

# FROM FOREST TO RESERVATION: TRANSITIONS IN FOOD-SHARING BEHAVIOR AMONG THE ACHE OF PARAGUAY

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*This article presents detailed quantitative descriptions of food distributions among a group of forager-horticulturalists, the Ache of Paraguay. Food transfer patterns for Ache during periods of nomadic foraging are compared with those of Ache living a horticulture-based existence at a permanent settlement. We further explore how characteristics of resources and the methods of production, group size, and the spatial landscape can influence the kinds of social arrangements found among the Ache. The results of these analyses are used to generate general predictions regarding food sharing and cooperation among other foraging and transitional horticultural populations.*

THE ACHE OF EASTERN PARAGUAY are a hunter-gatherer group known for their extensive food-sharing practices. If food is costly to acquire and if individual consumption impacts growth, survivorship, and fertility positively, then its transfer to other individuals requires explanation. First, what conditions foster high levels of food transfers within some groups but not others? Second, what factors influence variation in food transfer behavior among individuals within groups? Most quantitative food-sharing studies have focused on the second question, testing hypotheses generated from various evolutionary models, such as kin selection, tolerated theft, reciprocal altruism, or costly signaling, in an attempt to explain variation in the observed food-sharing patterns within small-scale traditional societies.

This article explores several factors that can influence the distribution of food-sharing practices within and between groups. We compare the food-sharing behavior observed among Ache adults on a series of temporary foraging trips from 1980 to 1982, reported by Kaplan and Hill (1985) and reanalyzed for this paper, with the food-sharing behavior observed among Ache living in a permanent settlement in 1998, first reported by Gurven et al. (2001). Differences in Ache sharing behavior across contexts may help us better understand the conditions favoring different sharing patterns across extant groups.

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In the hope of standardizing the ways in which researchers discuss food transfers, we operationalize the degree of food transfers by defining four dimensions that capture key aspects of distribution behavior—depth, breadth, equality, and balance. *Depth* describes the proportion of personal food production given to others. *Breadth* describes the number of individuals or families that receive shares. *Equality* reflects any disparities in amounts given to different individuals or families in the population. *Balance* describes long-term differences in amounts transferred between pairs of individuals or families. Each measure reflects a separate aspect of giving or receiving. Most important, these four measures allow detailed comparisons of sharing behavior within and across groups and can therefore facilitate intracultural and cross-cultural hypothesis testing.

We evaluate differences in these food-sharing measures across forest and settlement contexts in terms of three dimensions useful for understanding intra- and cross-cultural variation: (1) differences in resource type and production, including resource predictability, interforager variance in acquisition, size of harvested resources, and economies of scale in production; (2) differences in group size; and (3) differences in proximate determinants of food transfers, such as visibility of others' food possessions and eating areas, physical distances between households, and level of privacy. These dimensions are significant because they can greatly influence the costs and benefits of sharing.

### GENERAL MODEL PREDICTIONS

Several models are invoked to explain variation in food-sharing behavior (Kaplan and Hill 1985; Hawkes 1993; Bliege Bird and Bird 1997; Winterhalder 1997; Gurven et al. 2000a). Nepotism based on kin selection predicts that (larger) portions should be given (more frequently) to close kin than to distant kin or unrelated nuclear families. The payoff from nepotism-based sharing is an increase in inclusive fitness due to benefits accruing to biological kin. Reciprocal altruism predicts that shares should be given to those likely to reciprocate in-kind or with other goods or services at a future time. Tolerated theft predicts that shares of medium to large asynchronously acquired resources should be given to other individuals lacking those resources until all recipients have equal marginal value for the next piece (assuming equal differential costs of acquiring shares). Shares are therefore given to avoid the greater costs of hoarding. Costly signaling predicts that difficult-to-acquire foods (i.e., game or store-bought foods which require money) should be distributed widely if high production is an honest signal of phenotypic quality. However, any food that requires time and energy to harvest, if shared, may signal a commitment to engage in cooperative interactions. The payoffs from signaling may be any fitness-enhancing benefit, such as food, increased mating access, coalitional support during conflicts, etc.

Nepotism makes no simple predictions about depth or breadth but predicts that distributions should be unequal, patterned by biological relatedness. Sahlins (1972) and Hames (1987) have also argued that food shares among close kin should be less balanced than among pairs of unrelated families. This may not be



true, however, if close kin are more reliable partners for reciprocal altruism than are unrelated families and if food-sharing between kin is mainly reciprocal altruism.

Risk reduction, which predicts that asynchronously acquired resources should be shared more widely than other more predictable foods like manioc or corn, may explain differences in depth due to package size or acquisition variance, but risk reduction is a potential outcome of all four models. Reciprocal altruism makes no specific predictions about depth. However, it does predict restricted breadth (Boyd 1988) and unequal distributions, patterned by the likelihood of reciprocation. It also requires some balance between value given and value received, or contingency. Reciprocal altruism is the only model that requires balance in exchanges.

Foods shared by tolerated theft can be expected to have relatively equal distributions, subject only to differences in information and travel costs, which could be a function of both proximity of recipients to acquirers and differences in wealth and influence. In the simplest scenario, where all families hold a similar value for a given quantity of food, depth should be  $100(1-1/n)$ , where  $n$  is the total number of families, and breadth should be the total number of hungry families. Tolerated theft also predicts no bias in distributions to close kin, neighbors, friends, etc., although such a bias might exist when these classes of individuals exhibit different costs and benefits to receiving shares.

Costly signaling predicts that game distributions should have wider depth and breadth than other foods which carry low status or are easily acquired (Smith and Bliege Bird 2000). Sharing displays should then act as honest signals of underlying phenotypic quality. Our understanding of how food sharing operates as an honest signal is not yet developed enough to make specific predictions, especially given the ways valuable information is communicated among group members (Gurven et al. 2000b). Costly signaling makes no specific predictions about equality or balance, and so any result is consistent with the notion of costly sharing displays.

Precise predictions from each of these models require estimates of the value of food given by donors and received by others and the costs of soliciting and hoarding shares. Any factor which influences these values should also affect sharing decisions. Our emphasis on diet and production and on some proximate features of the social landscape reflects differences in these values and costs. It is important to realize that several or all of these models might play a role in explaining some observed food transfers and that their interaction makes empirical testing difficult. For example, with strong tolerated theft and kin selection operating, close kin may not receive portions more frequently than non-kin, although they may receive slightly larger shares. Focusing on four sharing measures, therefore, allows us to explore more precisely the relationships between predictor variables and sharing outcomes.

## ETHNOGRAPHY OF THE ACHE

### *Forest*

Extensive ethnographic details about the Ache are given in Hill and Hawkes (1983), Kaplan and Hill (1985), Hurtado et al. (1985), and Hill and Hurtado (1996).

We briefly describe some relevant aspects of Ache forest ecology here.

Roughly 78 percent of the calories Ache consumed on forest treks in the 1980s were meat from various game animals such as nine-banded armadillos, pacas, brown capuchin monkeys, and white-lipped peccaries (Kaplan et al. 2000). Women acquire much of the starchy palm fiber, fruits, and larvae that constitute the rest of the diet, while men acquire most of the meat and honey. Typically, men acquire about 4 kg of meat (live weight) per day spent hunting, although the probability of a single hunter not killing any game on a particular day is about 40 percent (Hill and Hawkes 1983). About 60 percent of all game was captured by men coordinating their efforts (Hill and Kaplan 1988). Ethnographic descriptions of sharing events and their social context can be found in Kaplan and Hill (1985) and Gurven et al. (2001).

Even in 1998, the Ache living at the Arroyo Bandera settlement spent about 20 percent of their time in the forest, and observations of food production and distribution patterns on recent forest treks lead us to believe that these patterns are similar to those reported in the 1980s. However, several differences between forest treks in the 1980s and those of recent years are worthy of mention. First, hunters no longer consistently abstain from eating portions of their own kills, a taboo once believed that, if broken, would make a good hunter lose his ability to hunt, thereby becoming *pane* (Clastres 1972). Second, white-lipped (and especially collared) peccaries and coatis have declined in their daily contributions to the game portion of the diet; armadillos, pacas, and capuchin monkeys are now the top three sources of animal protein (Hill and Padwe 2000). Third, while foraging trips from the 1980s were reported to contain smaller band sizes than those of precontact times (Hill and Hawkes 1983), foraging group sizes within the past five years are even smaller, as is the mean duration of trips (unpublished data).

