Fingerprints in the Landscape

Cultural Evolution in the North Rio Grande

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0 Abstract

The paper considers how the application of syntax syntax methods can aid archaeologists in discerning unobservable changes in social organisation from observed changes in the spatial configuration of prehistoric settlements. Although the prehistoric architecture of a group of Native Americans of the American Southwest, known as the Amasazi, has been studied for over 100 years, most studies have focused upon descriptions, measurements, and counts without attempting to explain fundamental relationships between the built environment and the social environment. In the simplest terms, architecture impresses a fingerprint upon the landscape. The particular fingerprint to which space syntax is applied is Arroyo Hondo Pueblo, located near Santa Fee, New Mexico. The analysis focuses upon room arrangements and connections within a series of individual room blocks. The numerical values obtained through space syntax analysis indicate that the use of space changed over time at Arroyo Hondo from a relatively more integrated, or accessible, to a more segregated, or inaccessible form. In addition, certain public area (plazas) became increasingly important as integrating spaces within the settlement as a whole. It is argued that the changes in the use of space mirrors changes in social organisation and that space syntax provides a degree of sensitivity to detail that is not available through traditional archaeological approaches.

1 Introduction

Despite a plethora of theories purporting to explain the relationship between social organization and spatial organization (e.g., Lawrence and Low, 1990; Rapoport, 1969a; Pearson and Richards, 1994), most efforts result in descriptions about the use of space without presenting a coherent procedure for studying the problem. Few theories about the built environment offer any methods with which to investigate the processes of architectural and social change beyond the assumption that social groups manipulate space in order to serve social needs. Space syntax analysis is a tool that permits such study by measuring how architectural forms direct and control social encounters as well as physical movement. Although developed primarily with reference to contemporary and historical contexts (Hillier and Hanson, 1984; Hillier, Hanson and Peponis, 1987; Orhun, Hillier and Hanson, 1995), space syntax analysis has attracted some notice among archaeologists (e.g., Banning and Byrd, 1989; Bonanno, Gouder, Malone and Stoddart, 1990; Chapman, 1990; Bradley, 1993; Ferguson, 1993; Laurence, 1994; Cooper, 1995). Standing alone, space syntax can analyse the potential for movement or communication within any system of nodes and linkages, but when coupled with the appropriate contextual information, it can be used to gain insights into the social organization of the groups responsible for arranging the observable architectural patterns. The challenge for archaeologists is in finding situations where the archaeological record is sufficiently developed so as to permit the application of the analytical methods and achieve meaningful results. Notwithstanding over 100 years of detailed descriptions, only a handful of archaeological studies in the American Southwest have successfully drawn substantial information concerning social organization from the well-preserved architectural remains that dot the landscape. Many earlier studies focused on large and well-preserved masonry structures, such as those found at Chaco Canyon, New Mexico (Vivian, 1990) , Mesa Verde, Colorado (Prudden, 1903) , or Wupatki, Arizona (Wilcox, 1975) . This paper focuses upon the northern Rio Grande region (see Figure 1) which has a long history of excavation (Nelson, 1914; Jeancon, 1923; Roberts, 1935; Cordell, 1980), but where few studies have attempted to glean social information from the architectural remains of prehistoric settlements.

