# Chapter 4

## The minimum viable group size effect

For most groups, there exists a minimum number of members below which the group cannot persist for long. The firmest, albeit not sharply defined, limit of this type is biological. Unless a group is accepting mates from outside, a very small group may not be a viable breeding population (Dobzhansky et al. 1977). Because the number of families is small, random circumstances affecting fertility and survival of both parents and children may have a greater impact on the number of surviving children than they would in a larger population, where random misfortunes are averaged out. Offspring of a highly limited, inbreeding gene pool are more prone to suffer from normally rare homozygous recessive genetic disorders, and the relatively elevated homozygosity of group members may make them less fit in general: more susceptible to disease, less successful at producing offspring, and so on. Each loss due to accident or illness takes a significant toll on the next generation, reducing the population and making it even more sensitive to the problems of small population size. The smaller the group, the sooner a random series of misfortunes can be expected to take the group to extinction.

Economic and technological factors may also define minimum viable group sizes (Beckerman 1983; Oliver and Marwell 1988; Smith 1983). Some agricultural regimes, transhumant pastoral adaptations, or multifaceted strategies such as those based on the complementarity of farming and herding or the simultaneous exploitation of different resource zones may not function efficiently or at all without some minimum input of labor. One or just a few families simply are not sufficient to succeed at some subsistence strategies. If the environment is such that irrigation is necessary for

farming, for example, then an agricultural group must be large enough to muster the necessary labor to maintain canals and to plant, irrigate, tend, and harvest the crops at the necessary times. If neighboring groups are hostile, a group must be large enough to raise a sufficient number of fighters to defend itself (Peoples 1982; Vining 1981). If a group falls below its minimum viable size, its members may either maintain their customary subsistence base by joining another similar group, perhaps through marriage, fictive kinship relations, alliances, or other mechanisms, or change their subsistence strategy or social and political position to one that has a lower minimum labor input. The first choice would reduce the number of groups in the area, while preserving the general adaptation and culture of the individuals involved. The second choice, changing the subsistence pattern, would probably alter both the rational and competitive forces acting on the TGN graph in complex ways; the effect of such a subsistence shift on the equilibrium group number would not be predictable in general, but would depend on specific circumstances.

Finally, organizational and ideological factors may influence a group's minimum viable size. If the group's organization involves craft or ceremonial specialists, partially or fully supported leaders, or ideological requirements for specific rituals, constructions, or other activities, some of these features may become impossible to support if the group becomes too small. As in the previous case, members of a group whose size fell below its viable minimum would have the option of maintaining their customary ways by merging with one or more similar groups, or of changing the organizational or ideological nature of their group. Again, the first choice would reduce the group number while maintaining the general level of organization and/or type of ideology to which the people are accustomed. The second choice could involve radical cultural changes that could have various results on the equilibrium

group number, depending on the specific circumstances.

The minimum viable group size may vary from group to group within a single social sphere. The combination of minimum viable group sizes for all the groups in a given social sphere affects the equilibrium group number by imposing a maximum number of groups that may exist in that social sphere, regardless of other forces. This limit is shown on a TGN graph in Figure 4-1. If the social sphere divides into more than this maximum number of groups, one or more will fall below its minimum viable size. That group will eventually either disappear through physical extinction or its members joining other groups, or will change its character such that its minimum viable size is reduced. In the first case, the TGN graph remains valid for the social sphere, and the group number returns to an allowed value. In the second case, the TGN graph may have to be reformulated to reflect the changed circumstances of the situation that it describes.

If the minimum viable group sizes are markedly different for the groups in a single social sphere, then the maximum number of viable groups will depend on the combination of groups with different minimum sizes. A combination with numerous groups of small minimum viable size and one group of high minimum viable size will yield a high maximum viable group number, while the same social sphere might permit a much lower maximum viable group number if several of the groups are of the type with a large minimum viable size. The single maximum viable group number threshold shown in Figure 4-1 is just a convenient approximation. The minimum viable group size effect is important primarily in circumstances where the social sphere is very small; when populations are low, the approximation of relatively similar levels of organization and labor requirements of subsistence for the possible groups is