#### *Reservation*

In 1978 the Northern Ache were settled in the Catholic mission, Chupa Pou, along the Jejui Guasu River. Details on the origin of this settlement and characteristics of the lifestyle are given in Hawkes et al. (1987). The Arroyo Bandera settlement was formed in 1980 when a group of Ache left Chupa Pou to accept the offer of a Protestant mission to live on the edge of a Guarani Indian reservation administered by that mission (Hill and Tikuarangi 1998).

For less than twenty years, the Ache have been cultivating small fields of manioc, beans, peanuts, corn, sweet potato, and sugar cane. They also raise chickens, pigs, and several cows and horses, as well as "pet" monkeys, coatis, and peccaries. Wage labor assisting ranchers and cultivating Paraguayan fields is not uncommon and provides the bulk of the income that the Ache use to purchase clothes and market foods such as yerba mate tea, salt, sugar, rolls, and pasta. The Ache also on occasion sell handicrafts (palm-woven fans, mats, bows and arrows) to missionaries or tourists to the reserve.

Many of the observations made about Chupa Pou in 1982 (Hawkes et al. 1987) are true for Arroyo Bandera in 1998. The division of labor is less extreme at the reservation than in the forest. Men usually clear, burn, and weed fields, while both

women and men harvest their garden produce. While women still actively engage in child care, food processing, and cooking activities, men also watch and feed offspring and cook food, and older, unmarried daughters often care for younger siblings.

The spatial expanse of an Ache reservation is much greater than that of an Ache camp, and it also accommodates a larger population. In Arroyo Bandera, 117 permanent residents lived in twenty-three nuclear-family-based households in 1998 (Gurven et al. 2001). Almost all nuclear families (adult man and wife and their dependent offspring) live in their own separate wood-board houses (area about 16 m<sup>2</sup>). This, and the fact that the average distance between any two houses is about 100 m, gives a higher level of privacy compared with Ache forest camps, in which typically three to ten nuclear families are arranged in a circular fashion (about 3-5 m radius) around three to six fires. Nevertheless, about half of all households at the reservation were visible from any other household (Gurven et al. 2001).

Preliminary analysis of production data indicates that the bulk of the calories consumed in the settlement comes from cultigens (80 percent), whereas 9 percent comes from store-bought foods, and only about 11 percent comes from meat (wild and domesticated).<sup>1</sup> Thus, daily consumption patterns are determined for the most part by individual agricultural efforts. Most cultigens (except peanuts) are rarely stored for more than several days at a time and are usually harvested as needed. Everyone has equal access to arable land for cultivating crops, and despite the high degree of self-reliance in food production on the reservation, people still cooperate with each other in daily tasks. For example, men often help each other clear forests for gardens, care for each other's livestock, construct new houses, invite others along for rare wage-labor opportunities, and share tools (e.g., machetes, bows and arrows, hammers, etc.) (Hill and Gurven n.d.).

## METHODS

Details of the data collection methods used on forest treks in the early 1980s are given in Kaplan et al. (1984) and Kaplan and Hill (1985), while those used at the Arroyo Bandera settlement are given in Gurven et al. (2000a). We briefly summarize both methods.

Forest food-sharing data were collected on nine foraging trips leaving from Chupa Pou between October 1981 and May 1982. Due to the difficulties of directly measuring flows of food among many people in camp, acquirers and recipients of specific food items were recorded by measuring "consumption events." For every consumption event observed, the consumer and acquirer of the resource and the resource type were recorded. Consumption events were sampled through a combination of focal-person sampling, instantaneous scan sampling, focal-resource sampling, and multiperson-focused observations. Most quantitative analyses of forest trips in this article were performed only on trips six through nine, which were sampled more systematically than earlier trips.<sup>2</sup> These trips ranged from ten to fifteen days duration and involved ten to fourteen nuclear families (four

to ten of two or more individuals), or 17 to 48 individuals. Because we define the nuclear family (NF) as adult husband and wife and their dependent offspring, older parents of adult offspring constitute a separate NF. This sample included 5,609 consumption events (2,661 for meat, 725 for honey, and 1,911 for collected items). A subset of observations also contains estimates of resource package size. Package sizes of whole resources were either weighed directly using spring scales or indirectly estimated using average unit weight conversions, yielding a total of 2,234 observations containing a package size estimate (in kilograms and calories).

Settlement food-sharing data were collected in Arroyo Bandera over fifty-five sample days between February and May 1998. A total of 380 complete food distributions were sampled using a combination of focal-household cluster observations (78 percent of all distributions), focal-resource sampling (10 percent), and interviews (12 percent). Focal-household cluster observations were three-hour observation blocks of all food distributions, consumption, and production of all members of two or three households. Each household was sampled in this manner for an average 56 hours, giving a total of 1,294 house-hours of observation for all twenty-three households in Arroyo Bandera. For each food distribution, we recorded the donor, the original acquirer (if different), all recipients, estimates of total resource package size, and amounts given to each recipient. Amounts were either weighed using 10-kg and 25-kg Homs spring scales or counted (as in sticks of manioc) and then converted to kilograms or calories by using unit weight measurements.

Despite the different methodologies used in measuring distributions in the forest and settlement samples, estimation of the four sharing measures facilitates detailed comparisons across contexts. Limitations, however, require us to standardize our measures (e.g., using percent given instead of kilograms).

All analyses reported in this article were done at the level of the NF, so that NF *A* gave to NF *B* if any member from *A* gave to any member of *B*. We define kinship between NF *A* and NF *B* as the closest relatedness between all pairs of individuals from the two NFs (using Wright's coefficient of genetic relatedness, *r*).<sup>3</sup>

Where appropriate, we examine factors that may affect the outcome of the above calculations, such as resource package size, resource type (whether meat, collected goods, cultigen, store-bought foods, etc.), the ratio of consumers to producers in the family, and residential proximity between households at the reservation and between campfires in the forest.

## RESULTS

### *Depth*

By Resource Type. Depth refers to the proportion of an individual's food acquisition given to other NFs.<sup>4</sup> On average, Ache NFs on forest trips gave away 80 percent of what they acquired to other NFs. Individuals, on average, gave 73 percent of palm heart, 70 percent of palm starch, 70 percent of fruit, 87 percent of honey, 59 percent of larvae, and 89 percent of meat away to other NFs.<sup>5</sup> Because there were an average of seven NFs (having two or more members) on trips six

through nine, equal sharing would predict a depth of about 85 percent. Only meat and honey were given this widely, with both resource types produced almost exclusively by men and both acquired in large packages (mean = 5.8 and 6.5 kg, respectively).

We calculate the same information for the main food resource types at the reservation in 1998: 78 percent of cultigens (manioc, beans, corn, and potatoes), 91 percent of domesticated meat (chicken, beef, and donkey), 90 percent of forest meat brought back to the village (armadillo, paca, monkey, tapir, and peccary), 91 percent of other forest items brought back to the village (larvae, honey, and oranges), and 75 percent of store-bought items (rolls, salt, sugar) were given to other NFs.<sup>9</sup> On average, Ache NFs on the reservation gave away 87 percent of what they acquired to other NFs (Gurven et al. 2001), comparable to the depth observed on forest trips. Since there were twenty-three other NFs that could potentially receive from any single distribution at the reservation, equal sharing would predict a depth of about 96 percent. Few resources were shared this widely.

**By Package Size.** We have previously reported that larger food items are shared more widely in both the forest (Kaplan and Hill 1985) and on the reservation (Gurven et al. 2001). Figure 1a shows the percentage of resources given away to other NFs in the forest as a function of the package size in calories. The proportion of the package given increases approximately linearly for packages less than 2,000 calories, whereas for packages greater than about 2,000 calories, about 70-90 percent is consistently given away. Indeed, the slope of depth for nonmeat items less than 2,000 calories is 0.018, but for items greater than 2,000 calories, it is 0.000. An exception to this pattern is game, which shows no change in depth as a function of package size (slope = 0.00,  $r = 0.30$ ). An analysis of nonmeat calories kept within the NF ( $[100 - \% \text{ given away}] * \text{package size}$ ) as a function of package size reveals that NFs generally kept about 1,500 to 2,000 calories, regardless of package size—even with packages as large as 20,000 calories! The data indicate that for nonmeat items, greater production does not mean greater consumption. Because the total calories produced from these resources is directly under the control of the acquirer and packages are often larger than 2,000 calories, we conclude that acquirers often obtain vegetable foods with the intention of giving them away.

Figure 1b shows a somewhat different pattern for foods at the reservation. While sharing depth increases significantly with resource package size for forest foods at the reservation (slope = 0.003,  $p < 0.0001$ ,  $r = 0.79$ ), there is almost no change in depth for cultigens (slope = 0.001,  $r = 0.41$ ) or store-bought foods (slope = 0.001,  $r = 0.21$ ). The argument made above about honey, fruit, and larvae still applies here to cultigens, although less emphatically: large quantities of manioc, corn, and beans are harvested even though much of the produce goes to other NFs. Given the flexibility acquirers may have in choosing package sizes to harvest or purchase, it is relevant to note that of the 207 cultigens and store-bought items included in the above analysis, 159 (or 77 percent) were packages less than 5,000 calories.