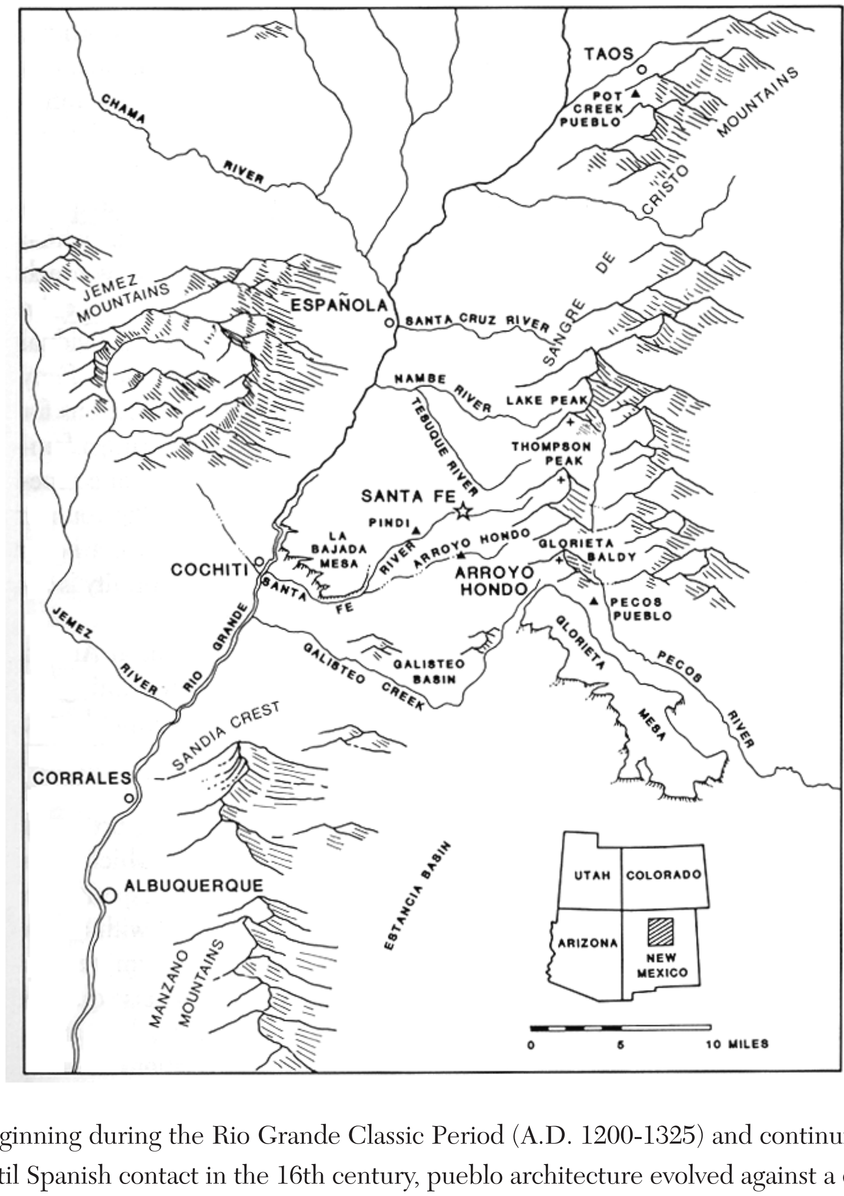


Figure 1.Location of Arroyo Hondo in the Northern Rio Grande Region

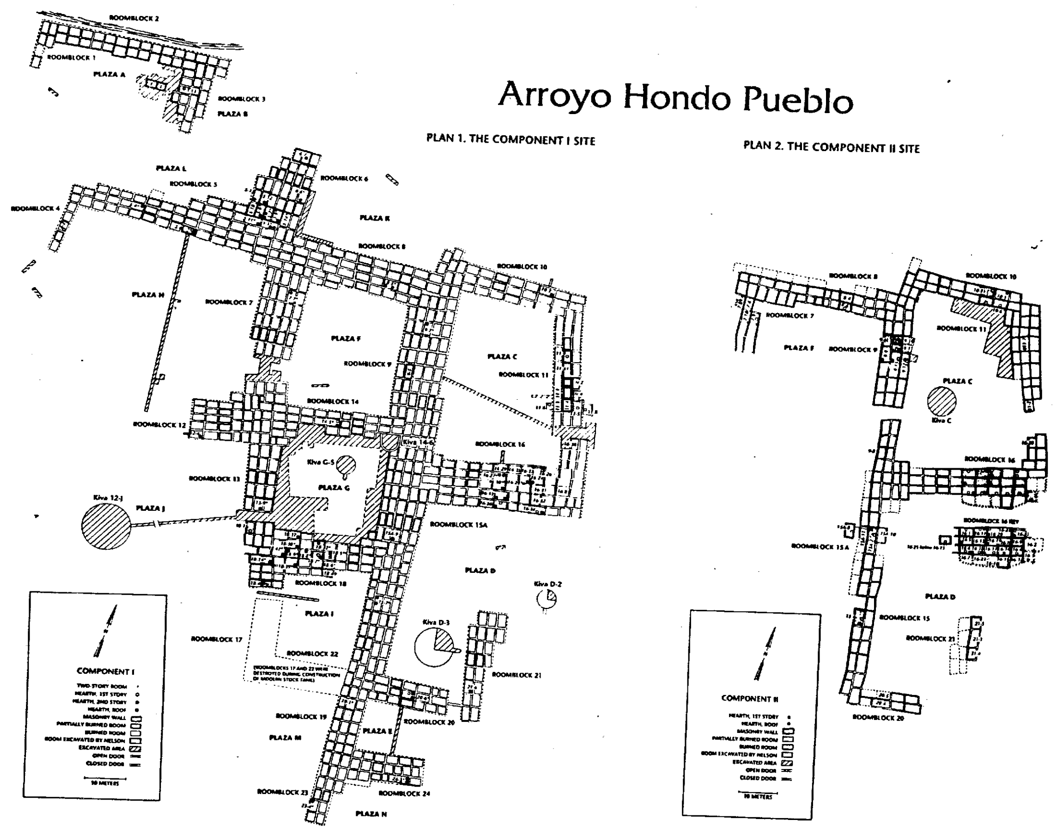
Figure 1 is reprinted by permission, from Food, Diet, and Population at Prehistoric Arroyo Hondo Pueblo *by Wilma Wetterstrom, (Figure 1, page 7). Map by Gigi Bayliss. © 1986 by the School of American Research, Santa Fe.*

Beginning during the Rio Grande Classic Period (A.D. 1200-1325) and continuing until Spanish contact in the 16th century, pueblo architecture evolved against a dynamic backdrop of demographic and social changes. Primarily as the result of in-migration, local populations both increased and aggregated into large settlements in which numbers of roomblocks were orthogonally arranged around one or more public plazas (Crown, Orcutt and Kohler, 1996). Pueblo architecture has been described as the irregular arrangement of regular forms in sequences that respond to critical needs such as shelter, defense or spiritual well-being (Hieb, 1992; Swentzell, 1992;

Wilcox and Haas, 1994) . In its simplest terms, all architecture impresses a social "fingerprint" upon the landscape. This study suggests that space syntax analysis is one way to "read" those fingerprints in the archaeological record, and the particular fingerprint to which the methodology is applied is Arroyo Hondo Pueblo, a 14th-15th century site located approximately 6 miles south of Santa Fe, New Mexico.

2 Case Study of Arroyo Hondo Pueblo

Arroyo Hondo Pueblo is an excellent site with which to compare architectural and organizational changes because its periods of occupation bridge the gap between the Rio Grande Coalition (A.D. 1200-1325) and Classic (A.D.1325-1600) Periods. Archaeological evidence reveals that Arroyo Hondo experienced two distinct occupations (identified as Components I and II) (see Figure 2) that were separated by approximately 25-30 years during which time the site was abandoned (Creamer, 1993). The two occupations (A.D. 1300-1345; A.D. 1370-1425) straddle the interface between the Rio Grande Coalition and Classic periods. Space syntax analysis reveals real and substantial differences in the manner in which space was organized during the two components, including a significant shift towards more "privacy" during the Component II occupation.



The fact that the occupation history of a well-excavated archaeological site straddles a dynamic period when major changes occurred in demographics, social organization and architecture, makes it a particularly good case study for applying methods that can relate observable architectural forms to unobservable forms of social organization. The existence of two separate and definable building periods provides an opportunity to examine a single settlement simultaneously from both a synchronic and diachronic perspective. Unlike pueblo sites such as Pecos, NM (Kidder, 1958) , Taos, NM (Reynolds, 1981) , and San Marcos, NM (Lycett, 1994) , which have long

Figure 2 is reprinted by permission, from The Architecture of Arroyo Hondo Pueblo, New Mexico *by Winifred Creamer (insert). Map drawn by Katrina Lasko. © 1993 by the School of American Research, Santa Fe.*

and sometimes complicated histories of occupation, modification and successive construction, Arroyo Hondo's two occupations are clearly defined and recorded through tree-ring and archaeomagnetic dates (Creamer, 1993:139-140, 156-164) . To the extent that architectural variables can be controlled in order to investigate change at a particular place and time, Arroyo Hondo is probably one of the more unique sites in the Southwest.

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Although this study is not the first to apply space syntax analysis in the context of Southwest archaeology (Bradley, 1993; Ferguson, 1993; Bustard, 1995; Cooper, 1995) , it is the first application to a large site in the northern Rio Grande. Archaeological investigation has already revealed a number of things about Arroyo Hondo's social organization (Creamer, 1993; Habicht-Mauche, 1993; Wetterstrom, 1986; Palkovich, 1980) and this study demonstrates how space syntax analysis can build upon an existing base of knowledge. Material culture is more than a simple text to be read and the richness of the social fabric of life at Arroyo Hondo Pueblo cannot be recovered entirely from walls, doorways and plazas. Nonetheless, a quantifiable, syntactic approach can illuminate ideas about life within the pueblo that are not otherwise accessible through either traditional archaeological or cognitive approaches and yet may work in concert with both.

3 Syntactic Analysis of Individual Roomblocks

In space syntax terms, the analysis of individual roomblocks within a pueblo is akin to looking at access patterns in a series of large houses. Cooper (1995) has demonstrated the efficacy of this approach with respect to Chacoan great houses by considering the ways that rooms are arranged within the buildings, together with the kinds of access routes that room configurations provide. An adjunct consideration is what these patterns express in terms of the social relations among residents and visitors. The application of space syntax to pueblo archaeological sites obliges one to address concerns relating to room usage and abandonment as well as the problem of determining movement among residence units. For example, during the Component II occupation when the majority of excavated rooms do not have doorways to indicate inter-room connections, there is a working assumption that two rooms, consisting of a living room and a storage room, comprised a residence unit (Creamer, 1993:130) . While this inference is well supported by excavation data, it does not resolve different questions regarding intra-roomblock movement and access. The problem can be illustrated by considering potential movement through a typical roomblock. Figure 3 represents a series of interconnected interior rooms that presumably had access to a plaza. In the absence of any doorways leading to the plaza, access must have been via ladders and rooftops. The question then becomes "Which roof can one cross?" The issue is further complicated by the archaeological fact that inasmuch as not all rooftops reveal evidence of domestic use, some rooftops were more likely to be used as transitional spaces than others. Stated in terms of ethnographic analogy, the question can be posed as to whether rooftop areas at Arroyo Hondo were more akin to the public walkways that Kroeber noted at Zuni (Kroeber, 1917:189) , or the individual front yards that Mindeleff found among the Hopi (Mindeleff, 1891:151) . Using historical maps and photographs of Zuni Pueblo, Dohm (1996) appears to dispute Kroeber and support Mindeleff when she concludes that "architecturally, the roofs are more or less private and the way rooftops are used is more or less private" (Dohm 1996:89). In addition to being used as "yards," Mindeleff noted other kinds of uses for rooftop areas that suggest potential impediments to unrestricted walking.

