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THE PROMISE AND PERIL OF SEDUCTIVELY LARGE TREE-RING DATE DISTRIBUTIONS

STEPHEN E. NASH

Southwestern archaeology and tree-ring dating have been inextricably entwined for more than a century (Nash 1999). Woven together like strands of a complex tapestry with compelling personalities, stunning discoveries, and analytical milestones, dendrochronological contributions punctuate the history of Southwestern archaeology with astonishing regularity. From the initial "bridging of the gap" in 1929 to the first use of tree-rings to calibrate the radiocarbon date curve in the 1970s; from detailed climate reconstructions that came to the fore in the 1960s to the first dating of an archaeological site in the southern Arizona desert in the 1990s, Southwestern dendroarchaeologists push boundaries and now benefit from a rich and detailed dendrochronological record (Dean, Slaughter, and Bowden 1996; Douglass 1929; Nash 2000; Nash and Rogers 2014). The challenge for Southwestern archaeologists is to ensure that our interpretations, based on comparatively low-resolution archaeological data (i.e., ceramics, architecture, etc.), remain in general agreement with the incredibly precise, high-resolution data provided by tree-ring dates, which offer annual, and in some cases seasonal, precision (Ahlstrom 1997).

As Southwestern archaeologists, we are blessed by an embarrassment of dendrochronological riches (Nash and Rogers 2014). As such, we can fall into a seductive analytical trap by taking large tree-ring date distributions for granted. We can fail to recognize that tree-ring dates are data that, like all archaeological data, must be critically evaluated within the contexts from which they derive. To

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be blunt, we should never accept large tree-ring date distributions at face value. We must always consider the nature and origins of the data of that comprise them before we attempt to interpret what those distributions mean with regard to pre-Hispanic Puebloan behavior.

There are now tens of thousands of reliable tree-ring dates available from thousands of archaeological sites across the American Southwest. Accepted at face value, the large distribution curve of those tree-ring dates is compelling, if not deceptive. What's not to like about a large tree-ring date distribution? It's composed of huge numbers of individually reliable dates, none of which have any associated statistical uncertainty (see the section "Dendrochronological Basics"). Analysis of the distribution is apparently easy—simply bin the dates by year, decade, or century, and plot them in a bar chart, line chart, or histogram. The resulting graph is a distribution with notable peaks and valleys that beg interpretation, often with compelling but unsupported narratives about construction activity, agricultural productivity, and other variables.

If only it were that simple.

In 2010, Michael S. Berry and Larry V. Benson used a database of 6,984 dates from 413 sites across the American Southwest to "estimate regional-scale timber-harvesting and construction activities between AD 600 and 1600" (Berry and Benson 2010, 53; see also Benson and Berry 2009). Although they acknowledged that sampling bias exists in their dataset, they "opted to consider the likelihood that these [tree-ring] data are, in fact, *representative of prehistoric reality*" (Berry and Benson 2010, 56; emphasis added). Building on Berry (1982), Berry and Benson (2010, 56) suggest that their database serves as a "relative measure of construction activity" in the portion of the northern Southwest they analyzed during the millennium in question. To be blunt, they assumed what they should have tested.

Kyle Bocinsky and colleagues (2016) analyzed a database of 29,311 tree-ring dates between AD 500 and 1400 from over 1,000 archaeological sites across the Southwest. They admit "potential sampling biases still exist [in their dataset] because of uneven preservation and investigation" but continue with the analysis because, in their words, "the size of our database and the robustness of the patterns identified by Berry [1982; Berry and Benson 2010], despite a much larger sample of dates [in our database], are reassuring" (Bocinsky et al. 2016, 3). In other words, they believe the visual patterns evident in their larger tree-ring date distribution map onto, and indeed build upon, those present in Berry and Benson's (2010) data.

As Jeffrey S. Dean (1985, 704) pointed out more than thirty years ago, "the assumption that the sample of C-14 and tree-ring dated sites is representative of the spatial and temporal variability in the total [Ancestral Pueblo] site population is demonstrably false." Yet Berry and Benson (2010) and Bocinsky et al. (2016) continue to assume that the size of their date distributions obviate whatever systematic bias may exist in the data.

To test their assertions, I will deconstruct a large tree-ring date distribution that consists of 19,436 dates from two regions—the northern Four Corners and

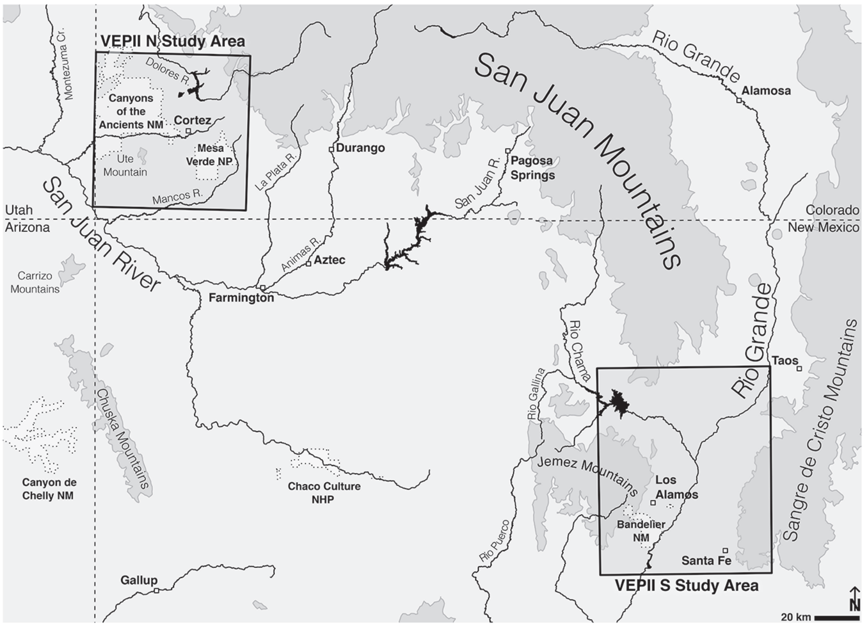


Figure 3.1. Study area for the Village Ecodynamics Project II run by Crow Canyon Archaeological Center. Bounded rectangles encompass the greater Four Corners region, including Mesa Verde National Park, in the upper left, and the northern Rio Grande region in lower right. All tree-ring dates considered in this chapter come from within those two rectangles. Map by Kyle Bocinsky, courtesy of the Crow Canyon Archaeological Center.

northern Rio Grande Valley (figure 3.1). I will examine the history of archaeological and tree-ring research in each region to determine if these variables contribute systematic bias to the date distribution. I will then assess whether archaeological context, in the form of site and subsite level provenience information, leads to systematic bias in the distribution. In so doing, I will consider several questions: (1) When were the various tree-ring samples collected? (2) Why were they collected? (3) Which sites were they collected from, and from what structures? and (4) How typical (i.e., representative) might, or might not, the dated sites and structures be within their respective contexts and regions? Once we answer those questions to the best of our ability, we can begin to consider whether large tree-ring date distributions represent some unknown, unbiased, "prehistoric reality."

As we shall see, the history of tree-ring research, differential preservation of wood and charcoal, and site- and subsite archaeological context matter, a lot. Each of these variables introduces substantial, systematic bias into large Southwestern tree-ring date distributions.

There is no need to throw the baby out with the bathwater, however. Tree-ring date distribution curves can, and indeed should, be used for analytical and interpretive purposes. We need to remain keenly aware of dataset composition. Before diving into the deconstruction of these curves, however, we need to review some basic precepts and prerequisites of archaeological tree-ring dating.