**Multiple Regression.** A multiple regression allows us to tease out the impact of each hypothesized effect on sharing depth while controlling for other contributing factors. We attempt to construct similar regressions for both the forest

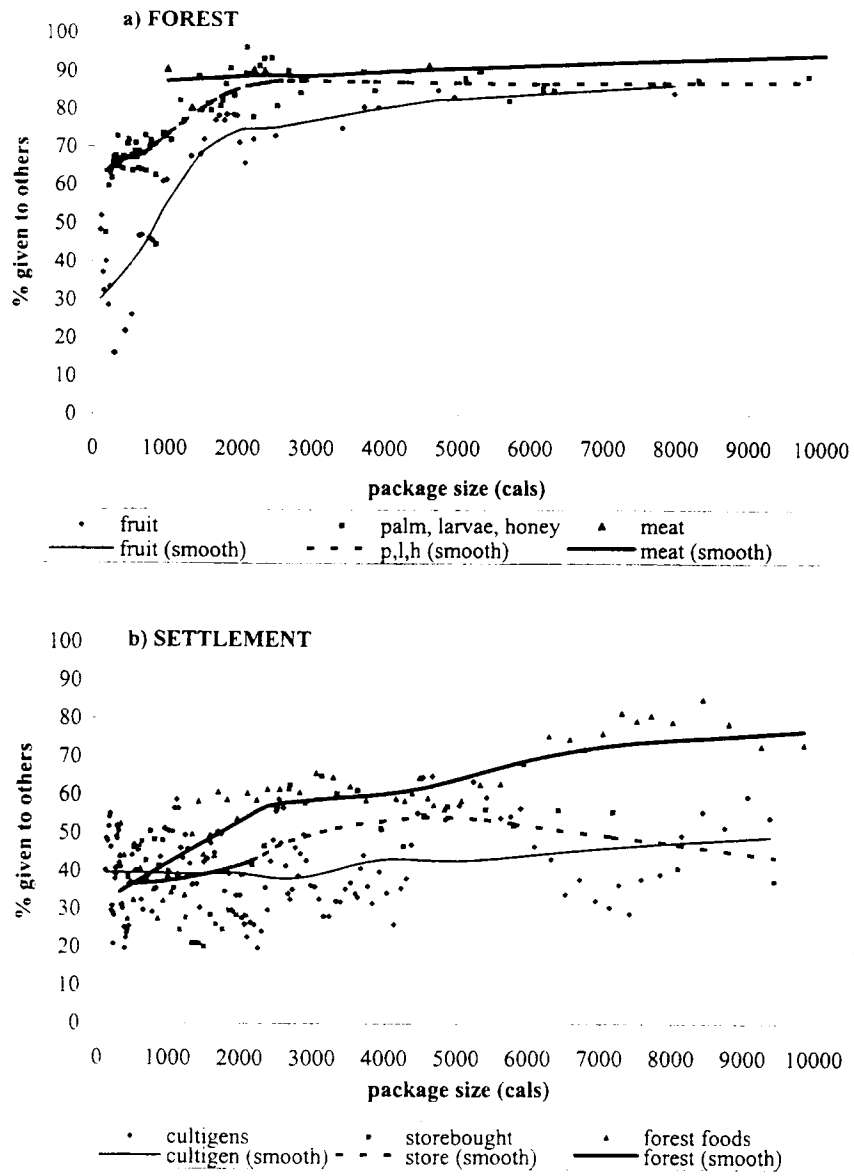


Figure 1. Percentage a Nuclear Family Gives Away by Package Size and Resource Type for (a) Forest and (b) Settlement

and the settlement samples, although the different methodology used to construct each sample means that some variables are present in one context but not in the other. In both cases, however, each data point describes a single resource distribution. In the forest sample, we regress the percentage of a single resource given to other NFs on resource type (meat, honey, or other), the sex and age of the acquirer, package size (in kilograms), the consumer-producer ratio of the acquirer NF (a measure of "need"), number of individuals present on the trip, and the number of items of the same resource type produced that day by everyone in camp ( $F = 25.05$ ,  $R^2 = 0.30$ ,  $df = 514$ ). The latter variable was included to see whether sharing depth is conditional on the availability of the specific resource type. Table 1 lists parameter estimates for each univariate effect, the partial parameter estimates obtained from the multiple regression (in both the given units and standardized), and the partial  $R^2$  for each effect.

Several important results are worth mentioning. First, while donor sex and age are significant univariate effects, they drop out of the multiple regression model because age and sex patterns correlate strongly with the types of resources acquired (Hawkes 1991; Kaplan and Hill 1985). Men were the only acquirers of game and honey, which displayed the greatest depth. Second, meat (and to a lesser extent honey) exhibit high sharing depth even when we control for package size. In fact, whether an item is meat acts as the strongest predictor of depth (partial standardized estimate = 0.43). Third, the number of items of the relevant resource type acquired that day is significantly associated with a decrease in depth in the multiple regression, even though the univariate effect of items acquired per day on depth is not significant. This result is consistent with tolerated theft and reciprocal altruism. For each additional item acquired that day, depth is reduced by roughly 3 percent. Fourth, each additional unit increase in the ratio of the number of consumers to producers in the donor NF is correlated with 15 percent less of a resource given to other NFs. Fifth, each additional member on a trip is associated with about 1 percent more resources given to other NFs, so that depth on the largest trip (trip nine, 40 individuals) was about 20 percent greater than that for the smallest trip (trip six, 17 individuals).

Table 2 presents the results of the multiple regression of sharing depth at the reservation by resource type (cultigen, domesticated meat, forest meat, other forest items, or store-bought), package size (in kilograms), donor sex and age, whether the food was raw or cooked, and the consumer-producer ratio ( $F = 7.3$ ,  $R^2 = 0.17$ ,  $df = 364$ ). Again, we find that the donor's sex and age are not significant predictors of depth in the multiple regression. Based on the standardized parameter estimates, package size and whether the item was forest meat are the strongest predictors of sharing depth. Each additional kilogram is associated with about a 0.7 percent increase in depth. Controlling for other factors in the model, raw foods (a proxy for primary distributions) show 10 percent greater depth than cooked foods (a proxy for secondary distributions), while forest meat items show about 16 percent greater depth than store-bought items (or about 24 percent more than cultigens). Each additional consumer relative to the number of producers results in a reduction of 4 percent given to other NFs.

TABLE 1  
Sharing Depth and Breadth in the Forest Sample

Variable	Sharing Depth			Sharing Breadth		
	Univariate Estimate	Partial Estimate	Partial Std. Est. $R^2$	Univariate Estimate	Partial Estimate	Partial Std. Est. $R^2$
Resource type						
Meat	32.23 ***	41.77 ***	0.43	1.36 ***	1.93 ***	0.30
Honey	20.73 ***	23.28 ***	0.21	1.12 ***	1.26 ***	0.18
Other	baseline	baseline	baseline	baseline	baseline	baseline
Package size (in kgs)	0.73 **	0.84 ***	0.17	0.04 **	0.05 ***	0.17
Consumer/Producer ratio	-6.15 *	-17.90 ***	-0.24	-0.16	-0.25	-0.05
Sex of acquirer (1 = male, 0 = female)	23.30 ***	4.92	0.06	1.07 ***	0.37	0.07
Age of acquirer	2.07 ***	0.81	0.21	0.08 *	-0.007	-0.03
Age squared	-0.03 **	-0.01	-0.22	0.00 ^	0.000	0.08
Number of individuals present	0.19	0.97 ***	0.17	-0.01	0.01	0.02
Number of items of resource class produced that day	-0.15	-2.68 ***	-0.29	-0.03 ^	-0.13 ***	-0.21

$F$ -value = 25.05;  $p < 0.0001$ ;  $R^2 = 0.30$ ;  $df = 514$  for depth

$F$ -value = 11.39;  $p < 0.0001$ ;  $R^2 = 0.17$ ;  $df = 514$  for breadth

\*\*\*  $p$ -value  $< 0.0001$  \*\*  $p$ -value  $< 0.001$  \*  $p$ -value  $< 0.05$  ^  $p$ -value  $< 0.10$