Even their [first floor room] roofs are largely utilized for the temporary storage of many household articles, and in the autumn, after the harvests have been gathered, the terraces and copings are often covered with drying peaches, and the peculiar long strips into which pumpkins and squash have been cut to facilitate their desiccation for winter use. Among other things the household supply of wood is sometimes piled up at one end of this terrace, but more commonly the natives have so many other uses for this space that the sticks of fuel are piled up on a rude projecting skeleton of poles, supported on one side by two upright forked sticks set into the ground, and on the other resting upon the stone coping of the wall. (Mindeleff 1891:103) .

Unfortunately, the archaeological record is not so complete so as to enable evidence of all of the foregoing kinds of activities to survive. Where there is evidence of doorways between first-floor rooms, there is an inference of potential movement between them. A corollary assumption, illustrated in Figure 3, is that rooftop movement follows the same pattern (Cooper, 1995:280) .

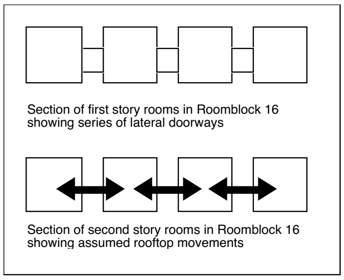

Figure 3. Illustration of Rooftop Movement.

In situations in which there is evidence of wall vents between two rooms, a similar assumption is made, namely that the existence of such vents (Creamer, 1993:113-116) implies enough of a connection between rooms so that movement across the roofs of vent-linked rooms is more likely than not. Inasmuch as vents may have functioned as a means of air circulation as well as sources of communication between rooms, their presence may reflect extended familial or some other kind of social connection between rooms. This assumption is buttressed by ethnographic information that describes how rooms were added onto an existing residences in order to accommodate growing households or married children (Mindeleff, 1891:102; Reynolds, 1981) . Where there are neither doors nor vents to suggest connections between rooms, it is assumed that interior rooms were accessible from plazas according to the shortest direct route across rooftops. This assumption includes the probability that people followed first-story rooftops and went around, as opposed to up and over, second-story spaces.

Finally, there are considerations underlying the manner in which space syntax analysis treats plaza space. Ethnographically, plazas represent much more than mere open space and have very strong ideological as well as functional associations (Hieb, 1992; Iowa, 1985; Scully, 1975; Swentzell, 1988, 1992) . The plazas associated with both occupations at Arroyo Hondo were heavily used, and any doubts about the efficacy of including plazas within the ambit of "built space" for the purposes of syntactic analysis should be eliminated in light of the architectural evidence.

Numerous features indicate that a variety of domestic activities took place in plazas; features included mealing areas, ovens, turkey pens, basins, dividing walls, ramadas or portales, and numerous burials (Palkovich 1980). Use of plazas for religious activities is indicated by the location of [semi-subterranean ceremonial] kivas in several of these open areas (Creamer, 1993:57) .

One might criticize the treatment of plazas as single unified spaces in light of evidence suggesting demarcated subdivisions within them (Creamer, 1993:72-73) . Some activities, such as burials and food preparation, undoubtedly had a spatial component in the sense that they were conducted in close proximity to roomblocks (Creamer, 1993:70, 76, 82, 87), whereas other activities occurred in a variety of locations within plazas. For the present analysis, the archaeological evidence is insufficiently fine-grained to justify any spatial subdivision within plazas and they are treated as single, indivisible spatial units.

3.1 Roomblock 16- Component I

The single most extensively excavated roomblock is roomblock 16, which was initially built during Component I and then rebuilt during Component II. Although this paper discusses only the details associated with roomblock 16, the complete study involves a series of sampled roomblocks, as reflected in Tables 1 and 2. Figure 4 is a schematic map of portions of roomblock 16, Component I, showing the relationships between the built spaces. A total of 15 rooms were excavated and there are several adjacent rooms about which some information is known (such as the presence of doorways), but which were not otherwise excavated. A number of second-story spaces have been identified (shaded portion on Figure 4) that form a group along the middle of the long axis of the roomblock. Archaeological evidence indicates that all of the second-floor rooms were living (habitation) rooms, a conclusion that is consistent with ethnographic information (Mindeleff, 1891; Morgan, 1881) . Regardless of the existence of several interconnecting doorways among first-floor rooms, the second-story rooms were all isolated in the sense that no second-story doorways were discovered, suggesting that entry into upper-story rooms would have been exclusively through floor and ceiling hatchways.

A distinguishing feature of this roomblock is the presence of lateral doorways. Cooper comments upon similar doorways in her analysis of Chacoan great houses and observes that such features not only permit a substantial amount of depth to develop in a relatively limited area, but also establish a pattern of alternative paths or circuits through the structure that are associated with higher levels of integration (Cooper, 1995). Component I is very different from Component II, in which both front-to-back connections and rooftop activity areas are more prevalent. Some of these observed differences may be the result of differential survival of components in the archaeological record but the impact of such differential survival is highly speculative. The suggested location of entry ladders (reflecting rooftop entries) is conservative and if additional ladder entries are added, particularly from plaza D (about which little information is available), such additions would tend to increase integration (i.e., the RRA values would be lower). In other words, to the extent that Component I roomblocks in general and roomblock 16 in particular exhibit a tendency towards more integration, these values are probably understated because of the incompleteness of the archaeological record.

Figure 5 is a partially justified access graph for roomblock 16, Component I. The access pattern is essentially symmetric and distributed, and while this graph is not the only possible set of connections, it represents a reasonable fit between potential access routes and the location of roomblock spaces. In this case, adding or eliminating one or two connections does not fundamentally alter the nature of the network, as the basic pattern of rings and depths is quite persistent. The primary space syntax measure used to analyse and differentiate the roomblocks is the integration value

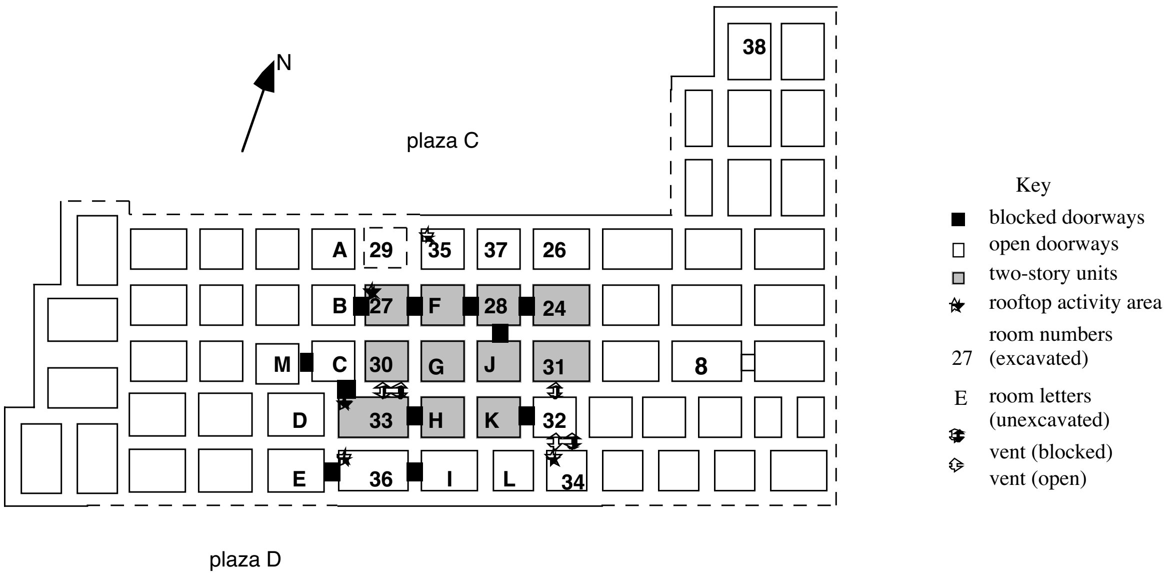

Figure 4. Roomblock 16, Component I Adapted from Creamer 1993: 113-114, 178-183.

formerly identified as "real relative asymmetry" (RRA) (Hillier and Hanson, 1984:111-112), considered to be most important in gauging the spatial relations within a system (Hillier, Penn, Hanson, Grajewski and Xu, 1993; Chapman, 1990:81).

