Chapter 9

The model and the results: summary and evaluation

The previous chapters have done two things. First, they presented the equilibrium group number model as a general and synthetic approach to understanding the fission and fusion of social groups, and developed a series of specific "effects," or processes that affect group number and are understandable outcomes of the model in response to particular circumstances. Second, they defined archaeologically detectable material correlates of each of the effects, and used these material correlates to show that the effects fit and explain some of the most interesting aspects of the culture history of the coastal Osmore valley and the Tiwanaku state. The substantive results are important because the Tiwanaku state was one of the largest and longest-lived indigenous states in the New World, and one that appears to have collapsed dramatically in a process that has not yet received the study it merits. The Osmore drainage, and especially the coastal segment of it, offers a well controlled case in which the valley's small size, relative isolation from neighboring areas, and extraordinary archaeological preservation make it practical to reconstruct the repercussions of Tiwanaku's collapse on a outlying region in some detail. In addition, I hope that identifying and labeling some effects of the equilibrium group number model as general and understandable patterns will provide useful building blocks for explanations and comparisons of changing numbers and relations of social groups in other archaeological or ethnographic settings. What follows is a brief summary of the equilibrium group number model and the six effects derived from it, a summary and evaluation of the utility of the model in general and for the Osmore drainage in particular, and a consideration of other implications and applications of the model and of the substantive results of the Osmore drainage research.

The equilibrium group number model is a graphical, qualitative approach to understanding the interaction of a wide variety of forces that affect the number of discrete social groups in a given social sphere and a given social and ecological niche. (These and other special terms are defined in the preceding chapters). Forces affecting the number of groups are qualitatively plotted on a Tension vs. Group Number (TGN) graph, which has the number of social groups as the horizontal axis and an intentionally vague variable labelled "tension" as the vertical axis (see Figure 2-4). Tension is variously defined for different forces that affect group number, with the idea that all the definitions could theoretically be standardized to a single scale if the proper conversion factors were known. People act in such a way as to reduce the total "tension" in their society, so the equilibrium group number is that which minimizes the sum of the tensions caused by each of the forces acting upon group number. Most forces that affect group number, including psychological factors related to categorizing behavior and rational-maximizing decisions or calculations related to maximizing economic, political, and ideological values, are all argued to have a generally concave up shape, usually with a minimum at or above one group. The sum of these forces should have a similar shape, so for most purposes all of them are lumped as a single line representing all the psycho-rational forces. The force of competition or competitive exclusion has a different shape, always tending downward towards a group number of one. The sum of the psycho-rational and competitive exclusion forces will generally have a concave-up shape with a minimum at or above one group. This minimum is the equilibrium group number towards which the society will tend to move.

Various circumstances will shift the psycho-rational and competitive exclusion

curves around in predictable ways, and changes in the population or extent of the social sphere and niche will also have predictable outcomes that will lead to predictable change or stability in group number. These expectable general processes are called "effects" of the model, and six are developed in detail in Chapters 3 through 8. Material correlates of each effect are defined and applied to the events of particular time periods in the Osmore drainage or the Tiwanaku state itself, in order both to illustrate the use of the model and to explain a major portion of the culture history of the coastal Osmore drainage and the events in the Andes that affected it.

The social sphere size effect suggests that as a social sphere expands or contracts in population or geographic extent, if the equilibrium group number remains constant, the groups within the social sphere will grow or shrink, fuse or split, in accordance with the changing size of the social sphere. A social sphere may change in size as a result of internal growth or decline in population, movement of people, or changing degrees and nature of social contacts through exchange, travel, and so on. This effect describes the action of changing social sphere size in isolation, without regard to other factors which may change the equilibrium group number while the social sphere changes in size. Under some circumstances, these additional factors may moderate or reverse the trends implied by the social sphere size effect. All other things remaining equal, individual groups will tend to grow as the social sphere expands, and to fuse together if the expansion involves incorporating additional groups. All other things remaining equal, individual groups will tend to shrink as the social sphere contracts, and to subdivide or fission if the contraction involves the loss of entire groups.

The minimum viable group size effect describes the limiting case in which the social sphere becomes so small that the number of people present are sufficient to

maintain only a small number of social groups, often only one. In this case, the small number of people in the social sphere overrides any psycho-rational forces that might otherwise encourage the formation of more distinct groups.