DENDROCHRONOLOGICAL BASICS

When properly derived, a tree-ring date yields an easily recognizable, understandable, and relatable calendar-year date with no associated statistical error (Bannister 1962; Stokes and Smiley 1996). If the tree-ring date in question is a "cutting date," it documents the tree's death date, and the dendrochronologist can state with absolute certainty "the tree from which that sample came died in [insert cutting date here]." With a solid understanding of the archaeological site and subsite provenience from which that specimen was recovered, the archaeologist may then go further, perhaps being able to infer "that tree was cut down in year X to serve as a roof beam in structure Y at site Z." Under such circumstances, tree-ring dates are some of the best, if not the best, archaeological and chronometric data available anywhere in the world.

In contrast to cutting dates, however, noncutting dates may predate the behavior in question by hundreds of years due to excellent wood and charcoal preservation conditions in the generally arid environments in much of the inhabited portions of the American Southwest (Ahlstrom 1997). Even with an interpretively less reliable noncutting date, the dendrochronologist can state with absolute certainty, "the last ring on that specimen was grown in [insert noncutting date here]." With a solid understanding of the archaeological site and subsite provenience from which the specimen was recovered, the archaeologist may yet go further, perhaps to infer that "the room in which this specimen was found dates after [insert noncutting date here]." Even under these circumstances, tree-ring dates provide archaeologists with remarkably precise chronometric information with which to work.

Whether dealing with cutting or noncutting dates, there are three prerequisites for successful tree-ring dating in archaeological contexts. The first is behavioral and requires that pre-Hispanic Puebloan construction workers used datable tree species. If those workers used cottonwood trees to build their houses and apartments, archaeologists would not be able to date those structures using tree-rings, for cottonwoods cannot be reliably tree-ring dated (Dean 1996a, 1996b; though see Meko et al. 2015).

The second prerequisite is good specimen preservation. If wood or charcoal does not preserve well in a given site, it can't be tree-ring dated even if copious amounts of wood were used in its construction. Simply put, preservation matters. Cliff dwellings at Mesa Verde National Park (MVNP) are sometimes well dated because wood construction beams are beautifully preserved in the dry rock-shelter environments of the Mesa Verde landform (though see caveats in the section "Mesa Verde National Park"). Sites in the Mogollon highlands of Arizona and New Mexico are, however, less well dated with tree rings because wood and charcoal specimens don't preserve well in clay-rich, well-watered, open-air soils and sites.

The third prerequisite is specimen recovery by archaeologists and subsequent analysis by dendrochronologists. Cliff dwellings at MVNP are well dated because the park has been the focus of intensive archaeological and tree-ring research for nearly a century (Nash 1999; see section "Mesa Verde National Park"). In contrast, the myriad and roughly contemporaneous cliff dwellings of Grand Gulch, Utah, and those on the Ute Mountain Ute Reservation in southwestern Colorado have not received a similar level of attention from dendrochronologists. In the case of the former, the cliff dwellings are difficult to reach. In the case of the latter, the Ute Mountain Ute tribe has not issued permits for dendrochronologists to work.

Even under the best of circumstances—in which (1) pre-Hispanic Puebloan workers used datable tree species, (2) wood or charcoal samples are well preserved, and (3) professional archaeologists have recovered those samples, and dendrochronologists have analyzed them—not all tree-ring samples yield dates. The Four Corners region of the American Southwest is undeniably one of the best places in the world to conduct archaeological tree-ring dating. Even so, fewer than one-third of all tree-ring samples collected there over the last century have yielded dates. In other parts of the Southwest, the ratio of tree-ring dates obtained per number of submitted samples is even lower. The vagaries of tree growth, sample preservation, modern and ancient human behavior, and other random and nonrandom formation processes interfere with the dating process, albeit in often predictable ways (Ahlstrom 1997).

To summarize, we know that archaeological sites are not randomly distributed across space or through time. We know that archaeologists have not examined a representative sample of those sites. Rather, they have tended to focus on the most obvious, the most interesting, and the most accessible. In recent decades, with the ascendance of cultural resource management–derived research, excavation projects follow modern development plans. Those plans—for highways, housing, energy, and other developments—don't proceed according to dendroarchaeological needs and interests. We therefore have ample reason to infer that a tree-ring date distribution curve can, and will, contain systematic bias. It's the nature of the beast.

THE DATA

Between 2009 and 2012, with funding provided by Crow Canyon Archaeological Center's Village Ecodynamics Project II (VEP II), I created a database of 19,436 tree-ring dates from the northern Four Corners and Rio Grande regions, which together constitute the VEP II project area (see figure 3.1). That dataset is larger than Berry and Benson's (2010), which does not include the Rio Grande region. It is smaller than Bocinsky et al.'s (2016), which includes dates from most of the greater Southwest. All three datasets are nevertheless built on the same collections and archives at the Laboratory of Tree-Ring Research at the University of Arizona. They are nested sets.

Seventy-two percent (13,929) of the dates in my distribution are from sites in the northern Four Corners region (i.e., in Utah and Colorado, but not New Mexico or Arizona); 5,507 (28%) are from the northern Rio Grande valley in New Mexico. There are 5,705 (29%) cutting dates, 11,791 (61%) noncutting dates, and 1,940 (10%) "near-cutting" dates. "Near-cutting" dates include specimens that, according to the dendrochronologist, are missing one or two growth rings from

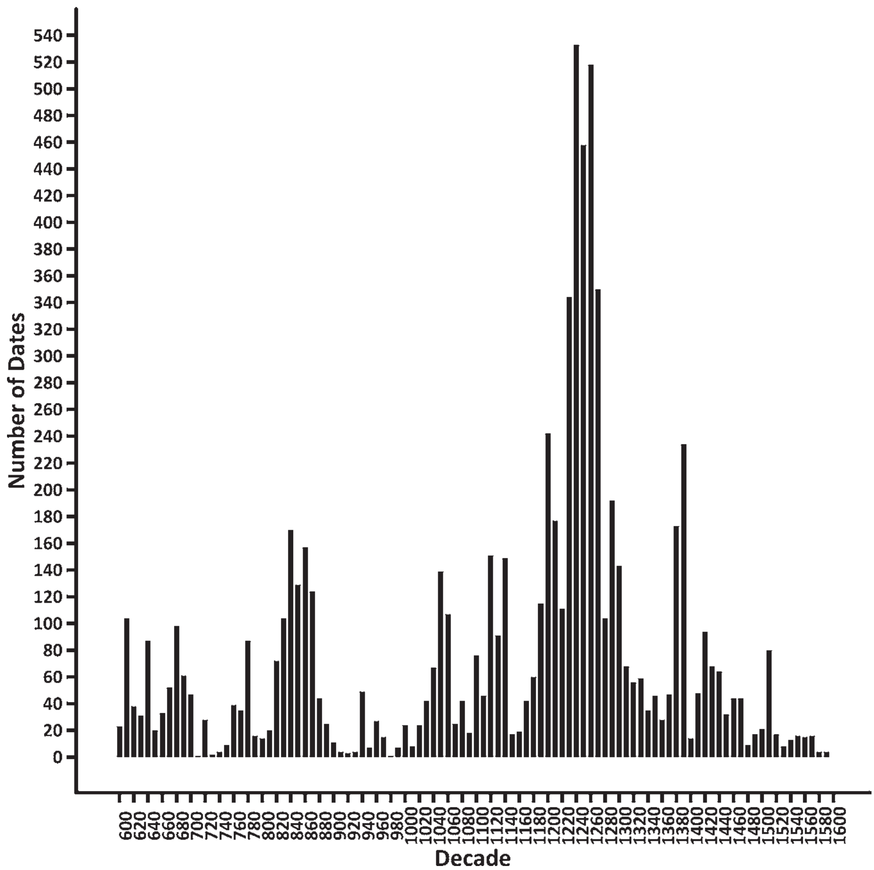


Figure 3.2. Bar chart of 7,611 cutting dates (binned by decade) from the northern Four Corners and Rio Grande regions, AD 600–1599. (Not shown: thirty-four dates from AD 445–599.) Figure by Holger Petermann.

the outside of the dated specimen. Although "near-cutting" dates are not cutting dates, they are usually within three years of a cutting date. As such, and following both Berry and Benson (2010) and Bocinsky et al. (2016), I include near-cutting dates in the following analysis. Noncutting dates are not considered further because we have no way of knowing how many rings are missing from the outside of the specimen. Given the often excellent preservation conditions at Southwestern sites, the number of missing rings can easily be in the dozens, if not hundreds, thus yielding tree-ring dates significantly earlier than the behavior in question (see Nash 1997).