The mean integration value is 1.01 (see Table 1) (a complete listing of values is provided in Appendix A), which is at the border of those values considered to be indicative of more segregated systems (Hillier and Hanson, 1984:113) . Even though there are a good many connections within the roomblock, the largest number of spaces are arranged so as to create substantial depth within the structure and contribute to relatively less integration (i.e., higher RRA values). In virtually all cases, the deepest, i.e., most controlled, rooms are first-story storage areas located towards the middle of the roomblock. On the other hand, the shallowest and most accessible spaces are a few first-and second-story residential units, rather than the plazas, a finding that is somewhat inconsistent with the traditional role assigned to plazas as integrating spaces (Anella, 1992; Swentzell, 1988, 1992) .

With regard to localized measures, the highest control values are associated with the rooftop spaces for rooms 32 and D, which maintain a high degree of access control relative to adjacent spaces. The rooms having the lowest control values are all first-floor rooms with no connections to other rooms except for the second-floor room immediately above. Thus, the most integrated spaces are not necessarily identical with those spaces that are the most controlling. Furthermore, the deepest and most controlled rooms are not always the same as the rooms that exercise the weakest control.

3.2 *Roomblock 16 - Component II*

Component II was a much less extensive settlement than Component I and consisted of approximately 200 rooms, all of which were one story, as opposed to Component I's nearly 1,000 rooms (Creamer, 1993:2) (see Figure 2). Although both occupations share the same fundamental material culture as well as a series of architectural forms and morphological features (Creamer, 1993; Habicht-Mauche, 1993), there are clear differences in the manner in which space was arranged.

Figure 6 is a map of roomblock 16, Component II. The spatial arrangement consists of a series of living rooms located directly to south of and fronting onto plaza C and backed by a series of storage rooms. Directly to the north of the storage rooms is a second row of living rooms that, in three adjacent cases, have connections to storage rooms via open doorways and have been identified as two-room residence units (Creamer, 1993:126, 128). To the north of this second row of living rooms and bordering plaza D are a series of utility rooms and trash disposal spaces. None of the rooms bordering either plazas C or D have doorways opening onto the plazas and the assumption is that these rooms were entered via ladders and ceiling hatchways (Creamer, 1993:47) . The portion of plaza C immediately adjacent to roomblock 16 was not excavated, but several ladder rests were identified from areas in plaza C adjacent to roomblocks 10 and 11 (Creamer 1993:48, 81-82) , leading to a supposition is that similar ladder rests would have been located in the vicinity of roomblock 16. Inasmuch as all Component II rooms are single story and plaza C is the only enclosed Component II plaza, it is assumed that all of the rooms were oriented towards plaza C in a front-to-back alignment. This assumption is supported archaeologically by noting that most of the interior doorways (three out of five) and all seven vents are oriented in the same direction, and ethnographically by the observed front-to-back

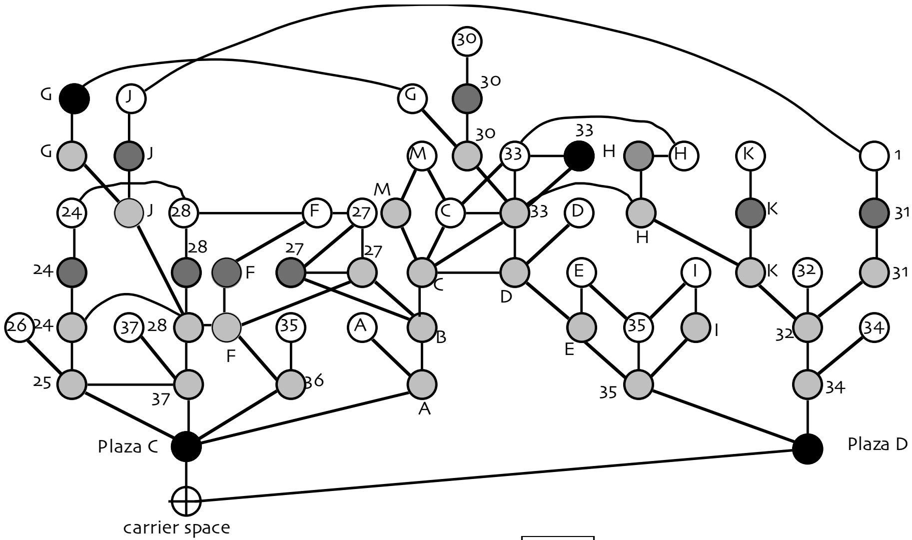

Figure 5. Partially Justified Access Graph, Roomblock 16, Component I

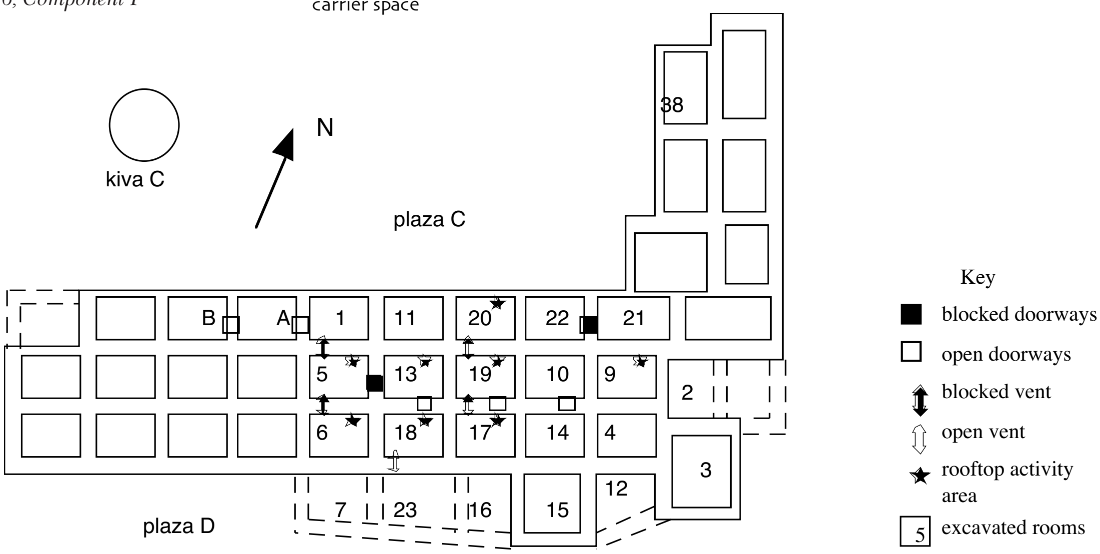

Figure 6. Roomblock 16, Component II. Adapted from Creamer, 1993.

association of rooms comprising residence units among a variety of pueblos (Lycett 1994:13; Kidder 1958:122-124; Mindeleff 1891:223; Nabocov and Easton 1989:371) . While the presence of several doorways suggests potential paths through the roomblock, treating this evidence consistently with that recovered from Component I roomblocks means that the absence of connecting doorways does not preclude the possibility that certain rooms were on the same access pathway.