The cascading divisions effect is a special case of the social sphere size effect as it applies to collapsing states. The cascading divisions effect describes the process by which an organizational split high in an administrative hierarchy may propagate downward through the hierarchy as the failure of each administrative link reduces the social sphere size of the splinter group through the loss of contact with higher levels of the administration and with parallel groups that were accessible primarily through their common links with superiors. The people in the new and smaller social sphere divide themselves up into more groups in order to maintain the number of groups in their social sphere in accordance with the social sphere size effect. Since this subdivision will typically be along the lines of the administrative hierarchy, it severs the next lower administrative link or links, which further isolates the new subgroups, shrinks their social spheres further, and causes the process to repeat itself.

The cascading divisions process continues until the increasingly numerous and small social spheres reach their "salient level," or the level at which forces independent of the state hierarchy come into play to prevent the social spheres from splitting further. If the state grew by absorbing existing groups and maintaining their organizations and leaders as the lower levels of the state administration, that is, if it was an empire, then the subdividing may stop when it reaches the level represented by the originally independent groups, which will have had traditional and practical reasons for their unity. The salient level will be relatively high and the resulting stable groups relatively large and complex. If the state grew by demographic expansion or

diffusion, or "mechanically," such that the culture was relatively uniform across the state and the administrative divisions were relatively arbitrary in relation to local conditions, then the subdividing may continue down to the level of settlements or kin groups, since there will be few ideological or practical incentives to maintain the old state groupings. The salient level will be low and the resulting stable groups small and simply organized. These ideas lead to various material correlates in the post-collapse distribution of cultural traits and political groupings that can be used to make inferences about the expansion and organization of the collapsed state.

The gold rush effect describes what happens when a new social and ecological niche opens up, through climatological, hydrological, technological, or social changes that may make an area absolutely or relatively more attractive for settlement than it was before. Competition is relatively low, and various incentives for the immigration of new groups or the splitting of existing ones lead to a rapid proliferation of distinct social groups.

The competitive exclusion effect comes into play as competition intensifies, either because of rising unmet demand for resources or increasing differences in the competitive abilities of the groups present. Unmet demand probably increases most commonly due to population growth, but changing expectations or declining productivity could also increase unmet demand. Differences in competitive ability are probably less common causes for competitive exclusion, and may often involve advantages in military strategy or technology that are enjoyed by only one group. Either factor (or both) may steepen the competitive exclusion curve to the point at which the equilibrium group number is one. All but one of the groups are absorbed, are driven out, or dwindle away by any of various mechanisms, leaving the social

sphere unified as a single social group.

Finally, the group number fixation effect describes the circumstances in which a social sphere continues as a single social group, undivided. Unlike biological fixation, group number fixation must be actively maintained by some combination of forces, since new groups may always arrive from outside the social sphere or arise internally through fission of the exclusive group. Forces that can maintain group number fixation include strong unmet demand and elevated competitive ability on the part of the exclusive group. The forces maintaining fixation tend to decay with time, and the most useful analysis generally begin by characterizing a given case as having been fixed for a relatively short or long time, and then consider the reasons why.

Other effects beyond the six presented here could probably be developed from the equilibrium group number model. In addition, the discussion could be extended to consider the various possible mechanisms by which a group may disappear from the social and ecological niche in question, since people need not literally leave the region or die out in order to move out of the niche. Alternative outcomes to emigration and extinction include the divergence of the social and ecological niches that competing groups occupy, leading to independent groups that do not compete, or to interdependent specialization or symbiosis. Another outcome that could be considered is the subsumption of one group into another at a lower social status level, such as an impoverished class, a lower caste, serfs, or slaves. All of these are equivalent to a reduction in group number, since in each case one or more groups effectively leave the social and ecological niche in question. In the case of absorption of a disadvantaged class, not only is the absorbed group demoted in level to a subdivision of the absorbing group, which reduces the group number as the equilibrium group number model

demands, but also the resulting compound group changes its social and ecological niche to one involving a new subsistence strategy that includes a dominated labor pool.

On the other hand, the further the model is pushed, the more serious the problems of defining groups, levels, niches, and social spheres become relative to the yield in understanding the social processes. The equilibrium group number model, like most general models, is at its best when it is simplest. In the interest of preserving this parsimony as well as out of mercy for the reader, this discussion will leave the implications of the model at the six simple effects already described.