The database includes a small number (thirty-four) of cutting and near-cutting dates from the earliest portion of the distribution, between AD 445 and 599. These early dates are dropped from further consideration because of the small number of dates and in order to create a clean cutoff date of AD 600, which, conveniently, is roughly the date in which robust woodworking tools (i.e., hafted stone axes) appear in the archaeological record (Ahlstrom 1997). That leaves us a large distribution of 7,611 cutting and near-cutting dates to examine. Figure 3.2 is a bar chart of those dates, binned by decade. Even with a quick glance, there are numerous obvious peaks consisting of hundreds, and in some cases thousands, of dates. Conversely, there are noticeable valleys as well, created by periods of up to several decades during which there are no, or very few, recorded cutting dates in either the northern Four Corners or Rio Grande regions.

As noted by Berry (1982), Berry and Benson (2010), and Bocinsky et al. (2016), what is compelling, if not startling, about figure 3.2 and similar distributions is that the peaks appear to correspond to named periods in the Pecos Classification (Kidder 1927); the valleys correspond roughly to the breaks between the originally defined Pecos periods (i.e., ca. AD 700, 900, 1100, and 1300).

Archaeologists designed the Pecos Classification in 1927, before tree-ring dates were available at all, much less in sufficient quantities to date the periods, which were defined and described on the basis of ceramic seriation, artifact and technological changes, and architectural changes. Within a decade, archaeologists assigned a clean if somewhat arbitrary 200-year window to each Pecos period, based on the limited number of tree-ring dates then available (see Douglass 1929; Nash 1999). In this new, semiempirical scale, Basketmaker III dated between AD 500 and 700, Pueblo I between AD 700 and 900, Pueblo II between AD 900 and 1100, Pueblo III between AD 1100 and 1300, and Pueblo IV between AD 1300 and 1500.

A quick glance at figure 3.2 reveals an apparent visual concordance between the Pecos periods and the tree-ring data: after a good cluster of dates in the 600s, the first half of the 700s has very few dates, thus apparently differentiating the Basketmaker III period. After a larger cluster of dates in the mid-800s, there is a nice valley for several decades around 900, thus differentiating the Pueblo I period. After a nice cluster in the 1040s and 1050s, there is a small valley in the distribution around 1090, apparently differentiating the Pueblo II period. The Pueblo III period, from 1100 to 1300, displays a nearly fivefold increase in the number of cutting dates before plunging at the end of the 1200s. Again, 1300 serves as a convenient break between the Pueblo III and Pueblo IV periods. Finally, the Pueblo IV period from 1300 to 1500 shows a significant but diminishing (especially after the 1380s) number of cutting dates through its end.

Accepted at face value, figure 3.2 therefore appears to present a compelling story of the ebb and flow of pre-Hispanic Puebloan history in the northern Four Corners and Rio Grande regions. Notice, however, that such a story is tendered without regard for the archaeological contexts from which the tree-ring dates in figure 3.2 derive and without regard for the history of archaeological research that led to the creation of that date distribution in the first place, much less anything about pre-Columbian agency and human behavior. Simply put, figure 3.2 offers banal insights into the "When?" question, but tells us nothing about the who, what, where, or why, much less how.

Once tree-ring dating burst onto the scene in 1929, archaeologists across the Southwest attempted to date, via tree-ring analysis, the phenomena they had been already been studying, including sites in Mesa Verde, Chaco Canyon, Canyon del Muerto, and other photogenic and extraordinary places (Nash 1999). In short, archaeologists entered into a period of circular research between site selection, tree-ring dates, and the interpretation thereof. Put another way, archaeologists focused their attention on sites that fit the Pecos period phases and patterns, not the sites that might date to the transitional periods in their new classification. So it is not surprising that the distribution of tree-ring dates maps onto the Pecos Classification periods—they derive from the analysis of artifacts and tree-ring samples the same sites!

Moving beyond this analytical feedback loop, we need to analyze the historical and contextual forces that shape figure 3.2. To do so, we will analyze it in three constituent components: MVNP, the northern Four Corners region beyond MVNP, and the northern Rio Grande valley.

MESA VERDE NATIONAL PARK

Nash and Christina Rogers (2014) analyzed the distribution of tree-ring dates available from MVNP at four critical points in the history of research there: 1929, 1951, 1974, and 2013. They specifically focused on the history of archaeological research to determine how it affects the aggregate date distribution curve for MVNP (figure 3.3).

In 1929, the MVNP distribution consisted of only eight (cutting and noncutting) dates from six sites, hardly a reasonable sample with which to draw anything but the most general conclusions (Douglass 1929; see Nash and Rogers 2014). For the first time, however, archaeologists learned that cliff dwellings in the park were built and occupied during the mid-late thirteenth century, which is not a trivial finding, especially when notable archaeologists such as Alfred Vincent Kidder had publicly assumed the sites at Mesa Verde and Chaco Canyon were up to circa 2,000 years old (see Kidder 1936).

The MVNP date distribution in 1951 consisted of ninety cutting dates (Smiley 1951). That distribution contained a noticeable cluster of dates in the 1270s and another, smaller cluster in the 890s (Nash and Rogers 2014, 314; see fig. 24.1). As such, that date distribution fit archaeologists' expectations at the time: there was evidence of more tree cutting, and therefore more construction activity and habitation, within MVNP in the late 1200s than there was in earlier times.

The MVNP date distribution curve in 1974 changed radically because of two large and important projects: the Laboratory of Tree-Ring Research's Synthesis Project and the Wetherill Mesa Archaeological Project (WMAP). The Synthesis Project was a comprehensive, systematic, and long-term project to reassess and confirm all tree-ring dates in the American Southwest, including those from MVNP (see Robinson and Harrill 1974). The WMAP was a massive archaeological project associated with the expansion of tourist facilities on Wetherill Mesa to alleviate overcrowding in decades-old infrastructure on Chapin Mesa. As such, WMAP excavated many large pithouse villages on the top of Wetherill Mesa while also examining some cliff dwellings in the surrounding canyons. Of importance, WMAP fully integrated dendrochronologists into its field research; they worked directly alongside the archaeologists. This led to the production of a large number of new tree-ring dates from previously poorly dated time periods and pithouse sites.

The 1974 MVNP date distribution curve includes 453 cutting dates (Nash and Rogers 2014, 314; see fig. 24.2). The resulting curve looks nothing like the distribution from 1951 or, more important, of 2013 (see later in this section).