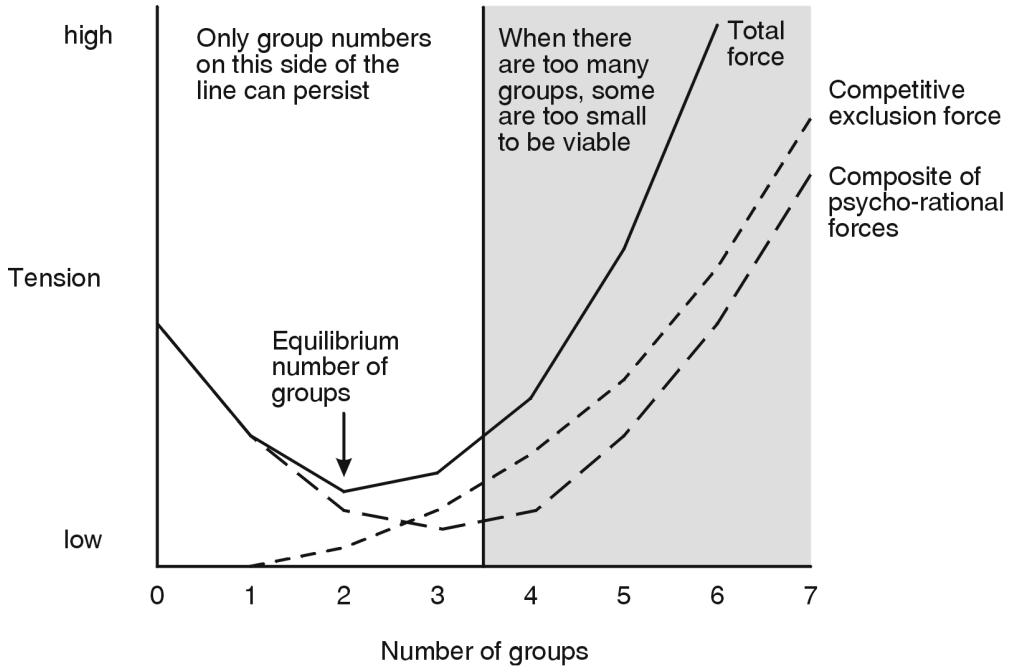


Figure 4-1. the minimum viable group size imposes a maximum number of groups that may persist.

likely to be reasonable.

Figure 4-1 shows a case in which the maximum number of viable groups is higher than the optimum determined by the other forces, so it has little effect on the ultimate number of groups in the region. The maximum number of viable groups may also be less than the equilibrium indicated by the sum of the psycho-rational and competition forces, in which case it overrides all the other forces. For example, individuals may feel that their interests would best be served by forming several separate groups to exploit resources in different pockets or of different types, but be stymied by the lack of sufficient numbers of people to successfully populate each location independently. In the extreme case, a social sphere may be so small that it can support only a single group.

**The Middle Horizon in the coastal Osmore**

The Middle Horizon is the time period associated with the wide distribution of Tiwanaku and similar, contemporary Wari ceramics throughout much of the Andes, and is conventionally dated around AD 600 to 1000 (Moseley 1992). As noted earlier, the excavation and survey work of PCCT indicates little or no Tiwanaku presence in the coastal Osmore. In fact, PCCT found strangely little evidence of any occupation at all during the Middle Horizon. The best guess at the moment is that the "BR Early Ceramic" pottery style, named after the Burgess-Reinhard site at which it was first identified, represents the coastal Osmore ceramic tradition of the Middle Horizon. (I have previously (Owen 1993) referred to the BR Early Ceramic style as "Late Formative," which should be abandoned as a potentially misleading use of a chronological term.) The BR Early Ceramic style is definitely represented at just six small and apparently shallow sites totalling less than five hectares, five of which are located within a single half-km radius (Figure 4-2; Appendix F). Although there were probably more sites of this type that have since been completely buried or eroded away, these six small sites must stand for the entire population of the coastal Osmore valley from AD 400 or 500 until the collapse of Tiwanaku around AD 1000 (Owen 1993). If the scarcity of BR Early Ceramic sites has anything at all to do with the valley's population at the time, this is precisely the sort of situation in which the minimum viable group size effect should come into play. In fact, the minimum viable group size effect fits nicely with the evidence of earlier phases and surrounding regions.

The paucity of remains from the Middle Horizon is not due to poor preservation or other factors that sometimes make earlier parts of the archaeological record harder