Applying the model and its effects to the Osmore drainage paid off in a number of concrete ways. The most obvious is that to the extent that the reader finds the equilibrium group number model to be valid and the dramatic changes in group number to be among the more interesting and essential features of coastal Osmore prehistory, using the model both made the proposed reconstruction of culture history plausible and explained why things happened as they did. The details and implications of these explanations are laid out later in this chapter.

In addition to this substantive benefit, using the model helped improve the analysis and presentation of the data. Each effect implied a series of specific questions to be asked of the archaeological data in order to justify the proposed explanations of culture historical processes, which gave purpose, direction, and focus to the reconstructions of population history, chronology, comparisons to material cultures in other regions, analysis of midden contents, and so on. These sorts of analyses are often included in any comprehensive archaeological report, but using them to test the fit of a theory moved the analyses away from dry description and towards process-oriented explanation.

Some specific implications of the model led me to reconsider data that had not seemed important before. For example, the three minor ceramic styles in the coastal valley, Osmore Multicolor, Ilo Multicolor, and Viboras, were all rare, poorly understood, and originally seemed to be sidelights to the overall flow of events in the valley that could reasonably be ignored or relegated to a brief mention. As the equilibrium group number model began to suggest that the gold rush effect might apply to the early Late Intermediate Period, it became clear that there should have been numerous small, shortlived groups present in the valley at that time. The minor ceramic styles and the people who made them suddenly became relevant, since they were evidence of exactly the multiplicity of groups that the model predicted. The seemingly insignificant footnotes to coastal Osmore prehistory became expectable, important features of the prehistoric record. Because the minor styles now had to carry explanatory weight, I had to perform additional analyses concerning them, such as a careful consideration of their ceramic associations in the site survey data in order to establish their temporal placement, that otherwise would never have been done.

Similarly, the BR Early Ceramic style did not seem particularly important to understanding the Chiribaya and Ilo-Tumilaca/Cabuza groups until the model suggested that the two later styles arose during a radical change in circumstances from earlier times. To clarify the events that led to the gold rush effect and the rise of the two major Late Intermediate Period cultures, it became necessary to understand what the coastal valley and its inhabitants were like immediately beforehand. I have done the best I can by hypothesizing from the limited survey data currently available, but this question will lead directly to additional fieldwork that might otherwise have been delayed or never carried out.

As important as the contributions of structure and analytical insights were to the analysis of the coastal Osmore data, any reasonable theoretical orientation should have provided similar benefits of guiding the argument and focussing attention on certain data. What is special about the equilibrium group number model specifically is that it goes to the heart of one of the basic issues of social process, the existence and interaction of social groups, and approaches it from a new angle. Previous theory has focussed on processes within individual groups (Adams 1966; Beckerman 1983; Conrad and Demarest 1984; Kosse 1990; Oliver and Marwell 1988; Tainter 1988; etc.), the dynamics of specific interactions between groups, such as the relations between a growing empire and the polities on its periphery (D'Altroy 1992; Browman 1978), or one particular type of interaction such as warfare (Carniero 1970; Peoples 1982; Webster 1975; Wilson 1988; Vining 1981). The equilibrium group number model is different in that it attempts to model in a general way the entire system of social groups at once, considering not the details of what goes on within any one group or between any subset of the groups, but rather the overall trend in fission, fusion, immigration, immigration, the shifting of individuals between groups through boundary "osmosis," and extinction of groups that leads to changes in the number of groups in a region, hence their sizes, and ultimately their social complexity.

Applying each of the six effects yielded specific substantive insights on the processes of cultural change in the coastal Osmore valley and the neighboring regions that affected it. The social sphere size effect seems to fit the pattern of expansion of the Tiwanaku state in several regions, including the valley of Tiwanaku itself, the middle Osmore valley around Moquegua, and possibly other areas as well. The implication is that the growth of the Tiwanaku state in at least some geographic