TABLE 2  
Sharing Depth and Breadth at Arroyo Bandera Settlement

Variable	Sharing Depth				Sharing Breadth			
	Univariate Estimate	Partial Estimate	Partial Std. Est.	Partial R <sup>2</sup>	Univariate Estimate	Partial Estimate	Partial Std. Est.	Partial R <sup>2</sup>
Resource type								
Cultigens	-6.21	-7.58 ^	-0.13	0.01	-0.29	-0.53 *	-0.11	0.01
Domesticated meat	6.95	2.26	0.02	0.00	1.68 **	0.36	0.06	0.00
Forest meat	17.64 **	16.00 **	0.19	0.02	1.01 *	0.40	0.06	0.00
Forest other	12.72	8.95	0.06	0.00	0.76	0.53	0.05	0.00
Store-bought	baseline	baseline	baseline		baseline	baseline	baseline	
Package size (in kgs)	0.74 ***	0.67 ***	0.19	0.04	0.20 ***	0.19 ***	0.66	0.45
Raw or cooked food (1 = raw, 0 = cooked)	11.90 ***	9.58 **	0.15	0.02	0.75 *	0.25	0.05	0.00
Consumer/Producer ratio	-4.17 **	-4.15 *	-0.14	0.02	-0.08	-0.16	-0.07	0.01
Sex of acquirer (1 = male, 0 = female)	5.19 ^	-3.11	-0.05	0.00	0.86 **	0.14	0.03	0.00
Age of acquirer	0.18	-0.28	-0.16	0.00	0.14 ^	0.07	0.40	0.00
Age squared	0.00	0.00	0.16		0.00 ^	0.00	-0.38	0.00

F -value = 7.3,  $p < 0.0001$ ;  $R^2 = 0.17$ ;  $df = 364$  for depth

F -value = 39.5,  $p < 0.0001$ ;  $R^2 = 0.52$ ;  $df = 367$  for breadth

\*\*\*  $p$ -value  $< 0.0001$  \*\*  $p$ -value  $< 0.001$  \*  $p$ -value  $< 0.05$  ^  $p$ -value  $< 0.10$

*Breadth*

For Single Resources. A single food item acquired in the forest is likely to be shared with 2.6 other NFs (s.d. = 2.6), or about 41 percent of the rest of the band. Meat and honey exhibit the highest breadth, given to an average of 3.4 and 3.6 other NFs, respectively. Larvae distributions display the lowest breadth, given to only 1.2 other NFs. Palm hearts and starch are each given to 2.3 other NFs, while fruits are given to 1.8 other NFs. Complete sharing of every resource to the entire band would predict a breadth of about 7.3 (the average number of NFs over trips six through nine).

A single food item is likely to be shared with 2.1 other NFs (s.d. = 2.6) at the reservation, or about 9 percent of the families at Arroyo Bandera. Domesticated meat items exhibit the largest breadth—shared with 4.4 other NFs. The single primary distributions of a 65-kg donkey and a 110-kg cow saw sixteen and nineteen other NF recipients, respectively, while the nine chicken distributions saw only a mean of 1.8 (s.d. = 1.3) other NF recipients. The food distributions of other resources, including meat and other items like honey and larvae brought back from forest trips, were transferred restrictively to less than three other NFs (2.4 for forest meat, 2.7 for other forest foods, 1.6 for cultigens, 3.0 for store-bought foods).

Multiple Regression. We perform multiple regressions on forest and settlement sharing breadth, using the same variables from the analyses of depth, and present univariate and partial estimates in Tables 1 and 2 (forest:  $F = 11.39$ ,  $R^2 = 0.17$ ,  $df = 514$ ; reservation:  $F = 35.9$ ,  $R^2 = 0.52$ ,  $df = 367$ ). In the forest sample, we find again that donor sex and age lose significance in the multiple regression model. Furthermore, meat and honey resources are still transferred to more NFs (an additional 1.9 and 1.3, respectively) even after controlling for package size. The number of resource items produced that day is a significant predictor of sharing breadth, and its significance (and magnitude) increases after controlling for other confounding factors. This result is consistent with tolerated theft and reciprocal altruism. The coefficient  $-0.13$  means that, on average, if eight other items of that resource class were acquired on that day, then there is one less recipient NF. Also, even though trips six through nine contained different numbers of NFs, there were no statistically significant differences in breadth across trips after controlling for other variables in the model. These results suggest that package size, resource type, and availability of different resource types are the main determinants of sharing breadth.

The analysis of reservation breadth reveals a strong significant effect only for package size (Table 2: partial standardized estimate = 0.66) and whether the resource item was a cultigen. An additional 5 kilograms is associated with an additional NF recipient, and cultigens were given to 0.5 fewer NFs. Donor sex and age and whether the food was raw or cooked all lose statistical significance when analyzed simultaneously.

Long-Term Breadth. It is possible that donor NFs interact with a larger pool of other NFs over multiple distributions. Here we analyze breadth over the span of each forest trip (range ten to fifteen days) and over the span of the reservation sample period (about four months). In considering the proportion of NF A's food

production given to NF *B* (where  $A \neq B$ ), we find that in the forest, only 3.4 percent of all 204 NF dyads (over the four trips) never transferred food. All instances of no transfers across NF dyads occurred on trip nine. This pattern contrasts sharply with that found at the reservation, where 33 percent of all 552 dyads saw no food transfers between NFs. This result is profound, especially given the much longer time depth of the reservation analysis. Additionally, 22 percent of forest dyads were flows of 5 percent of NF food production or less, while 82 percent of reservation dyads were of 5 percent or less.

Figure 2a shows the percentage of NF *A*'s food production given to each other NF *B*, ranked from those NFs that received the most to those receiving the least from *A*, averaged over all NF *A*s, for each of the four forest trips and for the reservation. (Note that Rank 0 refers to the percentage kept within the NF, even if this was less than the amount given to the NF receiving the most from the donor NF.) Several patterns are noteworthy. While Ache food sharing in the forest is one of the most widespread patterns documented ethnographically, it is still not strictly egalitarian. Completely egalitarian food sharing might predict a horizontal line at 25 percent for trip six, 11 percent for trip seven, 17 percent for trip eight, and 10 percent for trip nine (100 divided by number of NFs on trip). However, all lines are steeply sloped downward, with NFs keeping the highest proportion of their own production and each other NF receiving less. Unlike the reservation pattern, however, where all but four NFs received less than 5 percent, no NFs in trips six through eight received below 5 percent of a focal NF's production. In trip nine, three NFs received less than 5 percent. The impression given by the graph is that breadth is influenced by the number of NFs present and that the main difference between the forest and settlement patterns is the number of potentially interacting NFs.

We also investigated the possibility that the sharing of meat perhaps is more egalitarian than that of all foods in general (Figure 2b). The first notable pattern is that for all trips, and even at the reservation, each NF gave more to at least one NF than it kept for itself. Indeed, on trip eight, each NF gave more to all but one other NF than it kept for itself. Thus, while meat sharing is somewhat different than the pattern observed for all foods, it is still characterized by a steeply downward slope. On trip nine, four NFs received less than 5 percent, while on trip seven, one NF received less than 5 percent.

Analyzing breadth over entire foraging trips or over a sampling period illustrates wider breadth than that realized by only examining means for single resources. Self and two other NFs comprise about 13 percent of the NFs available at the reservation, but they receive about 64 percent of an NF's total production. Self and 2 other NFs comprise anywhere from 30 to 75 percent of the total NFs on a foraging trip and receive 56 to 84 percent of an NF's total foraging production.

## BALANCE

General Balance. General balance requires that food given to all other NFs is compensated with food received from all other NFs. Specific balance requires that food given to NFs be compensated with food received from those same NFs