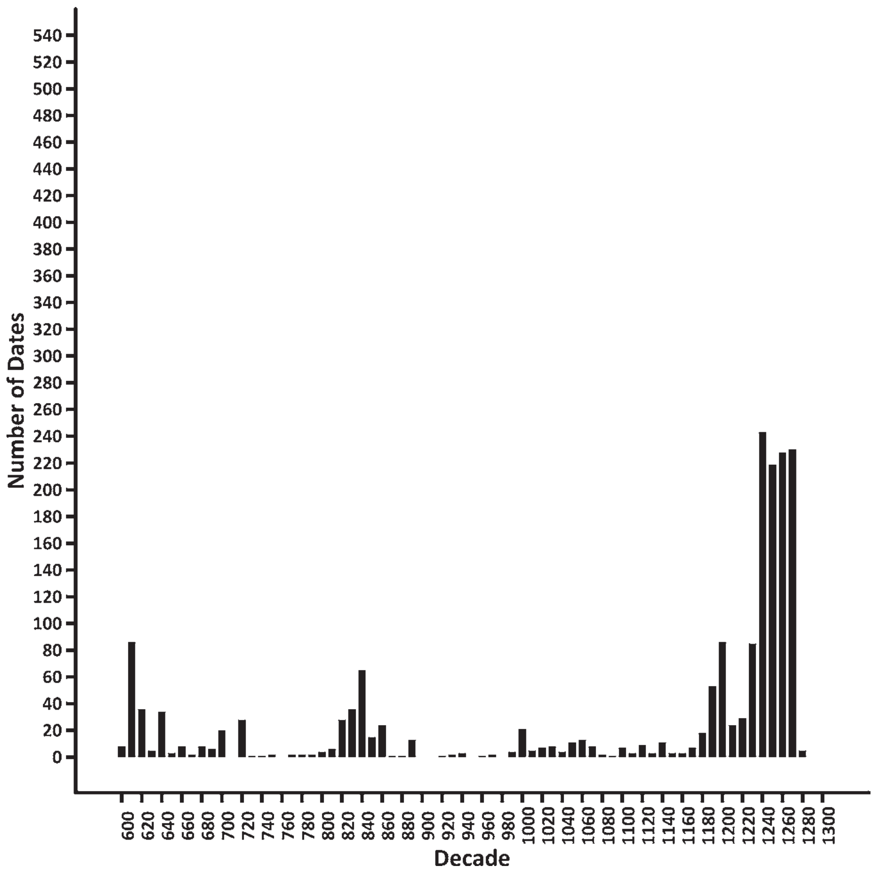


Figure 3.3. Bar chart of 1,819 cutting dates (binned by decade) from Mesa Verde National Park, AD 600–1300. (Not shown: thirteen dates between AD 445 and 599.) Figure by Holger Petermann.

The largest date cluster in the 1974 distribution is in the mid-800s, during the Pueblo I period of the Pecos Classification. Notable clusters from the early 600s, late 600s, and 730s are as large as that from the 1240s. Why? Because WMAP focused on the systematic excavation of pithouse sites on Wetherill Mesa! The date distribution curve therefore reflects the intensity of archaeological excavation after WMAP, not some "prehistoric reality."

If we accept the 1974 distribution at face value, we would infer that tree-cutting and construction activity were greater in the seventh through ninth centuries than they were in the thirteenth century at MVNP. Most scholars would rightfully find this to be a startling conclusion, based on our understanding of archaeological data from MVNP. Yet in the absence of critical historical and contextual analysis, that is exactly what the 1974 MVNP tree-ring date distribution suggests.

In 2013, the MVNP date distribution curve changed again. Thanks to a series of intensive, 100 percent sampling projects in cliff dwellings during the 1990s and early 2000s, there were now 1,819 cutting dates available. The total number of dates available more than tripled between 1974 and 2013. The distribution now has a huge, dominant peak in the thirteenth century, one that dwarfs the seventh- and ninth-century peaks that dominated the 1974 distribution (Nash and Rogers 2014, 315; see fig. 24.3). As such, the 2013 distribution fits within most archaeologists' expectations that the most intensive occupation of Mesa Verde occurred in the thirteenth century.

(It's worth noting that the average pithouse probably had five to ten times the number of construction logs than the average pueblo room at Mesa Verde, which had about a dozen wood beams on average [personal communication, Jeffrey S. Dean, December 5, 2018; see Nash 2000]. Given that, there may actually have been more tree-cutting activity in the seventh through ninth centuries than in the thirteenth century at Mesa Verde, but it's not evident in the current date distribution curve. That research requires further analysis beyond the scope of this chapter.)

Now that we've examined the analytical impact of large research projects on the date distribution curve, we can turn our attention to the impact of site and subsite provenience–level information. From the perspective of archaeological context, the substantial cluster in the 610s comes largely from the excavation of pithouses at only two sites: Step House and Mesa Verde 1824 (figure 3.3). Step House yielded 56 of the 86 (65%) dates in the 610s cluster; Mesa Verde 1824 yielded 19 (22%). Taken together, the dates from those two sites constitute 87 percent of the 610s cluster. The question is, How representative are those two sites for the time period at MVNP? We don't know, but we can't assume they are representative of the region until that fact is demonstrated by some other means.

The large 840s cluster evident in figure 3.3 is due almost entirely to the dating of a single structure—the great kiva at Morefield Canyon Group Site 1930, which yielded forty-eight cutting dates! As such, it provides 74 percent of all MVNP tree-ring dates from that decade. How representative is that single structure? We don't know.

Nash and Rogers (2014) provide a more detailed examination of the MVNP date distribution curve; enough has been said here to get to the point: If we accept the 2013 MVNP cutting date distribution curve at face value, we ignore several important facts about the history of archaeological research and tree-ring dating in the park. First, only 143 (ca. 3%) of more than 4,500 documented sites within the park yield tree-ring dates, because of both poor preservation and a lack of excavation. Second, even though virtually all datable wood from cliff dwellings within the park boundaries has now been collected and (if possible) dated, only about half the cliff dwelling sites yield dates at all (Nash and Rogers 2014). Third, only about half the park has been systematically surveyed. Are there going to be another 4,500 sites discovered on the unsurveyed half? Maybe, maybe not. Fourth, the vast majority of pithouse sites within the park have not yet been excavated. Until the park is completely surveyed and those undocumented pithouse sites are better understood, we won't have a complete understanding of MVNP's dendrochronological sampling universe. It is possible that new tree-ring dates will enhance clusters in the existing distribution; it is also possible that new dates from other structures and site will fill in gaps in the curve.

Another issue is that MVNP, as a US government administrative unit, occupies only a third of the Mesa Verde landform. The remaining two-thirds of the landform is Ute Mountain Ute land. We know there are dozens of large cliff dwellings and hundreds of smaller cliff sites on that land. We know there are hundreds, if not thousands, of pithouse sites on that land. We simply do not know, a priori, where on the date distribution curve those sites will fall when dated, but we can be sure that the pre-Columbian inhabitants of the Mesa Verde landform went about their business with no regard for these administrative boundaries. As such, we need to read the MVNP date distribution as a function of administrative geography and the history of archaeological research. We cannot assume that it is telling us anything about "prehistoric reality" based on its robust size alone (cf. Reese, Glowacki, and Kohler 2019).

What's the situation in northern Four Corners region beyond MVNP?

THE NORTHERN FOUR CORNERS REGION (SANS MVNP)

The contextual and historical analysis of the northern Four Corners region date distribution beyond the administrative boundaries of MVNP presents a different set of challenges. First, no overarching federal administrative unit has guided archaeological research in the northern Four Corners region as the National Park Service has done at MVNP since 1916. Instead, there is a complicated mix of federal, state, local, tribal, and private landholdings in the region. Private contract archaeology firms have conducted a large portion of regional archaeological research. Published site reports can be difficult to find. Thankfully, Crow Canyon Archaeological Center (CCAC) in Cortez, Colorado, is responsible for most of the major projects in the region and has done a wonderful job of publishing their data both online and in print (see Varien et al. 2007 and references therein).

