DATING CONSTRUCTION EVENTS AT GRASSHOPPER PUEBLO:

NEW TECHNIQUES FOR ARCHITECTURAL ANALYSIS

by

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TABLE OF CONTENTS

TABLE OF CONTENTS - *continued*

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

The analysis of architecture as a separate but important class of material culture has seen a resurgence of interest in archaeology in recent years. However, a body of analytical techniques equivalent to those used for the analysis of other types of material culture is still lacking in architectural analysis. Computer aided drafting programs offer one means of facilitating architectural analyses by providing both an analytical tool as well as a means of organizing spatial information. Computer techniques are used to combine a construction phase model with tree-ring dates at Grasshopper Pueblo. In the course of the analysis, principles for assigning temporal information to undated construction units are discussed and applied. Finally, the results of the combination of these two sets of information are discussed and a slightly revised site chronology is offered.

CHAPTER 1

INTRODUCTION

An architectural analysis represents but one important avenue of inquiry into past human behavior. As in the manufacture of other classes of artifacts, a complex set of behaviors is involved in the construction of a structure or dwelling. The physical expression of an architectural form is best conceived of as the product of a number of variables which can be broadly subdivided into the larger categories of environment, tradition, social organization, functional considerations, performance characteristics, and time. While the same can be said about ceramics or any other class of artifact, architectural spaces contain much more information concerning social relationships and cultural identity than any other class of material culture. Unlike portable material items, only architectural space can both physically denote the patterns of daily interaction within a group while shaping and reinforcing these same interactions (Hegmon 1989; Hillier and Hanson 1984; Reid and Shimada 1982). Furthermore, while ceramics and other material items are subject to movement through exchange relationships and can often travel long distances, architectural forms themselves are permanently fixed upon the landscape. For this reason they are far better indicators of cultural differences than portable materials. The division of space created by architectural features represents a three dimensional blueprint of the social interactions that occurred at a site or within a household. The architectural print left by a particular culture's attempts to impose order onto daily social interactions is one of the most distinctive cultural patterns left in the archaeological record.

The importance of architecture as an independent analytical category has gone in and out of fashion throughout the history of archaeological inquiry in the Southwest. Overall, architectural analysis has closely followed the various paradigmatic shifts in archaeology. Currently, the study of architecture has seen a resurgence of interest, especially with a revival of the notion of architecture as an artifact (Gilman 1987). To accompany this reassessment, new models and methods of analysis need to be developed for analyzing architectural phenomena. Along these lines, computerized techniques of analysis are useful for the study and display of spatial information. These procedures especially lend themselves to both quantitative analyses of space, as well as to more qualitative studies, which require that large sites be broken into smaller units of analysis. In this paper, it is argued that by applying computer based techniques of analysis to architectural spaces, the current gap in analytical techniques between architectural analysis and the study of other types of material culture can be eliminated. Several issues related to architecture are addressed in an attempt to provide new means of looking at the problem of dating the construction of Grasshopper Pueblo. The immediate purpose of this study is to apply Graves' (1991) revised cutting date estimates to Reid's (1973) construction phases at Grasshopper Pueblo. The ultimate goal is to present new techniques for looking at architectural data.

The first section of this thesis is devoted to presenting the framework for the current analysis. Chapter 1 provides a brief overview of the history of architectural inquiry in the American Southwest. I suggest that the current perspective in archaeology, which views architecture as a separate artifactual class with definable properties of function, manufacture, and use, is an old notion that has only recently come back into fashion. The next section (Chapter 2) focuses on the use of computer aided drafting programs as a means not only for displaying graphic information but also as an analytical and organizational tool useful in manipulating architectural entities. Chapter 3 presents a scheme for conceiving of architectural additions as a function of behavior and time. The third section of this paper examines pueblo construction as a relative sequence of architectural additions upon which absolute temporal information can be added to reconstruct the actual growth of a community. Finally, these computer techniques and concepts of pueblo growth are brought to bear upon the problem of testing Reid's construction phase model at Grasshopper Pueblo through the application of Graves' revised tree-ring dates.

Historical Overview

Architecture as an analytical category has been overshadowed by ceramic analysis in past years. In the early years of Southwestern Archaeology, considerations of ceramics and architecture were viewed as equal in most investigations. However, early ceramic studies demonstrated the utility of pottery as an indicator of time and long range social relationships (Colton and Hargrave 1937; Kidder and Shepard 1936), and ceramic analysis began to take precedence over architectural analyses to such an extent that by 1936, Roys was already calling for a renewed interest in architecture as an important analytical category. While the usefulness of ceramic analyses is not questioned, it is noted that a great deal has already been accomplished in the development of sophisticated analytical techniques. Currently, pottery is being studied on the sub-molecular level through various techniques that attempt to break the materials used in pot sherds down to their individual elements (see Rice 1987). In direct contrast, studies of architecture have scarcely evolved to a stage of sophistication analogous to the ware level of ceramic classification.

1880 - 1930: Architecture as Artifact

Early in the history of southwestern archaeology, architecture was seen as but one component in an overall complex of cultural traits (Cushing 1890; Fewkes 1907, 1912; Haury 1936; Kidder 1927; Mindeleff 1891). Early analyses focused on architecture as a separate artifact class, to be treated on the same level with other types of material culture. The classic early study of this type was Mindeleff's work on the architecture of Tusayan and Cibola (Mindeleff 1891). This early analysis was a detailed description of both prehistoric and historic architecture in the Hopi and Zuni areas. Taking a broad based approach, Mindeleff examined every aspect of architectural form, from the smallest architectural features to the rites and traditions surrounding architectural construction and use. The importance Mindeleff placed on architectural remains was not unique to the period. It can be argued that architecture in the early days of investigations in the Southwest had a much more prominent place in the archaeological literature. In Fewkes' work at Casa Grande and at Mesa Verde, for example, the site reports are largely architectural in their focus. In fact, Fewkes habitually devotes a great deal of attention to architectural descriptions, while all the "minor antiquities" are discussed in very little detail (Fewkes 1911, 1912). Clearly, much of the architectural emphasis of these early studies was based on the fact that most of what was available for study at the time consisted of architecture while the ceramic collections in this period were not yet well understood by many researchers.

1930 - 1960: Architecture as a Classificatory Device

Architecture has long been one of the defining characteristics of cultural affiliations and periodization schemes in the Southwest. As a result of the first Pecos Conference in 1927, architecture was put forth as being a major indicator of cultural change from the Basketmaker tradition to the Pueblo builders (Kidder 1927). The Pecos classification was in large part based upon a sequence of change in dwelling types, and its emphasis on architecture as a classificatory device helped to reduce architecture to a marker of cultural affiliation and change. Several studies from this period testify to the place of architecture as an indicator of cultural association and development (Haury 1928, 1936, 1985; Reed 1948, 1956; Roberts 1935; Wheat 1955).

By 1936, architecture had lost much of its prestige as an individual artifact class. The level of neglect is indicated by Roys' (1936:115-142) discussion of the architecture of the Lowry Ruin, in which he points to the gap between ceramic analysis and architectural analysis and calls for a better way of classifying, describing, recording, and sorting architectural data . Roys argues that architecture ought to be viewed as any other class of material item and that like ceramics, an analysis of masonry types can indicate not only cultural history but also shed light on "the mental traits of the builders" (Roys 1936:116). Despite the call by Roys for southwestern archaeologists to be more aware of architectural characteristics, the situation went largely unchanged until the rise of processual archaeology in the early 1960's, when architecture came to play a new role in southwestern archaeology.

1960 -1980: Architecture as an Indicator of Social Relationships

Foreshadowed by the earlier work of investigators such as Prudden (1903, 1918) and Steward (1937) and, coinciding in part with the coming of Processual Archaeology, several studies became available that set the stage for later investigation of architectural forms by processualists. As a result of the work of Bullard at the Cerro Colorado site (Bullard 1962) and Rohn's work at Mug House (Rohn 1965, 1971), architecture began to be recognized as an important analytical category once again. It was thought that individual households and discrete intrasocietal divisions could be identified on the basis of an architectural analysis (Dean 1969; Rohn 1965, 1971; Vivian 1970; Wilcox 1975).

With the coming of processual archaeology, and its focus on ecological and social theory (Binford 1962; Willey and Sabloff 1993), architecture became the object of a resurgence of interest in archaeological investigations. Dean's (1969) analysis of Betatakin and Kiet Siel remains the standard by which all subsequent architectural analyses have been judged. Dean's reconstruction of the growth of Betatakin and Kiet Siel incorporates the concepts of social theory that were important at the time while maintaining the perspective that architecture was an artifact constructed and maintained for human occupation. Considerations of construction techniques, use of construction wood, and intrasite processes of growth were all important to the study. Dean's analysis not only demonstrates what can be done with well preserved tree-ring material and good site preservation, but also how social groups can be identified and discussed through the use of detailed architectural analysis. The classification of architectural groups became an important concept in the work of subsequent analyses in other areas. Dean's investigations in Tsegi Canyon and, to a lesser extent, the work of Rohn at Mug House were influential to the excavation strategy at Grasshopper Pueblo in the late 1960s and early 1970s.

The cornering project and subsequent growth project instituted by the University of Arizona Archaeological Field School at Grasshopper was a direct outgrowth of the excavation of Broken K Pueblo and the later work of Dean at Tsegi Canyon. Beginning in 1967, the project was initially directed toward generating a site map and developing a typology of room types as had been done at Broken K (Longacre and Reid 1974). To this end, opposing room corners were excavated to facilitate mapping and estimation of room size (Longacre and Reid 1974; Wilcox 1982). As the cornering project progressed, the focus shifted toward identifying sets of room additions, perceived as representing social groups similar to those documented by Dean and Rohn. In 1969, the cornering operations came under the direction of David Wilcox who formalized procedures into the "Cornering Project." The identification of "construction units" became the central goal of the cornering project and, based on the idea that new architectural units which are added to existing units are always abutted to them, the interpretation of bond-abut relationships became important (Wilcox 1975, 1982). Later, due to some of the problems inherent in the interpretation of corner relationships, and following the work of Rinaldo (Rinaldo 1964; see also Dean 1969) at Carter Ranch, wall face analysis (Reid 1973; Reid and Shimada 1982) was also adopted as a means of identifying architectural additions (Reid and Shimada 1982).

The data recovered by the cornering project spawned the "Growth Project," which began in 1971 under Reid's direction to measure the rate and process of pueblo growth. With the major construction units identified by the cornering project, rooms in the earliest (core) construction units were excavated to obtain datable tree-ring samples to date the founding of the pueblo (Longacre and Reid 1974:22). The construction units were classified into sets of typological contemporaneity (see below) called "construction phases" as part of the attempt to measure site growth (Reid 1973; Reid and Shimada 1982). Through 1972 and 1973 the cornering and growth projects continued, and moved out of the room blocks of the main pueblo and into the outliers. The investigation of the outliers by the cornering project had determined them to represent largely jacal structures with masonry foundations, while investigations by the growth project found them to be constructed slightly later than the main pueblo (Longacre and Graves 1982; Longacre and Reid 1974; Reid 1973, 1989). The identification of social groups through the establishment of construction units guided much of the excavation strategy at Grasshopper in the late 1960s and early 1970s. The material and reconstructions generated by these analyses form the primary data base for the present analysis as well for reconstructions of the growth and abandonment of the community (Reid 1973; Reid and Shimada 1982).

The methods and models developed for identifying social groups through architectural relationships in the puebloan Southwest were later influential to work in the southern desert region. In the Hohokam area, investigators did not begin to formulate methods for recognizing social groups until the late 1970s and early 1980s. In Wilcox's reanalysis of Snaketown, he identified several clusters of pithouses that he referred to as "courtyard groups" (Wilcox et al. 1981). These assemblages of pithouses arranged around central courtyard areas were conceived of as representing a cooperative social unit comparable to those documented at Betatakin, Kiet Siel (Dean 1969), and Mug House (Rohn 1971). Since courtyard groups were identified at Snaketown, they have been found at several Hohokam sites (Doelle 1985; Doelle et al. 1987; Henderson 1987; Sires 1983, 1987), and are thought to represent an important part of the Sedentary to Classic transition (Sires 1987; Wilcox et al. 1981). As a result of this recent work, analysis of Hohokam domestic architecture is now at approximately the same juncture that puebloan architecture reached in the early seventies. In contrast, when considering Hohokam public architecture, archaeologists have come considerably farther in looking at architecture as an artifact.

1980 - Present: Architecture as Artifact Rediscovered

Hohokam archaeologists began to take a more artifactual view of architecture beginning in the late 1970s. Wilcox and Shenk's (1977) reanalysis of the architecture of Casa Grande is but one example of this refocused approach. The intent of the reanalysis was to obtain previously uncollected information about various aspects of Casa Grande construction and use. The analysis includes considerations of structural stability, construction techniques, bond-abut patterns, as well as functional and social aspects of the Casa Grande.

The most comprehensive study that considers the artifactual nature of Hohokam public architecture is Gregory's (1987) analysis of Classic Period Hohokam platform mound sites. This analysis views site structure as "the basic patterns of organization imposed by a population on the form of their settlement" (Gregory 1987:184). In other words, site structure is viewed, as with any other artifact, as the product of human behavior. To Gregory, Hohokam platform mounds are viewed as an artifact class that can be discussed in terms of the techniques of manufacture, use, and associated behaviors. The study incorporates a developmental sequence of platform mound construction as a means of determining the processes of construction and mound use. Finally, the association of various architectural features such as platform mounds, compound walls, and mound-top structures is used in combination with considerations of community layout as an association of "artifacts" to define a typical Classic period Hohokam community.

Although there is a long standing tradition of architectural analysis in Chaco Canyon, the 1980's saw an intensification of this trend. Architecture has always been the central focus of research in Chaco Canyon due to both the architectural presence of the ruins as well as the paucity of other artifact categories. Chacoan sites both in Chaco Canyon itself and throughout the San Juan Basin have been traditionally defined by architectural characteristics such as the large size of the ruins, core and veneer masonry, and their symmetrical layouts (Judge 1991; Lekson 1991; Vivian 1970). Additionally, Chacoan communities have also been traditionally defined by the presence of architectural types. A "typical" Chacoan community consists of several unit houses clustered around a central great house and great kiva (Lekson 1991:32). On the regional scale as well, it is architecture that defines the Chaco system as a whole (Lekson 1992; Lekson et al. 1988; Powers et al. 1983). The widespread similarities of architectural form throughout the eastern Anasazi region has spawned a number of regional models based largely on architectural similarities (see Vivian 1990 for an overview of the various models). Probably the best known and most complete architectural analysis in recent years is Lekson's discussion of Chacoan great house architecture (Lekson 1984). Analogous to

Mindeleff's study a century before, Lekson's analysis of Chacoan architecture takes a more holistic view. Construction techniques are considered in addition to discussions of form and the place of the architecture in the broader context of the Chacoan phenomenon.

Broadening the discussion of architecture as artifact to include Grasshopper Pueblo and the current analysis, it is necessary to take the discussion one step further. For this study, not only is Grasshopper Pueblo as a whole seen as an artifact with all of the accompanying properties, but each construction unit is also viewed as an individual artifact. While the models and methods of pueblo growth developed in the 1960's and 1970's (see above) are critical to the application of dates to Grasshopper construction phases, the analysis could not have been conducted without viewing Grasshopper as an assemblage of separate yet related artifacts. Individual construction units are as much a product of human behavior as any other artifact and, as such, are subject to the same sorts of theories and methods as any other artifact class. This conceptualization allows the construction units to be classified by means of phases of construction (Chapter 4) as well as in terms of individual artifacts with measurable properties of manufacture and use.

Discussion

The concept of architecture as an important analytical category has been back in fashion for over ten years now (Gilman 1987; Hunter-Anderson 1977; McGuire and Schiffer 1983). However, architecture as an artifact has yet to be subjected to the same sorts of rigorous theories and tests as the other categories of archaeological data. While comprehensive summaries of techniques and theory for both ceramic analysis (Rice 1987) and lithic analysis (Jelinek 1976) are available, comparable material focusing on the analysis of prehistoric architecture remains scattered and incomplete. With the re-emergence of the idea of architecture as artifact, it is now necessary to develop more sophisticated techniques to look at architecture as a separate analytical category. Structural spaces are a part of the constructed environment in which human beings interact on a daily basis. Because of this, the idea of an architectural unit with measurable properties and definable techniques of manufacture ought to pervade all stages of field work and data analysis, and be the guiding principle in any study of architectural form. The artifactual nature of architecture is a result of the same set of behaviors that produce other types of material culture. Thus, the generation of a site or room map represents not the end point of architectural analysis but rather the data collection phase analogous to a surface collection or a test excavation; it is the primary source of important architectural information. To conduct a complete investigation of an architectural entity, considerations of function, technology, aesthetics, and tradition are only some of the criteria that ought to be evaluated. This study is conducted from a perspective that it is possible to measure architectural spaces and to classify architectural forms in the same ways as portable artifacts have been measured and classified. To facilitate this study, it is necessary to turn to computer techniques as a means of analyzing and storing architectural information.

CHAPTER 2

ARCHITECTURAL ANALYSIS AND COMPUTER TECHNOLOGY

Having discussed the need for more sophisticated techniques of architectural analysis in Chapter 1, this section describes one method for looking at architecture as an artifact. The availability of methods for classifying and analyzing the data contained in a given assemblage is of initial concern in any analysis of prehistoric artifacts. Due to their very nature, architectural entities are difficult to manipulate in the same ways as other more portable artifacts. The great advantage of ceramic and lithic analyses is that the artifacts can be taken back to the laboratory and studied systematically. Architecture, on the other hand, must be well documented in the field so that analyses can be conducted after the site is backfilled. One way of facilitating the analysis of architecture is by inputting field data into a computer mapping program such as AutoCAD®. Entering site or house plans into the computer allows them to be manipulated in ways that were difficult or impossible using traditional mapping and graphic representation techniques.

In effect, the use of computerized mapping programs allows the analyst to take a full scale, three-dimensional representation of an architectural space in hand and look at it from all sides just as if it were a portable artifact. Furthermore, sites can be put on the same sheet and regularized for scale and orientation, and then compared visually just as any set of artifacts can be. The use of computer drafting programs also greatly facilitates the measurement of irregularly shaped spaces such as plazas and room blocks. Estimation of area, for example, can be made at a high level of precision, down to the millimeter level (well within the margin of error of the site plan). Computer mapping also allows sites to be pulled apart into smaller units such as households or construction units enhancing our ability to evaluate construction sequences and intrasite architectural relationships. Finally, the use of computer aided drafting software, in conjunction with various engineering packages, allows for the study and manipulation of architecture not only as dwellings and culturally produced artifacts but also as buildings with structural and spatial requirements.

Architecture, more than any other class of artifactual remains, by virtue of its physical characteristics, lends itself to graphic representation. As indicated above, our inability to take an architectural space back to the lab puts even greater emphasis on the need for more accurate display of architectural information. The graphic nature of architecture allows analyses to be divided into three broad categories: 1) considerations of the ways in which space is partitioned; 2) analyses based on stylistic characteristics; and 3) studies of the engineering and structural requirements of an architectural entity. None of these three classes is totally independent of the other two nor, as mentioned above, are any of them the result of a single behavioral variable. Each of these areas is interdependent; each is a result of the myriad of behavioral responses to the need to provide and maintain shelter and to denote territorial boundaries.

Partitioning of Space

The way in which space is partitioned can be broken down into two areas of study. Each of these benefits enormously from the use of computer aided drafting packages. Space can be conceived in both a qualitative and a quantitative fashion, and computer drafting programs are specifically designed to facilitate the manipulation of plan drawings in both ways.

Qualitative Analysis

Qualitative analyses of spatial relationships consist of such factors as linkages between rooms and houses, access to different areas of the site, and the relationships of various construction events to one another. Recently, several studies have taken advantage of the graphic nature of architecture to apply methods of graph analysis in order to measure the relationship between spatial integration and social integration (Ferguson 1992, 1993; Hillier and Hanson 1984). The graphic nature of architecture allows for the manipulation of discrete site units in order to reconstruct the various qualitative spatial relationships of a prehistoric community. The single most useful tool in AutoCAD® for the organization and manipulation of graphic information is the ability to draw in layers. Layers are a series of overlays, each of which can contain a different set of information. For example, the site plan presented in Chapter 4 (Figure 2) contains 52 different layers, including one for topography, fourteen for construction phases, two for the water courses, four for burials (these layers are turned off in Figure 2) and several other individual sets of information. The ability to draw in multiple layers not only allows information to be stored and presented by means of different categories of information but it also enables the map to be divided into temporal categories such as those displayed in Chapter 4 (Figures 3-16 and Figure 22). In the past, either several maps had to be drawn or numerous hatching patterns had to be utilized in order to display qualitative spatial relationships synchronically or diachronically. Computer drafting increases the speed and efficiency of these analyses by allowing several maps to be generated from one map simply by manipulating the different layers designated in the drawing. Not only can computer generated maps be reproduced numerous times at any scale (including full size) but, because they are stored in an electronic medium, they can be modified and revised without destroying the original drawing, and without retracing the original plan.

The current analysis largely focuses on the qualitative characteristics of the partitioning of space and thus relies heavily on AutoCAD® as an organizational tool. The construction phases and growth periods to be presented in the following pages were all generated from a single map using multiple layers organized by construction phase and by growth period. The division of Grasshopper Pueblo into these discrete units of analysis would have been, at best, difficult without the use of a computer drafting package. This analysis illustrates the usefulness of AutoCAD® not only as a device for displaying graphic information but also as a critical tool for organizing and storing visual data.

Quantitative Analysis

The most useful aspect of computer drafting programs in architectural analyses in archaeology is in the area of quantitative analysis of space. In the past, measuring the area of an irregular space from a map required the use of a basic length - width measurement. For example, attempts to accurately estimate the area of Hohokam courtyard groups have been founded on the idea that a simple length - width measurement approximated the area of houses and courtyards and that measuring all houses in the same manner consistently biased the estimation in the same direction in all cases. However, after limited work with two of the best documented sets of courtyard groups in the Hohokam area, it is apparent that measurements based on simple length - width relationships have been found to consistently misrepresent the actual area of houses and outdoor spaces.