directions was driven by the expansion of its social sphere, rather than the reverse as was the case with the Inka empire. The Tiwanaku social sphere grew in the core region through population growth *in situ*, and in peripheral regions both through population growth due to immigration and natural increase in areas already linked to Tiwanaku, and through extending and intensifying links with ever more distant areas through population movement, exchange and diplomatic contacts, and so on. This expansion of the social sphere resulted in the increasing size of the Tiwanaku state as a distinct social group in accordance with the social sphere size effect, such that the number of groups in the social sphere did not get too large. The growth of the Tiwanaku group led to increasing organizational complexity through the predictable effects of scale (Johnson and Earle 1987; Kosse 1990). The same effect, incidentally, suggests that other groups may have consolidated and grown in size and complexity at about the same time, perhaps including the polities on the western side of lake Titicaca that were eventually subsumed by Tiwanaku (Stanish 1992), or the group or groups at San Pedro de Atacama (Rodman 1992). Browman (1978), Kolata (1983), Nuñez and Dillehay (1978), and others have made related arguments concerning the importance of long-distance exchange contacts in the growth of Tiwanaku, while Goldstein (1989a,b) sees enormous growth simultaneously in population and complexity of Tiwanaku people in the middle Osmore valley. Recasting these ideas in terms of the social sphere size effect shows how they can be consistent with a more general model that describes other changes in the region, as well.

Meanwhile, the Tiwanaku state never seems to have extended into the coastal Osmore valley, although there may have been extremely limited exchange of decorated goods or a few visitors from Tiwanaku areas such as the middle Osmore valley. Instead, the population of the coastal valley declined from formerly higher levels, and

while a Tiwanaku temple, a hierarchy of large habitation sites, canal and field systems, and quantities of decorated ceramics, textiles, and other craft goods in Tiwanaku altiplano style dominated the middle valley, a single small social group with a unique local ceramic style seems to have eked out a living perched between the river and the *lomas* within a few km of the mouth of the coastal Osmore river. I suggest that this period illustrates the minimum viable group size effect, in which the population of the coastal valley became so small that it could support only a single social group, which I label after the type site as the BR Early Ceramic. The reason for the minuscule population of the coastal valley and its apparent shift from the valley floor towards *lomas* and possibly marine resources may relate to hydrological repercussions of the large-scale Tiwanaku irrigation works in the middle valley. Intensive irrigation around Moquegua may have deprived the coastal valley of enough water to maintain dependable agriculture, a large population, and more than a single social group.

The Tiwanaku state, or at least the parts around the southern end of lake Titicaca and the middle Osmore valley, collapsed around AD 1000 in a pattern that corresponds to some of the material correlates of the cascading divisions effect with a low salient level. What these terms mean is that the breakdown of the administrative hierarchy of the Tiwanaku state may have begun at a relatively high level, and propagated downwards through the hierarchy until all but the lowest, most local links were broken, as opposed to a pattern of "lateral pruning," in which the collapse of the state is the accumulated result of local groups independently splitting off from the administrative hierarchy.

If this interpretation is correct, it has several implications. First, it suggests that relatively high-level politics were the cause or at least the critical symptom that lead to

the state's collapse, rather than widespread managerial failures or grassroots unrest. In this interpretation, the initial steps in Tiwanaku's collapse would have involved the splitting off of large chunks of the state under leaders that were formerly high in the state hierarchy, possibly Tiwanaku nobility living in the urban capital itself. Second, it suggests that the state administrative hierarchy was a somewhat arbitrary imposition on a relatively homogeneous society that was not marked, at least in the regions discussed here, by profound cultural divisions, or that these divisions were not reflected in the state administrative hierarchy itself. Once it began to break down, the remaining subunits of the hierarchy did not correspond to existing group identities at a sub-state level, and so had little reason to persist. The Aymara kingdoms of the Lupaqa, Colla, and others on the western margin of lake Titicaca may be exceptions, but in much of the state there was nothing to maintain fragments of the hierarchy in the absence of the state itself until the units had dissolved down to a small regional level. Third, this pattern of collapse is expected in states which grew "mechanically," that is, by population expansion and/or unusually thorough cultural diffusion, such that the state is composed of a relatively homogeneous culture, rather than an assemblage of heterogeneous parts like the Inka empire.

These arguments about the growth and collapse of Tiwanaku and the strangely unimpressive concurrent events in the coastal Osmore valley are based on a heavy dose of theory and respectable, but not overwhelming, data. They are interesting and plausible, but aside from the negligible presence of Tiwanaku in the coastal Osmore, definitely need further evidence to confirm or disprove. The repercussions of Tiwanaku's collapse on the coastal Osmore valley, on the other hand, are dramatically attested to by ample survey, excavation, and lab analysis results from the Proyecto Colonias Costeras de Tiwanaku, and the events clearly correspond to the expected

material correlates of the remaining effects of the equilibrium group number model.