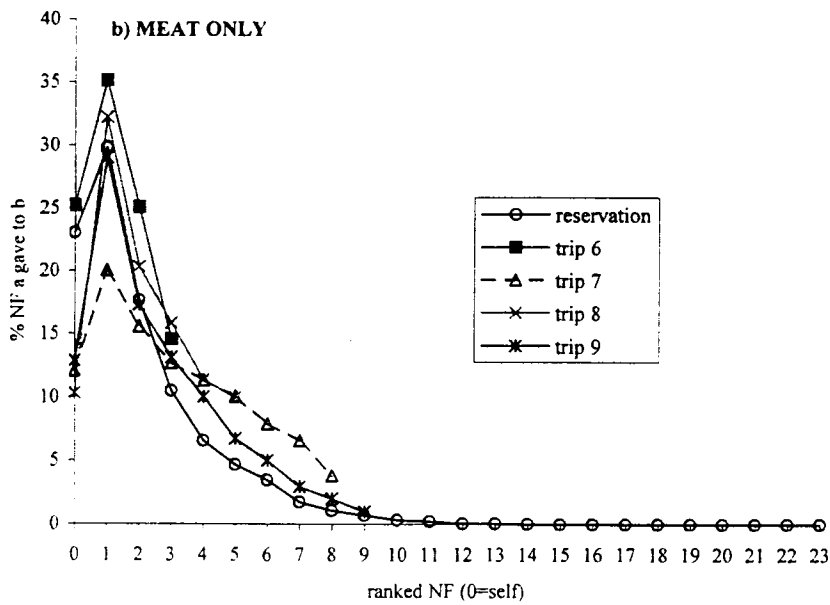
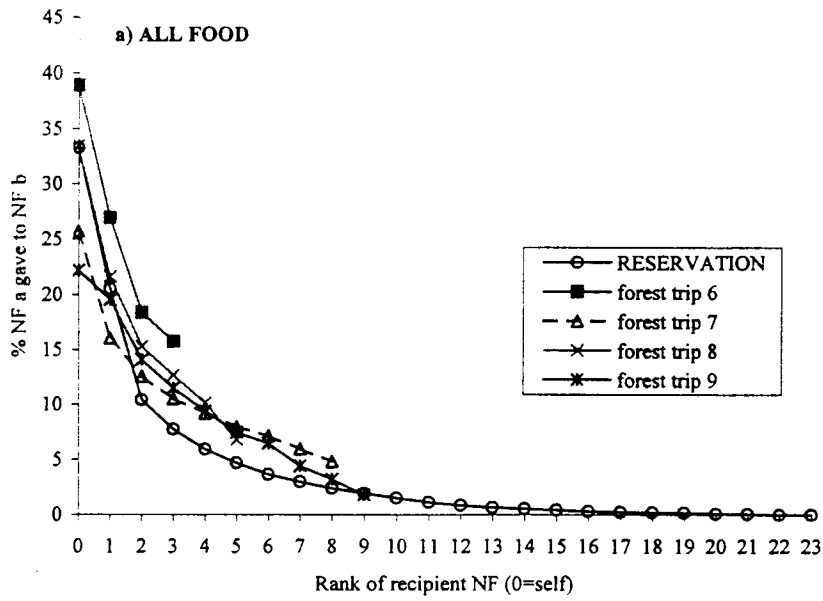


Figure 2. Average Percentage Nuclear Family A Gave to Nuclear Family B over the Span of Foraging Trips and a Three-Month Sample Period for the Settlement. Where Food Flows Include (a) All Food and (b) Meat Items Only

The x-axis represents the rank (from those who received the most to those who received the least) of all recipient NF B's, averaged across all NF A's. Rank 0 is the percentage NF A kept for its own members.

(Hames 2000; Gurven et al. 2000b). We operationalize general balance as the percentage of total production NF *A* gave to all other NFs as a function of the percentage of all shared food that was received by NF *A*. This relationship was not significant for meat ( $p = 0.38$ ) or nonmeat items ( $p = 0.11$ ) on forest trips. However, the percentage of all shared food received by NF *A* is significantly related to the total number of consumption hits where NF *A* was the acquirer for meat ( $r = 0.46$ ,  $p = 0.01$ ) and for nonmeat ( $r = 0.43$ ,  $p = 0.02$ ). These results suggest that relatively more food is given to NFs that share large absolute quantities of food, rather than to NFs that share a larger percentage of their production (cf. Gurven et al. 2000a). At the reservation, the percentage of all shared food received by NF *A* was only marginally correlated with the percentage of NF *A*'s forest food production given to others ( $r = 0.35$ ,  $p = 0.08$ ) and showed no relationship to the percentage of cultigen production given to others ( $r = -0.20$ ,  $p = 0.37$ ). Similarly, no linear relationship was found between the total mass of cultigens ( $r = -0.16$ ,  $p = 0.46$ ) or forest foods ( $r = 0.19$ ,  $p = 0.37$ ) given to others and the percentage of those resource types received by others. Since those who give more total food do not receive more food back, some NFs must be net producers and others net consumers.

**Specific Balance.** In Gurven et al. (2000b, 2001), we operationalized specific balance, or "contingency," as the slope of the regression of the percentage of NF *A*'s production given to NF *B* on the percentage of NF *B*'s production given to NF *A*. This slope estimates the percentage of NF *B*'s production received by NF *A* for every 1 percent of NF *A*'s production given to NF *B*. Due to the different methodology used in the 1982 forest study based on random eating hits, we calculate contingency here somewhat differently. For food shared on forest treks, we regress the difference between observed and expected number of eating hits flowing from NF *A* to *B* on the difference between observed and expected number of eating hits flowing from NF *B* to *A*. The slope from this regression is our estimate of contingency. This estimate describes NF *B*'s additional consumption of food acquired by NF *A* due to NF *A*'s additional consumption of food acquired by NF *B*.<sup>7</sup> This new measure of contingency allows for large discrepancies between observed and expected consumption to carry more weight in the regression than small discrepancies. To make direct comparison more feasible, we recalculated contingency measures for the reservation using this new measure.

As shown in Table 3, contingency in the forest exists for flows of nonmeat items (slope = 0.78,  $p < 0.0001$ ) and for all items pooled (slope = 0.26,  $p < 0.05$ ), but not for meat only (slope = -0.16,  $p = 0.19$ ). Significant contingency at the reservation exists for within-category transfers of forest items (slope = 0.10,  $p = 0.05$ ), cultigens (slope = 0.34,  $p < 0.0001$ ), store-bought foods (slope = 0.41,  $p < 0.0001$ ), and all foods together (slope = 0.36,  $p < 0.0001$ ). Because reciprocal altruism was originally formulated as an explanation for cooperation among non-kin (Trivers 1971), we also calculate contingency for pairs of closely related NFs ( $r = 0.5$ ) and for distantly related and unrelated pairs of NFs ( $r < 0.05$ ). For meat items in the forest sample, there is no significant contingency effect for kin; however, there is a significant negative effect for distant kin and unrelated NFs (estimate = -0.28,  $p < 0.05$ ). Thus, every additional eating hit by distantly related

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NFs of meat acquired by a focal NF is compensated by 0.3 fewer eating hits by that focal NF of meat acquired from the distantly related NFs. This is what we might expect if meat is transferred from haves to have-nots. Finally, transfers of nonmeat items in the forest show similar contingency effects for both kin and distantly related NFs. In the composite analysis of all foods, there is no contingency in flows among close kin, but there is strong contingency among distantly related NFs of lower magnitude as a result of the additive effects of the separate meat and nonmeat contingency effects described above.

These results for the forest contrast with those for the settlement. At the settlement, contingency is significantly stronger for flows among close kin than among distantly related NFs for all resource types (see Table 3). Furthermore, there is no negative contingency for meat flows among distantly related NFs. In summary, food is shared more with families who share those food types back on the reservation: the same is true in the forest for all food types except meat.

#### Equality

The issue of equality refers to discrepancies or biases in amounts given to different NFs. Are there biases to favor kin, neighbors, certain age/sex classes, and/or sharing partners? Figure 3 shows the frequency distribution of the percentage of each NF's production given to each other NF on each forest trip. The solid bars represent the expected percentage given if each NF receives equal portions of each other NFs production (100 divided by number of NFs on a given trip). The means of each distribution (listed in the figures) are close to an equality-based prediction, which reflects the fact that relatively little is kept within the NF of the acquirer.

TABLE 3  
Specific Balance in the Forest and Settlement

Group	Specific Balance					
	Forest 1982			Settlement 1998		
	Estimate	Corr. <i>r</i>	df	Estimate	Corr. <i>r</i>	df
All NFs <i>r</i> = 0.5 <i>r</i> < 0.5	All food			All food		
	0.26 *	0.22	100	0.36 ***	0.36	276
	0.03	0.02	17	0.45 **	0.45	29
All NFs <i>r</i> = 0.5 <i>r</i> < 0.5	Meat			Meat		
	-0.16	0.13	101	0.10 *	0.10	276
	0.11	0.09	17	0.16	0.16	29
All NFs <i>r</i> = 0.5 <i>r</i> < 0.5	Nonmeat			Cultigens		
	0.78 ***	0.63	101	0.34 ***	0.34	276
	0.78 *	0.49	17	0.63 ***	0.63	29
All NFs <i>r</i> = 0.5 <i>r</i> < 0.5				Store-bought		
				0.41 ***	0.41	276
				0.59 ***	0.59	29
			0.08	0.08	247	

