

**Biran A**, Abbot J and Mace R. (2004). Families and firewood: A comparative analysis of the costs and benefits of children in firewood collection and use in two rural communities in Sub-Saharan Africa. *Human Ecology* 32 (1) 1-25.

## **ABSTRACT**

Domestic firewood collection is compared across study sites in Malawi and Tanzania. The study focuses on accommodation of infant-care within wood collection, the influence of family size on firewood demand and the contribution of girls to firewood collection.

Malawian women carry their infants on wood collection trips. The Tanzanian women leave their infants behind. The shorter trips of the Tanzanian women, and the ready availability of allo-parental care may facilitate this.

Mean per-capita wood consumption was similar across the two sites. However, a marked economy of scale was evident in wood use at the Malawi site.

Girls at both sites assist with wood collection. Their contribution appears more than sufficient to compensate for their own wood use. Having a daughter therefore need not represent a net energetic cost to a woman in terms of firewood acquisition and consumption.

While family size and structure appear to influence to influence firewood consumption and acquisition, differences in the environment between the two sites may underpin much of the variation. The longer journey times, heavier loads and less frequent journeys undertaken by Malawian women may reflect the steep terrain and risks associated with firewood collection within a national park.

**KEY WORDS:** children's work, family size, child-care, firewood, Maasai, Tanzania, Malawi.

## **INTRODUCTION**

In this study we examine the female domestic subsistence task of firewood collection and the way in which performance of this task is affected by elements of family size and structure. Using data on patterns of wood collection from two African communities, the problem of incorporating infant care into work activities is examined. The relationship between household size and the firewood costs of additional household members is considered and the input of girls to the household economy is modeled in terms of the acquisition and consumption of firewood.

Wood is a vital source of household energy for the majority of people living in rural areas in developing countries and is essential in the preparation of many staple foods (Fleuret and Fleuret 1978, Hosier 1984, Brouwer et al 1989). The collection of firewood should therefore be regarded as an important subsistence task that compliments the production or acquisition of food in the provision of adequate nutrition.

The main burden of firewood collection falls on women (Bryceson and Howe 1993, Mehretu and Mutambirwa 1992) and this task can be an important consumer of time and energy. Studies from Kenya (Barnes, Ensminger & O'Keefe 1984) and Southern Africa (Shackleton 1993) report weekly per capita wood consumption figures of 6.8 and 13.2 kg, respectively. Women gather the wood and carry it home on their back or head.

Rural women in developing countries face a major problem of allocating time between competing activities (Boserup 1989, Berio 1984, Ellis 1988). The number of hours available to women is finite. Increased time spent on one activity must be matched by a decrease in the time spent on alternatives and women are forced to prioritize their use of time (Borgerhoff Mulder and Caro 1985). Caring for children can be particularly demanding on women's time, and trade-offs between child-care and other essential tasks have been documented (e.g. Popkin 1980, Hames 1998, Levine 1988).

Women must often decide whether to integrate child-care into their work activities or to leave their offspring behind, perhaps in the care of another individual if such assistance is available. Each strategy has its own problems. Blurton Jones (1972) suggests that, like other primate species, human infants have evolved to be carried rather than cached. However carrying an infant can reduce the efficiency with subsistence tasks can be performed (Blurton Jones and Sibly 1978). Leaving a child in the care of an allo-parent however, can be detrimental to the welfare of the child (Popkin 1980, Borgerhoff Mulder and Milton 1985, Levine 1988)

Notwithstanding the potential disadvantages, the use of other people's labor is one way through which women can attempt to meet the competing demands on their time. A woman who receives help with child-care or labor is likely to benefit in terms of an increase in household food supply or an increase in child survival as a result of improvements in the quality or quantity of child care (Turke 1988, Hames 1988). She may also benefit in somatic terms through a reduction in her own energy expenditure (Lee 1989).

Dependent children can be an important source of child-care or labor (Easterlin 1975, 1990, Caldwell 1977, 1983, Turke 1988, Becker 1991, Kaplan 1994). The significance of the contribution made by dependent children to the household economy has been the subject of discussion for a number of authors and it has been suggested that benefits to be derived from the labor of children may contribute to, or even drive, high fertility rates (e.g. Nag et al 1978, Blurton Jones et al 1989, Ulijaszek 1993, Kramer 2002).