The northern Four Corners date distribution, sans MVNP, contains 3,246 cutting dates that form several well-defined peaks and valleys (figure 3.4). Space constraints preclude a decade-by-decade historical analysis of the entire curve. Instead, I will focus on the analytical implications of some of the best-dated sites in the region, all of which CCAC excavated. Before moving on to that discussion, however, there are a few noteworthy examples of contextual bias in the distribution presented in figure 3.4.

First, more than half (45 of 85; 53%) of the large cluster in the 780s is created by 45 dates at 780 from Little Cahone Hamlet Pit Structures 1 and 2. A visual comparison of figures 3.2, 3.3, and 3.4 suggests that the entire 780s cluster is made of dates from the northern Four Corners region (there are only two 780s dates from MVNP; that decade predates the Rio Grande distribution in the next section, which begins at 1100). To belabor the point—dates from only two structures at one site constitute more than half of the 780s peak in the entire Southwest date distribution curve (figure 3.2)!

Second, the noticeable peak created by forty-six dates in the 940s, during an otherwise apparent century-long decline in the number of cutting dates, is largely created by forty-three dates from a single site—Stix and Leaves Pueblo. Most (41) of those 43 dates come from three structures—Pithouse 2 (22 dates), Kiva I (10), and Kiva K (9). Put another way, three structures from a single site are responsible for 89 percent of the 940s cluster evident in figure 3.4. We simply don't have any good way of determining how chronometrically typical, and

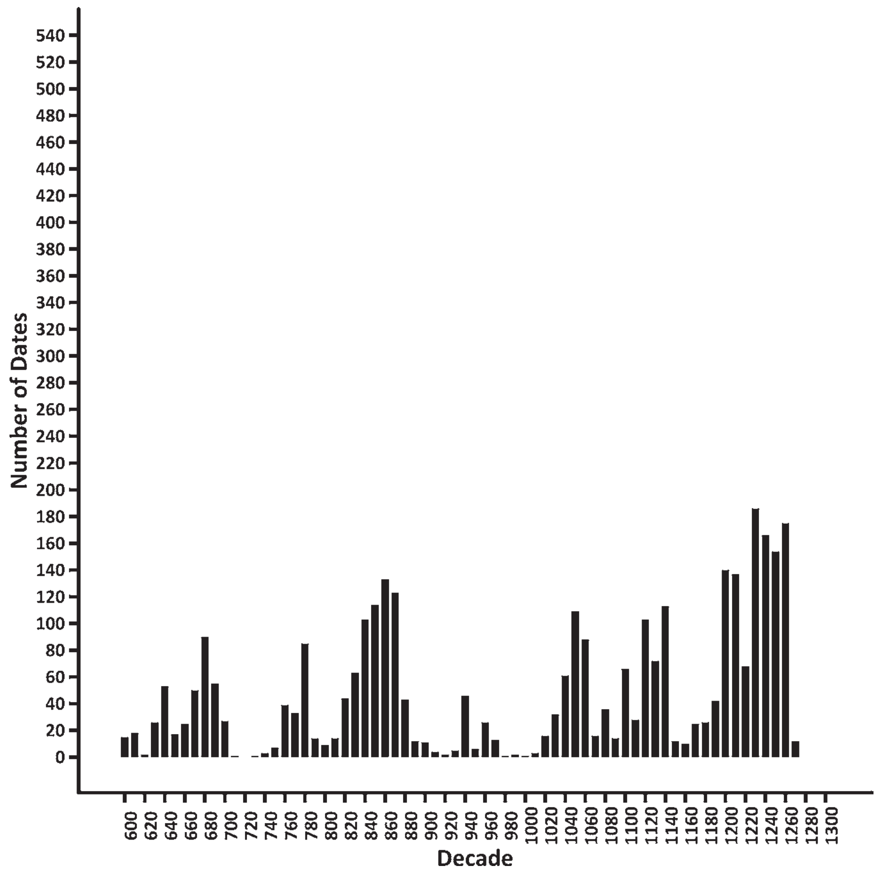


Figure 3.4. Bar chart of 3,246 cutting dates (binned by decade) from the northern Four Corners region, AD 600–1599. (Not shown: twenty-one dates between 445 and 599.) Figure by Holger Petermann.

therefore representative, those rooms are in the pantheon of Southwestern archaeology. Although it may be true that such rooms are somehow architecturally and technologically typical of that time period and region, we have to remember that such archaeological data aren't nearly as precisely resolved as are annual dendrochronological data. Remember, the Pecos Classification periods are each (arbitrarily) 200 years long; that represents twenty of our tree-ring date bins.

Third, the largest cluster in the eleventh century consists of 109 dates in the 1050s. Seventy-five (69%) of those dates come from a single structure (Kiva G) at Stix and Leaves Pueblo. The remaining thirty-four dates in the 1050s cluster come from a dozen other sites, with an average of fewer than three dates each. Is Kiva G more representative of Southwestern archaeology in the 1050s than the dozen other sites, or are the thousands of others across the Southwest? We simply don't know.

Focusing our attention on sites excavated by CCAC, we find that seven yielded more than 200 cutting and noncutting dates: Sand Canyon Pueblo (748), Castle Rock Pueblo (414), the Duckfoot Site (374), the Ewing Site (333), Stix and Leaves Pueblo (262), Shields Pueblo (237), and Hanson Pueblo (213). Crow Canyon excavated only about 10 percent of Sand Canyon Pueblo (Bradley 1993). Three structures, all kivas, accounted for 254 of the 748 (34%) dates from the site: Structure