Figure 7 is a justified access graph incorporating the excavated portions of this roomblock. For the most part, room arrangements are branched and candelabra-like and although there are some loops, the observed circuitry is much less extensive than in the Component I roomblocks. This asymmetrical and nondistributed arrangement suggests more social segregation. The average integration value of 1.30 (see Table 1 and Appendix A) is higher than the values calculated for the Component I roomblocks, and implies a difference in the manner in which space was arranged. In general, access to individual rooms was more easily controlled, or stated differently, more privacy could be maintained, particularly among the deeper spaces. The control values also show a different pattern, with plaza C having a substantially higher integration value than any other space in the roomblock (4.08). Although the presence of the kiva in plaza C contributes heavily to this control value, even if the kiva space is discounted, the control value remains substantially higher than those for the other spaces. The least controlling space is actually the kiva because it can only be accessed through one other space, namely the plaza. During the Component II occupation, the plaza spaces became much more important as demonstrated by plaza C exhibiting both the lowest integration value (the most connected space) and the highest control value (the most controlling space) within the entire roomblock.

4. Summary of Analysis

Table 1 summarizes a series of calculated values for both Components I and II. In the roomblocks that were tested, the integration values associated with Component I structures were consistently lower than those associated with Component II structures. Even though all of the roomblocks represent relatively segregated spatial arrangements, there is a noticeable trend over time towards even more segregation. This trend, together with an increase in the range of exhibited values, is graphically presented in the box plots contained in Figure 8 and is statistically confirmed (with the Student's T-test at the 95% level of significance). As can be seen in Table 1 and Figure 8, both the mean and the range of values increase between Component I and II occupations, with the strongest pattern exhibited in connection with roomblock 16.

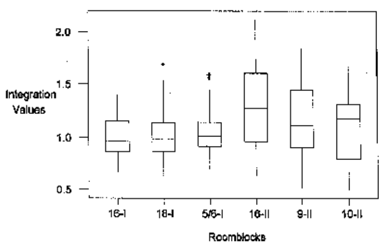

Figure 8. Box Plots of Mean Integration Values for Components I and II.

Table 1

roomblocks	*no. spaces*	*no. links*	*space:link ratio*	*average integration value*	*lowest value (for any node)*	*highets value (for any node)*	*Difference between high and low*
16 - I	62	84	1.35	1.01	0.68	1.23	0.55
18 - I	64	84	1.33	1.02	0.66	1.68	1.02
5/6 - I	48	63	1.31	1.02	0.69	1.58	0.89
16 - II	44	50	1.14	1.30	0.63	2.13	1.50
9 - II	21	24	1.14	1.16	0.51	1.84	1.33
10 - II	15	16	1.07	1.14	0.49	1.78	1.29

Table 1. Summary of Calculated Values for Components I and II.

The increased differences between high and low values demonstrated by the Component II roomblocks suggests a greater separation between what may be called private versus public functions, an important observation in light of the fact that plazas became the most integrating spaces during the Component II occupation. In none of the three Component I roomblocks was a plaza found to be the most integrating space. Instead, all three of the Component I roomblocks (16, 18, 5/6) had, as the most integrating space, one of several second-story rooftop spaces located above a habitation room in the interior portion of the roomblock.

Another pattern that emerges from the analysis is the increasing differentiation between functional spaces. Table 2 is a composite of all of the mean integration values, classified by known room function for Components I and II. Figure 9 excerpts only the living and storage room values from Table 2 and presents them as box plots. The relatively weak pattern of differences between storage and living rooms observed during Component I becomes clarified and more pronounced during Component II. In other words, the general overall trend towards higher integration values in the roomblocks correlates with a similar trend with respect to the relationship between storage and living rooms.

Table 2

roomblocks	*living*	*storage*
16-I	1.136	1.099
	n=8	n=7
18-I	1.037	1.028
	n=9	n=7
5/6-I	1.039	0.991
	n=5	n=2
16-II	1.503	1.618
	n=10	n=5
9-II	1.255	1.711
	n=4	n=2
10-II	1.278	•
	n=3	•

Table 2. Mean Integration Values by Function for Components I and II.

It is possible that what appears to be a clear pattern of spatial organization is merely the artifact of the assumptions applied to an admittedly imperfect data set. The original research strategy at Arroyo Hondo was not developed with space syntax in mind, so that excavation was directed towards numerous small groups of rooms rather than extensive groups of contiguous rooms within each roomblock. Roomblock 16 is an exception and the figures obtained from that roomblock argue against a narrow explanation. Both components of that roomblock were extensively excavated, and inasmuch as the assumptions that underlie the present analysis were applied consistently to both components, it is submitted that the observed patterns are a function of actual space usage, rather than a creation of the sampling or research design.

One statistic that has not yet been mentioned is the space:link ratio which measures the degree that the spaces within a structure are linked together and which is strongly influenced by the number of nodes within a network (Blanton, 1994:33) , thus implying difficulties in comparing systems of different sizes. Inasmuch as values of 1.00 indicate tree-like configurations with fewer alternative routes, whereas numbers above 1.00 indicate more ringiness and alternative pathways (Orhun, Hillier and Hanson, 1995:498) , the space:link values in Table 1 are consistent with the other measures and reveal a clear difference between the Component I and II values.

5. Relationship of Spatial and Social Structures at Arroyo Hondo

Correlating observed changes in architecture with concomitant changes in social organization is not an entirely new direction in Southwestern archaeology (see, e.g., Prudden, 1903; Rohn, 1965; Wilcox, 1975; Vivian, 1990), and the present study is but one example of efforts to discover quantifiable correlations between spatial and social patterns. Unlike many attempts to explain pueblo architecture, space syntax analysis is not bound by subjective descriptions of architectural styles or presumed cosmological connections, but relies upon replicable and testable spatial relationships. Having demonstrated that differences in spatial organization characterize Arroyo Hondo's Component I and II occupations, the question then turns to what those differences mean with respect to the nature of sociopolitical organization. The findings obtained from previous archaeological research at Arroyo Hondo suggest a relatively less complex, tribal type of society (Palkovich, 1980; Habicht-Mauche, 1993). Attributes suggesting more hierarchical organizational forms, such as differences among room sizes, features or paraphernalia (Stea and Turan, 1993:271), or specialized kinds of mortuary treatment (Howell 1996), have not been recovered generally at Arroyo Hondo, so that in a conventional sense there is no clear evidence to support the existence of social stratification.

Similarly, none of the measurements derived from space syntax analysis lead one to conclude automatically that any formalized ranking or other evidence of social complexity existed at Arroyo Hondo. Nevertheless, some spaces are clearly more accessible than others and the differences in how space was arranged between the two occupations implies that traditional definitions of "egalitarianism" (e.g., Fried, 1967) may not accurately describe social organization at Arroyo Hondo. Although the access graphs for Component I roomblocks appear well integrated with a variety of interior connections, their average integration values are relatively high, in the vicinity of 1.00, which implies an overall pattern of spatial segregation. Inasmuch as the calculations for this study are based upon some of the assumptions that guided previous studies involving the size of residence units, i.e., that interior doorways were open (Creamer, 1993:122), it is possible that these values underestimate the degree of spatial segregation. In other words, even if the access graphs were redrawn and integration values were recalculated based upon the existence of blocked doorways, there would be substantially less observed integration. The assumption of open doorways gives the benefit of the doubt to integration and yet the values associated with the Component I occupation are still suggestive of spatially segregated spaces! The existence of two-story structures together with lateral doorways permits the development of relatively deep networks within a relatively constrained area but the complete absence of any connections between second-story rooms ultimately contributes to a relatively segregated series of living rooms. In other words, Component I was arranged with the idea of relatively controlled living spaces and this pattern was expressed even more strongly during Component II. The emergent pattern is that over time, something was creating a need for closer control within the pueblo.