The present paper brings together data collected during two separate studies at contrasting study sites conducted through the Human Ecology Research Group at University College London in 1993-4. One data set comes from Malawi, from a farming and fishing community living in a national park on the shores of Lake Malawi (Abbot 1996, Abbot and Mace 1999, Abbot and Homewood 1999). The other comes from a community of Maasai agro-pastoralists living on the Simanjiro Plains of Tanzania (Biran 1996). While these two societies differ culturally and in their modes of subsistence, wood is an important source of energy in both societies. It is used for cooking and heating water on open fires, usually three-stone hearths. Among the Maasai it is also used as a means of heating houses from time to time, especially during cold weather or if a sick person or animal is present. Women at both study sites face similar tasks of wood collection and child-care and are able to call on the assistance of others in managing these tasks.

The data presented were not collected with a view to conducting a comparative study. However, the opportunistic use of the two data sets together provides a means of exploring a subsistence activity that has received little attention to date. Data collection during the same time period allows comparisons to be made between the two sites. This study does not set out to test explicit hypotheses but rather offers a quantitative, comparative description of firewood collection by women. Particular attention is given to the way in which women manage the demands of child care within this activity and to the role played by dependent daughters in provisioning their natal households with firewood.

## **METHODS**

This study makes use of a combination of demographic data, participant observation, quantitative measures of wood and quantitative observations of behavior. At each of the two study sites, data on wood collection formed part of a larger study of behavior patterns and resource use (Abbot 1996, Biran 1996). The methods used for data collection differ slightly between the two sites and are described below.

### ***Malawi***

#### *Study site*

Lake Malawi National Park, situated at the southern end of Lake Malawi, the southernmost basin in the African Great Rift Lakes system, was established in 1980. While established as an aquatic park to protect a sample of the Lake Malawi biome, 93% of the designated area is terrestrial comprising dry, deciduous woodland known as

*miombo* on steep and rocky slopes. The park incorporates five traditional fishing villages distributed along the shores of the park, and the two largest (Chembe and Msaka) were selected for the present study. The population of the five villages is estimated at 8440 people (Abbot 1996), giving a population density of 122 people per square kilometer of the park.

The Chewa, characterized by a matrilineal social structure, are the traditional and dominant ethnic group within the five villages. But they are outnumbered by a collective of seven other ethnic groups, particularly the patrilineal Tonga and Tumbuka from Malawi's Northern Region. Fishing is the primary economic activity within all the villages. It is undertaken by men although women are involved in processing and trading fish. Given the steep and rocky terrain of the park, there is limited land suitable for agriculture. Women, particularly amongst the original Chewa settlers, practice subsistence agriculture on the available flat land in Chembe and Msaka villages, but landholdings are small (averaging 0.6 hectares per household), and the short rains and high temperatures associated with the lake shore, make agriculture marginal.

The villagers depend on the protected woodlands for forest produce, especially firewood and building materials (Abbot and Homewood 1999), but there are restrictions on their use of natural resources from the park (Abbot and Mace 1999). Natural resources show specific collection patterns with regard to gender and age which reflect a traditional division of labor (Abbot 1996). Women and children are regular collectors of natural resources, both for subsistence and trading purposes. Cooking and other domestic activities are undertaken by women. As a prerequisite for cooking and a household requirement, firewood collection is undertaken by women.

#### *Demographic data*

An initial structured interview with a focal woman from each of 30 randomly selected households in each of the two villages of Chembe and Msaka was used to establish the age and identity of all household members (Oppenheim 1992). An extended family residing within one compound and eating together as a single unit is regarded as a household for the present study. Each month subsequently, the focal woman was asked how many people were residing in the household and her response compared with the original interview data. This enabled any visitors or absent members of the household to be detected. Demographic data from the 30 households in Chembe show that 37% of households contained either a maternal or paternal grandmother. Postreproductive women, as well as older children (especially girls), contributed to the household through caring for younger children.

#### *Wood collection and use*

Firewood consumption data were collected from the sixty randomly selected households in Chembe and Msaka. Firewood consumption was monitored monthly over a period of seven consecutive days in each of the study households. On the first day the household firewood stockpile was weighed. On each of the seven days, all firewood bundles collected or bought by the household were weighed and an estimate of the weight of any wood that had been sold or donated to other households each day was recorded. The

stockpile was re-weighed at the end of the seventh day. The survey was carried out for twelve months in Chembe village and for five months in Msaka village.

Quantitative observational data on wood collection activities were collected in Chembe village by focal group sampling using continuous observation (Altmann 1974, Martin and Bateson 1986). This allowed the time spent walking to and from the wood source and that spent gathering wood to be recorded. Focal groups were followed weekly, the day of observation being varied. On an observation day an observer walked through the village in the early morning or afternoon and selected the first group of firewood gatherers encountered. This method, while not strictly random, ensured that only women who were undertaking their routine firewood collection trips were followed. In total the study comprises forty-five groups of wood collectors from Chembe.

