to have become trapped by these organizational

forms over the long term. Rather, when conditions worsened—including massacres and a major drought—virtually everyone left the region. Although this was the end of a spectacular era in prehistory, it was clearly not the end of the people, many of whom moved south and established new ways of life that are ancestral to the Pueblo peoples of today.

In contrast, as conditions worsened in the Hohokam region, people stayed, in some cases enduring terrible health conditions for generations, until the social and physical infrastructure finally disintegrated. The concept of the "rigidity trap" seems applicable to this case, in that they created (consciously or not) a way of life that offered few alternatives. Farmers, even those engaged in intensive irrigation, often draw on wide-ranging social ties that allow them to move to other areas or to switch to less intensive strategies when conditions decline. But these alternatives do not appear to have been open to residents of the Phoenix Basin in the Hohokam Classic period. People may literally have felt trapped, perceiving no way to makes changes and no place to go, and so they stayed while things fell apart around them.

Our synthesis has drawn on newly available data and analyses by the LTVTP and compared them to our and others' analyses of other very large data sets collected by the Village Project and the Coalescent Communities Database. We believe the comparative synthesis of these cases, illuminating similarities and differences and relating the sequences to some of their consequences for humans in the past, is in itself a major contribution. Furthermore, this synthesis is given broad relevance (well beyond the confines of U.S. Southwest archaeology) by developing it in the context of examining propositions suggested by resilience theory. The comparison demonstrates that rigidity—lack of flexibility, suppression of innovation, and resistance to change—may delay change or transformation for some time but not forever. Furthermore, in such rigidity trap situations, the transformation, when it inevitably comes, is severe and associated with human suffering.

So why do people sometimes fall into the rigidity trap? Are we in one today? If we are, can we get out of it? If we are not, how can we stay out of one? Consideration of both the Hohokam case and other perspectives on vulnerability and transformation may be illuminating:

(1) Absence of social options: The large irrigation system long predates the Hohokam Classic period. But prior to the Hohokam Classic, people doing river irrigation were part of a large regional network, which gave them contacts across southern Arizona (Abbott et al. 2007). In Hohokam pre-Classic times, people facing problems with river irrigation had options: they could draw on this network and relocate to other areas. Linda Cordell and colleagues (2007) argue that this kind of network is what allowed people to migrate out of the Mesa Verde region in times of difficulty. But by the Hohokam Classic period, the regional system had ended, and people probably had few contacts outside their immediate area, making the decision to leave more difficult. In a more general sense, isolation contributes to rigidity.

(2) The limits of buffering strategies: The often-cited work by Holling (1973) that established the basis of resilience theory contrasted resilient and stable strategies. Recent work on robustness—the maintenance of some performance characteristic in the face of perturbations—is reaching similar conclusions, in that robustness in one realm is often achieved at the cost of vulnerability in another (Anderies 2006; Anderies et al. 2004). More specifically, the Hohokam canal irrigation system was highly robust to fluctuations in rainfall because it provided a buffer from temporal variation. But that robust buffer contributed to the creation of a system that was increasingly vulnerable to other social and ecological perturbations. There are always tradeoffs.

(3) Attachment to traditions: Anthropologists have long recognized the entrenchment of traditions, which sometimes appears as conservatism or resistance to change. Recent analyses have considered the continuance of traditions from various perspectives. Joseph Henrich (2001) and Kohler and colleagues (2004), in their discussions of conformist transmission, suggest that conformity (esp. at a large scale) begets further conformity. Marco Janssen and colleagues (2003) note that the "sunk costs effect" (i.e., resistance to abandoning a long-established course of action even when it is clearly disadvantageous) may have contributed to the vulnerability and collapse of ancient societies. Both of these factors could have been in effect in Classic Hohokam society. People lived in the same places with the same technological and sociocultural traditions for generations. A better understanding of conformity in various realms—including pottery and architectural style as well as household and productive organization—may make it possible to parse out these scenarios and better understand the tentative line between conformity as a positive contributor to cooperation and conformity as the suppression of innovation and a factor in rigidity.

(4) Attachment to technology: Clearly there is no hard line between cultural traditions and technology, but what appears to be attachment to tradition can also be understood in more strictly economic and technological terms. Although innovation may be beneficial in the long term, from the perspective of a malnourished farmer with marginal yields, innovation is impossibly risky. In the short term, for people on the margins, a low but predictable yield is preferable to the larger fluctuations that are likely to result from innovations, even if the average yield is higher (Cancian 1980). Thus, the worse conditions become, the more people are likely to resist innovation and, thus, to move more deeply into the rigidity trap.

(5) Attachment to place: The Hohokam irrigation system was a masterpiece of hydrological engineering. It carried millions of cubic feet of water to irrigate over 16,000 acres of arable land (Howard 2006) and took advantage of the hydrologic conditions of the Phoenix Basin. Specifically, along the lower Salt River there are nine natural reefs that raise the water above the level of the natural water table and create excellent conditions for canal head gates. All of these reefs were utilized, and they probably became important places culturally and socially as well as technologically. Thus, the system would have been

tethered to these places as well as to the rivers. Relocation of the irrigation system and associated social institutions would have been virtually impossible. Thus, attachment to place, whether cultural or technological, may contribute to rigidity.

(6) Path dependence: Some or all of the above may constitute a situation known as "path dependence" in literature on institutions and technology (see Pierson 2000 for a recent review). This term describes how the development of certain technologies, institutions, or land-use patterns (esp. in combination) often establishes a trajectory that becomes increasingly difficult to change, even if change is recognized as desirable. One contemporary example is our electrical grid system. Anticipatory governance is today considered one way of minimizing the development of path dependence, and knowledge of cases, such as those described here, may contribute to such governance.

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