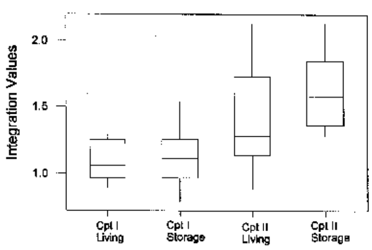

Figure 9. Box Plots of Mean Integration Values for Living and Storage Rooms.

Depth also indicates control, particularly in candelabra-shaped justified access graphs where the deepest spaces are found at the tips. These spaces are the most controlled in the system and embody those values that are preeminent to the group that arranged the spaces. Contemporary vernacular housing places bedrooms and bathrooms in the deepest spaces, illustrating the value of personal privacy for certain activities (Brown and Steadman, 1991). Business organizations place the chief executive in the deepest spot, often literally above, in terms of floors, and beyond spaces reserved for clerks, secretaries and lesser executives. In such a situation, depth equates with power and the ability to control an organization. In the late prehistoric Southwest, the deepest spaces are often identified as individual storage facilities (Bustard 1996), and Arroyo Hondo is no exception. Given the assumption that the activities conducted in the deepest spaces are among the most restricted, one may infer that to the extent storage spaces are the most controlled spaces in the pueblo, such a design suggests increased importance of individually stored food as opposed to public communal storage. Although economic uncertainty was often the case in the Rio Grande Valley, it was during particular periods of environmental uncertainty, such as during the Component II occupation when settlements aggregated around dependable water sources (Dickson, 1979; Rose, Dean and Robinson, 1981; Plog, 1995:197), that the overall trends toward segregation seen during the earlier period became more manifest. Stated differently, after the reoccupation that followed a (possibly) climatic-induced abandonment during the mid-14th century, there was a greater tendency for household groups to build more control around their food supplies. This observation need not imply that communal food redistribution did not occur, but that it was periodic and mediated by such overarching institutions as the katsina cult (Adams, 1991:157-158, 188-189). What is more likely is that the space usage changes between Components I and II may be reflective of general trends in pueblo architecture. For example, Kidder observed that sections of Pecos Pueblo lacked lateral doorways between apartments (1958:122-124). Although the portion of Pecos described by Kidder was constructed at or just after the point in time when Arroyo Hondo had been permanently abandoned, the front-to-back access to residential units is the same kind of arrangement that is seen in the Component II remains at Arroyo Hondo.

Component II's spatial access patterns appear shallower but more segregated than those of Component I. Explanations for these shallower patterns may involve the absence of two-story spaces, an architectural convention that permits the development of relatively deep spaces within a small area, or the nature of the Component II data set in which fewer rooms were excavated (than for Component I) so that the access graphs are more circumscribed. Even so, the deepest space for roomblock 16, Component II is seven steps from the carrier and is the same depth as the deepest space for that roomblock during Component I. As presented in Table 1 and Appendix A, the integration values are consistently higher for Component II than for the earlier occupation, suggesting a movement towards greater spatial control. While the Component II roomblocks present fewer excavated spaces to analyze than the analogous Component I roomblocks, the nature of the relationships, including fewer inter-room connections and the existence of front-to-back as opposed to lateral doorways, contribute to more segregated layouts.

It is possible that the spatial patterns within the roomblocks reflect a change to nuclear from extended families as residence units became smaller and more controlled (Beal, 1972) and as notions of privacy were spatially expressed (Dohm, 1990, 1996).

Notwithstanding the close day-to-day association among households, private space was maintained in the front-to-back connections that limited access into portions of residence units. It was at the larger community scale, within the plazas and kivas, that group activities occurred, much as they do today. During the Component II occupation, community activities undoubtedly focused upon plaza C in which the single Component II kiva is located. It may be the case that while public plazas served to integrate groups at the community scale, there was an opposite movement towards social segregation at the scale of individual domestic groups. Even though the residences are closely packed together, architectural devices such as walls, openings and pathways were arranged so as to control social encounters and maintain relative social segregation. In Hillier and Hanson's view, such a pattern equates to Durkheim's concept of mechanical solidarity and a more ascribed type of controlling hierarchy. Such a description does not correlate very well with the egalitarian tribal model presented for Arroyo Hondo's social structure (Palkovich, 1980), but it could be consistent with Brandt's (1994) views regarding pueblo social organization as being more hierarchically organized (see also Hage and Harary 1983:26-27).

Hillier and Hanson have associated structural patterns in which some spaces are shallow and distributed while others are deep and nondistributed, with ceremonial and religious architecture (Hillier and Hanson, 1984:180-182). Aside from a brief comment made by Bronitsky (1983:178), there is no suggestion or reason to infer that either component at Arroyo Hondo was designed as a ceremonial centre. Both components were residential settlements, although the large kiva (kiva J) built during Component I may have served a population greater than the immediate settlement. On the other hand, it is possible that religious or cosmological principles guided the design process (Hieb, 1992; Swentzell, 1992; Blanton, 1994). If the katsina cult or other religious influences (Adams, 1991, 1996; Lipe, 1995) had a significant impact upon social organization during the latter part of the 14th century, then the internal settlement structure might embody such a pattern. This possibility is supported by Bernardini's observation that "the degree to which architecture makes ritual and other socially sanctioned behavior public and visible can be read as a measure of the degree of behavioral monitoring and control experienced by residents of a settlement" (Bernardini, 1996:6). All activities within the plaza can be seen, heard, smelled, and in a broad sense, controlled. Private activities within controlled access residential units are not subject to the same community-wide observation and regulation (e.g., Evans, Lepore and Schroeder, 1996).

Connectedness is the concept that suggests how, over time, plazas became more integrated with the entire settlement. In the more segregated Component II roomblocks, the front-to-back linkages are more pronounced and indicate that the movement of people, energy or information, flowed to and from the plazas. The plazas are relatively shallow but exercise control over access to the interior spaces. In contrast, none of the Component I spaces expresses the same combination of high integration and low control values as the Component II plazas, and it is lateral rather than front-to-back linkages that are emphasized. Component I roomblocks are characterized by more pathways that facilitate the circulation of people and information. As the spatial arrangements become more asymmetric and branched, the relationship between the controlling spaces (integrated public plazas) and the controllable spaces (segregated private rooms and suites) becomes more strained and highlights the tensions between individual family groups and the entire community.

6. Conclusions

Architectural changes represent an adaptation to the increased demands presented by a variety of resource limitations that characterized both the physical and social environments of pueblo settlements but they may also perform additional functions. Architecture provides a physical refuge that affords people an opportunity to retreat from these environmental stressors (Hall, 1966; Evans, Lepore and Schroeder, 1996). Architecture is also a process that blends the utilitarian and the ideological (McGuire and Schiffer, 1983) . Over time, changes occurred in the interior arrangement and layout of seemingly similar roomblocks so as to facilitate or inhibit movement, i.e., social encounters. In other words, while a pueblo may be viewed as a relatively stable organic unit, the relationships among its constituent spaces vary over time. The argument follows that the relationships among constituent social groups also vary over time.