In addition to the observational data, each woman was asked when she had last collected wood. This allowed the frequency of wood collection to be estimated. Women were weighed with and without their firewood bundles using stand-on digital Salter weighing scales. Bundle weights were calculated by subtracting the woman's weight from the combined weight. The presence of daughters accompanying their mothers was noted and these girls and their bundles were also weighed. Records were made of nursing mothers collecting firewood with their babies tied to their backs.

## ***Tanzania***

### *Study site*

The study took place in a Maasai community living within the administrative boundary of the town of Terat in the Simanjiro District of northern Tanzania. The study population lived in 11 homesteads within a 6.5 kilometer radius of Terat. Homesteads were included in the study as permission was granted by their resident elders and were added to the sample until the maximum possible number had been included given the time available. No elders refused permission for their homestead to be included in the study.

The Maasai are known traditionally as a pastoralist people, gaining subsistence from their animals in a manner which has been likened to parasitism (Dyson-Hudson 1980). Today among Tanzanian Maasai, subsistence pastoralism has declined greatly. The alienation of the Maasai from former grazing lands by currently more powerful groups (including Europeans and North Americans) who use the land to raise crops (Galatay 1994) or for wildlife conservation (Homewood and Rogers 1991) has played a major part in this.

The Maasai in the current study population supported themselves through subsistence agropastoralism supplemented by small-scale trading activities. A number of women were involved in buying and selling small quantities of maize flour at the weekly market. Snuff and herbal medicines were also made by women from time to time for sale as well as personal use. Those women with access to the largest numbers of cattle sold small quantities of milk.

The study took place during a severe drought that had resulted in widespread loss of animals and crops. It is likely that this drought affected subsistence strategies and the daily activity patterns of adults and dependent children of either sex. However, no comparative data have been collected during non-drought years with which to assess this. The lack of crops and shortage of animals probably greatly reduced the time devoted to agriculture and animal husbandry and also removed opportunities to engage in paid agricultural labor. It is possible that women's involvement in trading activities increased as a means of coping with the drought. However, the activities of women with access to larger numbers of animals suggests that trading is a regular feature of Maasai subsistence activities.

The Maasai have a polygynous marriage system. At the time of the study 15 of the 52 Maasai women in the study population were monogamously married. The combination of polygyny and the housing and living arrangements of the Maasai often results in groups of adult women and their dependent children living in close proximity, offering the potential for co-operation in various domestic tasks including child care. Excluding breast feeding, thirty-one percent of all daytime care of children under 4 years was performed by carers other than the children's mothers (Biran 1996). A woman's dependent daughters and polygynous co-wives both provide important sources of child care.

A summary of daily, daytime activity budgets among Maasai women and girls in the study population is given in Table 1. These mean values give an indication of the relative importance of different activities in terms of the time devoted to them but they are not a good guide to the structure of a 'typical' Maasai day since not all activities are carried out on a daily basis. Data were not collected on weekly market days and therefore the time spent in town is underestimated and the time spent in commercial trading activities is missed.

#### *Demographic data*

A census was carried out of all homesteads involved in the study. The names and ages of, and the social and biological relationships between, homestead residents were recorded through interviews with all adult female household residents. A local events calendar was used to place the year of birth of individuals. These data were cross-checked by questioning other respondents during conversations throughout the study period.

A Maasai homestead consists of a cluster of houses located within a thorn bush stockade and surrounding an inner stockade that serves as an enclosure for livestock. The inhabitants of a homestead usually comprise one or more married men (the elders), their wives and the dependent children of their wives. The term *dependent children* is used here to denote unmarried girls and uncircumcised boys. Girls usually marry between the ages of 13 and 16, following which they go to live in the homestead of their husband (Homewood and Rodgers 1991). The circumcision of boys occurs around the age of 16 and marks their transition to warrior status, following which they frequently spend long periods of time away from home (Homewood and Rodgers 1991, Saitoti 1986). Within a

homestead the adult women generally each have their own house within which they cook and sleep along with their dependent children.

For the present study, residency in a Maasai home is defined primarily by eating arrangements. The residents of a house are those individuals whose food is prepared in that house. These individuals generally also sleep within that house. Polygynously married men alternated their residence (both eating and sleeping) between the houses of their wives. Temporary guests, who were recognized as such by residents, were not defined as residents. The term *household* is used in this study to imply all the residents of a single house.

