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# SPATIO-TEMPORAL MODELING OF NORTH AMERICAN PREHISTORY

## 1. Introduction

I have become increasingly interested in the way in which archaeology deals with problems at large scale, and because of that I am also concerned with the way in which we report our findings. The way in which we report our findings depends upon an implicit theoretical framework. I argue that if we make that theoretical framework explicit we discover that it is badly flawed. I suggest some steps to improve the way in which we study and report our findings. These changes entail a shift in theoretical assumptions.

To me the most interesting archaeological problems are those that operate at large scale. Such problems are the most likely to be of interest to other archaeologists, and they are also more likely to yield meaningful generalizations about past human behavior. Much of my work in recent years has been at this scale.

A major practical problem is that we tend to carry out our work at the site level, tailoring our methods and our reporting to specific small-scale problems of more local interest. Consider the analogy of weather reporting and weather forecasting. What would be the result if weather researchers individually made their own local choices about measurement standards, the proper tests to deploy, the intervals between readings, which data to publish, and so forth? No doubt there would be mountains of data on the weather, but no one would be able to easily comprehend the big picture. However, every day we are able to see large-scale animations of weather systems on television. These provide us with clear and understandable generalizations about the weather of entire continents, and at the same time they provide us with reasonably accurate summaries and predictions at specific locations. Somehow weather researchers have been able to turn a large number of local data into meaningful and accurate large-scale generalizations.

Now consider how we try to accomplish something analogous in archaeology. Most of us toil away at the site level. We are mindful of the destructive nature of excavation and the nonrenewable nature of our subject matter, and that leads us to become even more reductionalist and myopic than other scientists. We can spend an entire field season working in an area smaller than a standard classroom. Later we write reports that address small local problems, such as dating, flotation evidence, cross mending of artifacts, and so forth. While doing so we often protect our sites by being vague about

their locations, and we protect our reputations by being vague about dating and typology. Consequently, those of us who attempt to study regional archaeological problems often must depend upon reports that are typically vague about locations, dates, and assemblage contents, although each of these might be kept deliberately vague for different reasons. We do our best to bridge these gaps when we generalize, but we often simplify the complexities of the archaeological record when we do so.

An example from the American Southwest is instructive. Fig. 1 is a grayscale image derived from a larger one in color that I published in Atlas of Ancient America (Coe *et al*. 1986, 69). Like other traditional representations of the major prehistoric traditions of that region, this one shows overlapping areas. This is because the areas of the major Southwestern traditions expanded and contracted within the long time period covered by most standard representations. The traditions are seen to overlap because the distributions of their static remains do. The dynamism of the demographic processes that produced these patterns is not at all apparent in such representations.

If we electronically animate a map of the American Southwest in order to avoid the overlapping found on a static map we get an improved view. Tav. V, shows one from (AD 1250) of a 41 frame color animation that depicts the evolution of Southwest archaeological traditions at fifty-year intervals. However, in the time-transgressive animation from which Tav. V is taken we still have a view of Southwest archaeology that I judge is more simplified than necessary. This is because the various cultures that constitute the major traditions have been lumped together for convenience in this case. In other cases it might be because the archaeologist is too uncertain of some of the specifics. In either case meaningful variation is still obscured in the interests of exposition.

If one lists all the known phases of all the cultures that constitute the six major archaeological traditions of the American Southwest one finds that there are at least 119 developmental phases defined for 26 constituent cultures. Of course, the evidence is scattered through hundreds of sites. So the problem is how to generalize on this much information without obscuring meaningful variation. Fig. 2 shows an animation frame for AD 1250 that depicts separately all of the cultures of the main traditions of the American Southwest in that year. Although I have labeled only the traditions, the names of individual cultures (phases) could be easily provided as well. At this scale the additional information would clutter the figure. Fig. 2 is a significant improvement over both Fig. 1 and Tav. V. Unlike this representation of it, the animation is in color, which provides even more information to the viewer than do the subtle variations of gray in the figures shown here.