The events in the coastal Osmore valley associated with the collapse of Tiwanaku and its immediate aftermath clearly correspond to the gold rush effect. The coastal valley became a more desirable place to live when Tiwanaku collapsed, possibly because the abandonment of Tiwanaku irrigation works in the middle valley increased the flow of the coastal segment of the river, and possibly also because the loss of the state superstructure in the middle valley made conditions there comparatively worse, with lower production, more competition, increasing isolation and hostility between local groups. Certainly the coastal valley was able to support a far greater population than had lived there while Tiwanaku controlled the middle valley. As many as five distinct new social groups appeared in the coastal valley, just as expected under the gold rush effect. The Ilo-Tumilaca group evidently immigrated to the coastal valley from the middle valley. Another group that made what I call the Viboras style of pottery may have immigrated from a similar region or split off from the Ilo-Tumilaca group. The early (Algarrobal phase) Chiribaya group may have immigrated from another valley further south, or may have developed *in situ* from Ilo-Tumilaca roots or a melding of the local and Ilo-Tumilaca traditions, presumably in contact and synchrony with similar developments in neighboring valleys. Two additional variants of the Algarrobal phase Chiribaya pottery style, Osmore Multicolor and Ilo Multicolor, probably represent still other social groups with origins closely tied to the Chiribaya. If the local Early Ceramic tradition continued, the people who made those ceramics would represent yet a sixth group.

Although equating ceramic styles with social groups, reconstructing migrations, and debating the cultural and regional origins of groups are lines of argument often

relegated to the bad old days of non-anthropological archaeology, they are not only relevant, but crucial, to the prehistory of the coastal Osmore valley. At least for the Ilo-Tumilaca and Algarrobal phase Chiribaya groups, for which the most archaeological data are available, these issues have been dealt with in a rigorous manner. Pottery was not simply assumed to mark social groups, but was shown to covary with a wide variety of domestic and mortuary material cultural traits that seems to leave little doubt as to the existence of distinct social groups. Migrations were not carelessly asserted because of isolated material similarities, but were argued on the dual basis of the virtual identity in a broad spectrum of material cultural traits between the supposed immigrant and parent groups, and the clear absence of any remotely plausible antecedents in the coastal valley, again based not only on pottery, but on a wide range of traits made available not only by the archaeologist's good intentions but also by the extraordinary preservation of organic artifacts in the coastal desert. The same rigor could not be fully applied to the other three ceramic styles, since the data available for them are few, but in light of the strong arguments possible for the Ilo-Tumilaca/Cabuza and Chiribaya groups, I believe that the similar conclusions reached for the minor styles on less compelling grounds are nonetheless reasonable.

The collapse of Tiwanaku in the middle Osmore valley evidently led directly to the gold rush effect in the coastal valley. It is probably not correct to form images as dramatic as those of fleeing refugees, but nevertheless the effect of collapse was not only to alter the organization, settlement pattern, and lifestyles of people within the territory of the former state, but also to send people moving outward as displaced persons, settlers seeking better opportunities, or perhaps colonists of the new local polities. In accordance with the gold rush effect, these groups were initially small and numerous, lending the territory beyond the former state's periphery an unusually

diverse, multiethnic character.

The population of the coastal valley grew rapidly in the wake of Tiwanaku's collapse, and the competitive exclusion effect set in. The three minor ceramic styles and the groups presumably responsible for them disappeared quickly. The Ilo-Tumilaca group's population declined as they shifted to the increasingly perfunctory Ilo-Cabuza style of pottery. Meanwhile, the Chiribaya population exploded. The later, highly populous Post-Algarrobal phase Chiribaya society was characterized by highly elaborated craft goods that probably indicate increasingly specialized production, by the construction of circumvaling mounds and ditches around the prominently located central site of Chiribaya Alta, and the elaborate interment of individuals who probably represent powerful leaders with large quantities of craft goods, food, and even human attendants. The prestige of the Chiribaya seems to been rising along with their population and political and economic organization, which all are expectable results of the effects of scale as the group grew larger and larger. The Ilo-Cabuza group, on the other hand, was marked by declining elaboration of material culture which may indicate reduced general wealth, and no evidence of a leadership class or other social hierarchy. Various resources that were probably especially valued, including corn, cuyes, and various fruits, were all primarily controlled by the Chiribaya and not the Ilo-Tumilaca/Cabuza people. While the Ilo-Tumilaca group shared the site of Chiribaya Alta with the Algarrobal phase Chiribaya for high-status burials, the Ilo-Cabuza people may have been excluded from it. Eventually, the Ilo-Cabuza group also disappeared, leaving the huge population of the Post-Algarrobal phase Chiribaya as the sole social group in the valley.