\*\*\* *p*-value < 0.0001    \*\* *p*-value < 0.001    \* *p*-value < 0.05

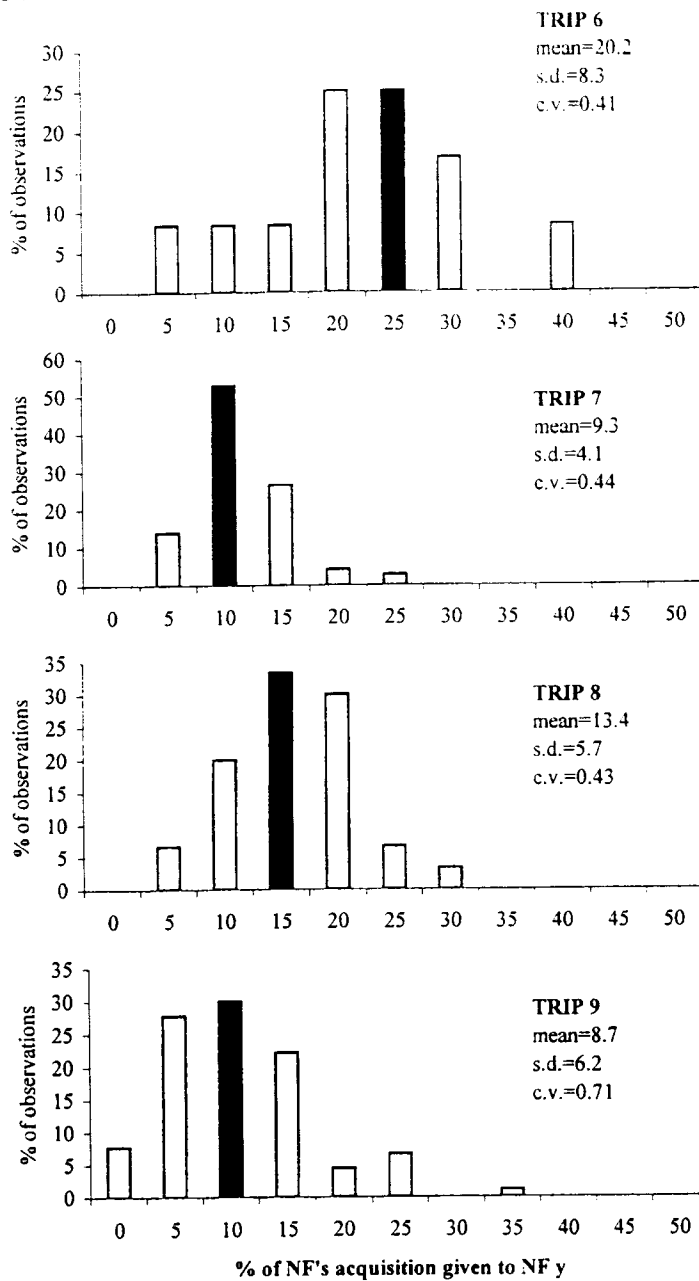


Figure 3. Frequency Distributions for the Percentage each Nuclear Family Gave to Every Other Nuclear Family over the Course of Each Foraging Trip

The solid bar represents the egalitarian mean percentage predicted if all nuclear families receive equal percentages from every other nuclear family's production (100 percent divided by the total number of nuclear families on the trip).

Standard deviations around the mean and coefficients of variation are also given to show the relative variation in percentages of NF production given to other NFs.

The same information for the Ache at the reservation is given in Figure 4. The striking pattern, suggested in the breadth analysis and here made more explicit, is the significantly higher variation in the amount of production given to other NFs at the reservation. Indeed, the coefficient of variation is three to four times greater for the reservation than for any of the foraging trips. We know from the discussion above that one large difference between the reservation and forest sharing patterns is that at the reservation, one-third of all dyadic interactions between NF pairs realized no exchange. Thus, instead of examining equality across all possible dyadic pairs from the twenty-four NFs at Arroyo Bandera, we focus on the top eleven NF recipients of each of the twenty-four NFs. In doing so, the number of zero flows drops substantially (shaded bars in Figure 4). These top eleven NFs received a mean of about 3 percent more food (5.8 versus 2.9) and observed a one-third reduction in the coefficient of variation (1.2 versus 1.8). Even though the number of eleven NFs is similar to the range of NFs observed on some foraging treks, this reduced level of variation in shared production at the reservation is still one-and-a-half to three times greater than that observed on those treks.

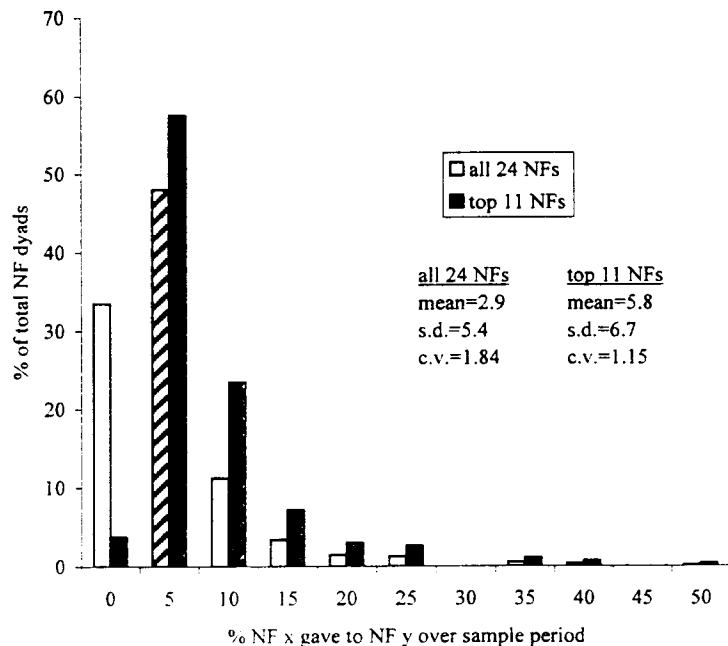


Figure 4. Frequency Distribution for the Percentage each Nuclear Family Gave to Every Other Nuclear Family over the Three-Month Sample Period at the Settlement

The first distribution includes all twenty-four nuclear families, with the hatched bar giving the mean egalitarian prediction of percentage given. The second (solid) distribution includes only the top eleven nuclear family recipients, with the solid hatched bar giving the mean egalitarian prediction of percentage given.

Because univariate analyses of kinship have been discussed in previous publications on the reservation and on forest treks (Gurven et al. 2000a; Kaplan and Hill 1985), they are only dealt with here in the final multivariate analysis. Measures of geographical proximity between NFs on the reservation have also been examined and shown to have strong effects on the likelihood of receiving shares (Gurven et al. 2000a). Here we explore the effect of proximity during foraging trips. Our only measure of proximity during foraging trips is the ranked distance between campfires on most nights for each trip. In general, proximity between campfires is only several meters, resulting in an overall camp circumference of about ten to twenty meters. We coded the ranked proximity of each NF to each other NF based on camp diagrams of forest treks made by K. Hill, H. Kaplan, A.M. Hurtado, and K. Hawkes. Because camps move frequently, mean proximities were obtained by averaging the ranked proximities between any pair of NFs over all days of a particular trip. These averaged ranked proximities range from 0 to 3. Over the course of a foraging trip, an NF that is one ranked distance further away from another gave that NF an average 2.2 percent less of its meat ( $p < 0.01$ ) and 2.3 percent less of its nonmeat production ( $p < 0.01$ ). Thus, the most physically distant NFs received about 7 percent less than other NFs at the same camp.

If we focus only on whether a recipient NF slept at the same campfire or at a different one, we find that those NFs which are more likely to sleep by other fires received 6.9 percent less meat ( $p < 0.01$ ) and 6.1 percent less nonmeat ( $p < 0.001$ ) production than those more likely to sleep at the same fire. Inspection of the ten NF dyads most likely to sleep by the same fire reveals an average kinship relatedness of 0.25 (s.d. = 0.26), while the remaining ninety-two dyads saw a mean kinship of 0.08 (s.d. = 0.18).

**Multiple Regression.** We examine the relative effects of kinship, proximity, contingency, and family size on the percentage of an NF's total food production given to each other NF, both over the foraging trips (F-value = 22.0,  $p < 0.0001$ ;  $R^2 = 0.54$ , df = 95) and at the reservation (F-value = 29.1,  $p < 0.0001$ ;  $R^2 = 0.26$ , df = 499). Table 4 shows partial estimates from a multiple regression analyzing the above variables both on forest trips and at the settlement. Distance between campfires of donors and recipients, the ratio of consumers to producers in the recipient NF, and the number of individuals present on the trip were the significant effects in the forest analysis. Each distance rank between donors and recipients resulted in 2 percent less of an NF's production given to another NF (similar to the univariate result above), while each consumer relative to the number of producers in the recipient NF resulted in 5 percent more given to that NF. The strongest partial effect, accounting for 45 percent of the variation in percent given, was the number of individuals present on the trip. Roughly 1 percent less was given to a specific NF for every two additional group members. An additional 10 percent of an NF's total food production was given to another NF on the smallest trip (trip six, 17 people) than on the largest trip (trip nine, 40 people). Contingency was not a significant predictor of the percentage of *all food* given to an NF, although contingency was significant for all nonmeat foods, even after controlling for proximity (estimate = 0.67,  $p < 0.0001$ ).