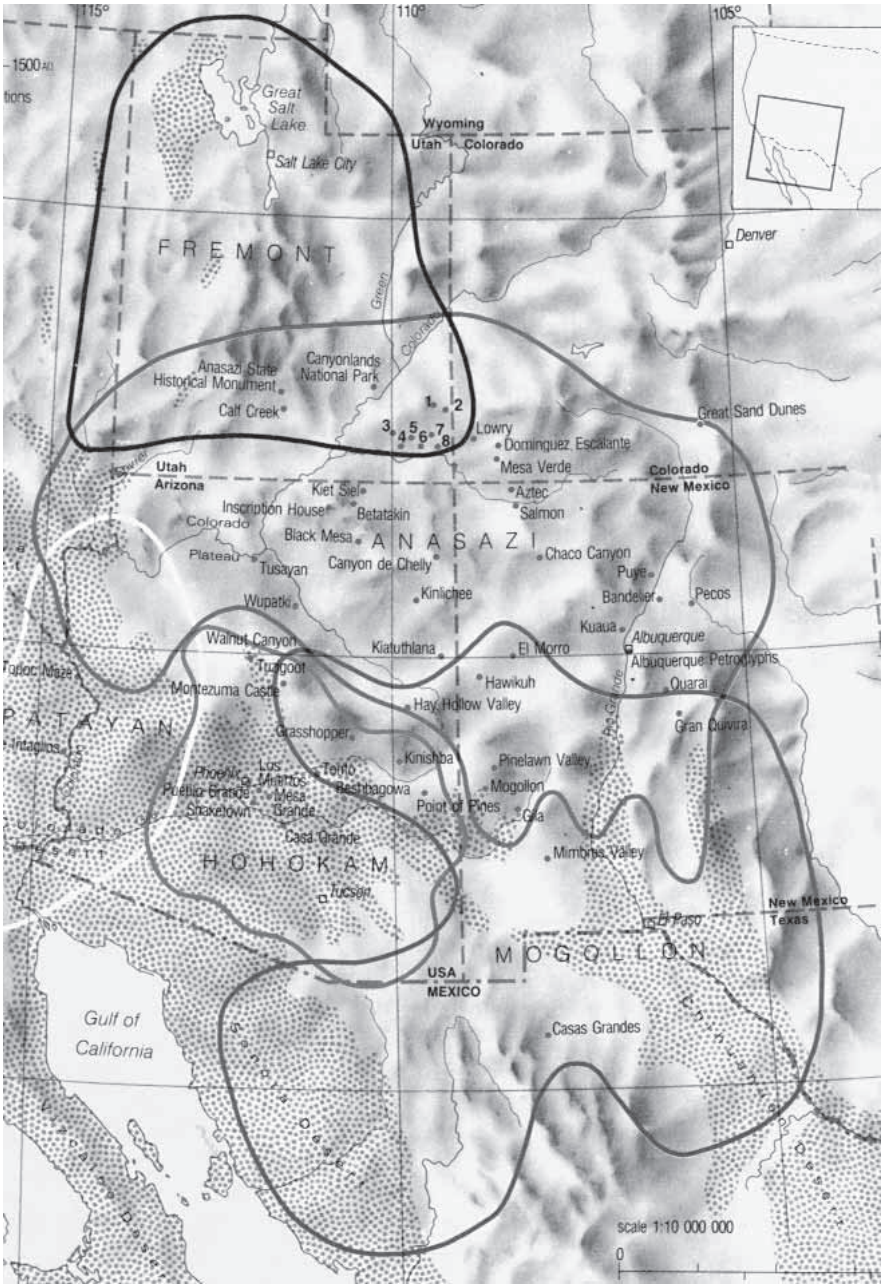


Fig. 1 – A simplified map of the prehistoric American Southwest AD 1-1500, derived from Coe *et al*. 1986, 69.