Recently, I have attempted to measure more accurately the areas of courtyard groups at Snaketown and La Ciudad using the AutoCAD® program. Although I applied a different technique for delimiting courtyard groups (see Sires 1987), a comparison of the individual house areas presented here to those of Wilcox and others (1981: Table 9) and Henderson (1987: Table 3), illustrates the problems of using simple length - width measurements (Table 1). In most cases, the area of Sedentary period houses presented in Table 1 is on average two square meters lower than the original estimations. This is due to the fact that using a length - width measurement to determine area assumes that a 90 degree quadrangle is being measured. The pit structures at Snaketown and La Ciudad are

Table 1. House Areas from Snaketown and La Ciudad

Snaketown - Sedentary Period Houses			La Ciudad - Sedentary Period Houses		
House No.	**Floor Area Wilcox et al. 1981**	**Floor Area this Analysis**	**House No.**	**Floor Area Henderson 1987**	**Floor Area this Analysis**
9G:3	54.9	54.43	804	15.58	14.59
10G:9	59.1	62.64	802	13.00	11.35
10G:18	51.8	48.57	1328	13.75	9.35
10G:16	37.5	36.96	1052	12.00	8.94
10G:3	25.5	24.88	800	15.00	16.00
10F:(9)	52.25	50.18	1060	11.25	11.36
10F:3	36.2	35.58	1725	21.00	21.08
10F:1	40.3	41.92	710	16.63	14.82
10G:6	29.4	28.01	1706	12.96	12.28
10F:4	25.3	23.54	715	11.86	14.91
10G:2	15.9	16.54	160	22.68	20.17
10G:4	36.1	35.03	688	11.16	10.03
10F:10	45.3	42.24	132	13.39	15.31
10G:8	31.8	30.39	807	24.50	24.41
10F:19	30.6	32.45	780	11.75	8.79
10G:10	24.6	22.28	157	16.10	14.78
10F:15	17.4	20.32	1349	12.74	11.44
10F:24	18.2	17.5	696	10.00	11.57
10F:4	25.3	20.4	1056	12.70	10.74
10F:17	22.6	20.08	808	21.00	14.3
10F:23	27.5	26.92	129	22.01	26.87
10F:16	18.9	21.53			
10F:21	27.2	23.06			
10F:9	21.4	21.89			
10F:11	27.1	25.94			
10F:5	18.1	17.23			

not quadrangular, nor are they regular in shape. The same holds true with the measurement of rectilinear spaces characteristic of the puebloan region. All of these spaces are at best only rectangle-like and their area cannot be measured precisely using a length - width measure.

One other related issue that must be addressed is the fact that the numbers presented in Table 1 are not lower than the original estimates in all cases, as would be expected given the previous discussion. Apparently, due to the extreme irregularity of the pit structures as well as the presence of the entryway, the estimates presented here are

Table 2: Courtyard Groups at Snaketown

Group	House No.	Floor Area	Average House Area	Total House Area(m^2)	Courtyard Area (m^2)	Total Area (m^2)	Public Space (% of total)	Public Space per House (m^2)
1	9G:3	54.43	54.43	54.43	810.94	865.37	93.71	810.94
2	10G:9	62.64	62.64	62.64	802.73	865.37	92.76	802.73
3	10G:18	48.57	36.80	110.41	635.84	746.25	85.20	211.95
	10G:16	36.96						
	10G:3	24.88						
4	10F:(9)	50.18	32.63	195.77	510.83	706.6	72.29	85.14
	10F:3	35.58						
	10F:1	41.92						
	10G:6	28.01						
	10F:4	23.54						
	10G:2	16.54						
5	10G:4	35.03	35.03	35.03	186.58	221.61	84.19	186.58
6	10F:10	42.24	27.53	165.18	551.44	716.62	76.95	91.91
	10G:8	30.39						
	10F:19	32.45						
	10G:10	22.28						
	10F:15	20.32						
	10F:24	17.5						
7	10F:4	20.4	22.23	88.93	338.54	427.47	79.20	84.635
	10F:17	20.08						
	10F:23	26.92						
	10F:16	21.53						
8	10F:21	23.06	23.06	23.06	191.61	214.67	89.26%	191.61
9	10F:9	21.89	21.69	65.06	256.33	321.39	79.76%	85.44
	10F:11	25.94						
	10F:5	17.23						

Table 3: Courtyard Groups at La Ciudad

Group	House No.	Floor Area	Average House Area	Total House Area(m^2)	Courtyard Area (m^2)	Total Area (m^2)	Public Space (% of total)	Public Space per House (m^2)
1	804	14.59	11.76	35.29	316.21	351.5	89.96	105.40
	802	11.35						
	1328	9.35						
2	1052	8.94	12.10	36.30	213.52	249.82	85.47	71.17
	800	16.00						
	2060	11.36						
3	1725	21.08	15.77	63.09	248.71	311.8	79.77	62.18
	710	14.82						
	1706	12.28						
	715	14.91						
4	160	20.17	20.17	20.17	N/A	N/A		
5	688	10.03	16.58	49.75	247.29	297.04	83.25	82.43
	132	15.31						
	807	24.41						
6	807	24.41	14.86	59.42	307.79	367.21	83.82	76.95
	780	8.79						
	157	14.78						
	1349	11.44						
7	696	11.57	11.16	22.31	219.46	241.77	90.77	109.73
	1056	10.74						
8	1056	10.74	17.30	51.91	185.52	237.43	78.14	61.84
	808	14.3						
	129	26.87						

sometimes higher than the original estimates. This indicates that the assumption that the use of a length - width measure consistently biases the results in the same direction, either up or down is not true in all cases. The investigation of Hohokam courtyard groups indicates that while there is a tendency for the computer generated numbers to be lower than the estimates previously available, it is not always the case, and the idea that all of the samples are biased in the same direction is inaccurate.

Once architectural spaces have been accurately measured, comparisons can be made between various spatial relationships. Tables 2 and 3 illustrate the types of comparisons that are possible once accurate estimations of area are made. These tables point out the fact that while the Sacaton phase courtyard areas and house areas at Snaketown and La Ciudad are markedly different from each other in terms of total area, the amount of available public space per domestic space is very similar. The analysis of Sacaton phase courtyard groups illustrates how computer aided drafting can be used to measure various spatial relationships and the accuracy and ease with which such analyses can be done.

Stylistic Characteristics

The ability to display several architectural entities on a single drawing regularized for scale and orientation allows for numerous sites to be compared at the same time. This is analogous to ceramic sorting, in which stylistic elements are used to subdivide sherds into various types. This type of analysis becomes possible when an entire site is conceived of as a classifiable artifact. Just as sherds can be sorted and classified by decorative style, temper type, or any other physical attribute, site plans can be sorted along several lines such as common orientation, plaza presence or absence, or using any feature that is expressed architecturally. Manipulating sites in this way can allow us to begin to get beyond the "ware level" in architectural analysis.

In terms of an intrasite investigation, the same can be done with masonry types, room layouts, feature distribution, or any other graphically significant aspect of architecture. For example, the study and classification of masonry types is greatly enhanced through the use of computer drafting in that photographs of walls can be digitized at a 1:1 scale and displayed on one drawing just as ceramic design elements can be. In conjunction with data imported through data exchange files (DXF) from programs such as Surfer, the distribution of features and artifacts can be plotted from existing data bases without the time consuming process of plotting individual points on a scaled drawing. Then by conceptualizing different combinations of features and artifacts as representing styles of rooms or habitation areas, room and feature types can be displayed and sorted as a ceramicist would do with an assemblage of sherds. Though these types of analyses have been possible in the past (Ciolek-Torrello 1978, 1985), it has not been easy to display and evaluate the spatial distribution of various rooms, artifacts and/or features without retracing the site plan and plotting their individual distributions. Furthermore, the availability of multiple layers allows distributions of architectural entities to be displayed in numerous ways that previously involved the use of multiple hand-drawn maps and an array of confusing symbols.

Engineering and Structural Characteristics

The usefulness of the AutoCAD® computer drafting program as a tool analyzing the structural and engineering requirements of buildings is not immediately apparent simply because, with the exception of Chacoan great houses, these avenues of inquiry have been largely ignored by archaeologists. The use of AutoCAD® in conjunction with engineering software allows the analysis of architecture on a more experimental level, analogous to the experimental work done on ceramic samples (see Rice 1987). Thus, not only does AutoCAD® facilitate the display, measurement, and storage of architectural data, it also provides a means by which architectural spaces can be viewed in terms of both compositional studies and structural requirements.

These types of analyses would serve to help clarify several current issues involving architectural information in archaeology. The most prevalent of these is the pithouse to pueblo transition, which in the past has been the subject of a variety of theories concerning the factors influencing the change in dwelling types. Cost and labor requirements (McGuire and Schiffer 1983), dwelling shape and spatial divisibility (Hunter-Anderson 1977), and seasonality (Gilman 1987) have all been seen as important variables in the pithouse to pueblo transition. Viewing the transition from an engineering perspective provides yet another avenue of research into the question of the pithouse to pueblo transition. While many of these analyses are beyond the area of expertise of most archaeologists, they represent an important line of evidence that must be evaluated in order to have a complete architectural analysis of a structure.

Discussion

In the following analysis, community growth at Grasshopper is viewed as the product of the relationship between time and social organization. As such, it is necessary to classify individual units of construction into temporal categories so that construction data can be easily displayed and manipulated. Various software packages are applied to these data not only to provide a means of data display, but also to manage the abundance of architectural information, to store and synthesize data, and to provide a means of ordering temporally distinct units in time. Figures 3-16 (Chapter 4) and Figure 22 (Chapter 4) illustrate how multiple layers were used to sort Grasshopper into temporally distinct units, first by construction phase and subsequently by growth period. In addition, the data base presented in Appendix B was linked to the base map so that all of the architectural information contained in the database can be retrieved for any single room space simply by selecting the room number on the map. In essence, by applying these techniques to construction data from Grasshopper, I have created a representation of the site that contains as much temporal and construction information as was collected from the ruin. Ultimately, through continued work, it will be possible to create databases for all available architectural information and to link them to the site map, thereby creating a computer version of Grasshopper that for analytical purposes will act as the site itself. In terms of the present analysis, however, the use of AutoCAD® is primarily helpful in classifying construction units and for making the temporal distinctions that are necessary to date undated construction units.

CHAPTER 3

TIME IN ARCHITECTURAL ANALYSIS

Once architectural units have been properly classified and organized, applying the appropriate temporal information becomes the next step in developing a reconstruction of site growth. Two features of prehistoric pueblo building allow for time to be estimated: the intrinsic behaviors related to room additions, which allow construction units to be ordered from earliest to latest in a horizontal sequence, and the use of datable wood species, which provides an independent means of assigning calendrical dates to construction events. The current analysis combines these two types of temporal methods in assigning absolute dates to the construction phases at Grasshopper Pueblo. Of primary concern to the present analysis is the distinction between intrinsic dating techniques and independent dating techniques (Dean 1978) as they relate to the examination of architectural additions.

Intrinsic techniques, as traditionally defined, are those dating methods that derive their temporal properties directly from the activities and behavior of humans. Intrinsic techniques include both relative dating methods such as seriation and horizontal stratification and absolute dating methods like ceramic cross-dating. In contrast, independent techniques derive temporal information from phenomena not directly related to human behavior. Independent dating techniques are also sub-divided into relative techniques including natural stratification and absolute techniques such as radiocarbon dating and dendrochronology. (Dean 1978; Willey and Sabloff 1993).

Dating Architectural Units

Intrinsic - Relative Dating

This analysis takes advantage of the fact that units of construction added over time serve to provide a stratigraphic sequence of site development in the horizontal dimension. As an intrinsic dating technique, the identification of construction episodes can place architectural units into relative sequences based upon the characteristics and requirements of wall construction. As with any type of stratigraphic technique, the construction phase model (Chapter 4) attempts to order units into a relative sequence based on their position with respect to one another. Instead of ordering materials into a vertical sequence based on the principles of natural deposition, however, construction phases are ordered in a horizontal sequence such that the earliest construction phases are the ones to which all subsequent phases are added. Of primary importance to the relative ordering of construction units is the notion of typological (classificatory) contemporaneity (Dean 1969).

Based on Reid's (1973) "Construction Phase Model" (see below), typological contemporaneity is assumed for all of the additions of the same construction phase at Grasshopper. Typological contemporaneity is assigned to each construction phase based on its relationship to both prior and subsequent construction phases. All units of a single construction phase are abutted to units of the immediately preceding construction phase and are themselves enclosed by units of the immediately following construction phase. Having seriated units of typological contemporaneity by means of construction phases provides a horizontal stratigraphic sequence to which absolute temporal information can be applied.

Independent - Absolute Dating

One goal of any analysis of community growth is to provide absolute dates for the units of architectural addition. Having determined the relative growth sequence of a site from initial to final construction is not entirely adequate to describe the trajectory of community growth. As the following analysis will indicate, simply ordering units of community growth does not adequately address issues of rate of growth nor does it illuminate differential growth patterns between non-contiguous architectural units. Fortunately, the nature of prehistoric architecture in the Southwest allows for highly accurate estimations of construction dates.

The advantage of architecture in the puebloan Southwest is that datable wood species were used for almost all construction purposes. With proper control over the recovery process (Dean 1978) and an understanding of the cultural and natural formation processes that affect wood preservation (Schiffer 1987), room construction can be dated through the use of dendrochronology. Although an in-depth discussion of tree-ring dating is not appropriate here (see Dean 1986), it should be noted that it is the only means by which absolute construction dates can be applied to room additions at pueblo sites. Following Dean (1969) once again, the notion of absolute contemporaneity becomes crucial to discussions of community growth. By providing absolute temporal ranges to construction units, our ability to perceive the overall pattern is greatly enhanced. While seriating pueblo additions provides a rough measure of site development, at best it is only a framework for the application of absolute temporal information.

Relative Growth and Actual Growth

The distinction between relative and absolute time allows growth to be envisioned in two ways: relative growth and actual growth. The behaviors related to room construction provide one type of temporal signal, i.e., a sequence of architectural additions through time. The growth pattern derived from such an intrinsic-relative analysis is referred to as *relative growth.* Relative growth, in this case, lacks absolute temporal information and simply represents the aggregate of all construction from earliest to latest. The construction phase model (Reid 1973) is the means used in this analysis for reconstructing relative growth. Actual growth, on the other hand, requires the application of some sort of absolute temporal information. *Actual growth* is here defined as a relative growth reconstruction that benefits from the availability of absolute dates. It is the use of wood as a construction material in pueblo roofs that links these two ways of estimating time.

Provided that roofs are constructed as part of all room additions, and taking into account factors such as reuse or stockpiling of timbers and remodeling, a newly constructed roof maintains the same relationship to a previously existing structure as the newly constructed walls that support it. Thus, the association of wooden roofs with their supporting walls provides the connection between the intrinsic behaviors that allow relative time to be measured and the independent characteristics of trees that allow absolute dates to be assigned to them. It is important that the distinction be made as to which type of growth is being discussed in an architectural analysis due to the fact that a relative growth reconstruction does not provide information as to contemporaneity of construction units or the rate of growth at a site.

In applying a relative/actual growth reconstruction it is best to conceive of the two types of growth as representing opposite endpoints on a continuum. At one end of the continuum is *true relative growth* which consists of a sequence of architectural additions that contains no absolute temporal information. *True actual growth*, on the other hand, refers to a construction sequence in which every architectural unit has an absolute date.

The best example of an architectural reconstruction that comes close to true actual growth is Dean's analysis of Betatakin and Kiet Siel (Dean 1969), while the 14 construction phases at Grasshopper presented in Chapter 4 represent a true relative growth reconstruction. Ultimately, the goal is a reconstruction of actual growth that comes as close to true actual growth as possible. The primary factor in determining the extent to which a relative growth reconstruction can be developed into an actual growth reconstruction is the resolution of temporal information available for the given architectural sequence. As the level of temporal resolution increases, the necessity of relying on the assumptions of a relative growth sequence such as typological contemporaneity and equal time intervals for phases decreases. As a result, relative phases are broken down into individual dated units which can then be regrouped into actual growth phases.(Figure 1)

Figure 1 shows a hypothetical growth sequence as it might be reconstructed using a relative growth model and using an actual growth model. As this figure illustrates, the basic relationships between constructed units remain the same in terms of their physical association to one another in both examples. However, the pattern of growth is expressed as being markedly different in each of the two cases. Relative site growth simply represents an ordering of construction units into groups of typologically contemporaneous phases. In Figure 1, the relative growth sequence causes units to be ordered in such a way that the construction phases cross-cut the individual room blocks to give the impression that the three room blocks grow at the same rate . However, when absolute temporal information is applied to the same units, growth cannot be represented in the same simple fashion. The actual growth pattern illustrated in Figure 1 indicates that the relative growth sequence, while accurate in terms of the physical pattern of room additions, may not adequately illustrate site growth. A comparison of the two examples in Figure 1 points to

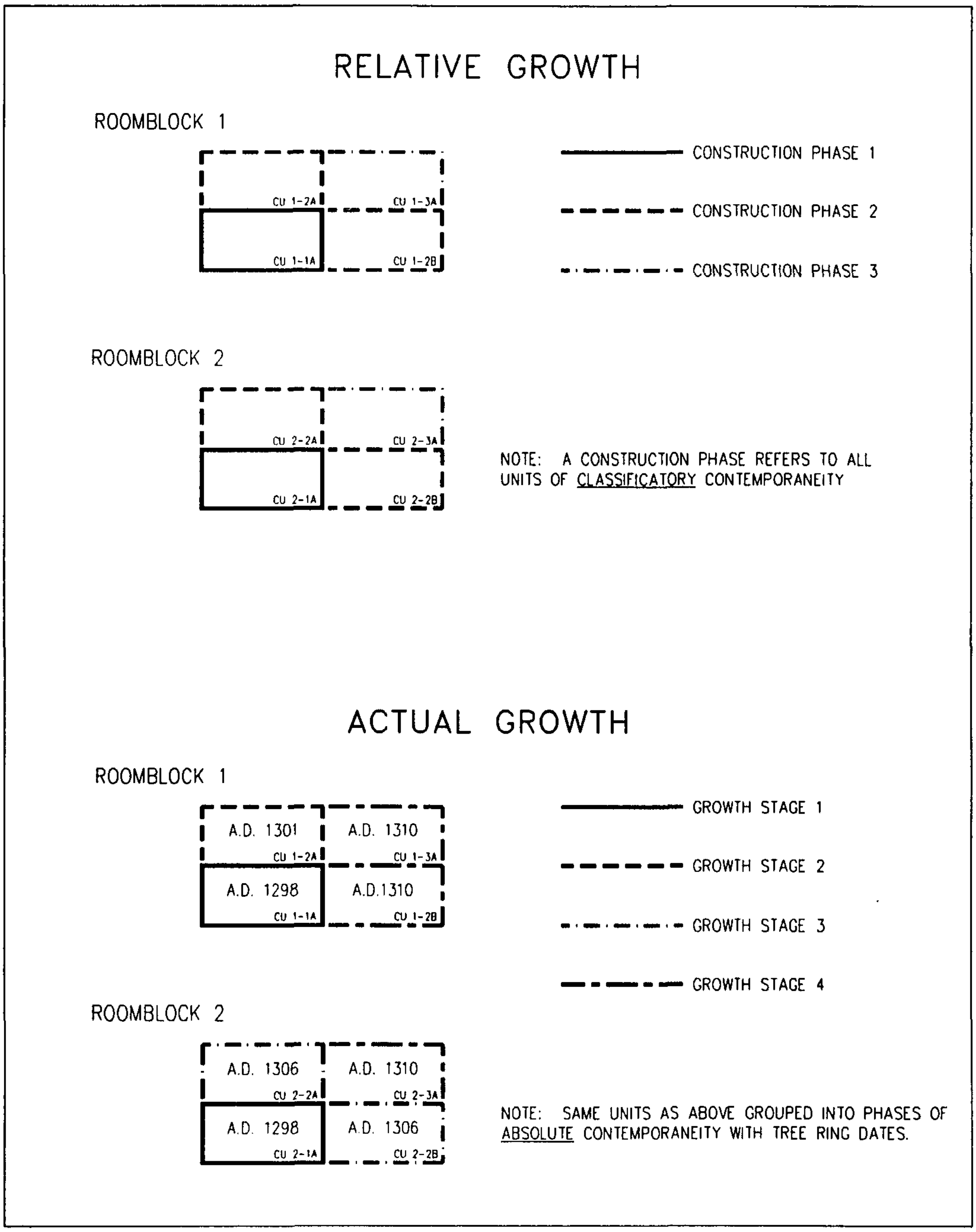

Figure 1. Schematic Diagram: Relative vs. Actual Growth

three important considerations in community growth analyses: 1) Growth in one room block may not reflect the growth trajectory of another; 2) The hiatus between construction events is not measurable without the use of absolute dating techniques; and 3) While construction units are valid as discrete entities, construction phases, as defined below, are best viewed as an analytical construct and may not be representative of actual community growth. However, it is important to note that as the construction phases begin to break down into a series of individually dated construction units, the construction phase itself is never invalidated in terms of the sequence of physical architectural relationships that allow it to be created, it merely ceases to be useful as a classificatory device.

The following pages apply the methods discussed thus far to the construction data from Grasshopper Pueblo. The construction units are organized and classified using the computer techniques presented in Chapter 2 and are then discussed in terms of relative and actual growth. Reid's (1973) construction phase model is used as a means of reconstructing the relative growth of Grasshopper pueblo. Following this, temporal information taken from Graves' re-analysis of Grasshopper tree-ring dates is applied to the relative growth sequence in order to test the construction phase model and develop an actual growth reconstruction.

CHAPTER 4

RE-ASSESSING PUEBLO GROWTH AT GRASSHOPPER

The Construction Phase Model

Using the data obtained by the cornering project and necessitated by the poor quality of the tree-ring dates at Grasshopper Pueblo (Figure 2), a construction phase model was developed and applied as a means of measuring community growth (Reid 1973; Reid and Shimada 1982). Although the community growth model developed by Reid (1973) did take into account the tree-ring dates from Grasshopper, the following re-assessment of the construction phase model as well as the current community growth reconstruction is undertaken in order to verify Reid's community growth phases and to evaluate the construction phase model in light of Graves' revised tree-ring dates.

The construction phase model relies on the premise that architectural form delimits behavioral space (Dean 1969; Reid 1973; Reid et al. 1975; Reid and Shimada 1982; Rohn 1971; Wilcox 1975). At the nucleus of the construction phase model is Wilcox's construction unit (Wilcox 1975, 1982). A *construction unit* (CU) is a set of continually bonded walls and their associated spaces (Wilcox 1975, 1982). *Core construction units* (CCU) are the earliest discernible units of construction in a room block upon which all succeeding additions are made. Core construction units are constructed independently of any other architecture, while non-core construction units are added to pre-existing ones. The largest architectural entity is the room block. A *room block* (RB) is defined as all additions forming a single contiguous set of room spaces (Reid 1973; Wilcox 1975).