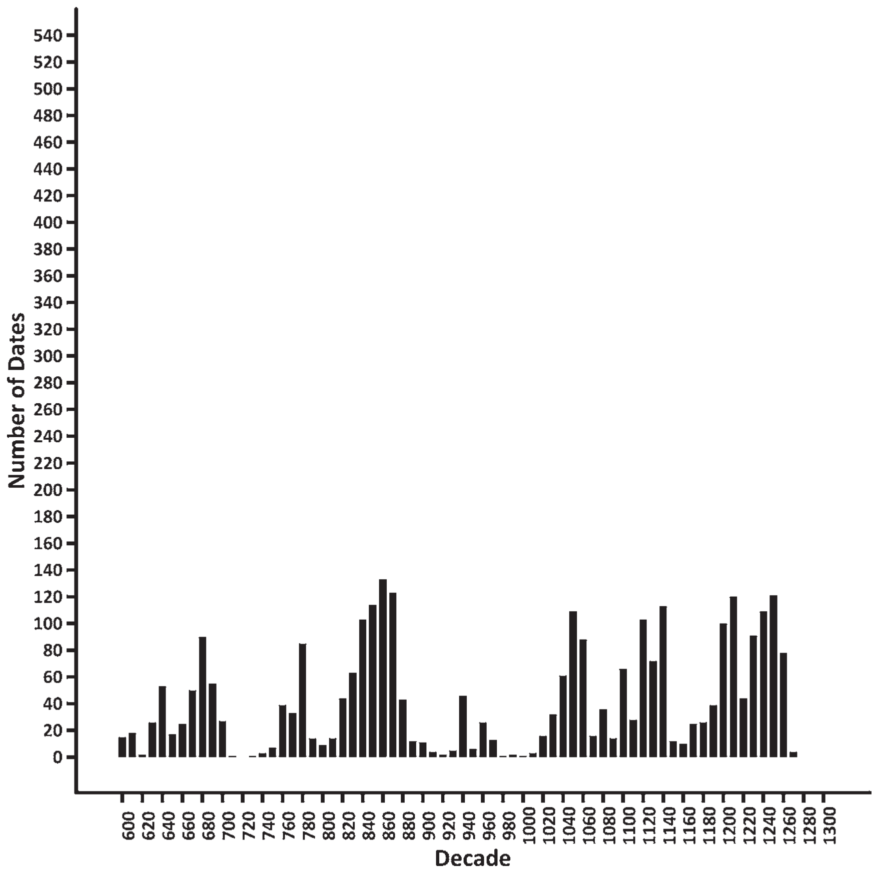
102 yielded 98 dates, including 42 cutting dates. Structure 501 also yielded 98 dates, 58 of which are cutting dates. Structure 1501 yielded 94 dates, 38 of which are cutting dates. By any measure, these three kivas are some of the best-dated structures in the American Southwest. By extension, it might be reasonable to conclude that Sand Canyon Pueblo is one of the best-dated sites in the American Southwest. But again, we need to be clear about something: half (138 of 274) of the cutting dates from Sand Canyon Pueblo come from only three structures, and only 10 percent of the site was excavated! Given that 90 percent of the site remains unexcavated, we simply do not know how representative those three kivas, nor their precise dates, are for the rest of the site, much less the rest of the Four Corners region or the entire American Southwest. It could be that new tree-ring dates from previously unexcavated portions of Sand Canyon Pueblo will bolster existing clusters in figure 3.4; the alternative might also be true—new tree-ring dates could fill in gaps in the distribution. We simply do not know in advance, and the archaeological data (i.e., ceramics, architecture, etc.) are too poorly resolved, from a chronometric perspective, to provide us with any insights.

Another exceedingly well-dated structure in the Four Corners region warrants attention. Kiva 1 at site 5MT1253 on the Ute Mountain Ute Reservation yielded sixty-seven cutting dates at 1233, comprising 36 percent of the 186 total dates in the 1230s cluster (see figure 3.4). Excavated by the University of Colorado–Boulder field school in 1972, 5MT1253 consists of only two rooms, two kivas, and a tower structure (Robinson and Harrill 1974, 160). To be abundantly clear, one-third of the largest date cluster in the northern Four Corners distribution (figure 3.4) is created by construction and subsequent dating of one kiva at one small site that is demonstrably not typical for the Pueblo III period in the region. Indeed, 5MT1253 is apparently a unit-pueblo that was still being constructed at a time and in a place where most of the population was living in large, aggregated pueblos such as those at Sand Canyon Pueblo, Yucca House, and Castle Rock Pueblo, just to name a few.

Given the extraordinary nature of the dating at these four structures (Kiva 1 at 5MT1253, Structures 102, 501, and 1501 at Sand Canyon Pueblo) and their effect on the date distribution curve in figure 3.4, one is left to wonder: What if CCAC never excavated those three kivas at Sand Canyon Pueblo? What if the University of Colorado–Boulder field school excavated a different kiva at 5MT1253, one which may not have yielded as many dates?

For argument's sake, figure 3.5 presents the northern Four Corners date distribution with the 341 cutting dates from those four, exceedingly well-dated structures removed. The post-1200 peak in the distribution is nowhere near as prominent as it is when those four structures are included. In fact, that peak is now the same size or smaller than peaks in the mid-600s, the mid-800s, and the mid-1000s. Note also that the Y-axis has shifted downward, reaching a peak of fewer than 140 dates, whereas in figure 3.4, with those four structures included, the Y-axis nearly reached 200. Figure 3.4 thus presents a date distribution that is not governed by some "prehistoric reality" but rather by research proclivities and decisions made by archaeologists in the last several decades, and by the overwhelming influence of dates from four exceedingly well-dated structures.

Figure 3.5. Northern Four Corners date distribution, minus 341 dates from Sand Canyon Pueblo Structures 501, 102, and 1501, and Kiva I from 5MT1253. Compare with figure 3.4. Note that the largest bins of dates in the 1200s have up to only 140 dates; in figure 3.4 the largest bins in the 1200s have up to 180 dates. The size and shape of this distribution are demonstrably different due purely to the history of research in the region. Figure by Holger Petermann.



To summarize, the fact that 341 tree-ring dates, from four structures, at two sites, can have such a large and disproportionate impact on the entire northern Four Corners regional date distribution should give us pause about accepting that distribution at face value.

The northern Four Corners region is one of the richest archaeological regions in the world, with tens of thousands of documented sites (Varien et al. 2007, and references therein), but fewer than 10 percent of those sites have yielded tree-ring dates. Of the dated sites, the vast majority have yielded less than a handful of dates. Conversely, and as noted earlier in this section, seven sites have yielded 200 or more tree-ring dates. How chronometrically representative are those sites? How many more exceedingly well-dated structures and sites are out there to be excavated and dated? Where might their dates fall when binned by decade? We don't know. Yet, even from this brief analysis, we know that four well-dated structures have a disproportionate and radical impact on the entire northern Four Corners tree-ring date distribution. That leaves us no choice but to conclude that the distribution contains systematic bias. It is composed, in no small fashion, of large numbers of dates from a small number of exceedingly well-dated structures in a smaller number of intensively excavated sites.

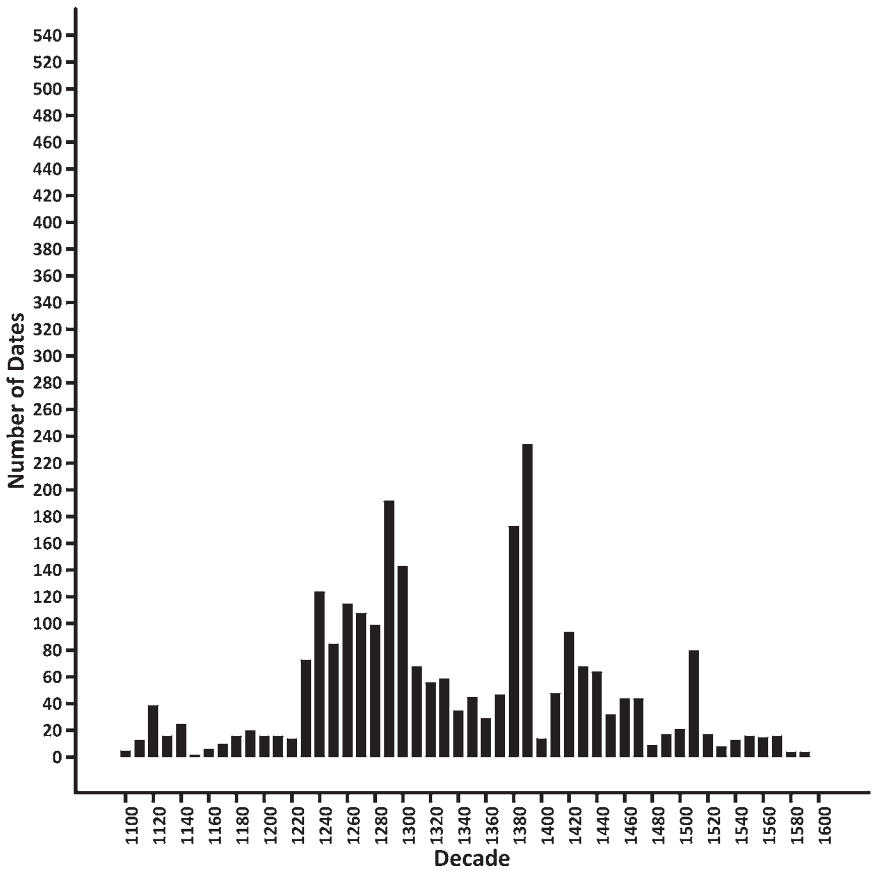


Figure 3.6. Bar chart of 2,511 cutting dates from the Rio Grande valley between AD 1100 and 1599. (Not shown: fifty dates from 800 to 1099.) Figure by Holger Petermann.