The physical form of the pueblo arises in large measure out of the interplay of social organization and ideology, but the form also enables the internal mechanisms for social control to operate (Rapoport, 1969b) . Analysis of the Component I roomblocks reveals more opportunities for internal spaces to exercise control, as suites of laterally connected rooms tend to dominate this component. This form may indicate extended family or clan-based authority maintaining access control over limited portions of the pueblo but does not readily support the existence of any apparent supervening authority.

This study suggests that the access patterns and integration values reveal a persistent temporal movement toward privately controlled (or at least potentially controllable) and segregated spaces. During the Component II occupation, it became more difficult for non-residents to gain access to the deepest, i.e., most controlled, portions of particular roomblocks. At the same time, the plazas became much more integrated, public and controlling. Whether such changes reflect a modification in basic social organization from extended to nuclear families, whether the potential for food shortages resulted in a need for more control over food supplies, or whether the most private elements of the developing katsina ceremonialism contributed to the architectural changes is not entirely clear. In any event, these spatial arrangements permitted individual households to exercise more control over social interactions and quite possibly enabled different ethnic or social groups to maintain defined spaces and so minimize the social friction attendant with the cohabitation of relatively large and dense populations.

As part of the same process of architectural change, large, open plazas enclosed by roomblocks became the primary spatial connectors for the community. The plazas performed these integration functions by serving as stages for community-wide ceremonies, but also as places where residents could observe their neighbours and be likewise observed. Despite their central location and shallow accessibility, the plazas were actually the spaces least subject to individual control yet were in a sense the most controlling spaces in the pueblo. These spaces synchronized with deeper residential and storage spaces to create a template for pueblo settlement form that was adopted throughout the northern Rio Grande and persisted until the Spanish entrada.

The archaeological record suggests that at Arroyo Hondo everyone shared essentially the same lifestyle (Palkovich, 1980), yet space syntax analysis indicates progressive spatial segregation among residential roomblocks and an increasing significance of plazas as community-wide integration spaces. Maybe the material manifestations were not so very different, but by the 1370s and 1380s, there appears much less potential freedom of movement. If space within roomblocks was becoming increasingly "privatized," there must have been some kind of mechanism to facilitate community decision-making in the absence of clear ranking. Prehistoric pueblo groups living in the northern Rio Grande during the Coalition and Classic Periods were conducting experiments in social and spatial organization. Archaeologists cannot see the actual decision-making but space syntax analysis helps them to understand the architectural manifestations of the decisions and shed some light onto the fundamental processes of social change.

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Appendix A

Roomblock Summaries - Arroyo Hondo Pueblo (LA 12) [1]

Roomblock 16 - Component I

Room/space number	*function* [2]	*description*	*integration value*	*control value*
24	•	rooftop space	1.2023	0.833
24	L	second floor	1.3947**	0.833
24	S	first floor	1.3562	0.833
26	•	rooftop space	0.9715	1.700
26	L	first floor	1.2552	0.250*
27	•	rooftop space	0.7647	1.500
27	L	second floor	0.9859	0.667
27	S	first floor	1.2552	1.333
28	•	rooftop space	0.7839	1.417
28	L	second floor	1.0000	0.583
28	S	first floor	1.1420	0.833
30	•	rooftop space	0.7069	1.200
30	L	second floor	0.9618	1.333
30	L/S	first floor	1.1253	0.500
31	•	rooftop	1.2744	0.750
31	L	second floor	1.1590	1.00
31	S	first floor	0.9618	1.000
32	•	rooftop space	1.0340	2.167**
32	S	first floor	0.9953	0.250*
33	•	rooftop space	0.7069	1.617
33	C	second floor	0.9618	0.533
33	CS	first floor	1.1253	1.333
34	•	rooftop space	1.0340	1.583
34	L	first floor	1.2792	0.333
35	•	rooftop space	0.9137	1.700
35	S	first floor	1.1975	0.333
36	•	rooftop space	0.9666	1.500
36	L	first floor	1.0532	1.250
37	•	rooftop space	0.8705	1.700
37	S	first floor	0.7839	0.250*
A	•	rooftop space	0.8410	1.700
A	•	first floor	1.1975	0.333
B	•	rooftop space	0.7434	1.367
B	•	first floor	0.9570	0.583
C	•	rooftop space	0.6800	1.533
C	•	first floor	0.9330	1.033
D	•	rooftop space	0.8320	2.033
D	•	first floor	1.1157	0.250*
E	•	rooftop space	0.9859	1.000
E	•	first floor	1.1734	0.583
F	•	rooftop space	0.8127	1.667
F	•	second floor	1.0340	0.583
F	•	first floor	1.1590	1.167
G	•	rooftop space	0.6657*	0.833
G	•	second floor	0.9371	1.000
G	•	first floor	1.2215	0.833
H	•	rooftop space	0.6925	0.950
H	•	second floor	0.9474	0.833
H	•	first floor	1.1494	∞0.833
I	•	rooftop space	0.9618	0.750
I	•	first floor	0.8705	0.833
J	•	rooftop space	0.7300	1.250
J	•	second floor	0.9522	0.833
J	•	first floor	1.1350	1.000
K	•	rooftop space	0.8897	1.667
K	•	second floor	1.1494	1.333
K	•	first floor	1.3321	0.500
M	•	rooftop space	0.7983	0.833
M	•	first floor	0.9089	1.167
plaza C	•	plaza	0.9618	1.667
plaza D	•	plaza	1.2071	1.083
carrier	•	outside	0.8041	0.583

average integration value = 1.01

Roomblock 18 - Component I

room/space number	*function*	*description*	*integration value*	*control value*
5	•	rooftop space	1.0181	1.667
5	L	second floor	1.0524	0.950
5	L/S	first space	0.9220	1.833
6	•	rooftop space	1.2752	1.033
6	NF	second floor	1.3004	0.667
6	S	first floor	1.1183	1.500
7	•	rooftop space	0.9072	1.533
7	L	second floor	1.0584	0.533
7	L/S	first floor	0.8568	1.000
8	•	rooftop space	0.8619	0.917
8	L	second floor	1.0282	0.533
8	S	first floor	0.7812	1.334
9	•	rooftop	0.6250*	1.530
9	L	second floor	0.8870	0.500
9	L/S	first floor	1.1080	1.083
14	•	rooftop space	1.0736	1.333
14	L	second floor	1.3508	1.833
14	L/S	first floor	1.5381**	0.500
32	•	rooftop space	0.9172	1.000
32	L	second floor	0.9828	0.833
32	S	first floor	0.9598	0.625
37	•	rooftop space	0.7560	0.875
37	L or S	first floor	1.0330	0.833
38	•	rooftop space	0.7107	1.333
38	L	second floor	0.9870	0.750
38	S	first floor	1.2504	1.200
39	•	rooftop space	0.6552	1.833
39	L	second floor	0.9120	0.533
39	L/S	first floor	1.1590	1.500
42	•	rooftop space	0.8316	1.667
42	L	second floor	1.0786	0.583
42	L/S	first floor	1.2701	1.167
49	•	rooftop space	0.8660	1.033
49	S	first floor	0.9828	0.833
A	•	rooftop space	0.8518	1.458
A	•	first floor	1.1391	0.333
B	•	rooftop space	0.8410	1.000
B	•	first floor	0.9324	0.583
C	•	rooftop space	1.0534	0.583
C	•	first floor	1.1744	1.167
D	•	rooftop space	0.8316	1.033
D	•	second floor	1.0786	0.533
D	•	first floor	1.2701	0.833
F	•	rooftop space	0.6855	1.400
F	•	first floor	0.9728	0.333
H	•	rooftop	1.1375	1.000
H	•	second floor	1.4073	1.333
H	•	first floor	1.6861	0.500
I	•	rooftop space	0.9224	0.833
I	•	second floor	1.1794	1.000
I	•	first floor	1.4264	0.833
M	•	rooftop space	0.8820	1.325
M	•	first floor	1.1693	0.333
N	•	rooftop space	0.9375	0.625
N	•	first floor	1.0937	0.625
O	•	rooftop space	0.9929	1.533
O	•	first floor	1.0786	0.500
P	•	rooftop space	0.8669	1.450
P	•	first floor	1.1540	0.333
plaza G	•	plaza	0.6905	3.700**
plaza I	•	plaza	0.6703	1.458
plaza J	•	plaza	0.8417	1.325
kiva G-5	C	ceremonial	0.9778	0.125*
carrier	•	outside	1.1290	0.333