The construction phase model assumes that all new construction units determined to be added onto existing construction units, through bond-abut or wall face analysis, were built either at the same time or later than the pre-existing rooms. *Construction phases* (CP), as defined by Reid (1973), are sets of rooms added on to existing ones. The

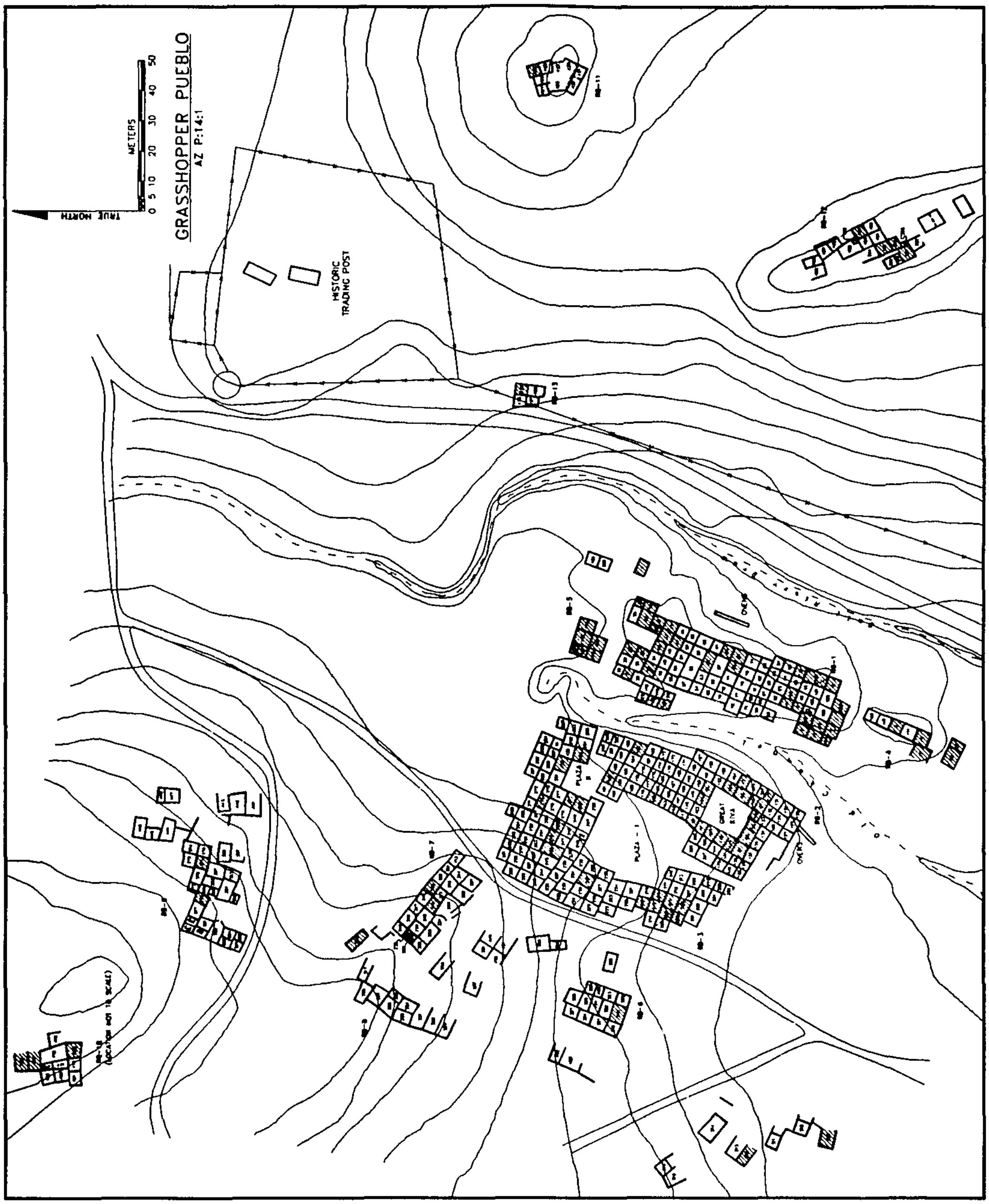

Figure 2. Grasshopper Pueblo: Site Plan

previously existing sets are considered to represent a single phase, while those added to them are part of the immediately succeeding phase. All typologically contemporaneous construction units (see above) are classified as a single construction phase, regardless of spatial connectivity (Figure 1).

The construction phase model is an analytical construct to seriate individual construction units. The addition of construction units is assumed to represent behaviorally significant clusters of habitation spaces. Basic to this notion is the supposition that individual rooms or groups of rooms, representing some fundamental level of organization, are being added in response to increasing requirements for domestic space (Wilcox 1975, 1982). Whether these additions represent steady growth through the natural budding off of resident household groups or whether they represent the influx of people into the site, while important to considerations of rate of growth, is irrelevant to the basic assumptions of the model.

The primary method of determining a construction sequence throughout the Southwest has been through bond-abut analysis (Rinaldo 1964; Rohn 1971; Wilcox 1975, 1982). Any bond-abut analysis is based on the simple fact that a bonded corner represents a single construction event while an abutted corner represents a coeval or later construction episode (Reid 1973; Wilcox 1975, 1982). While this seems to be a fairly straightforward concept, there are problems with using bond-abut data for ordering construction events. As with any artifactual material, architecture is subject to a wide range of cultural and natural formation processes (Schiffer 1987). The practice of remodeling can have dramatic effects upon the original corner relationships at a site (Wilcox 1982:22). Walls are often remodeled, rebuilt, and replastered, and in some cases, this can be quite extensive (Ferguson et al. 1990). In addition to the complexities arising from the human behaviors associated with walls, natural processes of decay can further obscure corner relationships. Pueblo walls collapse in a number of ways, creating a jumble of rubble where corners may have once existed. Not only can walls fall inward or outward, but a single wall can fall one way at the top and the other at the bottom, while collapsing in an entirely different manner at the other end and in the middle. With the four walls of a structure collapsing in this unpredictable manner, it is easy to see how corner relationships can become obscured.

Partially in response to the difficulties inherent in the use of bond-abut data, investigators turned to the use of wall face analysis as a tool for further clarifying construction sequences. Wall face analysis is based on the assumption that walls are constructed from the outside rather than the inside. As a result of this behavior, the exterior face of the wall is generally smoother due to its use as the plumb line for the construction of the wall (Reid 1973; Rinaldo 1964:49). For example, determining the range of variability in wall types at Grasshopper (see Scarborough and Shimada 1974) has allowed for more precise evaluation of the types of wall faces found. This in turn has augmented bond-abut data to make the identification of construction units possible. Because rooms are added to the outside of existing structures rather than to the inside, the identification of a smooth faced wall indicates that the wall in question was once an exterior wall and the space enclosing it was added on later. Again, remodeling may affect wall-face relationships to some extent but unless the wall collapses completely, the natural processes that can blur corner relationships do not act as dramatically on wall faces. In both cases however, good control and competent data recovery can alleviate many of the aforementioned problems. The ultimate limitation of both techniques is, of course, that neither method can do more than provide a relative sequence of construction events.

Although the construction phase model is very basic in its conception and is founded on a fairly firm set of assumptions, there are several possible sources of variability that must be accounted for. As Wilcox points out (Wilcox 1982), there is a hiatus between the building of one unit and the subsequent addition of another unit. The length of this gap can only be determined precisely through the use of an independent dating technique. Without applying independent dating to the construction phases at Grasshopper, there is no way to assign absolute contemporaneity to architectural units.

Non-contiguous room blocks also pose a problem in working out a relative growth reconstruction. One section of the site can grow at a different rate than surrounding units. For example, based on an analysis of bond-abut and room connectivity, Rohn reconstructed the growth of Mug House and found that in the early period of growth, there were two distinct clusters of habitation, the northern of which grew at a faster rate than the southern cluster (Rohn 1971). Of course, it was only through the availability of adequate dendrochronological data that the temporal distinction between the two units was possible. Turning to the Grasshopper example, Figure 3 illustrates a similar situation, except there are eight core construction units (as defined by Reid, personal communication) which eventually coalesced to form the three large core room blocks at the site (Figure 2). Although the display of these units makes them look is if they are absolutely contemporaneous, it must be kept in mind that they are only contemporaneous because of their inclusion in the analytical constructs of construction phases. Figures 3-16 show the 14 construction phases as cross-cutting the three room blocks. Although these units abut one another in the same sequence in all three of the room blocks, there is no way of physically relating them to one another across the core room blocks due to the spatial discontinuity between them. Thus, the construction phase model makes the necessary assumption that all units of typological contemporaneity (of the same construction phase) were added at the same time. When, in reality, of course, construction units, even within a given phase, may be added differentially at different times. Again, with adequate dating, the problems of comparing room additions between non-contiguous blocks of rooms can be minimized.

Grasshopper Construction Phases

Both bond-abut and wall face data have been used to reconstruct the relative growth of Grasshopper (Reid 1973; Reid and Shimada 1982) where a total of fourteen individual construction phases have been identified (Figure 3-6, Table 4). Relative growth of the site, based entirely on the ordering of these construction phases, reflects the pattern put forth by Reid (Reid 1973; Reid and Shimada 1982). The earliest units added (Phases 1 - 5) are all fairly large, indicating a process of demographic change in line with what would be expected for the influx of new social groups (Longacre 1975, 1976; Reid 1973; Reid and Shimada 1982). By contrast, the addition of units after Phase 6 seems to represent a marked decrease in the rate of site growth.

Table 4: Construction Phase Data

Construction Phase	***Additions to Room Block 1***		***Additions to Room Block 2***		***Additions to Room Block 3***		***Total Additions***	
	# CUs	***#Rms***	***# CUs***	***#Rms***	***# CUs***	***#Rms***	***# CUs***	***#Rms***
1	3	17	2	32	3	14	8	63
2	5	13	5	13	3	7	13	33
3	5	14	5	16	2	5	12	35
4	8	15	4	10	4	9	16	34
5	8	11	4	16	8	19	20	46
6	5	10	2	2	7	11	14	23
7	4	4	1	3	5	9	10	16
8	2	2	0	0	5	7	7	9
9	2	2	0	0	6	7	8	9
10	2	2	0	0	4	4	6	6
11	2	2	0	0	2	2	4	4
12	1	1	0	0	3	3	4	4
13	1	1	0	0	3	3	4	4
14	0	0	0	0	1	1	1	1
TOTALS	48	94	23	92	56	101	127	287

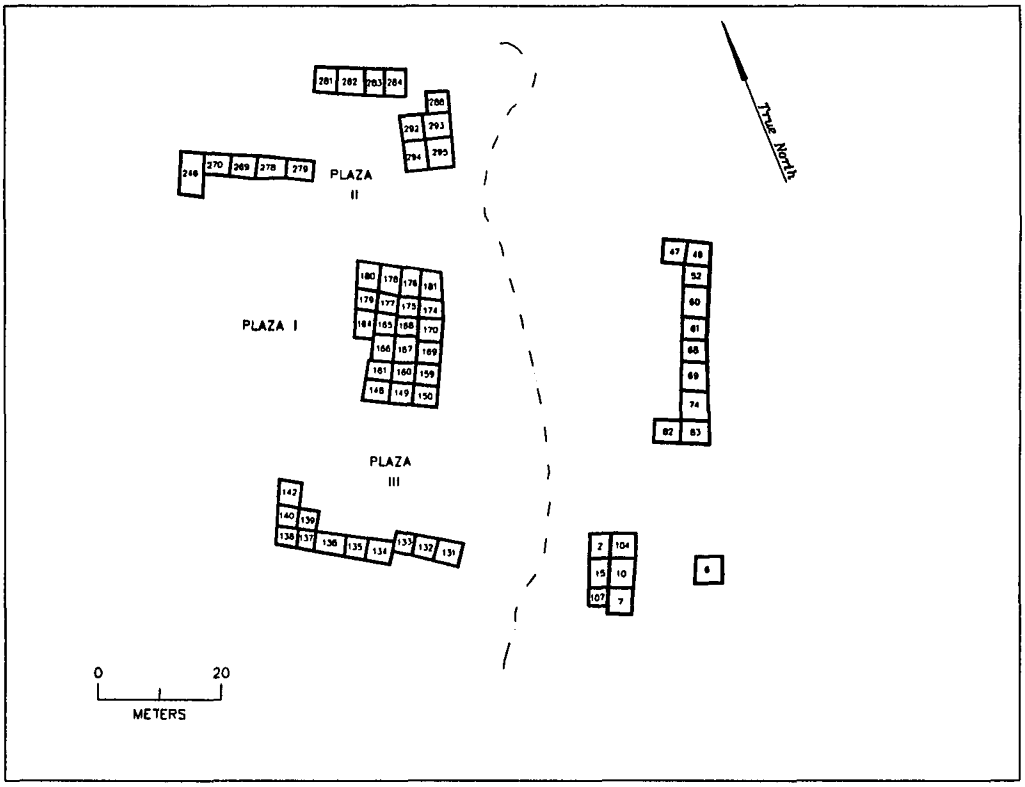

Figure 3.
Construction Phase 1

Construction Phase 1

Construction Phase 1 consists of eight spatially separate core construction units containing a total of 63 ground floor rooms. Three units are located on the east side of Salt River Draw while the remaining five are to the west of the draw. The clusters of rooms on the west side of the draw form two larger groups each arrayed around a central plaza area (Figure 3).

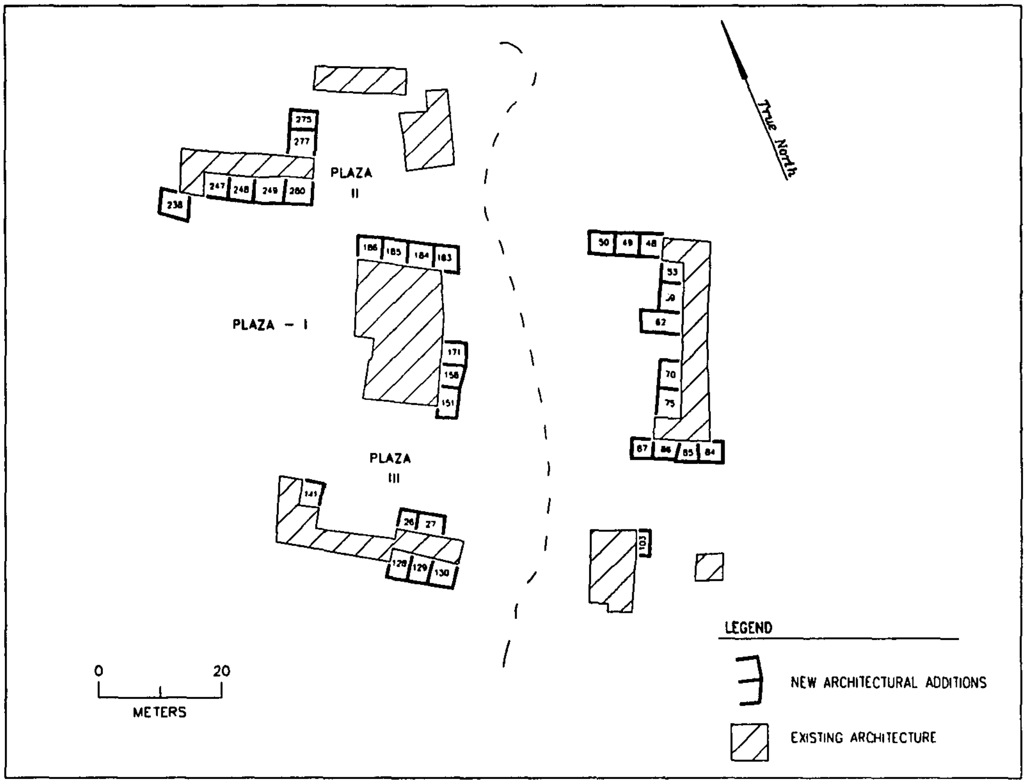

Figure 4.
Construction Phase 2

Construction Phase 2

In phase two, a total of 13 construction units, consisting of 33 ground floor rooms, are added to the largest blocks of Construction Phase 1. Additions on the eastern side of Salt River Draw are mostly to the west of the largest core unit. To the west of the draw rooms are typically added to the north and south of the existing room blocks (Figure 4).

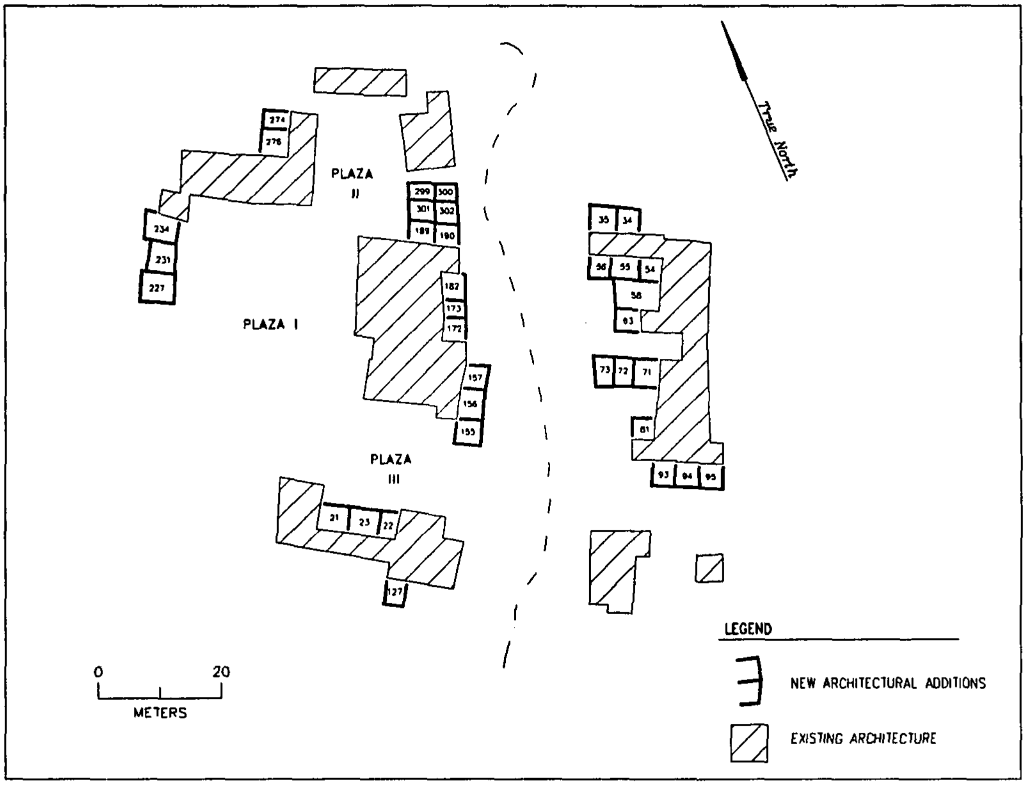

Figure 5.
Construction Phase 3

Construction Phases 3 and 4

Construction Phases 3 and 4 see the addition of 69 rooms as part of 28 individual construction units. Additions follow the same general pattern as that noted in Construction Phase 2. The majority of spaces added are to the section of the site that later becomes Room Block 2 with the six-room cluster to the north (Construction Unit 2-3a) defining the eastern corridor into Plaza II. Additionally, the plaza spaces as a whole are being defined in all three locations (Figures 5 and 6; Table 4).

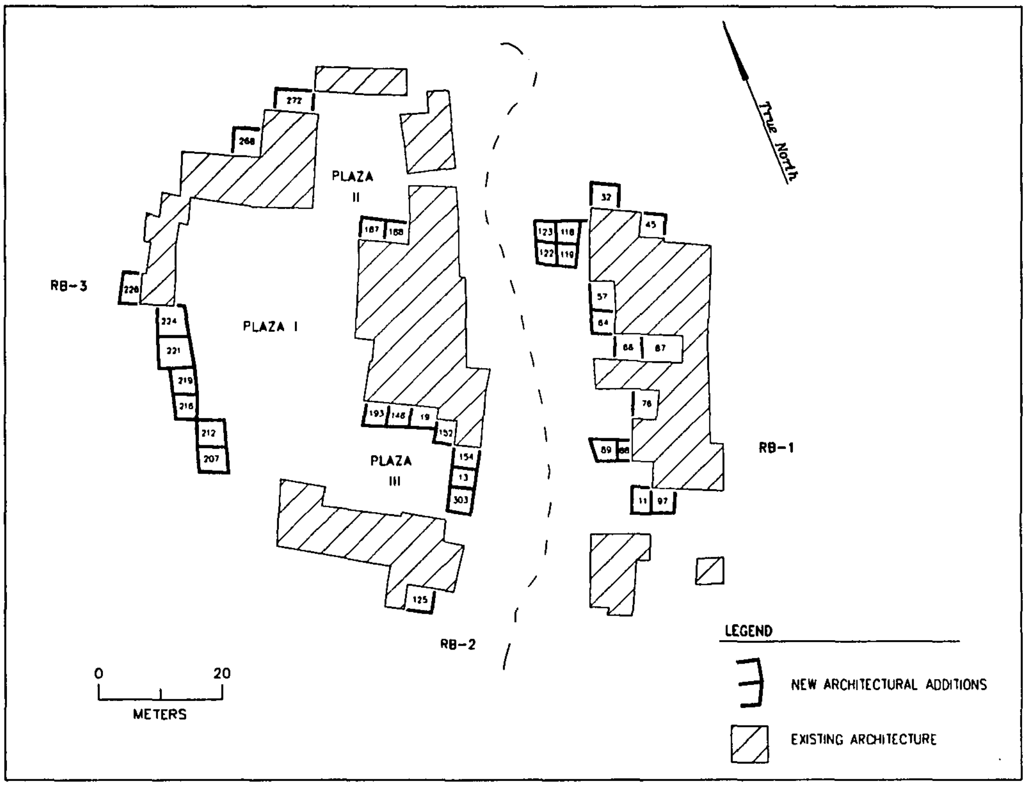

Figure 6.
Construction Phase 4

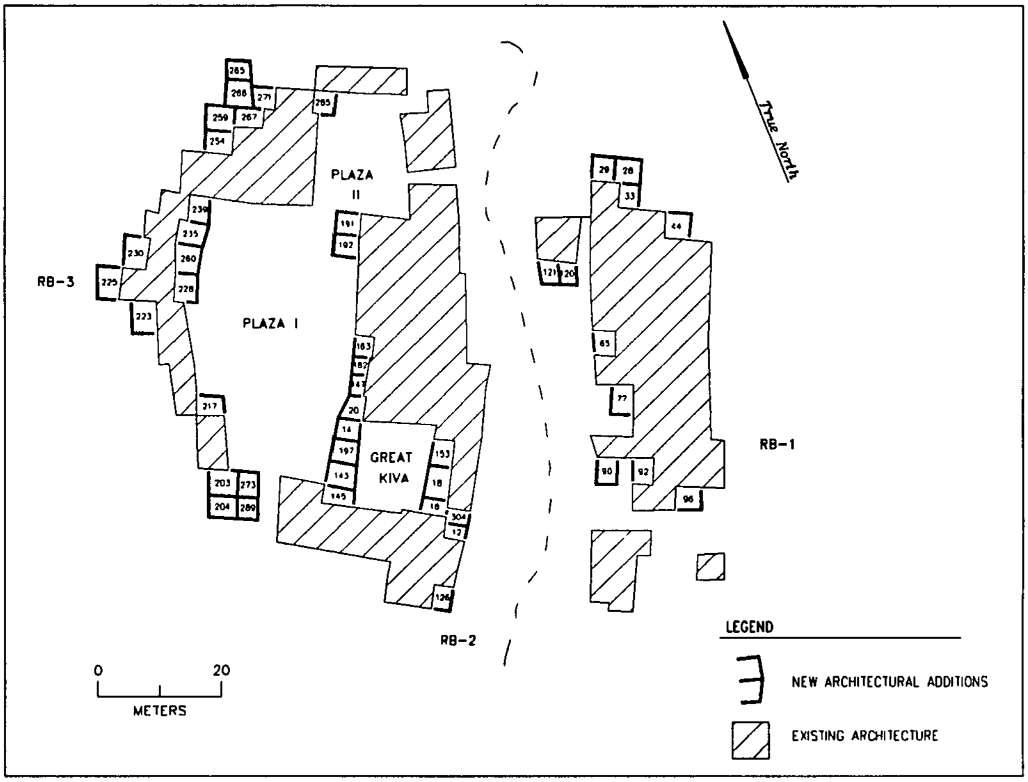

Figure 7.
Construction Phase 5

Construction Phase 5

Construction Phase 5 consists of 20 construction units and represents the largest construction phase in terms of the total number of rooms added. Forty-five ground floor rooms are added to the three core room blocks. Additions to Room Blocks 2 and 3 consist of several large construction units while the growth of Room Block 1 seems to already be experiencing a slow down in its rate of growth. The rooms necessary for the roofing of the southern corridor are added to the southern end of Room Block 3 and Plaza 3 is formalized into the shape it was to attain as the Great Kiva. Finally, the process of infilling is beginning in Plazas 1 and 2. (Figure 7; Table 4).