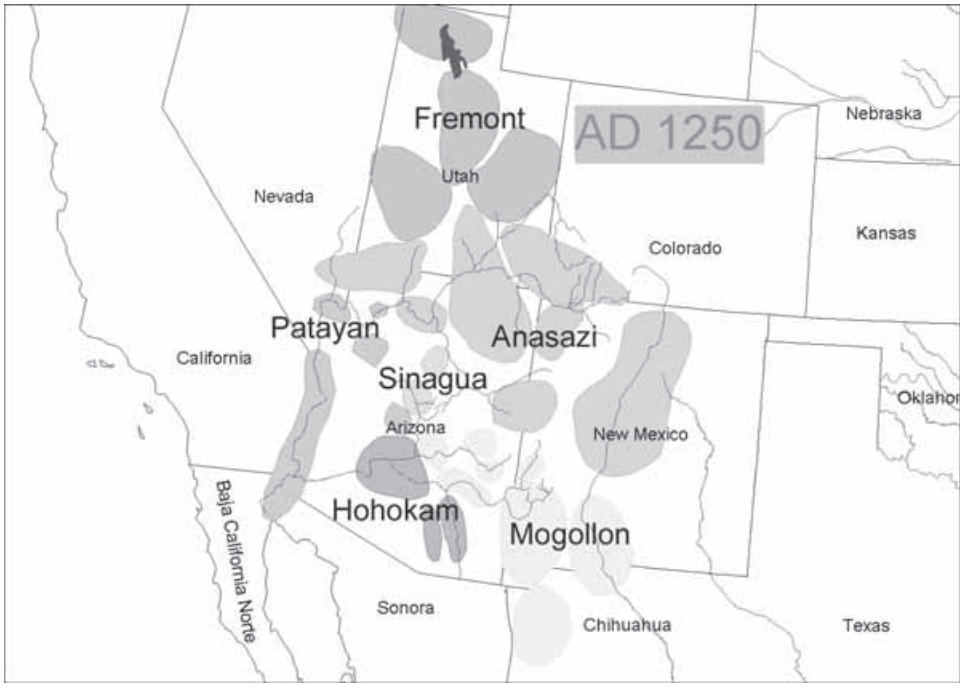


Fig. 2 – A single frame (AD 1250) from a color animated map of the prehistoric American Southwest, AD 1-1500, showing individual cultures of the five major archaeological traditions.

## 2. Animating maps

I have been working on animated GIS approaches for several years and I have presented the results of some of that work at various UISPP meetings. It is convenient to refer to the results as TGIS. At the same time Ian Johnson has also been developing something he calls TimeMap into a time-enabled GIS viewer, which he refers to as TMView. This set of programs allows for remote data download through the clearinghouse of the Electronic Cultural Atlas Initiative (www.timemap.net). Clearinghouse datasets are mapped and saved locally by this program. There is also a Java version of TMView that maps the datasets directly but does not save them locally.

My own approach has been to write programs that map from my own locally maintained MapInfo or ArcGIS files. This can be done in two ways. One can either create a series of images that are then strung together as a computer animation by means of a separate animation program, or one can create an animation interactively that draws directly upon the datasets but does not save the result.

What is new and different in these approaches is that one does not have to depend upon simplified regional syntheses written by other archae-

ologists to view the larger picture. Neither does one need hardware or software that is not readily available. One does have to depend upon published data, however, and because reporting standards are underdeveloped it is often difficult to find basic information.

Of course, getting the data into any data base is not easy. Every site and every phase of every culture must have both a beginning date and an ending date for the program to work properly. But this is something on which most archaeologists are likely to equivocate. Often they do not publish their best estimates at all, preferring to refer vaguely to generally used period designations. This custom is made worse by the tendency for archaeologists to use stages and periods interchangeably. For example, in the American Southwest the Pueblo I period is actually a stage of development, which occurs a century or so earlier in the eastern Anasazi tradition cultures than in the western ones. Traditional cross dating, with its implicit assumption of simultaneity is at odds with the use of stages when good absolute dating is available, as it is in the Southwest.

## 3. Problems in dating and mapping

Periods that are in fact cultural stages are the legacy of an earlier era in archaeology when cross-dating between regional sequences was common. The use of (1) stages and periods as if they were interchangeable concepts, the practice of cross dating, coupled with (2) the practice of mapping archaeological cultures as contiguous areas sharing common boundaries constitutes an implicit theoretical framework that does a continuing disservice to modern archaeology.

Let me deal with these two problems separately. Independent absolute dating techniques have made stage designations not just obsolete but counterproductive. This is particularly true in the American Southwest, where dendrochronology often provides very precise dating. Stages should be abandoned in any case, but requirements of TGIS bring a certain urgency to the issue.

Another problem has to do with the reporting of dates. Archaeologists should consistently report both beginning and ending dates when discussing sites and phases, even when these cannot be precisely known. We all understand the problems involved in accurate dating and we all know that dates are often little more than educated guesses. We all are willing to allow each other to revise earlier estimates as new data come in. A well-reasoned estimate from a professional archaeologist familiar with a site is better than no date at all.