Given the great population growth and hence increasing resource scarcity implied

by the survey data (interpreted conservatively and in several different ways), it is not surprising that the competitive exclusion effect should have run its course. Moreover, the increasing divergence in wealth, prestige, and social complexity between the Ilo-Tumilaca/Cabuza and Chiribaya groups offers ready mechanisms by which the number of groups in the coastal valley might have dropped from five to one. The disappearance of social groups does not imply the physical demise of individuals or family lines, only the disappearance of an ethnic or other group identity. When it is clearly preferable to be a member of one group over another, people can be expected to find ways in which to change their affiliation from the less to the more preferred group. The particular means could involve marriage patterns, adoptions, voluntary servitude, simple shifts of residence, or even some sort of tacit or explicit conversion procedures.

Of course, immigration and demographic or health differences could also have been involved. Any material correlates of immigration will probably be found in the neighboring areas that hypothetically received these immigrants; at the moment there is no evidence for immigration but research in the area is too preliminary to rule it out. Paleopathological and demographic studies of the human remains find no significant health or mortality differences between the groups, but very small differences that would be undetectable with the present samples could still have been sufficient to contribute to the disappearance of the Ilo-Cabuza group.

The competitive exclusion effect fits the archaeological data and explains that the number of social groups in the coastal valley would be expected to decline just as it did in response to increasing competition for resources due to population growth. The model does not specify what mechanisms might have been involved, and several

reasonable possibilities, including immigration and demographic differences, cannot be ruled out, but the positive evidence available suggests that at least part of the process took place through the "osmosis" of individuals across "porous" social group boundaries from groups of lower and declining status and power to the group of highest and growing status, wealth, and organization.

The model also does not specify why the valley's population rose, but rising populations should be no surprise during and after an episode of the gold rush effect. While the gold rush effect is in progress, ample resources are available and people may prefer to have large families in order to increase their labor pool and for whatever other values large families may have, while few of the common limitations on family size such as low fertility or high infant mortality due to poor nutrition and health are in effect. Practices and values that result in large families and rapid population growth are free to develop, if not actively encouraged by the gold rush circumstances (see MacArthur and Wilson 1967; Pianka 1970; Kirch 1984 on r and k selection in colonizing populations). These practices may persist for some time after the population has begun to strain the available resources and competition begins to heat up, as is routinely observed by demographers in the modern "demographic transition" (Theodorson and Theodorson 1969). When the competitive exclusion effect follows on the heels of the gold rush effect, it is reasonable to suspect that the competitive exclusion effect is driven by population growth resulting from practices established during the gold rush effect. Conversely, we can suggest that when the gold rush effect occurs, an episode of competitive exclusion may generally be expected to follow. It certainly did in the coastal Osmore.

Finally, the Chiribaya tradition remained the only one in the coastal Osmore

valley for an uncertain period of time, probably several generations at least, in an example of the group number fixation effect. The fixation effect can be maintained by various factors, including high unmet demand for resources, high competitive ability on the part of the exclusive group, and any number of factors that might keep the psycho-rational curve far to the left on the TGN graph. I suggested that in the coastal Osmore case, the unmet demand due to high population relative to the productivity of the valley probably continued or more likely increased over time and served as a principal factor in preventing other groups from immigrating to the coastal valley and the Chiribaya group from splitting up. Although this explanation is plausible given the data at hand, it cannot be properly confirmed or disproved. It is not even clear what conceivable material evidence might be capable of confirming or discounting such a claim. Explaining stasis is intrinsically harder than explaining change. In addition, the proximate mechanisms maintaining the fixation effect are not specified. It is easy to imagine unmet demand for resources giving the Chiribaya a strong incentive to keep newcomers out of their valley, as well as giving newcomers little incentive to try to move in, but why the pressure should keep the Chiribaya group together rather than split it apart is not so clear. Perhaps as resource scarcity increased the pressure to fission, incipient splits were ever more strongly suppressed. Alternatively, perhaps the Chiribaya did not remain a single social group at all, but after splitting apart simply did not diverge sufficiently in material culture to be recognizable as more than one social group. It may be some time before sufficient fieldwork and analysis has been done to even begin to approach these questions about the organization of the latest, most complex and numerous Post-Algarrobal phase Chiribaya people.