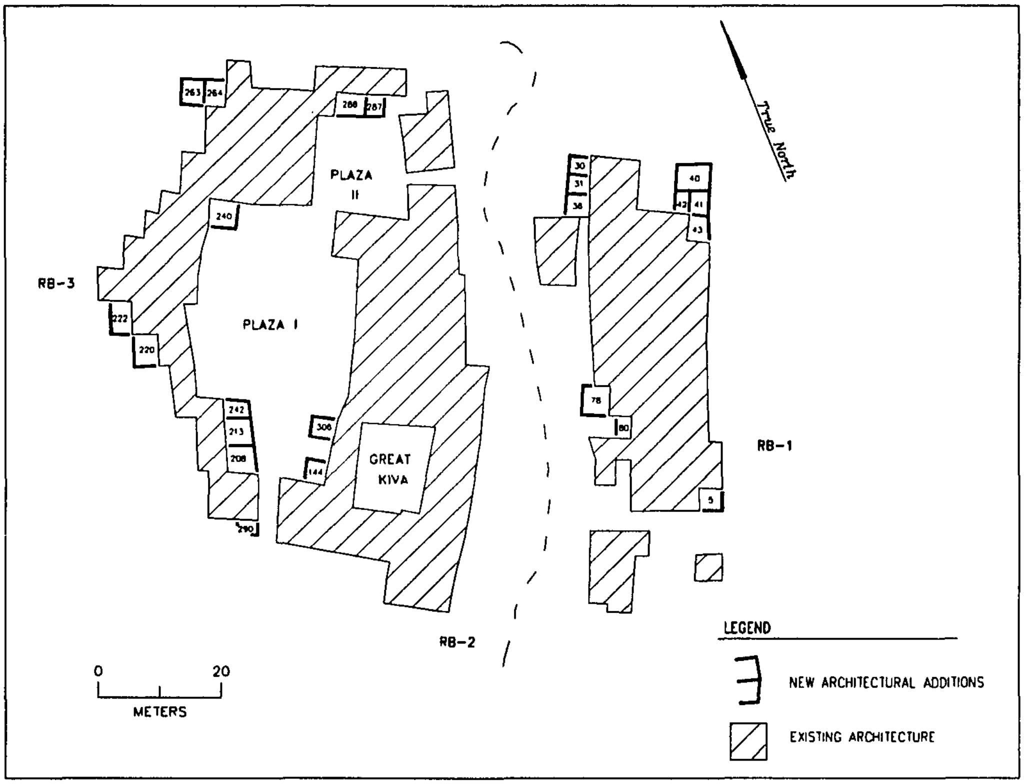

Figure 8.
Construction Phase 6

Construction Phases 6 and 7

Construction Phases 6 and 7 together consist of only of 24 construction units with a total of 39 rooms. These construction phases represent the first significant decrease in the number of added spaces (Table 4), with only 24 rooms being built in Construction Phase 6 and 15 rooms added in Construction Phase 7. By this period in the relative sequence, Room Block 2 reaches its final configuration and from here on site growth slows dramatically in Room Blocks 1 and 3 (Figures 8 and 9).

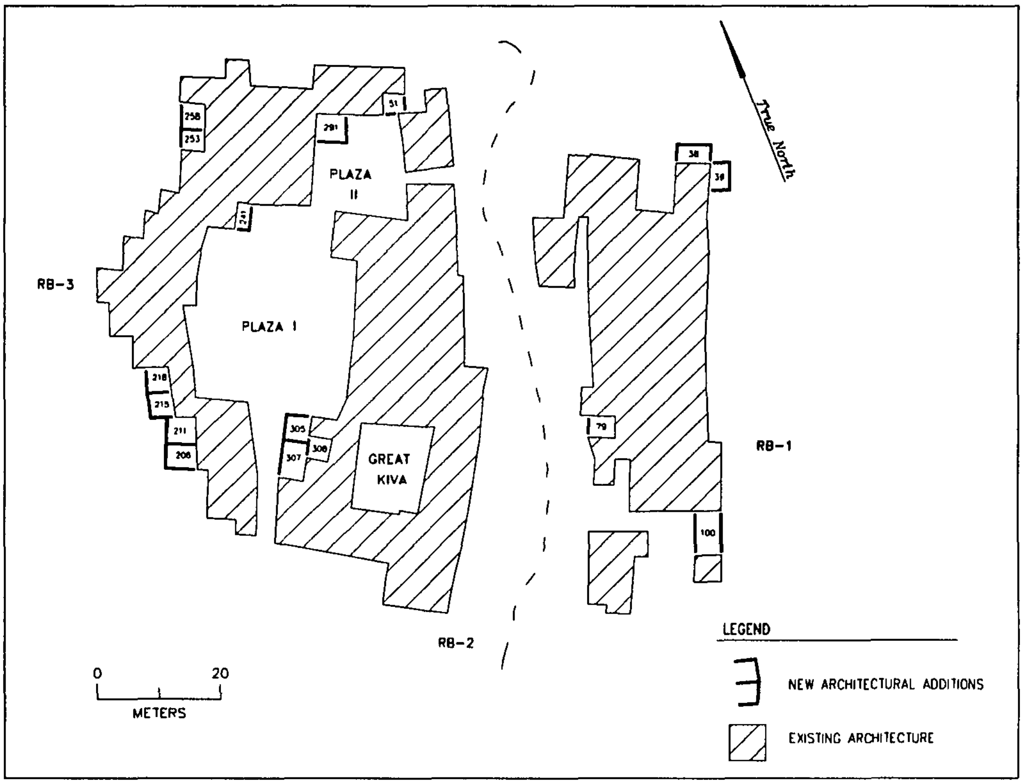

Figure 9.
Construction Phase 7

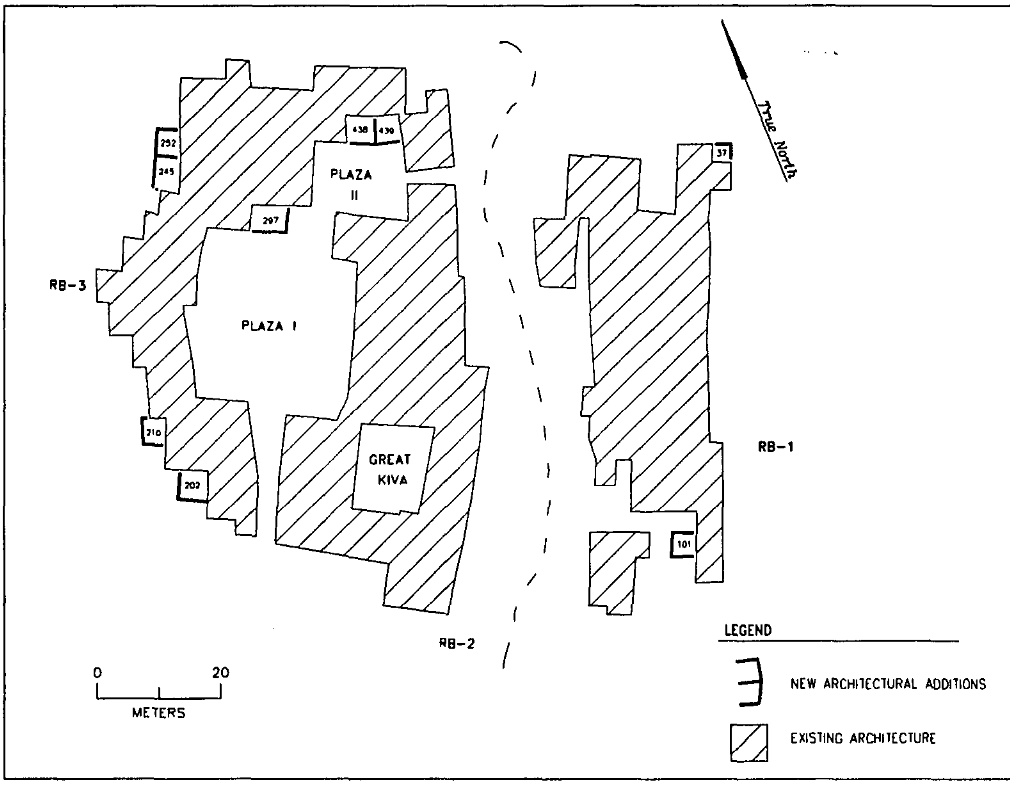

Figure 10.
Construction Phase 8

Construction Phases 8 through 14

These periods represent a dramatic decline in the rate of construction at the site. Some infilling still occurs but the majority of rooms are being added to the western side of Room Block 3 and to the southern end of Room Block 1 (Figures 10-16). The sum of all room additions for these seven phases amounts to only 39 additional room spaces in 34 construction units. This compared to a total of 249 room spaces in 93 construction units for the first seven phases indicates a dramatic reduction in the rate of architectural additions. This significant decline in the pace of construction argues for a major demographic shift sometime between Phases 5 and 7.