#### *Wood collection and use*

Detailed, quantitative behavioral data were collected on 52 women and 17 eldest dependent daughters. The sample included all 39 adult women resident in 9 of the homesteads and a random sample of 13 women drawn from the remaining 2 homesteads. The 17 dependent daughters were selected randomly from those available.

Behavioral data were collected using instantaneous scans of focal subjects (Altmann 1974, Martin and Bateson 1986). Each subject was followed continuously by an observer over 2 or 3, 11-h sampling-days. Sampling-days lasted from 07:30 to 18:30. Throughout these days the behavior of the subject was recorded by instantaneous scans at 15 minute intervals. Subjects were sampled and re-sampled in a random order. Data recorded in this way have been found reliable in estimating the time spent in various activities by subjects (Dunbar 1976, Gross 1984, Borgerhoff Mulder and Caro 1985) and are used in the present study as a measure of the time devoted to collecting fire wood.

Collection of wood occurred during daylight hours. Observers were present in the homesteads between 07.30 and 18.30 and were able to monitor the wood brought to houses. When wood was brought to a house the identity of the person bringing it was recorded and the bundle was weighed using a spring balance. Sixty houses were observed in this way on 2-20 days each. The usual wood source for each homestead was visited and its distance from the homestead estimated using a pedometer.

## **RESULTS**

#### *Wood collection at the two study sites.*

In both communities the collection of wood is the responsibility of women and girls. In the Malawi study, men and boys were never observed collecting wood for domestic use. In the Maasai community, of the 114 loads of wood which were observed being brought to houses, 54 were brought by women, 57 by girls and 2 by boys. Maasai men were never observed collecting wood.

Wood is picked off the ground, knocked out of trees using sticks or cut from trees and bushes using a machete. Once a sufficient pile of wood has been collected, a leather or grass strap is used to bind it into a bundle. Among the Maasai, bundles of wood are carried using the head strapping method by which bundles are carried on the back and held by a loop of the strap that is passed around the forehead of the carrier. In Malawi, women carry the bundles of wood on their heads (head loading).

The two study sites differ in the distances over which wood must be collected. The mean distance to the wood source at Lake Malawi National Park is 2.1 km (range 0.52 – 4.93 km) while in Simanjiro the mean is 1.1 km (range 0.9-1.3 km). The terrain which must be crossed by those collecting wood also differs. At Lake Malawi National Park wood collection involves a long and arduous climb to the wood source followed by a steep descent with a heavy load on the return journey. The large range in distances walked in the Malawi study is explained by the geography of the park and the villages being characterized by strip development along the lake shore. Long distances are incurred when women from Chembe village (often the central parts of the village) walk through the flat agricultural land behind the village and then climb up into the hills. The shorter distances are incurred by women who live on the edges of Chembe village and can then directly climb up into the hills. The Simanjiro terrain, though rough, is gently undulating rather than hilly.

The mean length of a wood collection trip among Maasai women (n=24) was 90 minutes (range 45 - 210). However, wood collection does not take place every day. The mean length of time spent daily on wood collection by Maasai women (n=52) was found to be 10 minutes (range 0 - 54). The mean length of a wood collection trip for the Malawian women was 241 minutes (range 130 – 369, n= 45 wood collecting groups). Wood collection in Lake Malawi National Park was undertaken on average every 3.8 days resulting in a mean daily time of wood collection of approximately 63 minutes.

#### *Wood collection and the care of infants.*

In Lake Malawi National Park, nursing women were seen to carry their infants strapped to their backs when they went to collect wood. The wood collection patterns of these women are compared with those women who did not bring infants with them and who are presumed to be non-nursing.

No significant difference is found between nursing and non-nursing women at Lake Malawi National Park in terms of journey times or mean weight of wood carried (see Table 2). Nursing women carry slightly larger bundles than non-nursing women, but the difference is only significant at the 0.10 level. This is despite carrying a mean additional load of 9.1 kg, which is the weight attributed to the baby tied to the mother's back.

Our observations suggest that these nursing women integrate child-care into the workplace by feeding babies during the rest periods that are associated with tying firewood bundles before returning to the village. No significant difference is found in woodland residence times (defined as the time spent searching for firewood, resting and tying bundles prior to head loading the wood back to the village) of wood collection groups with and without

nursing women (Table 2). It thus appears that Malawian women integrate child-care into normal patterns of firewood collection and do not slow their group by remaining longer in the woodland.