We might generalize a little further and describe a general process that could occur in many cases of the collapse of states. When the state collapses, competition

within the old state territory increases due to the loss of organization, dispute resolution mechanisms, and overarching political control. Any local tensions that were contained by the state may break out with more force than ever, since some or all factions will probably feel that they were discriminated against under state suppression of their disputes. The loss of the state's organization may also lead to declining productivity and increasing unmet demand as state infrastructural features such as canal, field, and water allocation systems, coordinated agricultural planning and scheduling, wild resource conservation practices, and so on break down for lack of management and maintenance. Overall, the conditions within the boundaries of the former state generally worsen. Meanwhile, the peripheral and even further outlying regions come to look more attractive than before. They may have been relatively less populated because people preferred to live closer to the core to maximize personal opportunity, minimize transportation costs, and so on. If so, farmland and other resources will be relatively more available, wild resources and soils will be less depleted, and in general the outlying areas will offer better opportunities than the crowded and now disorganized core. In cases such as the coastal Osmore valley, agricultural or other practices under the state may have actively deprived the outlying zones of water or other resources such that the areas were unattractive for settlement while the state existed but materially improved after the state disappeared. Both pushed by the poor conditions in the core and pulled by the opportunities of the outlying regions, people will tend to move outward in the wake of the state's collapse. In terms of the equilibrium group number model, the collapse of a state is prone to lead to the gold rush effect in the former periphery and beyond.

The expected result of the gold rush effect is a proliferation of small, distinct social groups in the outlying areas. These groups will tend to grow until their

territories are fully exploited, and continue to grow even as competition becomes more and more intense. The competitive exclusion effect comes into play, and eventually a small number of large groups dominate the former margins of the collapsed state. The same effect may occur within the boundaries of the former state as well, leading to the reunification or reformulation of the state, or the processes that led to the state's collapse may continue to act to suppress the unification of the resulting splinter groups. The large groups in the periphery will be naturally selected and intentionally adjusted to be the most competitively able of the gold rushing settlers or the local groups with which the immigrants competed, so they will tend to be efficient and probably well organized. The effects of scale will also tend to require increasing social, economic, and political complexity, all of which may come relatively easily to people whose cultures recently derived from one of a state. The result of the collapse of the original state, then, is a halo of large, complex societies, perhaps at the chiefdom or even state levels, surrounding what had once been the core of the defunct state.

Since this "halo of complexity" scenario is derived from work in the coastal Osmore valley, it naturally seems to apply to the collapse of Tiwanaku and the rise of the Chiribaya in that region rather well. It may also describe the events in the Cochabamba region and elsewhere when Tiwanaku collapsed, but more data will be needed to show that. As plausible as the halo of complexity scenario sounds, finding other examples is surprisingly difficult, and that in itself is illuminating.

A few possible other cases suggest themselves, but each is a poor fit for one reason or another. The Maya florescence in the northern Yucatan after the Maya collapse in the Peten might be one example, but the northern Maya seem to have already become numerous and complex before the collapse in the Peten (Hammond

1982). The rise of European chiefdoms with the collapse of the Roman empire might be another example, but again, these political units seem to have formed well before the Roman empire was defunct, and moreover, Rome did not collapse in the abrupt sense that the term usually implies (Bowersock 1988; Tainter 1988). A quick review of the careers of the early Mesopotamian states shows that their rises and falls were more a matter of transient military and administrative successes and "political fragmentation" (Cowgill 1988) than collapse in the sense of qualitatively changing levels of cultural and sociopolitical complexity (Yoffee 1988b).