TABLE 4  
 What Influences the Total Percentage of Nuclear Family A's Production  
 Given to Nuclear Family B?

Variable	Forest			Settlement		
	Partial Estimate	Partial Std. Est.	Partial R <sup>2</sup>	Partial Estimate	Partial Std. Est.	Partial R <sup>2</sup>
Percentage of NF B's total given to NF A	-0.06	-0.06	0.01	0.27 ***	0.27	0.07
Distance from A to B	-1.86 ***	-0.27	0.11	-0.01 **	-0.15	0.01
Visibility of NF B from NF A	N/A	N/A		0.55 *	0.13	0.01
Closest kinship between A and B	1.61	0.06	0.01	5.15 ***	0.16	0.03
Consumer/Producer ratio of B	4.61 ***	0.52	0.31	0.58 *	0.10	0.01
Number of individuals on trip	-0.47 ***	-0.69	0.45	N/A	N/A	

F-value = 22.0,  $p < 0.0001$ ;  $R^2 = 0.54$ ;  $df = 95$  for depth

F-value = 29.1,  $p < 0.0001$ ;  $R^2 = 0.26$ ;  $df = 499$  for breadth

\*\*\*  $p$ -value  $< 0.0001$  \*\*  $p$ -value  $< 0.001$  \*  $p$ -value  $< 0.05$

Unlike in the forest sample, in the reservation sample, the strongest predictor of the percentage NF A gave NF B, when controlling for other variables, is the percentage NF B gave NF A. Each additional percentage of production A gave B was compensated with 0.3 percent given back from B to A. Another important contrast between the forest and reservation regressions is that kinship is an important predictor of interhousehold sharing at the reservation when controlling for proximity. Closest kin ( $r = 0.5$ ) received about 3 percent more than unrelated NFs, a significant amount given the overall mean of given food of 3 percent (see Figure 4). Although the consumer-producer ratio was statistically significant, it only predicts 0.6 percent more given for each additional consumer relative to the number of producers, much less than the 5 percent more given in the forest analysis. Distance continued to be important, with the most distant NFs (about 300 m) receiving about 3 percent less than the nearest located NFs (about 20 m). Visibility is another measure of proximity that accounts for the fact that distance does not always reflect the ability to see other cooking events, etc., in other houses, given the topography and arrangement of houses in Arroyo Bandera. From the perspective of NF A, NF B was scored as having *very high*, *high*, *average*, *low*, or *zero* visibility (coded from 40 to 0, respectively), depending on the relative ease by which M. Gurven and W. Allen-Arave could see the entrances, cooking, and eating areas of each other household in the community. The partial estimate given in Table 4 indicates that the least visible NFs (visibility = 0) received about 2 percent less than the most visible ones (visibility = 4).

## SUMMARY

Our comparison of forest and reservation sharing patterns has revealed important similarities and differences:

1. Overall depth is quite high, as about 80 percent of all foods (by weight) produced are given to other NFs in both the forest and settlement.
2. Breadth, in terms of single resource distributions, is relatively low, at about two to three NFs for both the forest and settlement.
  - a. Meat and, to a lesser extent, honey are unique in that they exhibit higher depth and breadth in the forest and higher breadth at the settlement, even when we control for package size.
  - b. The same forest foods shared widely on treks show restricted breadth (similar to that of cultigens and store-bought foods) when brought back to the settlement.
3. Donor age and sex are poor predictors of breadth and depth in both samples, after controlling for resource type and package size.
4. Long-term breadth differs significantly across contexts, with about 97 percent of NF dyads exchanging food with each other on week-long foraging trips and only 67 percent of NF dyads exchanging food during four months at the settlement.
5. Kin bias of NF sharing is strong at the settlement, while much of the kin bias in sharing on foraging trips occurs within NFs (Kaplan and Hill 1985) or groups of NFs sleeping at the same campfire.
6. Physical proximity between NFs is an important predictor of sharing in both the forest and the settlement, although the mechanisms explaining these results may differ (see below).
7. Finally, contingency is an independent predictor of all food sharing among specific pairs of NFs at the settlement, while contingency on foraging trips exists independent of proximity only for nonmeat food items.

## DISCUSSION

We explore the implications of the above results in terms of diet composition and comparative systems of production, group size, and proximate features such as local privacy and distance between NFs.

*Diet and Production*

The forest diet contains a far more significant meat component than does the reservation diet. Acquisition of meat, especially paca, monkey, and white-lipped peccary, usually requires high levels of coordination and cooperation among hunters. Since an average hunter can expect to return to camp empty-handed on 40 percent of all days, pooling of game has been labeled an effective strategy for reducing the risk of daily protein-lipid shortfalls (Winterhalder 1986; Kaplan and Hill 1985). High sharing breadth and depth for meat in the forest and high breadth

in the reservation may result in greater risk-reduction benefits, even when this pooling may be due to tolerated theft, costly signaling, or reciprocal altruism. A similar argument has been made for the greater sharing depth and breadth of meat items among the Yanomamo (Hames 1990). Risk reduction, however, cannot explain the significant sharing depth and breadth of nonmeat items such as palm hearts and fruits in the forest and manioc and sweet potatoes on the reservation. Although ethnographies often claim that collected items are not typically shared outside the nuclear family, the few studies where data exist (e.g., Hames 1990; Gurven et al. 2000b) show substantial proportions of nonmeat items are transferred outside the nuclear family.

One explanation for significant carbohydrate sharing entails a communicative aspect, in that giving nonmeat items may act as a reliable social signal to recipients that one is interested in maintaining close ties. Such signals may yield real benefits at other times, such as obtaining needed assistance when sick or injured (Gurven et al. 2000a) or, at the reservation, obtaining shares of meat brought back by others from foraging trips. Sharing as signaling requires some control over the distribution of acquired foods, rather than assuming that breadth and depth are determined solely by resource or donor characteristics. There is some evidence that donors who share with high depth and breadth receive more food when sick or injured at the reservation (Gurven et al. 2000a) and that the sharing of meat items is slightly correlated with the sharing of nonmeat items (Gurven et al. 2001). In the forest, however, there is no contingency of meat sharing on nonmeat sharing ( $r = 0.04$ ,  $p = 0.68$ ,  $df = 100$ ).

Another explanation points to economies of scale that are outcomes of certain systems of production (Kaplan, Hill, and Hurtado 1990; Hames 1987; Gurven et al. 2001). If the fixed cost of walking to one's distant fields is a large portion of the total cost of harvesting, say, manioc, then it might behoove individuals to take turns harvesting large quantities of manioc and to share this surplus with other NFs back at the village, either directly or through secondary sharing. One peculiar aspect of economies of scale is that sharing portions of a daily harvest can occur even though every NF has its own fields. For economies of scale to work effectively, they require consistent turn taking. Without consistent turn taking, people might be more inclined to incur fixed costs repeatedly, rather than share with those who either do not produce or do not share. Thus, we might find variable breadth and depth of cultigens across NFs, depending on the magnitude of fixed costs relative to total costs for each NF and the amount of confidence in other sharing partners reciprocating the favor of harvesting. The fact that nonmeat items are shared widely, but with strong contingency of giving and receiving across NFs in both forest and settlement contexts, is consistent with this view.

On foraging treks, collecting palm products, extracting larvae, and gathering fruit, especially oranges, are possible economies of scale. However, in addition to economies of scale for specific resources, the economies of foraging trips, in general, differ from that of the reservation. The age-sex specific division of labor on foraging trips is highly pronounced, with individuals engaging in activities from which they can acquire food at the highest return rate. Children work little, and

adult women produce most of the carbohydrate calories. Adult men hunt, and even among hunters, more-skilled hunters might indicate a source of honey or oranges to less-skilled hunters and continue their search for animal prey. Why would a hunter share this valuable information if he were not assured a share of the other men's produce? Recent analyses of time allocation indicate that 17 percent of men's and 11 percent of women's active foraging time is spent in activities that increase the potential caloric return rate of other individuals at the expense of their own (Hill n.d.). While comparative time allocation statistics do not exist for the reservation, we suspect that they would be much lower. It appears that food production on forest treks is a cooperative venture even though not all tasks require the coordinated efforts of multiple individuals. Each able adult member of the band is expected to work at productive tasks.