Mapping also has been difficult. Most published maps are small so that they can fit on to a book page. Site locations are usually imprecise because the scale of publication makes precision unnecessary. In the United States it is often impossible to locate a site to within fewer than 50 kilometers using published archaeological sources. Sometimes this is deliberate because ar-

chaeologists wish to protect sites that are vulnerable to looting. However I argue that modern GIS standards should require sites to be located more precisely by means of standard coordinates. If site security is an issue the last digits can be dropped from the published coordinates, whether they are UTM coordinates or latitude/longitude.

There is a related problem in the representation of spatial distributions of cultural phases. Archaeologists tend to dislike empty spaces. But the pre-state societies that most of us study did not have well-defined spatial boundaries, let alone boundaries that were contiguous with those of neighboring societies of the same types. Many maps of archaeological cultures show contiguous boundaries between neighboring cultures when it would be more accurate to show empty spaces between them. Notice that Fig. 2 does not represent cultures as having contiguous boundaries but instead relies on the distributions of their constituent sites to define small culture areas separated by buffer zones.

It is also almost always the case in American archaeology that when a culture is poorly known it is assumed to have a rather broad distribution. As additional sites are discovered and more is known about the culture the mapped distribution usually is shown as more restricted on later published maps. Of course the edges of spatial distributions are as fuzzy as their temporal ones are, but here again we should not complain about the false precision implied by sharp edges. Like dates these are or should be generally understood to be approximations.

Cultures and traditions are constructed from data on sites and phases, so the patterns that emerge at the larger scale should be the focus of our interest. Some critics argue that the larger units are based on false precision, but we need to be able to map both spatially and temporally in TGIS if we are to see the larger patterns embedded in our data. The methodological issue here is basically that of sampling. Perhaps we cannot be blamed if after investing large amounts of time and money on site excavations we find it difficult to think of them as just items in a larger sample. However, to make sense of Iroquoian demography over time I had to compile data on hundreds of Iroquoian village sites. It does not matter whether I precisely dated the first occupation and the abandonment of the Otstungo site (which I spent two years excavating) so long as there were a sufficient number of other sites like it that were also dated independently if just as imprecisely. The pattern emerges from the sample despite the imprecision of any particular observation.

## 4. Conclusions

I argue that we need to adopt a new set of reporting standards that will both facilitate TGIS and eliminate implicit theoretical assumptions that have hampered scientific progress in archaeology. Put briefly these are as follows:

– Periods that are in fact cultural stages should be abandoned.
– Archaeologists should consistently report both beginning and ending dates when discussing sites and cultural phases with the understanding that they are almost always informed approximations.
– Archaeologists should consistently report site locations and map cultural phases clearly and precisely.
– Buffer zones should be usually assumed to exist between pre-state cultural phases, even those assigned to the same cultural traditions.
– Sharp spatial boundaries can be drawn but all should generally understand that these are not meant to be taken literally in the case of pre-state societies.
– TGIS data should be aggregated at a scale that is appropriate to the study of the patterns of interest.
– Archaeologists should make better use of readily available hardware and software to study problems of general interest.

Larger scale patterns that unfold over time can be accurately perceived in a sufficiently large sample even if dates and locations of the observations used to compile them are only imprecisely known. While too many data can clutter and obscure larger patterns of interest, too much aggregation and oversimplification is also a problem. Yet most archaeological publications tend to move to one or the other of these two extremes. I think that we can do better, and the needed technology is readily available.

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ABSTRACT

A new dynamic spatio-temporal model of North American prehistory and protohistory from 14,000 BP to 200 BP allows researchers to visualize the ebb and flow of culture change and demographic processes at any of many possible scales. The authors of past syntheses of such changes over time and space at large scale in North America have depended upon aggregating lower-level syntheses and summaries prepared by various regional specialists. One advantage of the model is that it eliminates much of the bias and filtering that is typically entailed by this dependence. It does so by directly referencing site-specific data recorded and maintained in a GIS format. These are called up and displayed as animations of spatial change over time. The animations in turn can be mapped against environmental changes over time and space. The model raises theoretical and methodological questions about how we record and disseminate our data. These are briefly discussed.