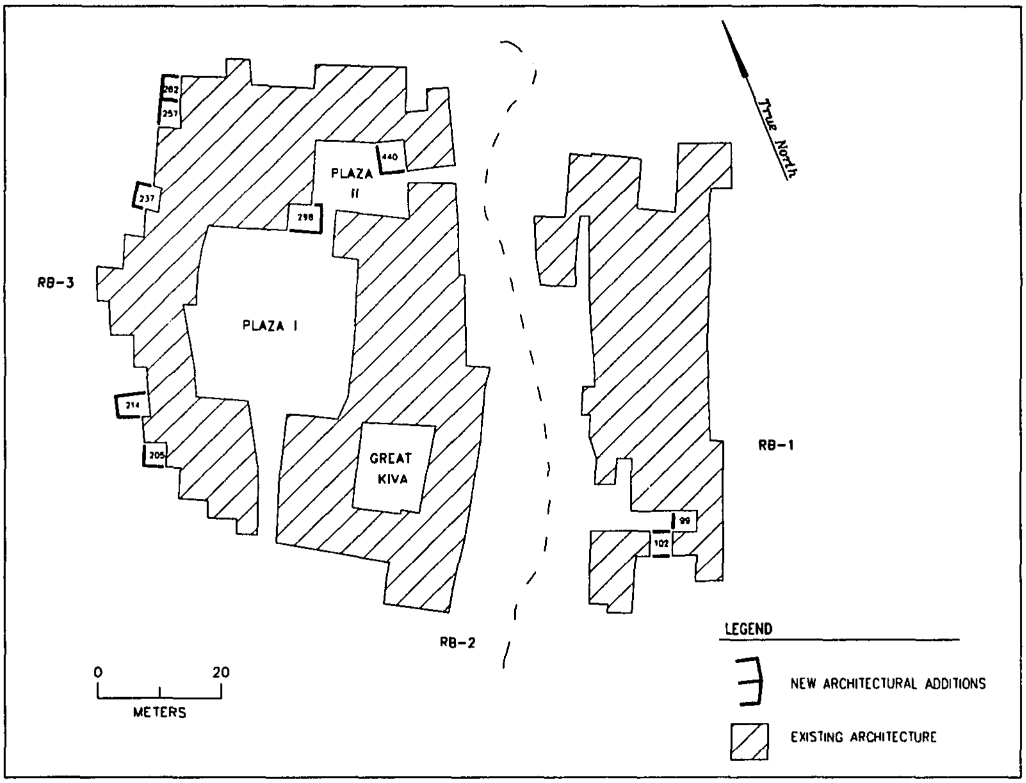

Figure 11.
Construction Phase 9

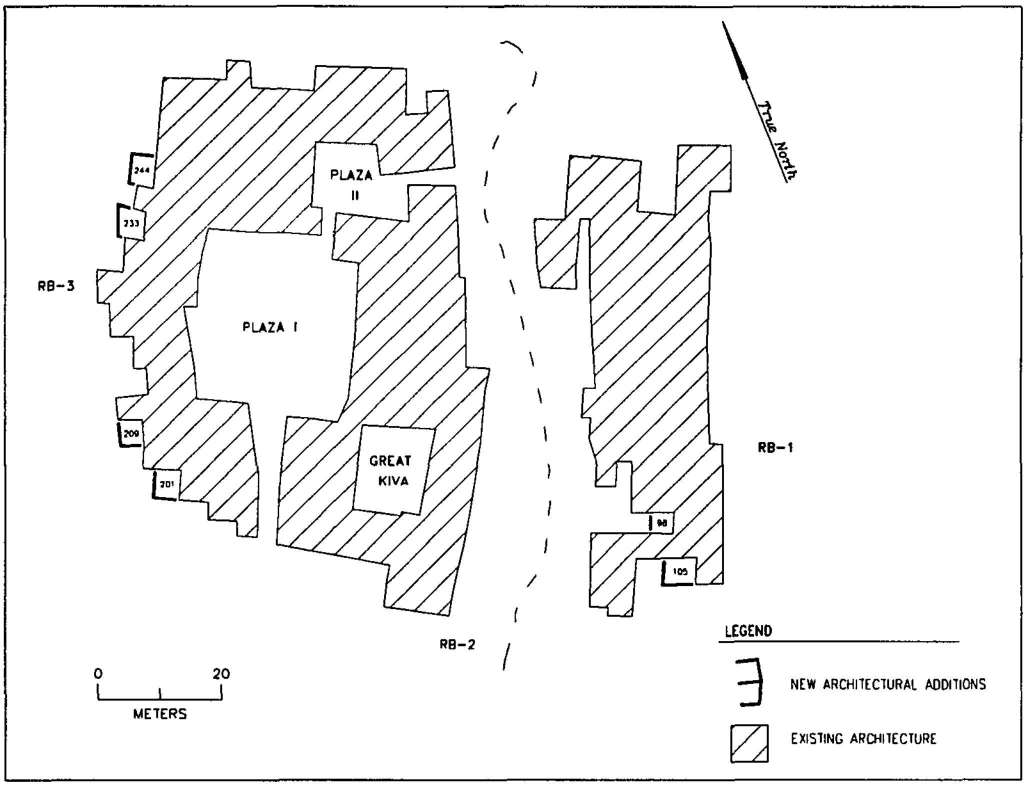

Figure 12.
Construction Phase 10

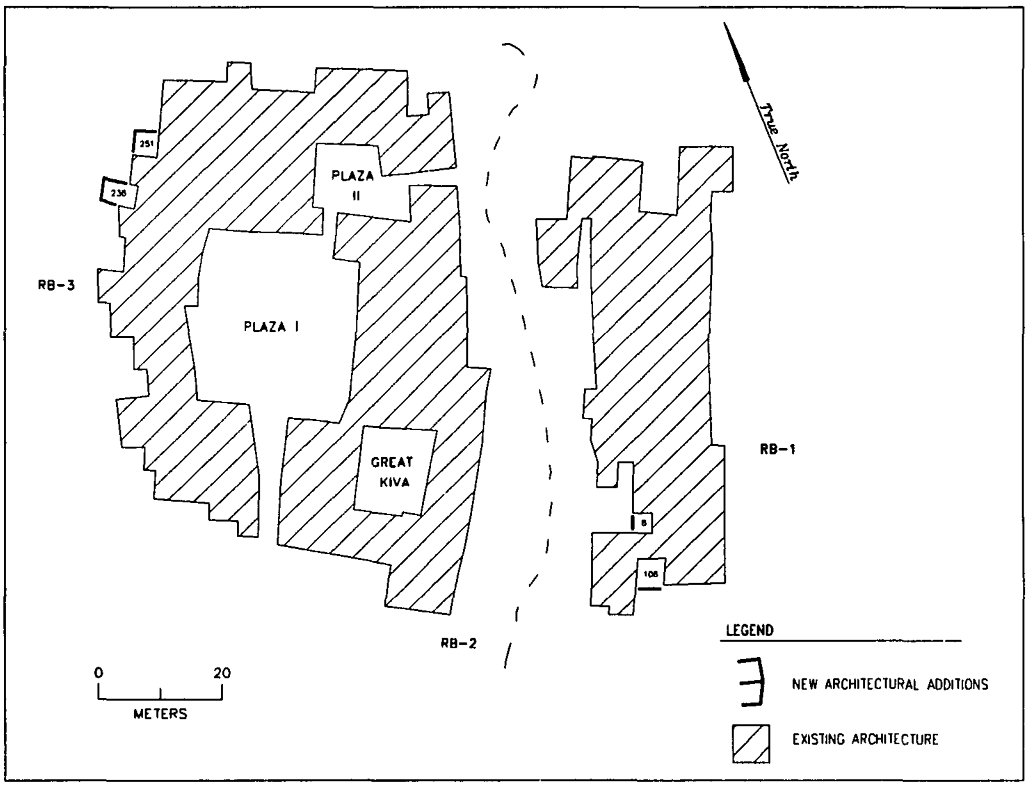

Figure 13.
Construction Phase 11

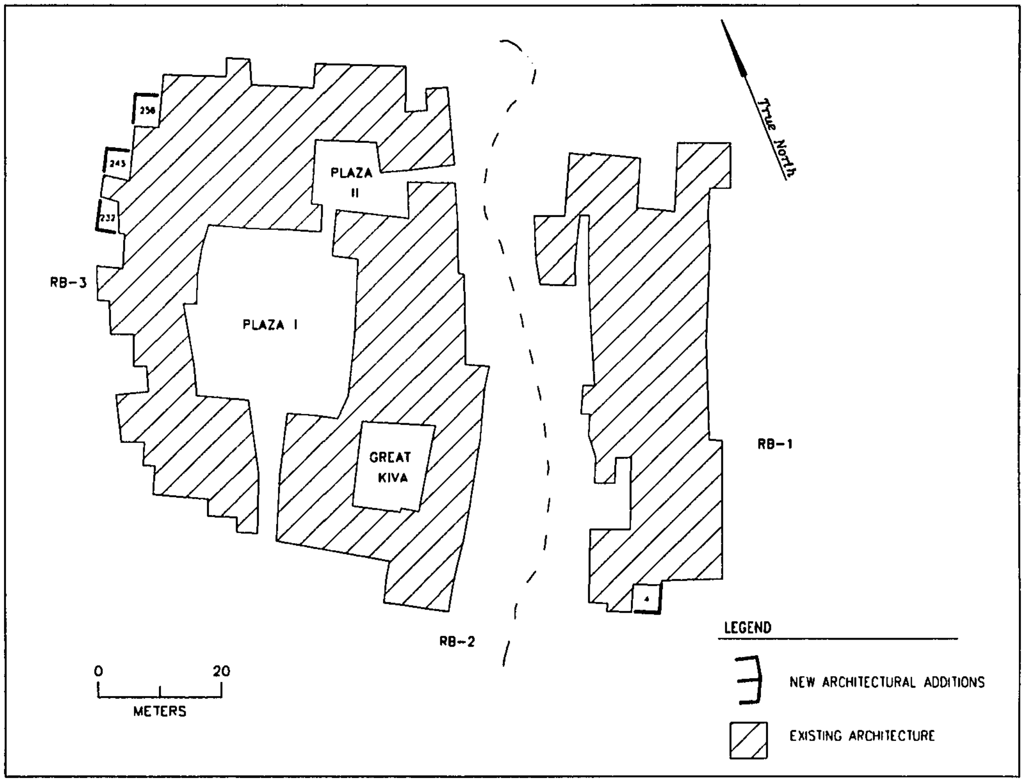

Figure 14.
Construction Phase 12

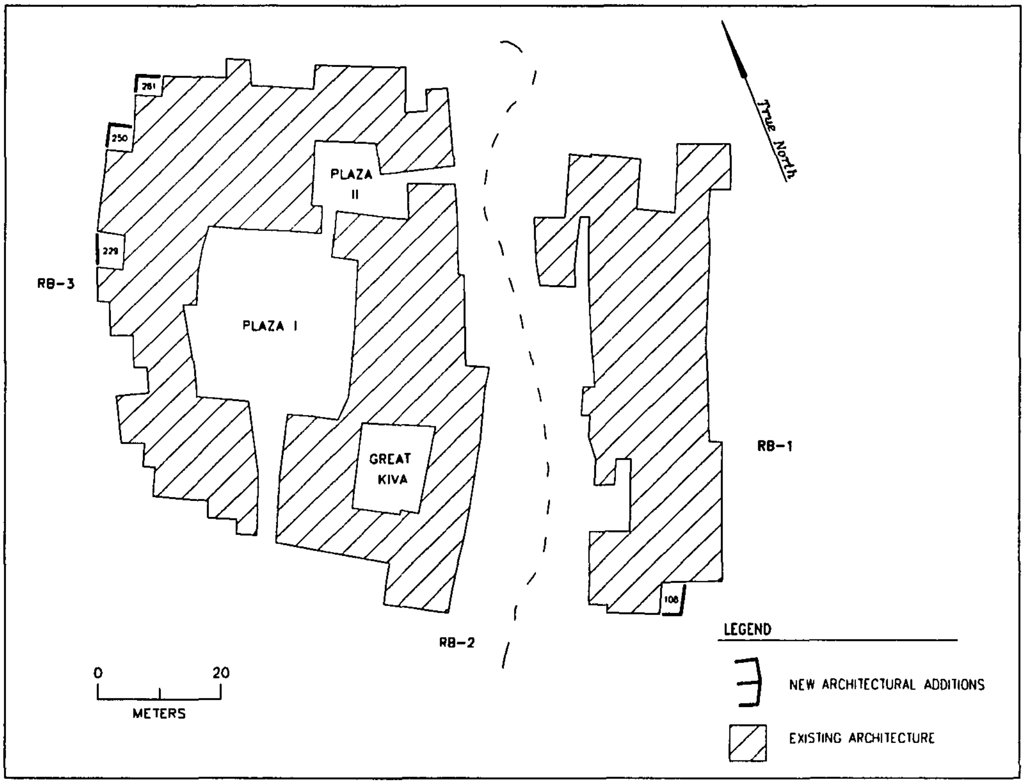

Figure 15.
Construction Phase 13

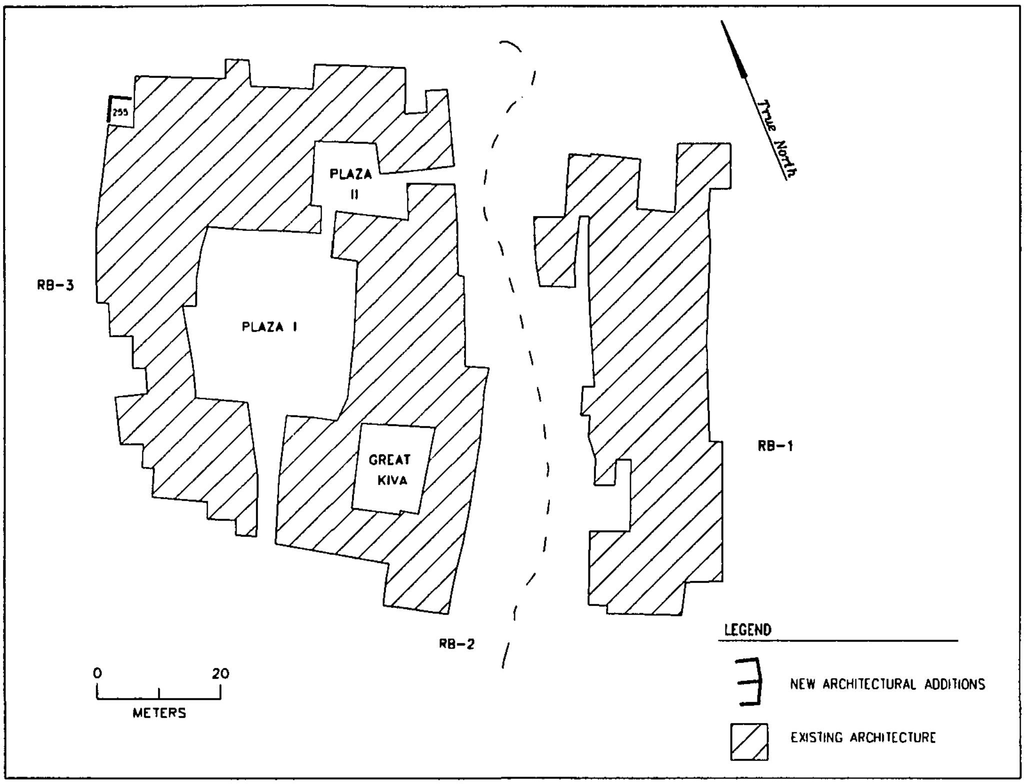

Figure 16.
Construction Phase 14

Discussion

The analysis of the sequence of construction at Grasshopper indicates that there is a distinct pattern to the relative growth of the site. Figure 17 shows the cumulative growth curves for the three individual room blocks of the Main Pueblo based on the assumption of equal temporal intervals for each of the construction phases. Examination of the curves indicates that there is both an overall trend of growth, but that each of the three room blocks also grows in a slightly different way. All three of the room blocks follow an overall pattern of rapid growth with a subsequent period of slow growth, or no growth at all. Room Blocks 1 and 2 exhibit the fastest growth and are largely complete by

Construction Phase 6 or 7. Room Block 3 exhibits a more gradual course of development in which construction increases at a fairly moderate rate until the end of the sequence.

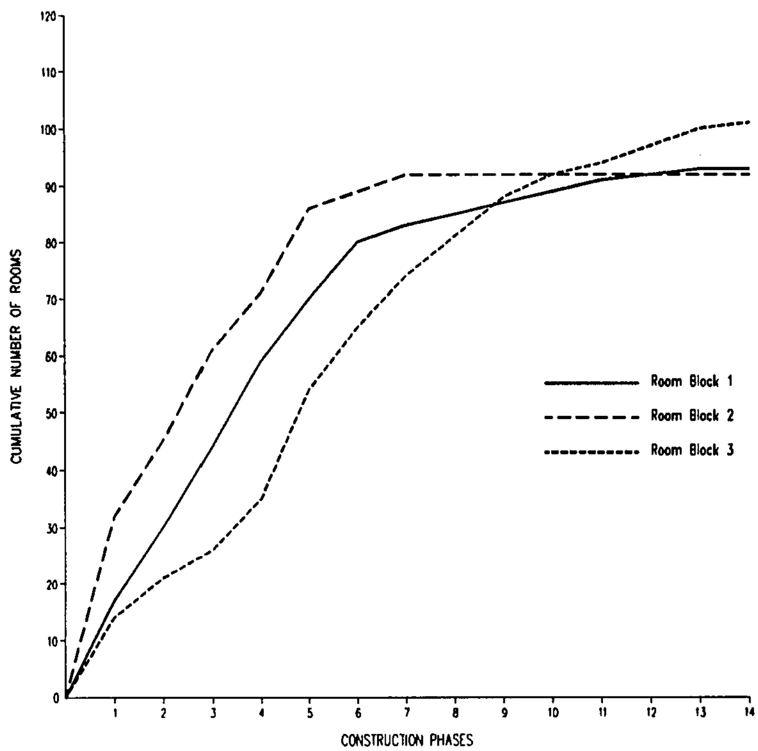

Figure 17.
Relative Growth Curves: Room Blocks 1, 2 and 3

The composite growth curve shown in Figure 18 provides a look at the aggregate relative growth sequence for the three room blocks of the Main Pueblo (cf. Ciolek-Torrello 1978, Figure 6). As was the case with the three individual room blocks, a pattern of relatively rapid growth is illustrated followed by a period of slowed growth after Construction Phase 6. Once again, the composite relative growth curve for the core area reflects past reconstructions of site growth (Ciolek-Torrello 1978; Longacre 1975, 1976;

Reid 1973, 1989; Reid and Shimada 1982). However, as discussed above, relative site growth is only one step in determining the actual site growth. Only the application of tree-ring dates yields the temporal resolution necessary to build an actual growth sequence.

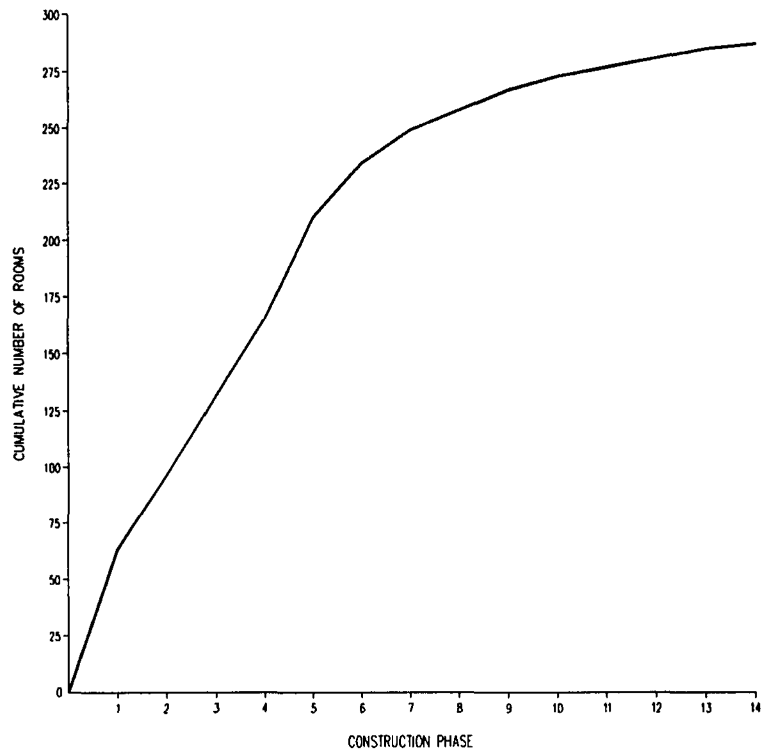

Figure 18.
Composite Relative Growth Curve

Absolute Dates for Growth

A test of the growth model at Grasshopper Pueblo requires that each of the room additions be assigned an absolute temporal position. Given the relatively short span of occupation at Grasshopper, at a time of such dramatic population increase in the region (Longacre 1975, 1976; Reid 1973, 1989), the necessary temporal resolution can only be obtained through tree-ring dating. In the best of all situations, it is preferable to have a large number of tree-ring dates from each of the rooms added (Dean 1969:9-10). However, because Grasshopper is an open air site and the tree-ring remains are buried beneath a deep layer of rubble and alluvium, it is not possible to sample every room at the site. The sample size necessary to adequately test the rooms for datable material is one variable that needs to be addressed.

Table 5: Sampling Chart for Construction Units

Number of Rooms in Unit	*50% Sample of Unit*	*40% Sample of Unit*	*30% Sample of Unit*	*20% Sample of Unit*	*10% Sample of Unit*
21	11	8	6	4	2
19	10	8	6	4	2
18	9	7	5	4	2
17	9	7	5	3	2
16	8	6	5	3	2
15	8	6	5	3	2
14	7	6	4	3	1
13	7	5	4	3	1
12	6	5	4	2	1
11	6	4	3	2	1
10	5	4	3	2	1
9	5	4	3	2	1
8	4	3	2	2	1
7	4	3	2	1	1
6	3	2	2	1	1
5	3	2	2	1	1
4	2	2	1	1	1
3	2	1	1	1	1
2	1	1	1	1	1
1	1	1	1	1	1

If the basic assumptions related to the construction unit are correct, then all rooms in a construction unit are absolutely contemporaneous in terms of the behavior associated with their construction. In light of this, a small representative sample of 20% of the rooms in each construction unit would yield the information necessary to order construction units in absolute time. Table 5 summarizes the number of rooms that must contain datable material in each construction unit size class based on several sample sizes. To obtain a 20% sample from the 287 ground floor rooms of the core room blocks requires that 57 rooms, stratified by means of individual construction units, yield datable tree-ring remains (Table 5). Although a small stratified sample of the Main Pueblo would adequately date the construction phases at Grasshopper, there are several issues that must be considered.

The difficulties in applying tree-ring dates obtained from Grasshopper to the construction of room-sets arise from numerous sources including the problem of dead wood (Dean 1969, Schiffer 1987), remodeling events, reuse of timbers and any number of other cultural or natural processes. In addition, in order for the sequence to benefit from the high resolution of tree-ring dating, the majority of tree-ring dates must be cutting dates; otherwise, only a range of time can be applied to any given construction unit (Dean 1969). Ultimately, the sample that must be obtained is one in which each individual construction unit yields a representative number of datable specimens, so that what is being sampled is not the room spaces themselves but rather the dendrochronological contents of those spaces. If, for example, a room contains no datable wood remains, then another must be selected in order to fulfill the requirements of the sampling strategy. However, even with complete and thorough sampling, the randomness of the processes that affect the preservation of wood remains (i.e., burning of a room) makes recovery of datable materials difficult.

This sampling strategy would be the next step in testing the growth sequence of Grasshopper Pueblo. Fortunately, a large assemblage of tree-ring specimens has already been obtained from the site (Dean and Robinson 1982; Graves 1986, 1991). However, the context and quality of these samples is far from ideal in terms of the strategy outlined above. Because of this, it is necessary to expand upon Wilcox's discussion of construction units (Wilcox 1975, 1982) to formulate several principles for applying Graves' revised cutting-date estimates to the construction phases at Grasshopper.

Grasshopper Tree-Ring Dates

The remainder of this analysis combines the cutting-date estimates devised by Graves to Reid's construction phase model for Grasshopper Pueblo. The purpose of this analysis is three-fold: 1) To present a method for applying dates (or date ranges) to undated units of construction based on their relationship to dated construction units; 2) To evaluate the construction phase model as it has been applied at Grasshopper, and 3) To test the long standing model of rapid growth at the site (Graves et al. 1982; Longacre 1975, 1976; Longacre and Graves 1982; Reid 1973, 1989).

Ceramic dates from Grasshopper firmly place the major occupation of the site in the 14th century, however, poor preservation of wood remains has hampered efforts to assign precise dates to most of the construction events at Grasshopper. In spite of the fact that more than 2000 dendrochronological samples have been collected from Grasshopper Pueblo, only 164 of these provide a date. Of these, only one sample represents a cutting date (Dean and Robinson 1982). Unfortunately, the recovery of this sample from Oven 2 increases the probability that it represents dead wood. Because of the lack of cutting dates and the poor quality of the samples in general, Dean and Robinson (1982), in their initial analysis of the tree-ring material, could only provide construction dates for two areas of the pueblo. The earliest major building episode, for which they had adequate dates, is the roofing of the southern corridor leading into Plaza 1 which was assigned a date of A.D. 1320 or slightly later (Dean and Robinson 1982:47). The last major event which could be dated was the conversion of Plaza 3 into the Great Kiva. Although Dean and Robinson could only say that this occurred sometime late in the sequence, Graves (1991) places the construction of the Great Kiva at A.D. 1347-1360 or later (Table 6).

In his recent analysis of the tree-ring dates from Grasshopper, Graves (1986, 1991) uses a method for estimating ring loss from dendrochronological samples and for providing a probable range of construction dates for rooms at Grasshopper. The intent of Graves' analysis is to provide a means of estimating the gap between the dated event (last ring) and the reference event (the death of the tree) (Graves 1991:85; see also Dean 1978). Ultimately, his goal is to relate the last dated ring to the target date (room construction). The method employed by Graves improves upon the technique for estimating ring loss used by S. Plog (1977, 1980). To account for the shortcomings of Plog's method, the tree-ring samples were separated by species and only samples from the same region and general time period were utilized (Graves 1991:89) Graves' samples consist of material from several pueblo period sites in the mountains of east-central Arizona, including Grasshopper. By comparison with the estimator group of 38 sites, he is able to determine that with the exception of Douglas Fir, the Grasshopper series is typical in the mean number of rings present as well as in terms of the patterns of prehistoric wood use at the site (Graves 1991:101-112). Combining his technique for the estimation of ring loss with the more traditional methods of analysis such as date clustering and date overlap (Bannister 1962; Douglas 1935; Haury 1934), Graves generates ranges of dates from the tree-ring samples recovered at Grasshopper. The following pages discuss the methods used and the results obtained from the testing of Graves' construction date estimates against Reid's construction phase model.

Table 6.
Tree-ring Dates and Construction Dates of Rooms from Graves (1991 Table IX) with Associated Construction Unit Designations

Room Number	Latest Date	Estimated Construction Date	Associated Construction Unit	Number of Samples
Room Block 1				
8	1385	1385-1400	1-11a	3
11	1375	1375-1395	1-4h	2
31	1280	1320+ (see Rm 35)	1-6a	1
33	1311	1311-1325	1-5a	3
35	1310	1310-1325	1-3a	6
39	1282	1309-1321 (see Rm 44)	1-7b	3
42	1330	1330-1350	1-6b	2
43	1199	1309-1321+ (see Rm 44)	1-6b	1
44	1309	1309-1321	1-5b	2
Room Block 2				
18	1347	1313-1323+ (see Rm 26)	2-5c	5
19	1311	1311-1321	2-4b	3
21	1288	1319-1331 (see Rm 23)	2-3d	2
23	1319	1319-1331	2-3d	6
26	1313	1313-1322	2-2d	6
145	1320	1320-1330	2-5b	1
153	1346	1326-1338	2-5c	5
164	1298	1298-1308	2-1a	1
183	1342	1323-1333	2-2a	9
187	1332	1332-1344	2-4a	5
197	1366	1366-1376	2-5b	2
Great Kiva	1353	1347-1360+	none	20
Room Block 3				
211	1313	1313-1323	3-7e	1
216	1323	1323-1333	3-4d	1
231	1305	1305-1317	3-3b	6
246	1228	1307-1316+ (see Rm 269)	3-1a	1
269	1343	1307-1316	3-1a	12
270	1229	1307-1316+ (see Rm 269)	3-1a	2
274	1302	1302-1315	3-3a	2
279	1308	1308-1317	3-1a	3
280	1373	1309-1328	3-2c	4
438	1331	1331-1340	3-8b	2
Corridor	1333	1320-1325	none	28

Methodology

The method used in this analysis is based in the concepts of the construction phase model (Reid 1973) and ideas concerning room-set additions put forth by Wilcox (1975, 1982). The computer drafting techniques and data management programs discussed above are used in conjunction with these concepts to analyze and display construction data from Grasshopper Pueblo. After a discussion of the methodology used in assigning absolute dates to the construction phases at Grasshopper, the results of the analysis will be presented and discussed both in terms of Graves' dating of the site as well as in relation to existing reconstructions of community growth.

Problems and Assumptions

Two major problems are inherent in attempts to assign absolute dates to Grasshopper. The first of these is the lack of cutting dates from the site (see above). However, the use of Graves' date estimates provides a solution to this problem. Although the rooms analyzed are not dated to individual years, they are assigned a tighter range of time than was available in the original formulation of Reid's growth model (Reid 1973; Reid and Shimada 1982). The second problem in assigning dates to construction phases is the fact that not all rooms yield tree-ring dates. Because the preservation of wood remains is greatly enhanced by the entirely random event of burning, the extensive excavations at the site were unable to fulfill the requirements of the sampling strategy outlined above and did not provide a dated room from each of the construction units. However, models concerning site growth and room set additions (Wilcox 1975, 1982) provide the basis for a number of principles that allow undated clusters to be assigned a range of dates based on their relationship to surrounding dated units.

Before discussing these principles in detail, it is necessary to note some of the assumptions that must be made prior to such an analysis. The first of these is directly related to the construction unit. Because a construction unit is defined as a single, absolutely contemporaneous set of rooms sharing a common, continually bonded wall (Reid 1973; Wilcox 1975, 1982), it can be assumed that dating one room in a construction unit provides a construction date for all the rooms in the unit. The second assumption is more specific to the present analysis. The method used by Graves for estimating cutting dates is assumed to accurately reflect a range of time in which the actual construction of a room occurred. Since a reevaluation of Graves' methods is beyond the scope of this analysis, all of the construction estimates provided by Graves are applied as given. The final assumption is related to the construction phase model which presupposes that all construction units of a single phase in all three room blocks of the Main Pueblo are contemporaneous. This assumption also forms the first step in the overall methodology.

Methods

Given the distinction between relative and actual growth discussed above, the assumption of contemporaneity is a necessary starting point for applying temporal information to construction units that cannot otherwise be assigned absolute dates. However, individual construction units, for which temporal information is available but which do not fit within the temporal range of the construction phase to which they belong, are removed from that phase and placed in the temporal period in which they are dated. This is done in order to increase the precision with which the actual growth sequence is developed.

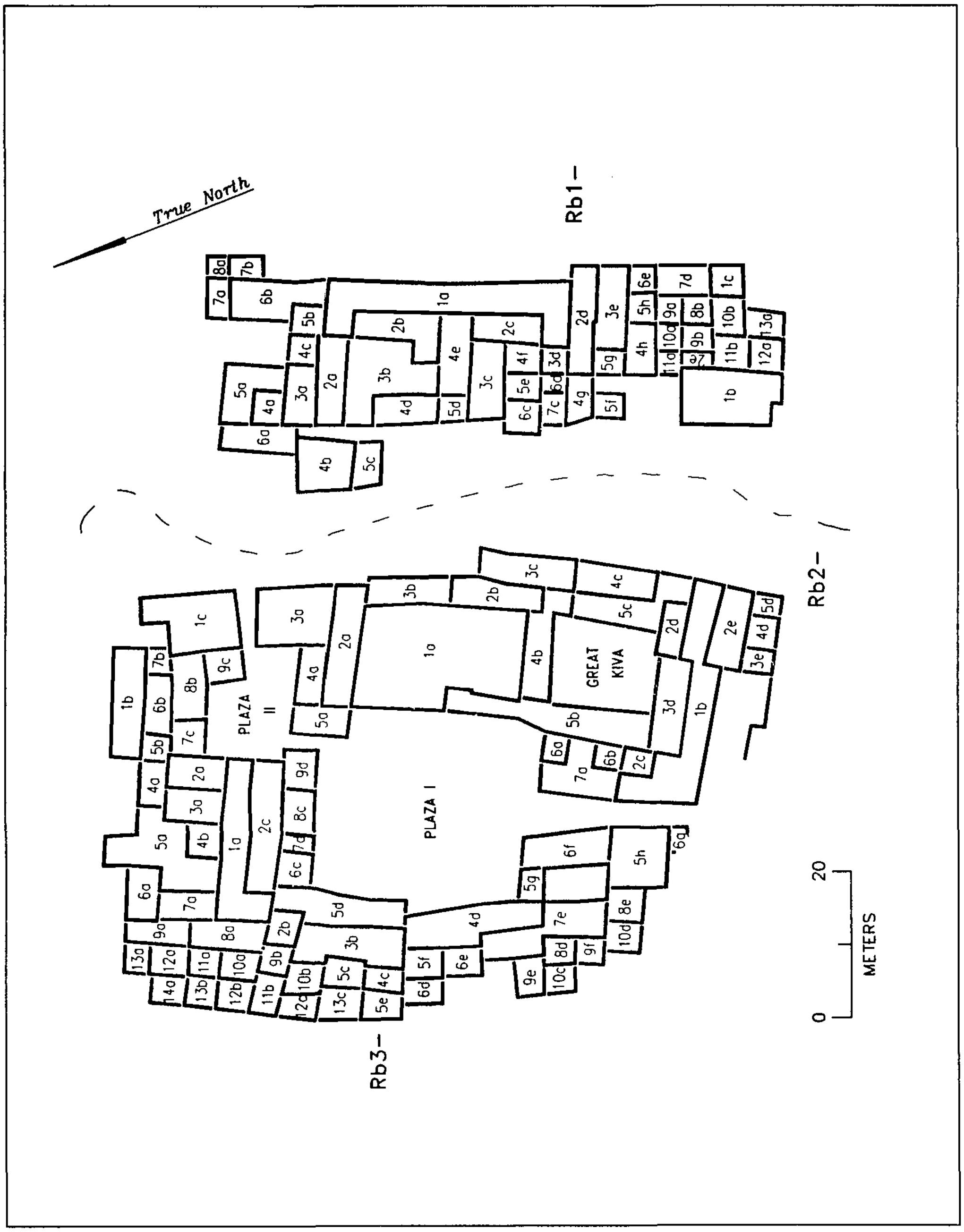

Figure 19. Construction Units at Grasshopper Pueblo: Main Ruin

The next step in applying Graves' cutting-date estimates to the construction phases at Grasshopper is to assign each of the individual construction units its own sub-phase designation. Figure 19 shows the breakdown of the core room blocks by construction phase with each of the sub-phase designations provided. To do this, each construction unit is given a three-part name. The first part of the classification, followed by a dash, designates the room block in which the unit occurs. The second number refers to the construction phase (Figures 3-16) to which the unit belongs. Finally, the letter appellation represents the single unit referent which distinguishes the unit from all the others of the same phase within the room block. This classification system gives each unit a designation that not only facilitates discussion and manipulation of the individual units in a data base but which also contains information as to what room block and phase the unit belongs (Figure 19, Appendix B).