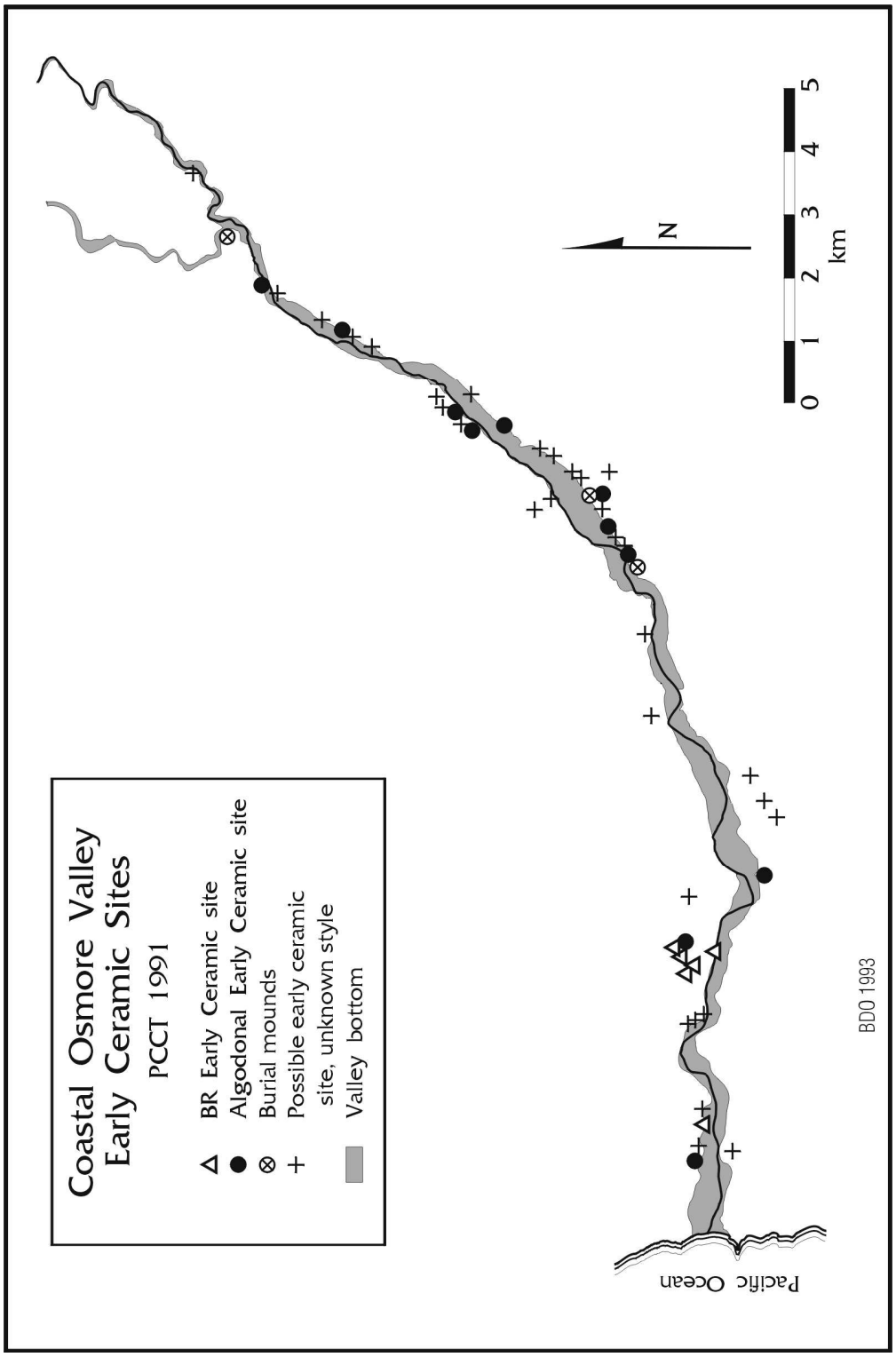


Figure 4-2. Early Ceramic sites in the coastal Osmore.

to find. On the contrary, PCCT excavations encountered abundant evidence of prolonged occupations marked by the still earlier "Algodonal Early Ceramic" style at El Algodonal and Loreto Viejo, and the PCCT survey identified at least eight other apparently substantial sites located all along the coastal valley, for a total of almost 24 hectares of thick Algodonal Early Ceramic habitation debris (Figure 4-2; Appendix F). (I have previously referred to the El Algodonal Early Ceramic style as "Olla sin cuello," which should be abandoned as a potentially misleading use of a widespread descriptive term.) Algodonal Early Ceramic pottery is securely associated with three radiocarbon dates from occupation deposits compacted onto intact living surfaces on two different domestic terraces excavated by PCCT at El Algodonal. Including the one-sigma error terms, the calibrated dates fall between 100 BC and AD 380 (see Appendix C for dates, Appendices B and F for excavation and survey data). The Algodonal Early Ceramic style could have started earlier and/or continued later at other sites, but it probably continued until at least around AD 400, and as a guess may have lasted as late as AD 600 or 700 or even later (Owen 1993). The BR Early Ceramic style has no radiocarbon dates associated with it at all, but on stylistic and technological grounds it seems reasonable to place it in what would otherwise be a gap in the archaeological record between Algodonal Early Ceramic and the arrival of settlers from the middle valley around AD 950 or 1000 (Appendix C).

The limited excavation and survey data suggest that the BR Early Ceramic population was much smaller than the earlier Algodonal Early Ceramic population, perhaps small enough for the minimum viable group size effect to apply. If so, the evidence should indicate a shrinking of the social sphere to a very small size, and a concurrent reduction of independent groups to a number low enough to suggest that opportunities to maintain multiple groups that were formerly supported by psycho-

rational forces were being contained by the overriding effect of excessively low numbers of people. The very scarce evidence from areas peripheral to the coastal Osmore valley itself suggest that this may indeed have been the case.