average integration value = 1.02

Roomblock 5/6 - Component I

room/space number	*function*	*description*	*integration value*	*control values*
5	•	rooftop space	0.7035	1.250
5	L	second floor	0.9470	0.700
5	L/S	first floor	1.0958	0.750
6	•	rooftop space	0.9876	1.283
6	L	second floor	1.2717	0.750
6	O	first floor	1.5555	1.000
7	•	rooftop space	0.7373	1.200
7	L	second floor	0.9538	0.500
7	L/S	first floor	1.0350	1.667
8	•	rooftop space	0.8456	1.333
8	L	second floor	1.0620	0.500
8	L/S	first floor	1.0891	1.917
9	•	rooftop space	0.7509	0.900
9	L	second floor	0.9606	0.667
9	L/S	first floor	1.0282	0.950
10	•	rooftop space	0.8456	1.083
10	S	first floor	1.0485	1.000
11	•	rooftop space	0.8320	1.333
11	C	second floor	1.0891	0.750
11	CS	first floor	1.2244	0.833
12	•	rooftop space	0.9876	0.917
12	L or S	first floor	1.1432	1.083
13	•	rooftop space	1.0079	1.167
13	L or S	first floor	1.1635	0.667
14	•	rooftop space	0.7103	1.667
14	S	second floor	0.9335	0.400
14	L/S	first floor	0.9876	1.917**
A	•	rooftop space	0.9132	1.917**
A	•	first floor	1.2244	0.250*
B	•	rooftop space	1.0079	1.500
B	•	first floor	1.3190	0.333
C	•	rooftop space	0.9200	1.700
C	•	first floor	1.2311	0.250*
D	•	rooftop space	0.8456	1.400
D	•	first floor	1.1567	0.333
E	•	rooftop space	0.8117	1.450
E	•	first floor	1.1228	0.333
F	•	rooftop space	0.6967*	1.283
F	•	first floor	0.9267	0.458
G	•	rooftop space	0.8388	1.283
G	•	second floor	1.1364	1.250
G	•	first floor	1.4476	0.500
H	•	rooftop space	1.0214	1.000
H	•	second floor	1.3055	0.833
H	•	first floor	1.5897**	1.000
plaza K	•	plaza	0.9731	1.667
plaza L	•	plaza	0.9438	0.583
carrier	•	outside	1.0079	0.533

average integration value = 1.02

Roomblock 16 - Component II

21.20

room/space number	*function*	*description*	*integration value*	*control values*
1	•	rooftop	0.7476	1.458
1	L	first floor	1.0433	0.583
4	•	rooftop	1.3390	1.333
4	L	first floor	1.6676	0.500
5	•	rooftop	0.9611	1.000
5	L or S	first floor	1.2240	0.667
6	•	rooftop	1.2733	1.333
6	L	first floor	1.6019	0.500
9	•	rooftop	1.0261	1.750
9	S	first floor	1.3550	0.333
10	•	rooftop	1.2076	1.500
10	S	first floor	1.5197	0.833
11	•	rooftop	0.9447	1.125
11	L	first floor	1.2733	0.500
13	•	rooftop	1.6033	1.500
13	S	first floor	1.8155	0.833
14	•	rooftop	1.4869	1.333
14	L	first floor	1.7991	0.833
15	•	rooftop	1.7991	1.333
15	S	first floor	2.1276**	0.500
17	•	rooftop	1.4705	1.000
17	L	first floor	1.7826	1.000
18	•	rooftop	1.8155	0.833
18	L	first floor	2.1276**	1.000
19	•	rooftop	1.1583	1.333
19	L	first floor	1.4705	0.833
20	•	rooftop	0.8790	1.625
20	L	first floor	1.2070	0.333
21	•	rooftop	0.7476	1.292
21	L	first floor	1.0597	1.000
22	•	rooftop	0.9611	1.083
22	S	first floor	1.2733	0.833
38	•	rooftop	0.9447	1.625
38	S	first floor	1.2733	0.500
A	•	rooftop	1.0269	1.000
A	•	first floor	1.3222	1.000
B	•	rooftop	1.3390	0.833
B	•	first floor	1.6348	0.833
plaza C	•	plaza	0.6325*	4.083**
plaza D	•	plaza	0.9529	0.625
kiva C	C	ceremonial	0.9611	0.125*
carrier	•	outside	0.9529	0.625

average integration value = 1.30

Roomblock 9 - Component II

room/space number	***function***	***description***	***integration value***	***control value***
6	•	rooftop	1.1333	1.667
6	S	first floor	1.5777	0.500
8	•	rooftop	1.4444	0.833
8	S	first floor	1.8444**	1.000
9	•	rooftop	1.4444	0.833
9	L or S	first floor	1.8000	0.833
10	•	rooftop	0.8222	1.643
10	L	first floor	1.2666	0.333
11	•	rooftop	0.8222	1.643
11	L	first floor	1.2666	0.333
12	•	rooftop	0.7333	0.976
12	L	first floor	1.0881	0.667
13	•	rooftop	1.0444	1.333
13	L	first floor	1.4000	1.333
A	•	rooftop	0.7333	1.476
A	•	first floor	1.1777	0.333
B	•	rooftop	1.0444	1.500
B	•	first floor	1.4444	0.833
plaza C	•	plaza	0.5111*	3.500**
plaza F	•	plaza	0.9333	0.643
kiva C	C	ceremonial	0.9555	0.143*
carrier	•	outside	0.9333	0.643

average integration value = 1.16

Roomblock 10 - Component II

room/space number	*function*	*description*	*integration value*	*control value*
3	•	rooftop	1.2519	1.333
3	L	first floor	1.7830**	0.500
4	•	rooftop	0.7967	0.400
4	L	first floor	1.1760	0.667
5	•	rooftop	0.7967	1.700
5	L or S	first floor	1.3278	0.333
6	•	rooftop	0.4932*	1.533
6	L	first floor	0.8725	1.200
A	•	rooftop	0.7967	1.200
A	•	first floor	1.1760	1.200
B	•	rooftop	1.2519	1.500
B	•	first floor	1.7830**	0.500
plaza C	•	plaza	0.7208	2.533**
plaza F	•	plaza	1.6692	0.833
kiva C	C	ceremonial	1.1760	0.200*
carrier	•	outside	1.1381	0.700

average integration value = 1.14

Notes

[1] The following six tables present a summary of the individual integration values associated with each room incorporated into the analysis. The highest integration and control values are marked with a double asterisk (**) and the lowest values are marked with a single asterisk (*).

[2] The following abbreviations are used: L=living room (habitation); S=storage room; L/S=living room converted to storage room; L or S=living or storage room; C=ceremonial room; CS=ceremonial storage room; O=other function; NF=function indeterminate (Creamer 1993:115).