The next stage of the analysis was to assign the date ranges provided by Graves to the construction units from which the dated rooms came. Out of a total of 127 discrete construction units, only 23 (18%) could be directly dated by the application of Graves' cutting-date estimates (Figure 20), excluding the Great Kiva and the southern corridor. As Figure 20 illustrates, there are an essentially equal number of dated clusters in each unit (RB1 and RB2 = 8 each, RB3 = 7) however, Room Block 1 suffers from a lack of dates in the central section while no dates are available for the outermost rooms of any of the core room blocks. The lack of dated samples from rooms on the outer margins of the three core room blocks creates numerous problems in assigning terminal dates to large portions of all three of the core room blocks, but especially Room Blocks 1 and 3.

DATED ROOMS AND CONSTRUCTION UNITS AT GRASSHOPPER PUEBLO: MAIN RUIN

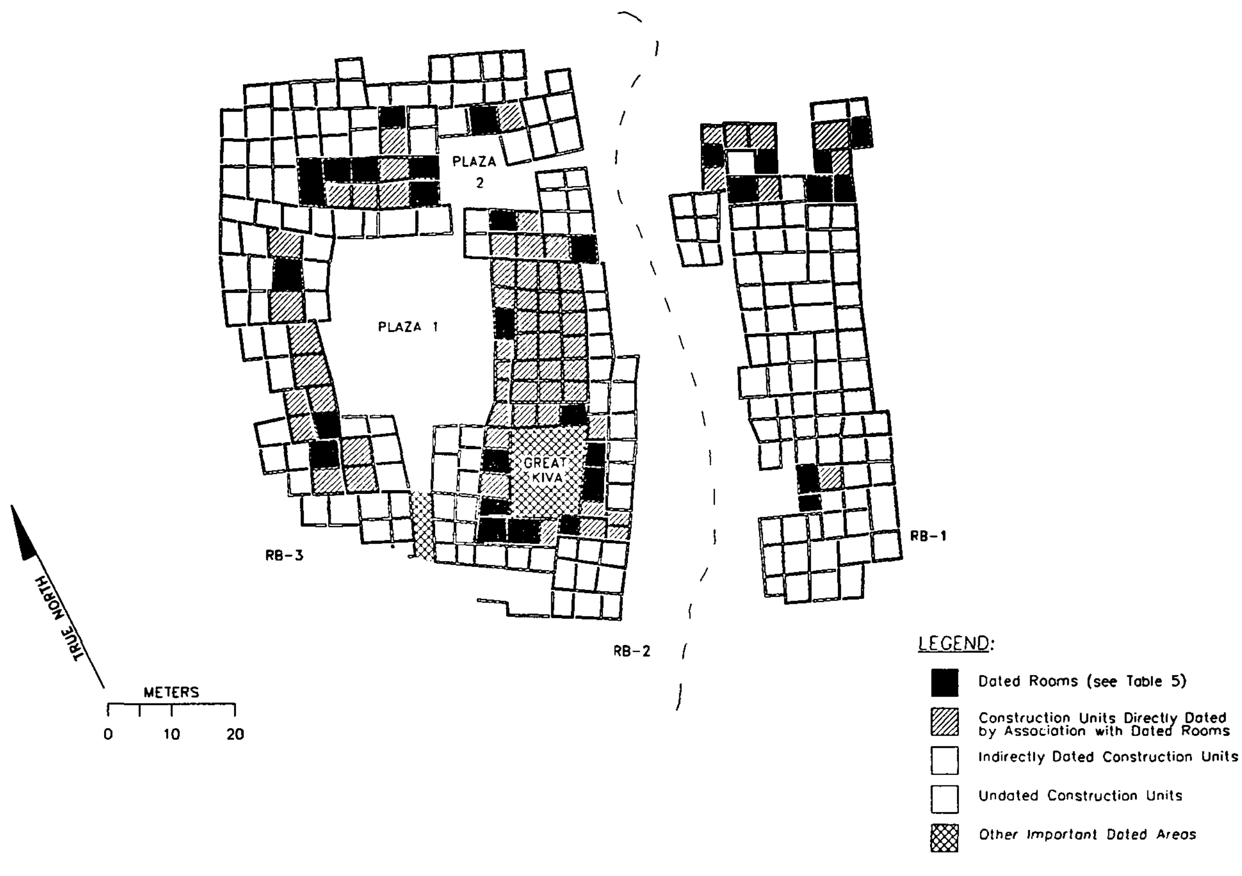

Figure 20.
Dated Rooms and Construction Units at Grasshopper Pueblo: Main Ruin

To date the remaining 104 undated construction units necessitates that several definitions and principles be devised for establishing the temporal relationship between the spatially related construction units. Many of the principles are obvious in their conception and reflect basic common sense. However, to provide consistency in the application of tree-ring dates to construction units, it is necessary to formalize them into a set of eight axioms that can be applied to all of the units equally and without bias.

Definitions

1. Terminal Date - The last possible date that a construction unit could have been built.

2. Initial Date - The earliest possible date that a construction unit could have been built.

3. Dependent Construction Unit - Any construction unit that depends on the prior existence of one or more other units for its construction. This definition is crucial in assigning dates to units for which there are not dates. A dated dependent unit can provide a *terminal* date for all of the units on which it is dependent (Figure 21a).

4. Independent Construction Unit - Any construction unit that is added independently of other units. An independent unit provides an *initial* date for all units that are dependent upon it if other information is not available. Considerations of dependence and independence are not necessarily predetermined by the nature of a construction unit (i.e. whether it is a core unit or not) but are more related to the locations of units in relation to one another in the sequence of additions (Figure 21a and b).

Principles

1. Given the construction unit model, one dated room in a construction unit dates that unit.

2. Any room or unit abutted to a dated unit assumes the initial date of the unit it abuts as its *earliest possible construction date* (Figure 21c).

3. Any dated construction unit abutted to a non-dated construction unit provides the non-dated unit with a terminal construction date, i.e. the latest date in the added construction unit (Figure 21d).

4. The construction date range for any non-dated unit between two dated ones assumes the initial date of the one it abuts and the terminal date of the one that abuts to it (Figure 21e).

5. The coincidence of the initial date from a construction unit with the terminal date of a construction unit that is abutted to it dictates that the construction date for both units can be only the single date that the two units have in common (Figure 21f).

6. For any dated unit in such a position that it is situated between two other dated units, but which does not fit in the sequence, the date is assumed to be anomalous and is considered to represent either remodeling or reuse depending on the direction in which the date is in error (Figure 21g).

7. Construction units that are separated from dated units that are dependent on them are assigned the terminal date of the dependent units if no dated units are in between them regardless of the distance or number of abutments (Figure 21h).

8. Date ranges are never modified to include dates outside of the range specified by Graves 1986, 1991; if dates cannot be modified to fit within this range, the dates are considered anomalous.

Results

This section presents the results of the analysis. First, a discussion of the growth of each room block is presented, followed by a discussion of the overall trends observed in the growth of Grasshopper Pueblo.

Room Block 1

As Figure 20 illustrates, Room Block 1 is the least adequately dated of the three core room blocks. The northern part of the room block is well dated while rooms in the southern portion of the room block are: 1) not well dated, and 2) seem to be late in the construction sequence. Figure 20 also indicates the major obstacle in assigning dates to rooms in the central section of the room block. The middle of Room Block 1 is highly problematic in that there are no dated rooms to provide terminal dates for the units to the east and south of Construction Unit 1-2a (Figure 19).

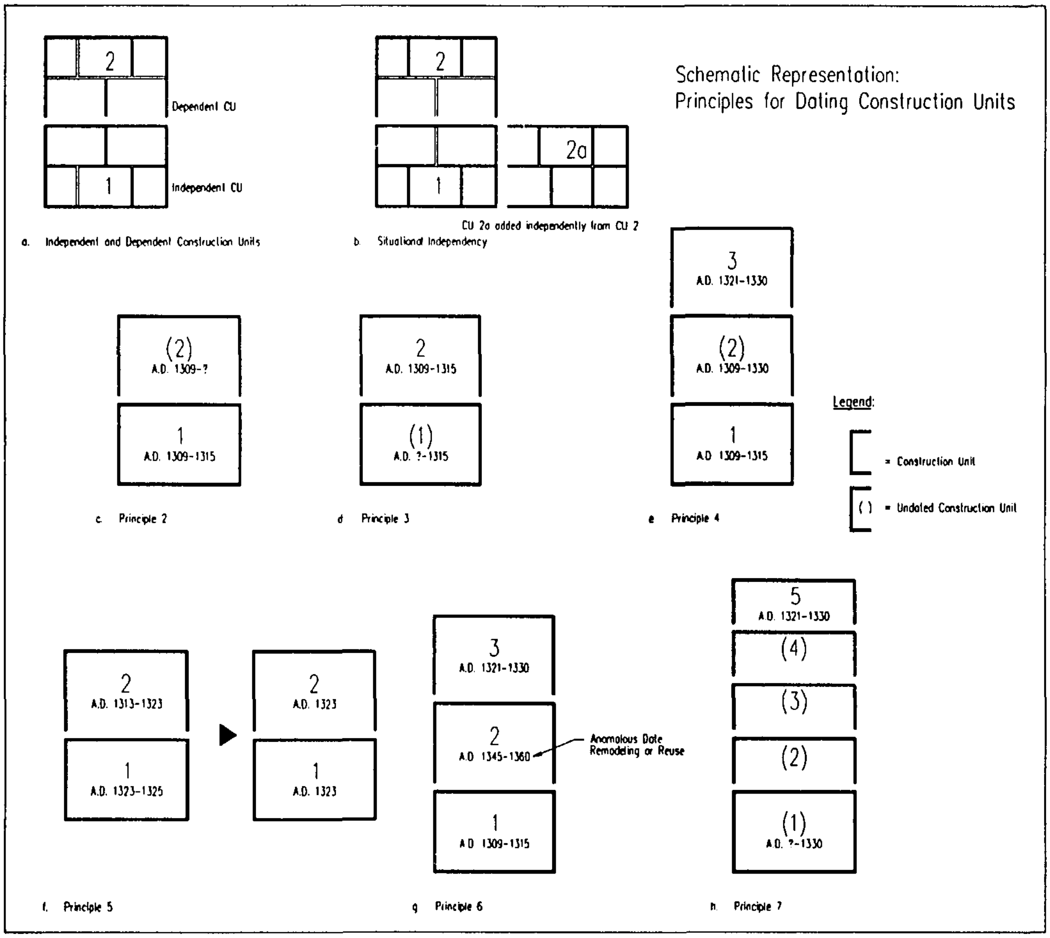

Figure 21. Schematic Diagram
Illustration of Principles for Dating Undated Construction Units

The best evidence for the establishment date of Room Block 1 comes from the northern portion of the room block. Unfortunately, the large core unit (Construction Unit 1-1a) does not itself contain any dated rooms. The founding date for Room Block 1 is based on the addition of Construction Unit 1-3a, which has a date of A.D. 1310-1321. Construction Unit 1-3a is a key addition in terms of estimating the founding of Room Block 1. Based on Principle 3, a terminal construction date of A.D. 1321 is assigned to the core unit as well as Construction Unit 1-2a, which the addition of Construction Unit 1-3a is dependent upon. However, because the addition of Construction Unit 1-3a is separated from the core unit by one construction phase and since the other two room blocks have founding date ranges earlier than A.D. 1310-1321, the founding date for Room Block 1 is estimated at A.D. 1305 to A.D. 1321. Establishment of the southern part of Room Block 1 is difficult to estimate because the earliest dependent date for construction is A.D. 1375.

From Construction Unit 1-1a, growth in Room Block 1 proceeds west and northward with most of the rooms to the north being added by A.D. 1321 and having initial dates of A.D. 1310 or earlier. However, since the central portion of the room block is not well dated, there is no way of accurately assessing the growth trajectory south of Construction Unit 1-2a. Growth in the southern section of Room Block 1 appears to be different from growth in all other parts of the main ruin (see Figures 3-16). The pattern of growth reflects what looks to be infilling of the space between the two southern core construction units by single room additions. Although growth in the southern section of Room Block 1 appears different than other growth patterns seen in the main pueblo, the rate of growth for Room Block 1 reflects traditional hypotheses for growth at Grasshopper (Ciolek-Torrello 1978; Longacre 1975, 1976; Reid 1973, 1989).

Based on the Construction Phase Model , and assuming contemporaneity of the construction units of each phase for which absolute temporal information is not available, the rate of growth in Room Block 1 appears to be rapid until about A.D. 1325 when growth tapers off considerably and continues to decline until around A.D. 1385 after which no construction dates are available. Overall the lack of sufficient dates for much of Room Block 1 necessitates that the actual growth reconstruction presented here rely heavily on the assumption that all construction units of a single phase are contemporaneous (see Chapter 3). Finally, the late dates for the southern portion of Room Block 1 may indicate a later occupation of this part of the site. This may affect the distribution of dates in terms of the main occupation of Grasshopper.

The completion date for Room Block 1 is estimated to have been between A.D. 1375 and 1400. Room Block 1 is the only portion of the Main Ruin to yield a date later than A.D. 1350. The southern section of the room block consists of several single room additions that are dependent on Construction Unit 1-4h which dates to A.D. 1375-1395. While the late date for this construction unit is the basis for assigning such a late completion date to Room Block 1, it must be pointed out that this section of the room block may have been reoccupied late in the occupation of Grasshopper. The dating of Construction Unit 1-4h is based on two dates from Room 11, both of which are vv dates and one (1331) is thought to be the result of reuse (Graves 1991:Table IX). Consequently, an alternative interpretation is that Construction Unit 1-4h is constructed earlier than Graves indicates and the tree-ring samples recovered from this unit represent either late remodeling or a reoccupation of this portion of the site. A similar explanation is offered for Room 8 (Table 6) which is also dated late by Graves (A.D. 1385-1400). The argument for later re-use of the southern section of Room Block 1 is further supported by tree-ring samples from Room 100, which Dean and Robinson (1982) indicate represent a unique assemblage of wood types in comparison to the other rooms at the site. The use of non-typical wood species for construction may result from deforestation of the area which in turn dictated that new types of material be used for construction (Dean and Robinson 1982:47).

Room Block 2 and the Great Kiva

The founding of Room Block 2, based on the available evidence occurs earlier than either of the other two room blocks of the main pueblo. The 21 room core construction unit (2-1a) is dated by Graves to have been constructed sometime between A.D. 1298 and 1308. Although this is based on a single date from one room, the early founding date is further supported by the addition of Construction Unit 2-4b, which is added on to two intervening construction phases and has a date range of A.D. 1311-1321 (Table 6). For the southern core construction unit (2-1b) no dates are available that would yield an initial construction date. However, the addition of Construction Unit 2-2d to the north sets the terminal date for the completion of Construction Unit 2-1b at A.D. 1322. The roofing of the southern corridor by 1325 provides additional evidence for completion of Construction Unit 2-1b by this time (Principle 3). Thus, based on an assumption of contemporaneity of construction phases, and strengthened by the closing of the southern corridor, the southern core unit is also given an early founding date (Figure 22).

Growth in Room Block 2 proceeds from the south of Construction Unit 2-1a to surround the space later to become the Great Kiva and to incorporate Construction Unit 2-1b and the additions to the north of it. The direction of growth implies that the demarcation and closing off of the Great Kiva was perhaps a driving force behind the constructions south of the initial founding of the room block. Additions to the north of Construction Unit 2-1a appear to have occurred slightly later than those to the south of the core unit and probably represent the closing off of Plaza II sometime around A.D. 1340 (see Room Block 3).

The rate of growth for Room Block 2 is similar to that seen in Room Block 1 except that more construction dates for Room Block 2 yield a more accurate depiction of actual growth for the room block. Most of the construction units in Room Block 2 are large additions and many have terminal dates. Additionally, there are no additions to Room Block 2 after Construction Phase 7 in which a three room construction unit is added north of the southern corridor (Figure 19). Thus, assuming that Construction Phase 7 occurred relatively early in the sequence but sometime after A.D. 1325, all of the construction in Room Block 2 was likely complete prior to A.D. 1350. The only serious dating problem that occurs is with the rooms to the far southern end of the room block, which have no available terminal dates. Although these rooms (Construction Units 2-2e, 2-3f, 2-4d and 2-5e) are assumed to be contemporaneous with the other construction units of their given phases it is possible that they represent additions after the major growth period at the site. However, since temporal information is not available for these rooms, they are included in Growth Period 1 (Figure 22).

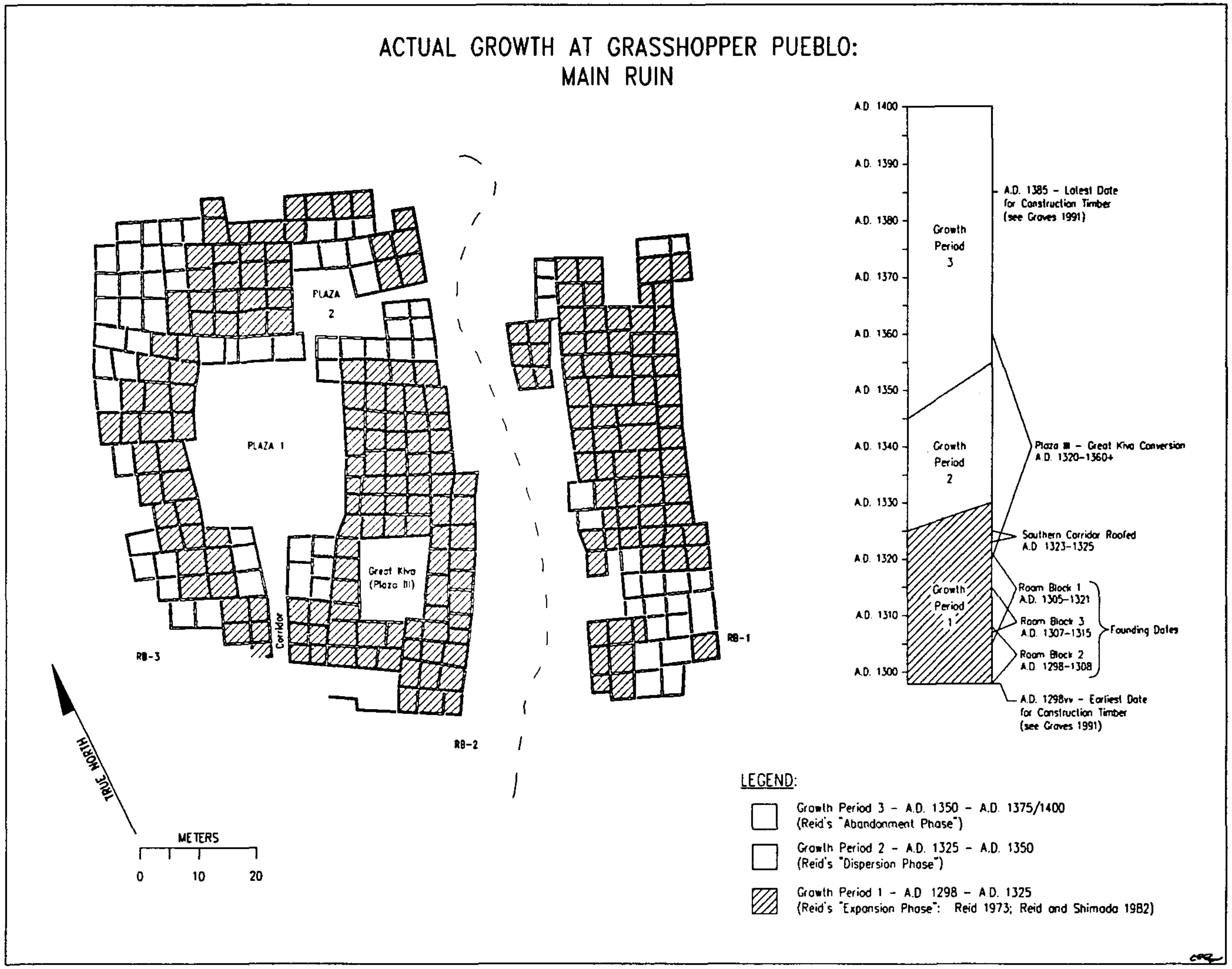

Figure 22. Actual Growth at Grasshopper Pueblo: Main Ruin

Because of its relationship to Room Block 2, the dating of the Great Kiva is included here in order to round out the discussion of Room Block 2. If the earlier date for Construction Unit 2-5b is valid (see Table 6), then conversion of Plaza 3 into the Great Kiva could have occurred any time after A.D. 1326 (see Construction Unit 2-5c, Figure 19, Table 6). The late construction date proposed by Graves is based on four dates out of a total of 20 dated specimens from the Great Kiva. Although the context of the four late samples is not provided by Graves, it is suggested that the late dates for the Great Kiva and the late dates from Room 197 may represent a possible remodeling episode sometime between A.D. 1347 and 1376. Based on the available temporal information, the conversion of the Great Kiva is given a range of construction between A.D. 1326 and A.D. 1360+. Additional tree-ring evidence further suggests that the Great Kiva was still in active use perhaps as late as A.D. 1376 when corroborating evidence for remodeling in Room 197 suggests that the late dates for the Great Kiva may also represent a late remodeling episode.

Finally, the completion date for Room Block 2 is difficult to asses due to a lack of terminal dates for construction in the margins of the room block. The latest dates for construction in Room Block 2 come from the Great Kiva and Room 197 in Construction Unit 2-5b which also contains an earlier dated room (Table 6). However, these dates most likely represent a remodeling episode and are discounted as true construction dates (see below). The latest dates that appear to represent true room construction occur to the north of the central core construction unit. Construction Unit 2-4a has a date range of A.D. 1332-1344 which places the construction of this particular unit and the one that abuts it (Construction Unit 2-5a) after the period of major growth defined by the current analysis (Figure 22). The dating of Construction Units 2-4a and 2-5a provide an ideal example of the breaking apart of construction phases discussed in Chapter 3. While the remaining construction units of these two construction phases are assumed to be contemporaneous (and occurring before A.D. 1325/1330), the availability of temporal information enables the two construction units in question to be removed from their positions in the relative growth reconstruction and to be placed in the proper position in the actual growth sequence.