Part of the difficulty in finding other cases may be due to a relative dearth of scholarly attention paid to periods between the collapse and rise of states. Collapse in the abrupt sense may not be so common in prehistory, either (Yoffee 1988a; Cowgill 1988). The most important reason, however, is probably that few states were surrounded by sufficiently underdeveloped peripheries and neighboring areas for the gold rush effect to have taken place on a pronounced and widespread basis when they collapsed. Tiwanaku may have been an unusually "pristine" state not only in its rise, but also in its collapse, bounded on at least some sides by a relative vacuum of sociopolitical development. Presumably the fragments of the collapsed Wari state to the north would not constitute such a vacuum, but the coastal Osmore and possibly adjacent Pacific coast valleys to the south, the Cochabamba area, and maybe other zones such as San Pedro de Atacama and the jungle east of Titicaca would. If future research upholds the halo of complexity scenario for the collapse of Tiwanaku, then pursuing how Tiwanaku came to be and remained along some of its frontiers a solitary state surrounded by underexploited, underdeveloped outlands rather than the apparently more common chiefdoms and secondary states might offer further insights into the nature of one of the earliest, largest, and longest lasting regional states in the Andes.

All of this discussion of Tiwanaku and the halo of complexity scenario has been qualified with limitations to certain parts of the Tiwanaku's territory and periphery. One virtue of the equilibrium group number model is that despite its inherent generality and vagueness, its explicit focus on the interactions of social groups inhibits exactly such overgeneralizations as would result by characterizing the entirety of the Tiwanaku state with a single pattern of interaction or collapse. Tiwanaku grew, operated, and probably collapsed in different ways in different parts of its territory, and the forces affecting group number were different from place to place. Trying to shoehorn the entire state process at any one time into one of the six effects of the model leads to contradictions and simply highlights the heterogeneity of the state. Instead, the best understanding of the state and its interactions with other groups is gained by modelling the group numbers of various social spheres defined from the local or regional point of view, spaced throughout the territory of the state and around its periphery in order to reflect the regionally variable nature of the state's interactions and impact on group numbers. The analyses presented here have focussed primarily on the social sphere of people in the coastal Osmore valley, drawing some parallels to possibly analogous areas. The full picture remains to be completed with other subregions of the Tiwanaku state.

As satisfying as it might be to characterize Tiwanaku in one way and contrast it with the Inka and Wari states, for example, the result would be little more than a parody of the states involved. Tiwanaku seems to have grown through the social sphere size effect in parts of its core area, in the middle Osmore drainage, perhaps in the Cochabamba area, and possibly to the south towards San Pedro de Atacama. It may have grown by competitive exclusion along the western shores of lake Titicaca as

it absorbed existing complex polities there, perhaps driven more by unmet demand than by dramatic differences in competitive ability (but see Kolata 1992, who argues that Tiwanaku never lacked for subsistence resources). Tiwanaku seems to have affected group numbers differently in the middle Osmore and the Atacama areas, and it may have collapsed in different ways regionally, as well. The Inka state probably grew in part through the social sphere size effect in its initial development in the area around Cuzco (Bauer 1992), while it clearly expanded its imperial territory later through competitive exclusion driven less by unmet demand for resources than by its exceptionally high competitive ability both in military and to a lesser degree in administrative sectors (D'Altroy 1992). The Wari state is even less well known, but in places it seems to have gained and retained territory probably by competitive exclusion in much the same way as did the Inka (Schreiber 1987), while in others even the presence of major Wari centers seems to have had little effect on the group number or any other feature of the local social sphere (Isbell and McEwan 1991; Borges 1988). A meaningful comparison of the growth, functioning, and collapse of states using the equilibrium group number model, or any other model for that matter, would require a complex, variegated analysis and regional data of a quality that is presently available for few regions. In the end, the principal benefit would probably be in understanding the variability within each state, as much as the commonalities and differences between them.

In summary, the equilibrium group number model is a broad, graphical conception of the interaction of psychological categorizing, rational or economic decisions, and the force of competition as it works between social groups. The model and the six effects derived from it correspond well to the turbulent culture history of the Osmore drainage and the neighboring areas that affected it, through the expansion and collapse

of the Tiwanaku state, and its lasting aftereffects even beyond the state's former boundaries. The model makes the changing numbers of social groups in the Osmore drainage understandable. By fitting them to general processes independent of the specific case, it also makes them potentially comparable to similar events in other times and places. The model focussed and organized a variety of distinct analyses on a coherent set of testable hypotheses, and more could certainly be derived from it. Ultimately, the study of the processes affecting the number of groups in an area should complement the already richly developed study of the processes that occur within growing, shrinking, or stable groups, providing another way of looking at some of the most fundamental and sometimes dramatic developments of past and present human societies.