THE RIO GRANDE VALLEY

Figure 3.6 presents a bar chart of 2,511 cutting dates from 124 sites and 570 dated contexts within the Rio Grande Valley. The data are binned by decade between AD 1100 and 1599. (The X-axis has an arbitrary beginning date of 1100 so that we may focus on the larger, later date clusters. Apart from the 1050s, only one decade [the 1060s] in the 300-year span between 800 and 1100 has six or more dates; the six dates in the 1060s come from four sites, so are not terribly informative for our purposes anyway. In contrast to the Mesa Verde and Northern Four Corners distributions, there are no tree-ring dates between AD 600 and 800.)

Space constraints prohibit a detailed decade-by-decade analysis of the Rio Grande Valley date distribution, but a quick examination of several arbitrarily selected decades from earliest to later in the distribution serves to illustrate the challenge inherent in accepting this large tree-ring date distribution at face value.

The early portion of figure 3.6, through the 1150s, includes just two decades with more than 20 dates—the 1120s and 1140s. There are 39 dates from the 1120s, dominated by 29 dates from just two sites: 14 AD 1122 dates at site LA 742 and 15 dates between 1125 and 1127 from Kiva A at Arroyo Negro Pueblo. Taken together, those 29 dates therefore provide strong evidence for early twelfth-century construction episodes at just one site (LA 742) and one structure (Kiva A) within a very large site (Arroyo Negro Pueblo). Of 23 dates from the 1240s, 19 are AD 1245 cutting dates from a single structure (Kiva B at Arroyo Negro Pueblo). Again, we must ask: How chronometrically representative are these structures and sites? We simply don't know, and the archaeological data (i.e., ceramics, architecture, etc.) aren't resolved to a degree that would make them truly compatible with annually resolved or decadally binned tree-ring data.

Between 1150 and 1230 there is a steady but small number of cutting dates per decade; only the 1190s has as many as twenty. That decade is dominated by clusters from two rooms at Mocho Group II (seven AD 1192 dates from Room 6 and nine AD 1194 dates from Room 8). The point is that only two sites, one large (Arroyo Negro Pueblo) and one small (Mocho Group II), dominate the largest peaks in the Rio Grande distribution between 1100 and 1230.

Nearly half (44%; 32 of 73) of all cutting dates from the Rio Grande region during the 1230s come from two rooms (1 and 5) at the Archuleta Site—the remaining 57 percent of the dates come from only thirteen sites in one of the archaeologically densest regions of the American Southwest.

The large 1290s distribution consists of 192 cutting dates from twelve sites. LA 27 dominates the cluster with 56 dates (29%), followed by LA 309 (51; 27%), Pueblo Largo (24; 13%), Pot Creek Pueblo (19; 10%), Burnt Corn Pueblo (16; 8%), Manzanares (12), and six sites with fewer than five dates each. Thus, more than half (56%; 107 of 192) of the second largest decadally binned cluster of tree-ring dates from the northern Rio Grande valley's date distribution curve comes from only two sites (LA 27 and LA 309). Indeed, 93 percent (178 of 192 dates) of the 1290s cluster comes from only six sites (LA 27, LA 309, Pueblo Largo, Pot Creek Pueblo, Burnt Corn Pueblo, and Manzanares). How chronometrically or archaeologically representative are these six sites of 1290s "prehistoric reality" in the Rio Grande Valley? Archaeologists have typed them together in the 200-year-long Pecos III period, but surely "prehistoric reality" changed in some way, shape, or form during that period. We may have ideas about these things, but we don't yet know. We can assume, but we shouldn't.

The 143 dates from the 1300s bin come from most of the same sites as those for the 1290s, though there are no dates from Las Madres or Tesuque Williams I. There are, however, a few dates from Water Canyon Pueblo and Tsiping. The 1300s cluster is dominated by 73 dates (51% of the total) from Pot Creek Pueblo, followed by smaller numbers at LA 309 (20), Burnt Corn Pueblo (19), Pueblo Largo (6), LA 27 (4), LA 76 (4), Tijeras Pueblo (4) Water Canyon Pueblo (4) and Tsiping (2).

There is a large cluster of dates in the 1380s in figure 3.6. That bin includes 173 dates from eight sites: Arroyo Hondo Pueblo (89 dates), Tijeras Pueblo (56), Arrowhead (12), LA 6869 (11), Sapawe (2), Posi (1), Pueblo Largo (1), and Tyuonyi (1). Note that 83 percent (144 of 173) of the 1380s cluster is therefore from only two sites: Arroyo Hondo Pueblo and Tijeras Pueblo. Note also that more than half (59%; 33 of 56) of the Tijeras Pueblo dates come from a single room (Room 64), which is one of at least 250 rooms in the site. How representative is that room, much less that site, of regional archaeology, much less chronometry? From the perspective of tree-ring dating in the northern Rio Grande valley, both are anomalous in that they are exceedingly well dated.

The 1390s cluster continues this pattern. It has 233 dates from nine sites, dominated by 199 dates from Tijeras Pueblo, followed by Arrowhead (23), and six sites with fewer than a half dozen dates each. Thus 85 percent (199 of 234) of the 1390s cluster comes from one site—Tijeras Pueblo. A full 87 percent (174 of 199) of the 1390s Tijeras Pueblo dates come from only four rooms: Room 64 (52 dates); Room 40 (40), Room 100 (45), and Room 58 (37).

To summarize, nearly two-thirds (62%; 255 of 407 dates) of the largest cluster in the Rio Grande valley date distribution (i.e., the 1380s and 1390s) comes from one site—Tijeras Pueblo. Four-fifths (81%; 207 of 255) of the Tijeras Pueblo dates come from five rooms in that 250-room pueblo (Cordell 1977).

Taken at face value, the 1380s/1390s cluster in the Rio Grande valley date distribution would appear to be the most important in the 500-year range presented in figure 3.6. Given what we know about the source of these dates, how can we state with any degree of confidence that the 1380s/1390s peak in the Rio Grande valley distribution is at all representative of regional Ancestral Pueblo activity in the region? We can't, and shouldn't.

The last large cluster in the Rio Grande Valley distribution consists of eighty dates from the 1510s. Dates from only three sites comprise this cluster: Pueblo del Encierro (LA 70; in the Cochiti Dam Group), Gran Quivira, and Pecos Pueblo. Thirty-five (44%) of these eighty dates come from Feature 279 at Pueblo del Encierro, a large pueblo with 198 surface rooms, nine kivas, and several pit structures. Feature 279 is a kiva built and repaired in the late 1510s, but excavators believe that Pueblo del Encierro was occupied continuously from circa 1175–1550 (Snow 1978). Feature 279 is therefore considered, by the excavators, to be representative of only a portion of the site's history, much less that of the entire region and time period. It is, however, an exceedingly well-dated kiva that clearly dominates the tree-ring date distribution. What portion of "prehistoric reality" does that constitute? It's but one construction episode at one site in a large, archaeologically dense, and complicated region.