Room Block 3 and the Southern Corridor

The best dated single construction unit in the entire site is the central core unit in Room Block 3 (Construction Unit 3-1a). Four of the five rooms in the unit are dated by 18 tree-ring samples (Table 6). The range of construction for the core construction unit (Construction Unit 3-1a) falls between A.D. 1307-1315, which sets the founding date for Room Block 3. Additions to Construction Unit 3-1a, which have dates of A.D. 1309-1327 (Construction Unit 3-2c) and A.D. 1307-1315 (Construction Unit 3-3a), further support the building of Construction Unit 1-3a after A.D. 1300 and prior to A.D. 1315 (Principle 3). Subsequent additions to the early units to the east, west, and to the north of Construction Unit 1-3a are difficult to date since there are no dated dependent units until the addition of Construction Unit 3-8b (A.D. 1331-1340) to the dependent units east of the Construction Unit 1-3a (Figure 19) . The dating of construction in the northeastern portion of the room block suggests that Plaza II was fully demarcated sometime between A.D. 1330-1340, while the date for the final configuration of Plaza II cannot be assigned absolute dates.

In spite of the problems in dating the northern section of Room Block 3, the southern portion of the room block is the most tightly dated of the entire site. As was the case in the dating of Room Block 2, the closing of the corridor is a crucial event in dating the southern section of Room Block 3. The closure date of A.D. 1325 for the southern corridor (Dean and Robinson 1982; Graves 1991; Reid 1973) sets the terminal date for

Construction Unit 3-5h (Figure 19; Principle 3). This unit immediately abuts a construction unit (3-4d) dating from A.D. 1323-1333, thus providing a possible two year range of construction for Construction Unit 3-4d (A.D. 1323-1325) (Principle 3). Construction Unit 3-7e, which is abutted directly to Construction Unit 3-4d, has a date range of A.D. 1313-1323 (Table 6, Figure 19). However, because Construction Unit 3-7e could not have existed prior to the construction of Construction Unit 3-4d (A.D. 1323-1325), its date range is narrowed to a one year span, in A.D. 1323. In other words, the coincidence of the terminal date for Construction Unit 3-7e with the initial date of Construction Unit 3-4d dictates that A.D. 1323 represents the construction date of not only Construction Unit 3-7e but also Construction Unit 3-4d (see also Construction Unit 3-5f and Construction Unit 3-6e; Principle 5).

Past reconstructions of Grasshopper's growth have placed the roofing of the southern corridor at around A.D. 1320 (Dean and Robinson 1982:47; Reid 1973, 1989:83; Reid and Shimada 1982:17). Graves' evaluation of the tree-ring dates further supports this interpretation by suggesting that the corridor was roofed sometime between A.D. 1320 and A.D. 1325 (Graves 1991). Given the preceding discussion of growth in the southern part of Room Block 3, the present analysis provides a more precise estimation of the closure date of the southern corridor by placing the construction of the roof to within a three year span between A.D. 1323-1325. It is proposed that the corridor could not have existed before A.D. 1323 and the tree-ring dates indicate that it could not have been constructed later than A.D. 1325.

The overall growth pattern of Room Block 3 follows that of the two previously discussed room blocks (Figures 22 and 23). The rate of growth is extremely rapid in the early stages of construction followed by a continuously more gradual rate of growth until abandonment. Additions to Construction Unit 3-1a proceed very rapidly to the south of the construction unit, finally closing the southern entrance into the community between A.D. 1323 and 1325. The core units in the northeast section of the room block (Construction Units 3-1b and 3-1c; Figure 19) that bound Plaza II have no initial temporal information but are assumed to have been constructed contemporaneously with Construction Unit 3-1a. Rooms added onto these construction units are terminally dated by the addition of Construction Unit 3-8b, which has a date range from A.D. 1331-1340. Thus, coupled with similar dates from Room Block 2 (see above), the completion of Plaza II probably occurred sometime prior to A.D. 1340 or 1350. Finally, the enclosed space between Room Blocks 2 and 3 known as Plaza I was fully enclosed by no later than A.D. 1325 (Graves 1991; Reid 1973). While the final completion of Plaza I is difficult to estimate because of a lack of terminal dates for the construction units that are added on the inside of the plaza, it probably occurred around the same time as the completion of Plaza II, given that the same construction phases are being added into both spaces (Figure 19).

As was the case in Room Blocks 1 and 2, a complete lack of temporal information in the marginal areas of the room block makes the completion date for Room Block 3 difficult to estimate. Furthermore, unlike the seven total construction phases of Room Block 2, there are 14 construction phases in Room Block 3 and a large section of the room block lacks terminal dates. To the west of Construction Unit 3-1a, there are no dependent dated units and a terminal date of A.D. 1375 is given for all rooms west of Construction Unit 3-3a (Figures 19 and 20). The northwestern corner of Room Block 3 is particularly problematic because Construction Phases 4 through 14 are represented yet no room in this portion of the room block yields a date of any kind. Once again, the construction phase model is applied in order to provide temporal placement for rooms in this section of Room Block 3. It is assumed that units of a particular construction phase were added contemporaneously with all other additions of the same construction phase as these construction units cannot be assigned temporal information by any other means.

Discussion

Dating Construction

Combining Graves' cutting-date estimates with Reid's construction phase model at Grasshopper allows for pueblo growth to be verified and refined in terms of the discussion presented in Chapter 3. While the actual growth reconstruction presented here (see Figures 22 through 24) is by no means a *true* actual growth reconstruction (Chapter 3), several overall trends can be seen. There is strong evidence for rapid early development prior to A.D. 1325 from all three of the room blocks in the main pueblo. By this time, the southern corridor is roofed and Plaza I is fully demarcated. Additionally, there is evidence to suggest that the Great Kiva may have been constructed in Plaza III before A.D. 1330. The definition of Plaza II by architectural units seems to have occurred somewhat later in the sequence, but was probably complete by A.D. 1350. The completion dates for the three room blocks are difficult to estimate due to a lack of terminal dates. The completion date of A.D. 1375 used in this analysis is a rough estimate based on three lines of evidence. First, the early constructions at Grasshopper all occurred within a 25-year period which is well dated (see above). The second line of evidence comes from the construction units around Plaza II, which (when temporal information is available) all date in the A.D. 1330 to 1340 range. This suggests that a second 20- to 25-year growth period occurred beginning before A.D. 1330 and ending with the completion of Plaza II sometime after A.D. 1340. Finally, the late construction dates from the southern end of room block one indicate that some construction activity was occurring at around A.D. 1375, which indicates a third, roughly 25-year period, of community development.

Relative and Actual Growth

At the completion of the analysis, the revised relative growth curves for Grasshopper were plotted including the temporal information obtained from the tree-ring dates. Figures 23 and 24 illustrate the overall pattern and rate of growth at Grasshopper, first by room block and then for the entire core of the site. The growth curves illustrate the rapidity of community development at Grasshopper in the first half of the 14th century. When compared with the relative curves drawn without tree-ring dates (Figures 17 and 18), it is clear that the temporal information causes the curves to compress laterally with the major growth of the site occurring between 1300 and 1325. Differences in intrasite growth are presented in Figure 23, which illustrates the fact that while the three room blocks grow at similar rates, there are subtle differences between the ways in which each develops through time. Room Block 2 appears to grow very rapidly and then levels off relatively early in the sequence, while Room Block 3 displays the most gradual rate of growth. By contrast, Room Block 1 represents the middle range between the two. The only factor that may be influencing this picture somewhat is the lack of closing dates for most of the rooms from Room Blocks 1 and 3, while Room Block 2's overall growth sequence is far more complete.

In building the revised chronology for the main pueblo, the discussion of relative and actual growth in Chapter 3 played an important part. The construction phase model with its assumptions of equal intervals for construction phases and contemporaneity of all units of a single phase was used as a base line for adding the revised tree-ring date estimates provided by Graves (1991). The principles outlined above were also utilized in developing an actual growth reconstruction.

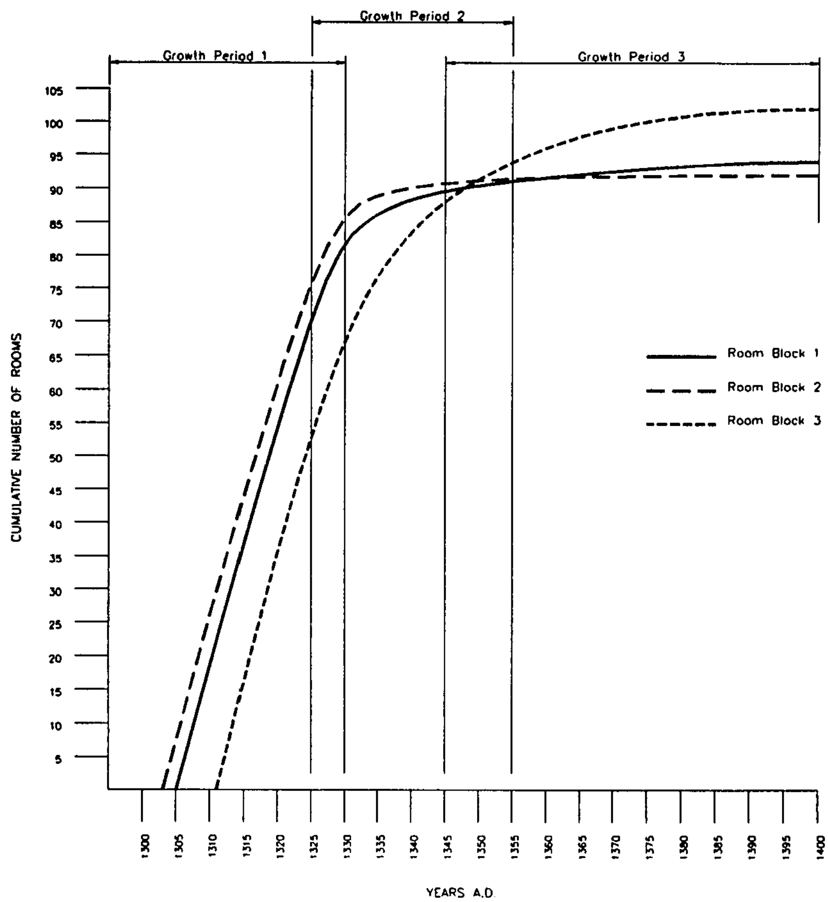

Figure 23.
Actual Growth Curves: Room Blocks 1, 2 and 3

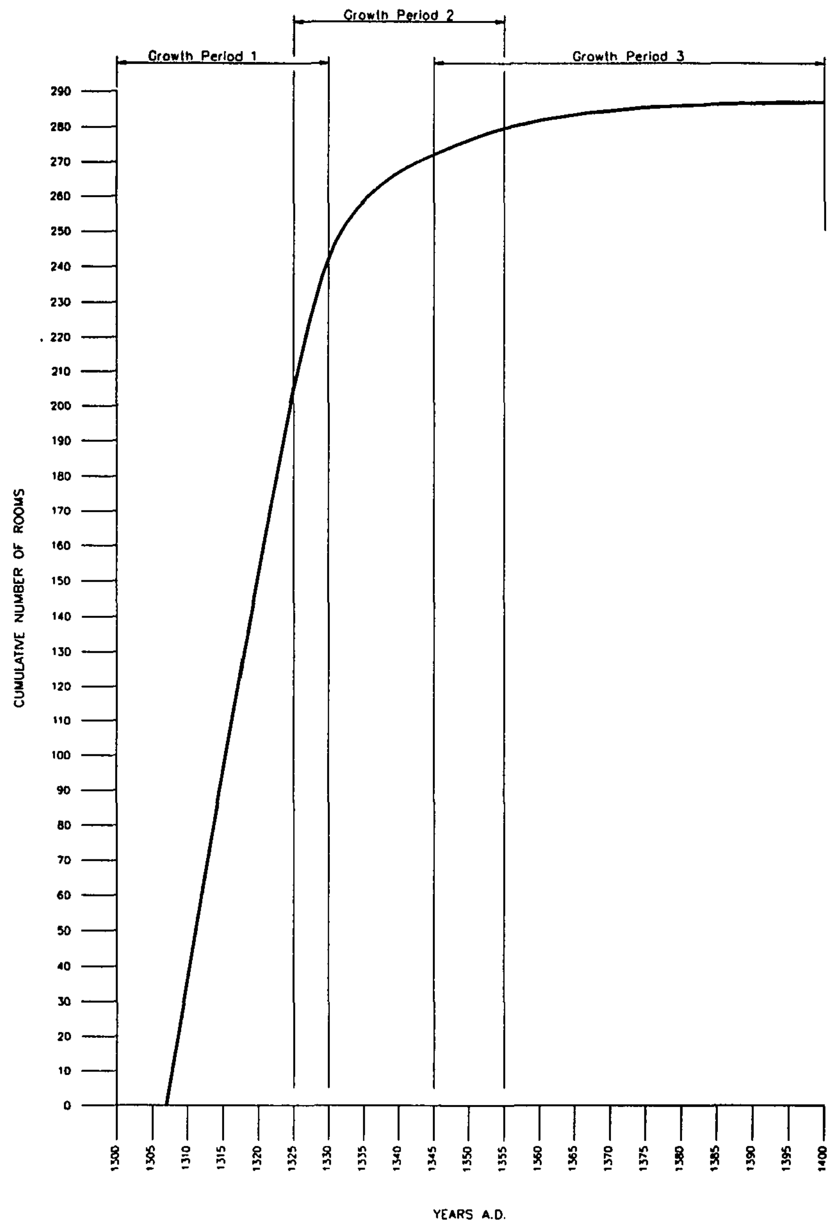

Figure 24. Composite Actual Growth Curve

As discussed in Chapter 3, contemporaneity was assumed for all units in a construction phase, and construction phases were dated based on temporal information for any construction units in that phase. In most cases, when more than one construction unit in a phase could be dated, the dates for each construction unit overlapped and thus reinforced the dating of the phase. By applying the principles for dating individual construction units discussed above to entire construction phases, it was possible to further refine the actual growth sequence. Following Principle 3, all construction *phases* abutted by dated construction phases were assigned the terminal dates of the added phases. If individual construction units in that phase could be dated independently and the logical sequence of construction additions was not violated, those construction units were removed from the phase in question and placed in the proper position in the actual growth sequence.

For example, in Room Block 2, Construction Phases 1 - 5 are all well dated to before A.D. 1330. However, Construction Unit 2-4a dates after A.D. 1330 (Table 6) and is not included in Growth Period 1 with the rest of Construction Phase 4. Additionally, Construction Unit 2-5a is dated after A.D. 1330 (Principle 2) and also is not included with the rest of its construction phase in Growth Period 1. In this case, the addition of Construction Units 2-4a and 2-5a were not terminally dated by any of the construction units that were dated earlier, and removing them temporally from Growth Period 1 did not violate the logical sequence of relative growth. This example illustrates the means by which relative growth reconstructions can be fashioned into actual growth reconstructions. It also points out how construction phases can begin to break down with the addition of temporal information.

To apply the terminology discussed in Chapter 3, the application of Graves' revised construction dates to Reid's construction phases moves the growth sequence for

Grasshopper to a point along the continuum between true relative growth and true actual growth. Although a true actual growth reconstruction can never be developed for Grasshopper, this analysis has indicated that certain parts of the site can be precisely dated in spite of the complete lack of cutting dates

Pueblo Growth

After combining the revised construction dates with the construction phases from Grasshopper, it became apparent that no significant modifications to the overall site chronology were necessary. Figure 22 shows the chronology based on the addition of Graves' cutting-date estimates to the construction phases. Comparison of the chronology presented here with that devised by Reid (Reid 1973; Reid and Shimada 1982) illustrates that the two reconstructions are essentially the same with the exception of the A.D. 1275 establishment date, which is based on evidence for a previous occupation underlying the 14th century constructions (Reid 1989). The earliest dated core unit at Grasshopper is Construction Unit 2-1a in Room Block 2, which is assigned a construction date estimate of A.D. 1298 - 1308 (Table 6, Figure 22). Dates for the other core units, whether directly dated or dated by dependent construction units, all occur after A.D. 1300 (see Construction Unit 3-1a and Construction Unit 1-1a, also Appendix B) while the remaining core units cannot be assigned an initial construction date.

The chronology presented here divides growth at Grasshopper into three growth periods spanning roughly 25 years each. Growth Period 1, which is equivalent to Reid's Expansion Phase (A.D. 1300-1330), dates from A.D. 1298 to A.D. 1325/1330 and includes Construction Phases 1-5 (with the exception of those individual construction units for which contrary temporal information is available, see above). Growth Period 2, comparable to Reid's Dispersion Phase (A.D. 1340 to Abandonment Phase) dates between A.D. 1325/1330 to A.D. 1345/1355 and consists of Construction Phases 6 - 10 (again with the exception of those units with contrary absolute temporal information). Finally Growth Period 3 is roughly synonymous with Reid's Abandonment Phase (Dispersion Phase to A.D. 1400) and dates from A.D 1340/1350 to A.D. 1375/1400 (see above). Figure 22 illustrates both the current chronology as well as provides a map of the individual rooms that are associated with each growth period. Examination of Figure 22 makes it clear that early growth at Grasshopper was very rapid and to some extent guided by a notion of the centrality of public space. The actual growth reconstruction presented here fits in well both with Graves' new tree-ring dates (Graves 1986, 1991), and also with Reid's community growth model which sees a period of rapid expansion followed by a period of slowed growth and eventual abandonment of the community (Reid 1973, 1989; Reid and Shimada 1982).

Summary and Conclusions

Not only is architecture an artifact produced to fulfill the demands of providing and maintaining shelter, it also serves to structure the daily interactions of the people who build and maintain an architectural space. In the early period of southwestern archaeology, architectural analysis was equivalent in importance to the study of other artifactual classes. Subsequent to this early period, however, architecture began to lose some of its importance as an analytical category and became more of a classificatory device important to the identification of cultural and temporal differences. Foreshadowed by the early work of C. Mindeleff (1900), Prudden (1903, 1918) and Steward (1937), and coinciding with the rise of processual archaeology in the 1960's, the focus shifted somewhat to a view of architecture as an indicator of social relationships. As such, a community was viewed as a composite of a number of different social groups each represented by some type of architectural unit. Based on the idea that the added units of construction in a building sequence are representative of a some sort of domestic unit, several models were developed for determining social relationships and community growth.

In the 1980's the focus of archaeology shifted back to the notion of architecture as an artifact. Combining this approach with the models of architectural additions and community growth developed in the 1960's and 1970's enabled the current analysis to view the individual construction units as distinct artifacts that together make up the overall assemblage known as Grasshopper Pueblo.

With the rediscovery of the idea of architecture as artifact, it is now necessary to develop new methods and techniques for analyzing architectural data. One means of providing a more sophisticated architectural analysis is through the use of computer technology. Computer aided drafting programs such as AutoCAD® are not only useful for quantitative analyses which are structured around the measurement of area, distance, and volume, they also lend themselves to architectural studies that call for the classification and control of large sets of data. The use of multiple layers, which can be turned on and off as necessary for analytical and display purposes, allows for the classification of architectural entities on the map itself. Additionally, studies involving stylistic comparisons and analyses of structural and engineering characteristics are also greatly facilitated by the use of computer technology.

For this analysis, AutoCAD® was used primarily as a device for organizing and classifying the various architectural data presented above. The availability of computer drafting allowed for two different growth reconstructions to be presented. For this analysis, growth was conceptualized as being the product of the relationship between time and behavior. This characteristic of community growth follows a basic set of principles that can be used to reconstruct a relative growth sequence. The use of trees as construction materials allows temporal information to then be assigned to the relative growth reconstruction. This dichotomy in the ways in which temporal information is represented allows for community growth to also be viewed in two ways: relative growth and actual growth. Reid's construction phase model was used as a means of reconstructing relative community growth. To this base, Graves' revised construction dates were applied as a means of developing an actual growth sequence for the main pueblo at Grasshopper, and for testing Reid's community growth model. Before this could be done, however, it was necessary to formulate several definitions and principles for applying absolute dates to undated construction units.

Fourteen construction phases were presented for the main pueblo at Grasshopper. These consisted of a total of 127 individual construction units made up of 287 ground floor rooms. Plotting the cumulative curves for relative growth in the main pueblo indicated a three-part division in the growth sequence. The first period consisted of Construction Phases 1-5 and represented rapid early growth. This was followed by an intermediate period made up of Construction Phases 6 and 7 in which a reduction in the rate of community growth was indicated. Finally, the third relative growth period was characterized by very slow growth to no growth at all ending with the abandonment of Grasshopper.

Because adequate temporal information was difficult to retrieve from the site, the application of Graves' revised cutting-date estimates to the construction phases at Grasshopper necessitated that the assumptions of the construction phase model be maintained where adequate temporal information was not available. As a result, the actual growth reconstruction presented did not approach a true actual growth reconstruction. However, the addition of Graves' revised cutting-date estimates to Reid's construction phases did allow for several statements to be made concerning the growth of Grasshopper Pueblo.

The combination of these two data bases indicated that the actual growth reconstruction closely approximated Reid's model of community growth at Grasshopper. A comparison of the relative and actual growth curves indicated that the application of absolute temporal information to the relative sequence caused the actual growth curves to compress laterally, portraying a more rapid rate of community growth. The application of Graves' cutting-date estimates to the construction units at Grasshopper supports previous analyses by indicating a very rapid growth rate for the community. (Ciolek-Torrello 1978; Graves et al. 1982; Longacre 1975, 1976; Reid 1973, 1989). Furthermore, this analysis indicates that community growth at Grasshopper Pueblo may have been more rapid than has been estimated in the past. In fact, Graves proposes that the site was 60 percent complete by A.D. 1325 (Graves 1991:108). The present evaluation indicated a 73 percent level of completion for the main pueblo by A.D. 1325/1330. Although this study focused only on the three large room blocks of the main pueblo and did not consider the outliers or second story rooms, Graves' reconstruction also did not account for second story rooms. Furthermore, the addition of outlying room blocks to the sample probably would not amount to a 13 percent difference given that there is evidence to suggest that some of the outliers were already under construction prior to A.D. 1330 (see Graves 1991:Table IX).

Finally, it was not necessary to revise the overall site chronology in any significant way. Growth was broken down into three growth periods, each spanning about 25 years. Growth Period 1 began around AD. 1300 and ended between A.D. 1325 and 1330. Growth Period 2 began after A.D. 1325 and lasted until as late as A.D. 1355. The final growth period, Growth Period 3, began as early as A.D. 1345 and ended with the final abandonment of the community sometime after A.D. 1375. This revised picture of community growth closely approximates both that put forth by Graves in his reanalysis of the tree-ring material from Grasshopper (Graves 1986, 1991) as well as Reid' s developmental growth model (Reid 1973; Reid and Shimada 1982).