While meat is given "unconditionally" to those who may not have produced any meat, all adult men actively hunt for about six hours per day when in the forest. Although men's hunting abilities vary (Hill and Kaplan 1988), random factors play an important role in men's daily hunting returns. When luck plays a large role in determining returns, a fair rule of thumb might be to reward effort, rather than actual returns. This is consistent with results in economics experiments where random assignment of players' roles induces more generosity than when one player "earns" the right to be stingy (Camerer and Thaler 1995). Similarly, while collected goods in the forest might be given to others who engaged in other productive tasks (e.g., hunted, cut trails, babysat offspring, etc.), giving these items away is contingent on receiving them because returns from collecting are more a function of time invested rather than luck. However, exceptions may be made for sick individuals or pregnant women who reduce their workloads and can expect to be subsidized by other group members (Hurtado et al. 1985).

At the reservation, variance in cultigen production is largely due to differences in time spent planting, clearing, weeding, and harvesting, rather than luck. Cultigen transfers are highly contingent and more limited in breadth, consistent with the argument that where time investment predicts production, restricted sharing is expected. Additionally, the package size of a harvest brought back to a house is a decision made by the acquirer, who can choose to bring back four sticks of manioc, or 20 kg, while package size of bagged game is limited to whatever the hunter is lucky enough to find in a given bout. Since large packaged items exhibit higher depth and breadth than smaller items, the decision to harvest large amounts should carry a desire, or at least an expectation, of sharing. A similar argument may explain the collection of large quantities of fruits and vegetables on forest treks.

#### *Group Size*

It has often been argued that cooperation, or specifically reciprocal altruism, requires small numbers of interactants because levels of free riding can increase in larger groups (Boyd 1988), while the additional gains of risk reduction from pooling food with another member may be small (Winterhalder 1986). Indeed, ethnographic reports of large groups fissioning into smaller groups due to complaints of inadequate meat consumption, as among the Yanomamo (Good

1989). are consistent with this view. Nonetheless, there has been little direct study of group size effects on cooperation in real settings. In our multiple regression analyses for single distributions, breadth did not vary across trips, and depth was proportionally greater on those trips with the greater number of NFs (see Table 1). These results are inconsistent with tolerated theft and costly signaling.

While sharing behavior in terms of single distributions does not appear greatly affected by the relatively small differences in group size evident from the foraging trips, the breadth and equality of sharing over the course of foraging trips, or over the settlement sampling period, does appear sensitive to group size. The mean percentage of an NF's production given to each other NF was negatively correlated with the number of NFs present ( $r = -0.82, p < 0.10, df = 4$ ), which derives, in part, from the result that the number of NFs present on a foraging trip is negatively correlated with the percentage of total production kept within the NF ( $r = -0.95, p < 0.05, df = 3$ ); the first column of points in Figure 2a, above). These results are consistent with tolerated theft, costly signaling, and reciprocal altruism. The similar shapes of the curves generated in Figure 2a suggest that breadth increases at a decelerating rate with increases in group size, so that additional NFs in the group receive only small shares from some NFs. This trend is most evident by examination of trips six and nine and the reservation. It is interesting to note that an NF at the reservation kept a similar proportion of its production with the family as did an NF on the foraging trips (66.7 percent versus 69.9 percent, the average for trips six through nine), despite differences in average group size.

#### *Privacy and Distance*

We have seen that the distance between households or campfires is a significant predictor of the proportional flow of food production between NFs (see Table 4). For the settlement, visibility is another proximate determinant of food transfers between NFs, while in forest camps, there are probably few, if any, differences in visibility due to close in-camp proximities. Significant proximity effects have been interpreted as evidence in favor of tolerated theft (Bliege Bird and Bird 1997), although the causal link between proximity and receipt of shares could be due to other reasons. While nearby individuals might attain privileged information at a lower cost than those further away, it is possible that the main reason certain individuals live nearby and receive favoritism in food distributions is because consistent sharing partners prefer to live near each other (Gurven et al. 2000b). We find that NFs with higher visibility and higher proximity to most other NFs do not give a higher percentage of their production away to other NFs, either over the entire sample period ( $r = 0.30, p = 0.17, df = 21$  for visibility;  $r = 0.10, p = 0.66, df = 21$  for distance) or per event ( $r = 0.00, p = 0.15, df = 368$ ;  $r = 0.00, p = 0.93, df = 362$ ). Nor do visibility and proximity correlate with the total number of NF recipients over the sample period ( $r = 0.00, p = 0.84, df = 21$ ;  $r = 0.28, p = 0.20, df = 21$ ). These results are inconsistent with tolerated theft. Because more visible NFs and those living in denser clusters do not give away more food, or to more NFs, it is more likely that proximity is an outcome of a prior desire to pool resources and labor. Proximity, however, may have an effect on receipt of food

during secondary distributions, with small children hanging around houses where food is being cooked and being somewhat successful in receiving shares (unpublished data).

Houses in Arroyo Bandera are now made of wood and contain a window, a door, and a porch where most households process and cook food. It is possible that individuals could store certain foods, such as oranges, sugar, salt, and roils, in their houses without other individuals in the village being aware of their presence. Additionally, in our observations of reservation food consumption, there were several examples of individuals cooking food on the porch and then consuming it inside the house with the door closed. We suspect that small, store-bought goods are the ones most susceptible to in-house hoarding. Nonetheless, there is still privacy with regard to consumption of game, domesticated animals, and, to some extent, cultigens. When men return from hunts, they must often pass through the center of the village where many witness their arrival, and even when men take shortcuts through their fields to return to their houses, news of bagged game circulates quickly. Thus, relatively high proportions of foods kept within families and low sharing breadth at the reservation are not merely by-products of increased privacy.

### CONCLUSION

Comparisons of Ache sharing in the forest and on the reservation are useful for understanding general principles that may explain food transfer patterns. We have discussed how predictability of the diet and interindividual variance in acquisition, cooperation in production (e.g., economies of scale), group size, proximity, and privacy each can affect sharing breadth, depth, equality, and balance. We believe these key dimensions can perhaps more appropriately explain widespread variation in sharing practices among different populations than can generalizations based on macrolabels of groups, such as "hunter-gatherer" or "horticulturalist" (Gurven 1999).

With respect to evolutionary models of food sharing, we believe that reciprocal altruism, tolerated theft, costly signaling, and nepotism are all relevant to understanding different aspects of Ache food sharing. Nepotism may explain much of the intra-NF sharing observed in both forest and settlement contexts. While nepotism also seems important for inter-NF sharing at the settlement, we do not find strong imbalances in exchanges among kin (cf. Hames 1987; Feinman 1979; Sahlins 1972). In fact, giving to kin is highly contingent on receiving, a requirement of reciprocal altruism. Restricted breadth and depth and the existence of contingency are all consistent with reciprocal altruism, even when items given are not reciprocated kilogram for kilogram. We believe, but have yet to show, that giving in the forest context is contingent on work effort and that sanctions exist to punish shirkers. One reason why this has been difficult to show is because Ache men and women adhere to the norm so well that there are no observed cases of individuals simply refusing to work. Nonetheless, the emphasis on relative need, which plays an important role in tolerated theft-based sharing, may be instrumental

in the kinds of norms that govern Ache sharing, even though producers may exhibit control over the foods they acquire (see Kaplan and Gurven 2001).

### NOTES

1. This breakdown is similar to that reported by Hawkes et al. (1987) for Chupa Pou, based on consumption hits during focal observations. They report a diet consisting of 65 percent cultigens, 10 percent store-bought goods, and 15-21 percent meat.

2. Of the 8,288 consumption hits across all nine trips, only 2,679, or 32 percent, of all hits were made on trips one through five.

3. The *mean* relatedness, obtained by averaging all *r*s between all pairs of individuals from any two families, is highly correlated with and less conservative than the measure of *closest* relatedness reported here (Allen-Arave, Gurven, and Hill n.d.).

4. In a related measure, Hames (2000) calls *intensity* the proportion of what an NF consumes that was given by other NFs. While depth and intensity may vary across NFs, mean depth and mean intensity for the population are equivalent.

5. The percentage of resource type X given to other NFs is calculated as the percentage of all eating hits of type X where the consumer was a member of a different NF than that of the acquirer.

6. These figures were calculated by multiplying percentages given for the source of raw and cooked foods.

7. The expected number of eating hits by NF B of NF A's production is calculated by multiplying NF A's shared production times NF B's proportional consumption. This is simply the total number of eating hits where NF A was the acquirer (but not the consumer) times the proportion of total (non-NF A) eating hits where NF B was the consumer.

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