The early ceramic styles that have been described from neighboring areas all have styles and/or dates roughly corresponding to the Algodonal Early Ceramic, but all are sufficiently distinct that they may correspond to different ethnic and/or political groups. From the coast just north of the Osmore, the early ceramic cemetery of Wawakiki is dated to AD 340 (Buikstra n.d.; Bawden 1989a), and is markedly different from Algodonal Early Ceramic in pottery style and burial pattern. Between Wawakiki and the mouth of the Osmore, the undated Carrizal pottery style has clear ties to Algodonal Early Ceramic, but is also clearly distinct from it (Bolaños 1987). The Alto Ramírez burial mounds of the Azapa valley are dated contemporary with Algodonal Early Ceramic, but include different pottery, textiles, and other artifact types (Muñoz 1987; Dauelsberg 1985). The Huaracane phase ceramics in the middle Osmore valley have a single date of AD 50, resemble Algodonal Early Ceramic, but also have distinctly different pastes, paints, and forms, and a markedly different burial pattern (Feldman 1989; Goldstein 1989a).

Aside from several confusing dates from the Azapa area (Rivera 1985; note that these dates must be calibrated before making direct comparisons to the chronology here), there are no radiocarbon dates at all for comparable material that fall in the proposed span of the BR Early Ceramic style. The only other ceramics that I know of that approximate the BR Early Ceramic style are from the recently discovered site of El Atajo, southwest of Tacna (Manuel Garcia pers.com.). They are different enough from BR Early Ceramic material to represent a distinct group, but the site suggests

only a modest, dispersed population. The general impression is that the time of Algodonal Early Ceramic was characterized by more and more substantial sites, more people, and more distinct groups making their own styles of pottery, burials, and other artifacts. The time of BR Early Ceramic, on the other hand, is represented by a small number of shallow sites, a small population, and a minimal number of social groups. If the social spheres of these people included the entire coastline from the Osmore to the Caplina (Tacna) valleys, then the total group number known at the moment is just two. If the social spheres did not reach so far, then each apparently supported a group number of only one, where several existed before. This may be the minimum group size effect in action.

The minimum group size effect provides a rationale for very low group numbers when the social sphere is very small. The explanation begs the question, though, of why the population was so small in the first place. In the case of the coastal Osmore valley, and possibly of the coastal regions nearby, the apparently dramatic decline in population may be linked to the expansion of Tiwanaku irrigation works in the middle valley. While there had been some minor canal irrigation in the middle valley bottom in the Huaracane (Early Ceramic) phase, and at least one Omo phase site was associated with a canal and irrigated fields, in the Chen Chen phase the middle valley population expanded substantially, and a "vast system of...canals and fields" was constructed in the middle Osmore (Bermann et al. 1989; Goldstein 1989a:57,61,69, 1989b:226,237,240). In the extremely arid environment of the middle Osmore valley, extensive irrigation would have lead to large losses of water to the atmosphere through evaporation and transpiration. These losses may have reduced the groundwater flow of the drainage sufficiently that the coastal Osmore and possibly the coastal spring systems supporting the Carrizal and Wawakiki groups no longer flowed with sufficient

volume or reliability to support agriculture or, perhaps, to provide year-round drinking water. Population would have declined by emigration or reduced fertility and survivorship, the social sphere would have contracted, and the former multiplicity of groups may have collapsed into one or a very few. Whatever psycho-rational forces might have encouraged the maintenance of multiple social groups, the minimum viable group size effect overruled them and kept the group number down to, apparently, one.

Circumstantial evidence that this process of hydrological robbery is possible can be found in the water budget of the drainage in recent times, prior to 1952, when the potentially confounding effect of water use for industrial copper ore processing in the upper drainage was added to the picture. According to local informants, at this time the middle valley was (as it still is) heavily irrigated, and the coastal Osmore flowed on the surface for only several weeks each year. Agriculture depended on deep wells and pumps, for neither of which is there evidence in prehistoric times. Coastal Osmore valley farmers believe, I suspect rightly, that the present scarcity of their ground water is at least in part due to the heavy use of water higher up in the drainage, although they tend to overlook the recent history of drought years, and are now prone to blame the mining operations more than irrigated agriculture.

If this scenario is correct, then the culture history of the Osmore drainage represents a see-sawing effect in the balance between the coast and the middle valley. In the Early Ceramic, population was relatively dense in both areas. As the Tiwanaku population in the middle valley grew and increased its irrigated agricultural area, the coastal Osmore river dried out and the coastal valley was at least partially depopulated. In the next few chapters, we will see how the balance shifted back in favor of the coastal valley after Tiwanaku collapsed.