The vast amount of construction data gathered by the University of Arizona Archaeological Field School at Grasshopper has provided both a wealth of information concerning the processes of pueblo growth as well as a framework for the application and use of computerized techniques of analysis. Future research on the architecture of Grasshopper will benefit from this analysis in that a tighter temporal framework will be available for individual rooms than has been accessible in the past. This analysis has joined the revised tree-ring dates established by Graves (1986, 1991) to Reid's construction phase model at Grasshopper Pueblo (Reid 1973). In the course of this endeavor, it has become clear that the construction phase model as applied at Grasshopper is a useful analytical construct for estimating pueblo growth. Although the division of units into phases of typological contemporaneity in itself does not reflect the true rate of actual village growth (Figures 3-16, cf. Figure 22), the individual construction units in almost all instances fit well with Graves' tree-ring estimates. The method used in this analysis has allowed for the chronological placement of undated units of construction based on their relationship to dated construction units. While exact dates still can not be applied to all of the construction units, the method outlined above allows for more formalized application of the principles necessary to solve the chronological problems addressed in this paper. The methods and principles set forth in the preceding pages, although mainly relevant to growth at Grasshopper, could be used in estimating architectural growth at other sites. This method can be used to obtain similar results from extant data bases, or will be useful as a blueprint for subsequent research designs that attempt to target community growth.

APPENDIX A
GRASSHOPPER: MAIN PUEBLO
TREE RING DATES (After Graves 1986)

Room Number	Terminal Date	Species	Stockpiled or Reused	Firewood	Remodeled
8	1309vv	Ponderosa	+		
8	1371vv	Ponderosa	+		
8	1385	Ponderosa			
11	1333vv	Juniper			
11	1375vv	Juniper	+		
18	1204vv	Fir	+		
18	1206vv	Ponderosa	+		
18	1238vv	Ponderosa	+		
18	1269vv	Ponderosa	+		
18	1347vv	Ponderosa	+		
19	1252vv	Ponderosa			
19	1301vv	Ponderosa			
19	1311vv	Ponderosa			
21	1267vv	Ponderosa	+		
21	1288vv	Ponderosa	+		
22	1261vv	Ponderosa	+		
23	1247vv	Juniper	+		
23	1301vv	Ponderosa	+		
23	1311vv	Ponderosa			
23	1312vv	Ponderosa			
23	1318vv	Fir			
23	1319vv	Fir			
26	1300v	Ponderosa	+		
26	1302vv	Pinyon			
26	1303vv	Juniper			
26	1308vv	Juniper			
26	1310vv	Ponderosa			
26	1313vv	Ponderosa			
31	1280++vv	Juniper		+	
33	1243vv	Juniper	+		
33	1305++vv	Juniper			
33	1311vv	Ponderosa			
35	1229vv	Juniper	+		
35	1242vv	Ponderosa	+		
35	1305vv	Juniper			
35	1305++vv	Ponderosa			
35	1306vv	Ponderosa			

Room Number	Terminal Date	Species	Stockpiled or Reused	Firewood	Remodeled
35	1310vv	Ponderosa			
39	1181vv	Ponderosa		+	
39	1278vv	Juniper		+	
39	1282vv	Juniper		+	
42	1329vv	Juniper			
42	1330vv	Juniper			
43	1199vv	Juniper	+		
44	1304vv	Ponderosa			
44	1309vv	Fir			
114	1301vv	Pinyon			
145	1320vv	Ponderosa			
153	1286vv	Ponderosa			
153	1312vv	Ponderosa	+		
153	1312vv	Ponderosa		+	
153	1326vv	Fir			
153	1346vv	Ponderosa			+
164	1298vv	Ponderosa			
183	1294vv	Ponderosa	+		
183	1303vv	Ponderosa	+		
183	1305vv	Ponderosa	+		
183	1305vv	Ponderosa	+		
183	1309vv	Ponderosa	+		
183	1319vv	Ponderosa			
183	1319vv	Ponderosa			
183	1323vv	Ponderosa			
183	1342vv	Fir			+
187	1329vv	Ponderosa			
187	1330vv	Fir			
187	1332vv	Fir			
187	1332v	Fir			
187	1332v	Fir			
197	1237vv	Ponderosa	+		
197	1366vv	Ponderosa			
211	1313vv	Ponderosa			
216	1323vv	Ponderosa			
231	1234vv	Ponderosa	+		
231	1291vv	Ponderosa	+		
231	1298+r	Ponderosa	+		
231	1302vv	Ponderosa			
231	1303vv	Fir			
231	1305vv	Fir			

Room Number	Terminal Date	Species	Stockpiled or Reused	Firewood	Remodeled
246	1228++vv	Fir	+		
269	1240vv	Ponderosa	+		
269	1273vv	Ponderosa	+		
269	1284vv	Ponderosa	+		
269	1287+vv	Ponderosa	+		
269	1293vv	Ponderosa	+		
269	1301vv	Fir			
269	1302+vv	Ponderosa			
269	1305vv	Ponderosa			
269	1307vv	Ponderosa			
269	1325vv	Ponderosa			+
269	1332vv	Ponderosa			+
269	1343vv	Fir			+
270	1198vv	Ponderosa	+		
270	1229vv	Ponderosa	+		
274	1231vv	Fir	+		
274	1302vv	Fir			
279	1265+vv	Pinyon	?	?	
279	1303vv	Ponderosa			
279	1308vv	Ponderosa			
280	1268vv	Ponderosa	+		
280	1297+vv	Ponderosa	+		
280	1309vv	Juniper			
280	1373vv	Fir			+
438	1274+vv	Ponderosa	+		
438	1331vv	Ponderosa			
Corridor	1090vv	Ponderosa	+		
Corridor	1101vv	Ponderosa	+		
Corridor	1129vv	Ponderosa	+		
Corridor	1184vv	Ponderosa	+		
Corridor	1190vv	Ponderosa	+		
Corridor	1240vv	Ponderosa	+		
Corridor	1248vv	Ponderosa	+		
Corridor	1253vv	Ponderosa	+		
Corridor	1271vv	Ponderosa	+		
Corridor	1291vv	Fir	+		
Corridor	1293vv	Ponderosa	+		
Corridor	1304vv	Ponderosa	+		
Corridor	1308vv	Ponderosa	+		
Corridor	1311vv	Ponderosa			
Corridor	1314vv	Ponderosa			

Room Number	Terminal Date	Species	Stockpiled or Reused	Firewood	Remodeled
Corridor	1315vv	Ponderosa			
Corridor	1315vv	Ponderosa			
Corridor	1317vv	Ponderosa			
Corridor	1318vv	Fir			
Corridor	1318vv	Ponderosa			
Corridor	1318vv	Ponderosa			
Corridor	1318vv	Fir			
Corridor	1318vv	Ponderosa			
Corridor	1318vv	Fir			
Corridor	1319vv	Fir			
Corridor	1320vv	Ponderosa			
Corridor	1320vv	Fir			
Corridor	1333vv	Ponderosa			+
Great Kiva	1190vv	Ponderosa		+	
Great Kiva	1194vv	Ponderosa		+	
Great Kiva	1194vv	Ponderosa		+	
Great Kiva	1200vv	Ponderosa		+	
Great Kiva	1205vv	Ponderosa	+		
Great Kiva	1208vv	Ponderosa	+		
Great Kiva	1209vv	Ponderosa		+	
Great Kiva	1225vv	Ponderosa	+		
Great Kiva	1226vv	Pinyon		+	
Great Kiva	1253vv	Juniper	+		
Great Kiva	1267vv	Pinyon		+	
Great Kiva	1272vv	Pinyon		+	
Great Kiva	1273vv	Pinyon		+	
Great Kiva	1287vv	Pinyon	+		
Great Kiva	1309vv	Fir	+		
Great Kiva	1321vv	Ponderosa	+		
Great Kiva	1336vv	Fir			
Great Kiva	1347vv	Ponderosa			
Great Kiva	1347vv	Fir			
Great Kiva	1353vv	Pinyon			

APPENDIX B
DATES FOR ROOMS IN THE MAIN PUEBLO

Room	Date(s)	Unit Designation	Associated Rooms
2	1305-1375	1-1b	7, 10, 15, 104, 107
4	1375-1400	1-12a	none
5	1375-1400	1-6e	none
6	1305-1375	1-1c	none
7	1305-1375	1-1b	2, 10, 15, 104, 107
8	1385-1400	1-11a	none
10	1305-1375	1-1b	2, 7, 15, 104, 107
11	1375-1395	1-4h	97
12	1313-1338	2-5c	16, 18, 153, 304
13	1311-1338	2-4c	156, 303
14	1320-1330	2-5b	20, 143, 145, 147, 162, 163, 197
15	1305-1375	1-1b	2, 10, 15, 104, 107
16	1313-1338	2-5c	12, 18, 153, 304
18	1313-1338	2-5c	12, 16, 153, 304
19	1311-1321	2-4b	146, 152, 193
20	1320-1330	2-5b	14, 143, 145, 147, 162, 163, 197
21	1319-1330	2-3d	22, 23
22	1319-1330	2-3d	21, 23
23	1319-1330	2-3d	21, 22
26	1313-1322	2-2d	27
27	1313-1322	2-2d	26
28	1311-1325	1-5a	29, 33
29	1311-1325	1-5a	28, 33
30	1320-1375	1-6a	31,36
31	1320-1375	1-6a	30,36
32	1310-1325	1-4a	none
33	1311-1325	1-5a	28, 29
34	1310-1321	1-3a	35
35	1310-1321	1-3a	34
36	1320-1375	1-6a	30, 31
37	1310-1375	1-8a	none
38	1310-1375	1-7a	none
39	1310-1321	1-7b	none
40	1310-1321	1-6b	41, 42, 43
41	1310-1321	1-6b	40, 42, 43
42	1310-1321	1-6b	40, 41, 43
43	1310-1321	1-6b	40, 41, 42

Room	Date(s)	Unit Designation	Associated Rooms
44	1310-1321	1-5b	none
45	1310-1321	1-4c	none
46	1305-1321	1-1a	47, 52, 60, 61, 68, 69, 74, 82, 83
47	1305-1321	1-1a	46, 52, 60, 61, 68, 69, 74, 82, 83
48	1305-1325	1-2a	49, 50
49	1305-1325	1-2a	48, 50
50	1305-1325	1-2a	48, 49
51	1307-1340	3-7b	none
52	1305-1321	1-1a	46, 47, 60, 61, 68, 69, 74, 82, 83
53	1305-1325	1-2b	59, 62
54	1305-1375	1-3b	55, 56, 58, 63
55	1305-1375	1-3b	54, 56, 58, 63
56	1305-1375	1-3b	54, 55, 58, 63
57	1305-1375	1-4d	64
58	1305-1375	1-3b	54, 55, 56, 63
59	1305-1325	1-2b	53, 62
60	1305-1321	1-1a	46, 47, 52, 61, 68, 69, 74, 82, 83
61	1305-1321	1-1a	46, 47, 52, 60, 68, 69, 74, 82, 83
62	1305-1325	1-2b	53, 59
63	1305-1375	1-3b	54, 55, 56, 58
64	1305-1375	1-4d	57
65	1305-1375	1-5d	none
66	1305-1375	1-4e	67
67	1305-1375	1-4e	66
68	1305-1321	1-1a	46, 47, 53, 60, 61, 69, 74, 82, 83
69	1305-1321	1-1a	46, 47, 53, 60, 61, 68, 74, 82, 83
70	1305-1375	1-2c	75
71	1305-1375	1-3c	72, 73
72	1305-1375	1-3c	71, 73
73	1305-1375	1-3c	71, 72
74	1305-1321	1-1a	46, 47, 53, 60, 61, 68, 69, 82, 83
75	1305-1375	1-2c	70
76	1305-1375	1-4f	none
77	1305-1375	1-5e	none
78	1305-1375	1-6c	none
79	1305-1375	1-7c	none
80	1305-1375	1-6d	none
81	1305-1375	1-3d	none
82	1305-1321	1-1a	46, 47, 53, 60, 61, 68, 69, 74, 83
83	1305-1321	1-1a	46, 47, 53, 60, 61, 68, 69, 74, 82
84	1305-1375	1-2d	85, 86, 87

Room	Date(s)	Unit Designation	Associated Rooms
85	1305-1375	1-2d	84, 86, 87
86	1305-1375	1-2d	84, 85, 87
87	1305-1375	1-2d	84, 85, 86
88	1305-1375	1-4g	89
89	1305-1375	1-4g	88
90	1305-1400	1-5f	90
92	1375-1400	1-5g	none
93	1305-1395	1-3e	94, 95
94	1305-1395	1-3e	93, 95
95	1305-1395	1-3e	93, 94
96	1375-1400	1-5h	none
97	1375-1395	1-4h	11
98	1375-1400	1-10a	none
99	1375-1400	1-9a	none
100	1375-1400	1-7d	none
101	1375-1400	1-8b	none
102	1375-1400	1-9b	none
103	1305-1400	1-2e	none
104	1305-1375	1-1b	2, 7, 10, 15, 107
105	1375-1400	1-10b	none
106	1375-1400	1-11b	none
107	1305-1375	1-1b	2, 7, 10, 15, 104
108	1375-1400	1-13a	none
118	1310-1375	1-4b	119, 122, 123
119	1310-1375	1-4b	118, 122, 123
120	1310-1375	1-5c	121
121	1310-1375	1-5c	120
122	1310-1375	1-4b	118, 119, 123
123	1310-1375	1-4b	118, 119, 122
125	1298-1375	2-4d	none
126	1298-1375	2-5d	none
127	1298-1375	2-3e	none
128	1298-1375	2-2e	129, 130
129	1298-1375	2-2e	128, 130
130	1298-1375	2-2e	128, 129
131	1298-1322	2-1b	132, 133, 134, 135, 136, 137, 138, 139, 140, 142
132	1298-1322	2-1b	131, 133, 134, 135, 136, 137, 138, 139, 140, 142
133	1298-1322	2-1b	131, 132, 134, 135, 136, 137, 138, 139, 140, 142

Room	Date(s)	Unit Designation	Associated Rooms
134	1298-1322	2-1b	131, 132, 133, 135, 136, 137, 138, 139, 140, 142
135	1298-1322	2-1b	131, 132, 133, 134, 136, 137, 138, 139, 140, 142
136	1298-1322	2-1b	131, 132, 133, 134, 135, 137, 138, 139, 140, 142
137	1298-1322	2-1b	131, 132, 133, 134, 135, 136, 138, 139, 140, 142
138	1298-1322	2-1b	131, 132, 133, 134, 135, 136, 137, 139, 140, 142
139	1298-1322	2-1b	131, 132, 133, 134, 135, 136, 137, 138, 140, 142
140	1298-1322	2-1b	131, 132, 133, 134, 135, 136, 137, 138, 139, 142
141	1298-1330	2-2c	none
142	1298-1322	2-1b	131, 132, 133, 134, 135, 136, 137, 138, 139, 140
143	1320-1330	2-5b	14, 20, 145, 147, 162, 163, 197
144	1320-1375	2-6b	none
145	1320-1330	2-5b	14, 20, 143, 147, 162, 163, 197
146	1311-1321	2-4b	19, 152, 193
147	1320-1330	2-5b	14, 20, 143, 145, 162, 163, 197
148	1298-1308	2-1a	149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
149	1298-1308	2-1a	148, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
150	1298-1308	2-1a	148, 149, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
151	1298-1321	2-2b	158, 171
152	1311-1321	2-4b	19, 146, 193
153	1313-1338	2-5c	12, 16, 18, 304
154	1311-1338	2-4c	13, 303
155	1311-1321	2-3c	156, 157
156	1311-1321	2-3c	155, 157
157	1311-1321	2-3c	155, 156
158	1298-1321	2-2b	151, 171

Room	Date(s)	Unit Designation	Associated Rooms
159	1298-1308	2-1a	148, 149, 150, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
160	1298-1308	2-1a	148, 149, 150, 159, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
161	1298-1308	2-1a	148, 149, 150, 159, 160, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
162	1320-1330	2-5b	14, 20, 143, 145, 147, 163, 197
163	1320-1330	2-5b	14, 20, 143, 145, 147, 162, 197
164	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
165	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
166	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
167	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
168	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 169, 170, 174, 175, 176, 177, 178, 179, 180, 181
169	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 170, 174, 175, 176, 177, 178, 179, 180, 181
170	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 174, 175, 176, 177, 178, 179, 180, 181
171	1298-1321	2-2b	151, 158
172	1323-1375	2-3b	173, 182
173	1323-1375	2-3b	172, 182
174	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 175, 176, 177, 178, 179, 180, 181

Room	Date(s)	Unit Designation	Associated Rooms
175	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 176, 177, 178, 179, 180, 181
176	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 177, 178, 179, 180, 181
177	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 178, 179, 180, 181
178	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 179, 180, 181
179	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 180, 181
180	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 181
181	1298-1308	2-1a	148, 149, 150, 159, 160, 161, 164, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 179, 180
182	1323-1375	2-3b	172, 173
183	1323-1333	2-2a	184, 185, 186
184	1323-1333	2-2a	183, 185, 186
185	1323-1333	2-2a	183, 184, 186
186	1323-1333	2-2a	183, 184, 185
187	1332-1344	2-4a	188
188	1332-1344	2-4a	187
189	1323-1344	2-3a	299, 300, 301, 302, 190
190	1323-1344	2-3a	299, 300, 301, 302, 189
191	1332-1375	2-5a	192
192	1332-1375	2-5a	192
193	1311-1321	2-4b	19, 146, 152
197	1320-1330	2-5b	14, 20, 143, 145, 147, 162, 163
201	1323-1375	3-10d	none
202	1323-1375	3-8e	none
203	1323-1325	3-5h	204, 273, 289
204	1323-1325	3-5h	203, 273, 289
205	1323-1375	3-9f	none
206	1323	3-7e	211, 215, 218

Room	Date(s)	Unit Designation	Associated Rooms
207	1323	3-4d	212, 216, 219, 221, 224
208	1323-1375	3-6f	213, 242
209	1323-1375	3-10c	none
210	1323-1375	3-8d	none
211	1323	3-7e	206, 215, 218
212	1323	3-4d	207,216, 219, 221, 224
213	1323-1375	3-6f	208, 242
214	1323-1375	3-9e	none
215	1323	3-7e	206, 211, 218
216	1323	3-4d	207, 212, 219, 221, 224
217	1323-1375	3-5g	none
218	1323	3-7e	206, 211, 215
219	1323	3-4d	207, 212, 216, 221, 224
220	1323	3-6e	none
221	1323	3-4d	207, 212, 216, 219, 224
222	1323-1375	3-6d	none
223	1323	3-5f	none
224	1323	3-4d	207, 212, 216, 219, 221
225	1307-1340	3-5e	none
226	1307-1323	3-4c	none
227	1307-1317	3-3b	231, 234
228	1323-1375	3-5d	235, 239, 260
229	1307-1375	3-13c	none
230	1307-1375	3-5c	none
231	1307-1317	3-3b	227, 234
232	1307-1375	3-12c	none
233	1307-1375	3-10b	none
234	1307-1317	3-3b	227, 231
235	1323-1375	3-5d	228, 239, 260
236	1307-1375	3-11b	none
237	1307-1375	3-9b	none
238	1307-1317	3-2b	none
239	1323-1375	3-5d	228, 235, 260
240	1323-1375	3-6c	none
241	1323-1375	3-7d	none
242	1323-1375	3-6f	208, 213
243	1307-1375	3-12b	none
244	1307-1375	3-10a	none
245	1307-1375	3-8a	252
246	1307-1315	3-1a	269, 270, 278, 279
247	1309-1328	3-2c	248, 249, 280

Room	Date(s)	Unit Designation	Associated Rooms
248	1309-1328	3-2c	247, 249, 280
249	1309-1328	3-2c	247, 248, 280
250	1307-1375	3-13b	none
251	1307-1375	3-11a	none
252	1307-1375	3-8a	245
253	1307-1375	3-7a	258
254	1307-1375	3-5a	259, 265, 266, 267, 271
255	1307-1375	3-14a	none
256	1307-1375	3-12a	none
257	1307-1375	3-9a	262
258	1307-1375	3-7a	253
259	1307-1375	3-5a	254, 265, 266, 267, 271
260	1323-1375	3-5d	228, 235, 239,
261	1307-1375	3-13a	none
262	1307-1375	3-9a	257
263	1307-1375	3-6a	264
264	1307-1375	3-6a	263
265	1307-1375	3-5a	254, 259, 266, 267, 271
266	1307-1375	3-5a	254, 259, 265, 267, 271
267	1307-1375	3-5a	254, 259, 265, 266, 271
268	after 1307	3-4b	none
269	1307-1315	3-1a	246, 270, 278, 279
270	1307-1315	3-1a	246, 269, 278, 279
271	1307-1375	3-5a	254, 259, 265, 266, 267
272	1307-1340	3-4a	none
273	1323-1325	3-5h	203, 204, 289
274	1307-1315	3-3a	276
275	1307-1315	3-2a	277
276	1307-1315	3-3a	274
277	1307-1315	3-2a	275
278	1307-1315	3-1a	246, 269, 270, 279
279	1307-1315	3-1a	246, 269, 270, 278
280	1309-1328	3-2c	247, 248, 249
281	1307-1340	3-1b	282, 283, 284
282	1307-1340	3-1b	281, 283, 284
283	1307-1340	3-1b	281, 282, 284
284	1307-1340	3-1b	281, 282, 283
285	1307-1340	3-5b	none
286	1307-1340	3-6b	287
287	1307-1340	3-6b	286
288	1307-1340	3-1c	292, 293, 294, 295

Room	Date(s)	Unit Designation	Associated Rooms
289	1323-1325	3-5h	203, 204, 273
290	1323-1325	3-6g	none
291	1307-1340	3-7c	none
292	1307-1340	3-1c	288, 293, 294, 295
293	1307-1340	3-1c	288, 292, 294, 295
294	1307-1340	3-1c	288, 292, 293, 295
295	1307-1340	3-1c	288, 292, 293, 294
297	1323-1375	3-8c	none
298	1323-1375	3-9d	none
299	1323-1344	2-3a	300, 301, 302, 189, 190
300	1323-1344	2-3a	299, 301, 302, 189, 190
301	1323-1344	2-3a	299, 300, 302, 189, 190
302	1323-1344	2-3a	299, 300, 301, 189, 190
303	1311-1338	2-4c	13, 156
304	1313-1338	2-5c	12, 16, 18, 153
305	1320-1375	2-7a	307, 308
306	1320-1375	2-6a	none
307	1320-1375	2-7a	305, 308
308	1320-1375	2-7a	305, 307
438	1331-1340	3-8b	439
439	1331-1340	3-8b	438
440	1331-1375	3-9c	none
Corridor	1323-1325	n/a	none
Great Kiva	1320-1360+	n/a	none

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