As with the greater Four Corners region beyond MVNP (see figures 3.4 and 3.5), it is interesting to consider what would happen to the tree-ring date distribution if the University of New Mexico (UNM) field school never excavated Tijeras Pueblo, or, more specifically, if they had never excavated those five exceedingly well-dated rooms in a huge, 250-room pueblo.

Figure 3.7 presents the Rio Grande date distribution with the 255 Tijeras Pueblo dates removed. The impact of a single archaeological field school, which was in the field at that site for just two seasons, is immediately evident. The 1380s/1390s cluster is now at least a third smaller than the 1290/1300s cluster. Note also that the Y-axis only reaches 200 dated samples in any decade; in figure 3.6 the Y-axis reached nearly 250 dates. Taken at face value, figure 3.7 would form the basis of a very different narrative about "prehistoric reality" than figure 3.6. As such, neither is about "prehistoric reality" sensu stricto; both illustrates the disproportionate and radical impact on the tree-ring date distribution curve of

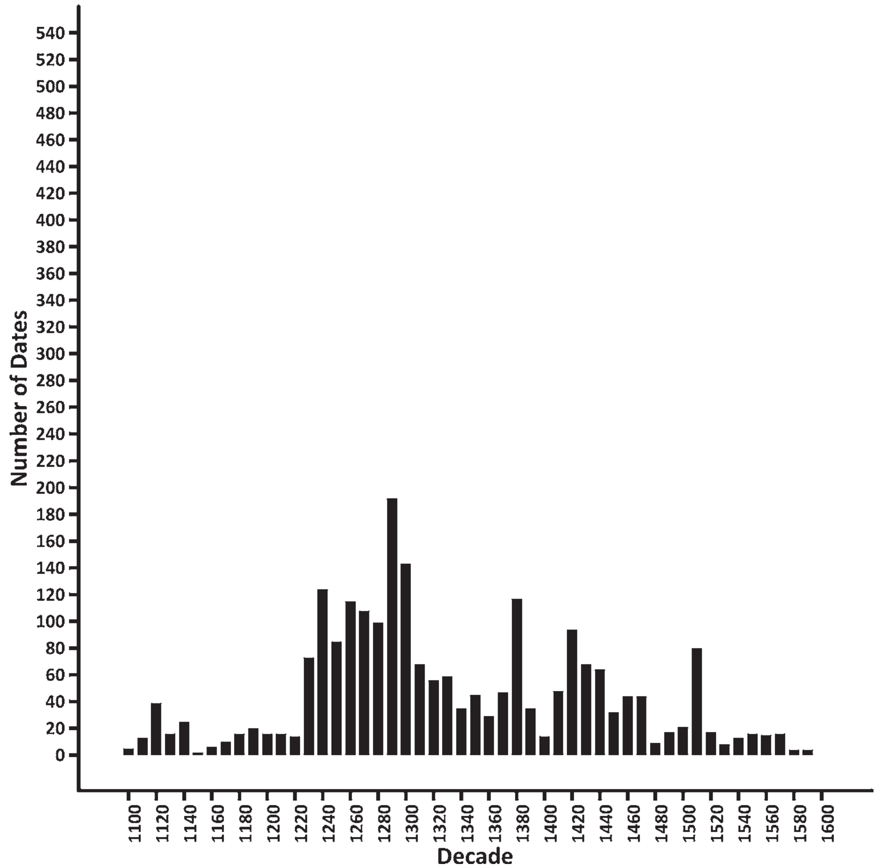


Figure 3.7. Rio Grande valley date distribution, minus 255 dates from five rooms at Tijeras Pueblo. (Compare with figure 3.6.) Figure by Holger Petermann.

a small number of exceedingly well-dated rooms in a handful of well-dated sites. By extension, these curves tell us something about the history of archaeological research in the region, and to a lesser degree about the preservation and analysis of wood and charcoal specimens at sites in the area.

A BRIEF NOTE ABOUT MONTE CARLO SIMULATION OF TREE-RING DATE DISTRIBUTIONS

Bocinsky et al. (2016, 9) performed a Monte Carlo resampling of their tree-ring date distribution to test the robustness of the peaks evident therein (and in figure 3.2). Their description is worth quoting at length:

> For each of 999 replications, we drew a single tree-ring date from each site (n = 1002 sites) and then plotted the smoothed counts of cutting versus noncutting dates through time. This simulated what the tree-ring date distribution would look like if a dendrochronologist collected only a single date from each of the 1002 sites; replicating the process 999 times allows us to establish how different the patterns would be had different beams been selected. *This method did not model the potential uncertainty in the dating of under sampled sites* but controlled for the effect of oversampled sites. (Bocinsky et al. 2016, 9; emphasis added).

The problem here is that the Monte Carlo simulation is performed on tree-ring dates from a distribution that demonstrably contains, and indeed is composed of, systematically biased tree-ring dates. Their simulation is circular because it draws "a single tree-ring date from each [dated] site" but ignores the potential influence of (as yet) undated sites in the region, of which there are tens of thousands. The problem remains: we don't have a good idea of where, precisely and dendrochronologically, undersampled sites would land on the date distribution curve if they yielded dates, and Monte Carlo simulation can't resolve that situation for us. And remember, those undated sites might still yield huge numbers of dates—the distributions deconstructed herein are demonstrably dominated by the excavation of a small number of well-dated structures from a small number of sites. Tree-ring dates are therefore a blessing and a curse: they give us fantastic chronometric, environmental, and behavioral data at annual and in some cases seasonal intervals, but those data have to be interpreted within archaeological contexts and for archaeological questions that are, by definition, far less precisely resolved.

CONCLUSION

Archaeologists working in the American Southwest have tens of thousands of precise, accurate, and reliable tree-ring dates with which to guide their analyses. Size matters when dealing with large tree-ring date distributions; it is obviously better to have more rather than fewer tree-ring dates to work with. Nevertheless, it should now be clear that archaeological context and the history of archaeological research and tree-ring dating all matter, and matter a great deal. As we have seen, these three variables introduce significant systematic bias into tree-ring date distributions, no matter how large they may be. We simply cannot assume that size obviates bias.

The case studies offered herein demonstrate three things. First, federal administrative interests and the history of tree-ring research have an impact on the date distribution at Mesa Verde National Park. Second, research programs and decisions made by Crow Canyon Archaeological Center, a single, nonprofit archaeological research firm, dominates the northern Four Corners date distribution. Third, excavation decisions made by the University of New Mexico archaeological field school have disproportionately affected the shape of the date distribution curve in the northern Rio Grande valley. To be sure, and from an interpretive and chronometric standpoint, we would be far worse off if MVNP, CCAC, and UNM had never conducted this research. But we are left with a tantalizing situation in which it is easy to assume that binned tree-ring date distribution curves are representative of both "prehistoric reality" and the entire archaeological record in each region. Nothing in the data presented herein suggest this is the case. Indeed, quite the opposite.

This historical and contextual deconstruction of Southwestern tree-ring date distributions demonstrates that we should never accept such curves at face value. Site- and subsite archaeological context matters, and matters a lot. It is demonstrable that dates from a small number of exceedingly well-dated structures, from an even smaller number of well-dated sites, dominate even the largest of our tree-ring date distributions.

Tree-ring dating is a highly specialized, time-consuming, and therefore expensive process that does not work in all time-periods or regions of interest to Southwestern archaeologists. Tree-ring dates are some of the best archaeological data to work with and are undeniably the best nondocumentary chronometric data available to archaeologists anywhere in the world. When tree-ring dates are binned into decadal clusters and graphed, the resulting date distribution curves can be seductive, begging for analysis and interpretation. Despite their robust size, those distributions still contain systematic bias, and a lot of it. Proceed with caution.

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