The Simanjiro Maasai women never carry infants with them when they collect wood. The foraging efficiency of these women cannot therefore be constrained either by carrying the extra load of an infant or by the time needed to care for an infant while out collecting wood. The possibility exists however, that nursing women might be constrained in terms of the time which they are able to devote to wood collection because of the needs of the infants they have left behind.

In the Maasai sample, nursing women are defined as those ever observed breast feeding their infants during the study period. A comparison of nursing women (n=38) with women who were not nursing but who were responsible for looking after at least one child (n=12) revealed no significant difference in the amount of time spent on wood collection per day (Mann Whitney U test, 2 tailed, U=208, p= 0.5751). The responsibilities of infant care do not appear to constrain wood collection activities among the Simanjiro Maasai.

#### *Household size and firewood use*

Owing to the hot and equable climate on the southern shores of Lake Malawi, firewood is not used for space heating in Lake Malawi National Park and there is little seasonality of use (Abbot 1996). Firewood consumption at this site is expressed as weekly per capita firewood consumption averaged across the months of the study, giving a figure of 10.1 kg per capita per week. These data reveal a striking economy of scale in household wood consumption (Figure 1). A two-person household uses over 40 kg of wood per week, however, per capita firewood consumption declines rapidly with increasing household size, such that in a household of six each person consumes under 10 kg per week.

Figure 1 suggests that household size is a good predictor of per capita firewood consumption. Least squares regression indicates that 64 per cent of the variance in per capita weekly consumption can be explained by one variable: the number of individuals resident in the household ( $R = .635$ ,  $F = 100.84$ ,  $p < 0.01$ ,  $n = 60$ ). An inverse curvilinear model is used to describe the relationship between *per capita* firewood consumption and household size, generating the equation:  $y = 2.98 + (39.0/x)$ , where  $y$  is an estimate of per capita firewood consumption and  $x$  is the number of individuals resident in the household.

The data from Simanjiro showed no relationship between household size and the mean daily quantity of wood brought to the household. Mean daily per capita wood consumption among the Maasai was estimated by dividing the total wood collected for all study houses by the total number of person-days for which these houses were observed (a person-day was calculated by multiplying the number of days a household was observed by the total number of people living in the household). The result was an estimated weekly per-capita wood requirement of 9.1 kg.

*The role of dependent daughters in firewood collection.*

Unmarried girls living in their natal households participate in wood collection at both study sites. The Malawian girls assist their mothers on wood collection trips from about the age of ten years (cf. Berry and Petty 1992). Among the Maasai, girls were observed collecting wood from the age of 5 years. In contrast to Malawian girls, Maasai girls in Simanjiro generally collect wood alone or in the company of other girls rather than accompanying their mothers.

The duration of wood collection trips made by women at Lake Malawi National Park who are assisted and unassisted by their daughters are shown in Table 3. Women accompanied by their daughters appear to undertake longer wood collection trips and gather larger bundles than women who are not accompanied by their daughters. However there is no significant difference in the woodland residence times of assisted and unassisted women. As there are no significant differences in the distance traveled (Table 3), it appears that the journeys are slower when women are accompanied by their daughters. This may be because of the large loads that are transported back to the village.

The mean weight of firewood bundles collected by women and girls at the two study sites is included in the summary table (Table 7). The relatively light mean loads returned by Maasai girls do not appear to result from their participation in wood collection from a younger age since the difference between Maasai and Malawi girls remains even when girls of a similar age group are compared. Although Malawian girls carry slightly smaller loads than adult women the difference in load size is not significant (Mann Whitney U test,  $n=227$  women,  $n=31$  girls,  $U=3139$ ,  $p=.3132$ ). Adult women weigh significantly more than daughters (Mann Whitney U test,  $U=231$ ,  $p<.001$ ). Adult women carry firewood loads of approximately half their body weight whereas girls carry loads of around two-thirds of their body weight.

The mean length of a wood collection trip for a Maasai girl ( $n=13$ ) is 114 minutes (range = 60-180), exceeding the mean trip length for a Maasai woman by 24 minutes. The mean length of time devoted to wood collection daily by Maasai girls ( $n=17$ ) is 30 minutes. Maasai girls thus devote more time to this activity than adult women (Mann Whitney U test,  $U=318.5$ ,  $p=.0457$ ,  $n=17$  girls,  $n=52$  women).

The mean quantity of wood returned by Maasai girls ( $n=21$ ) is lower than that brought back by Maasai women ( $n=29$ ) (Mann Whitney U test,  $U=162.5$ ,  $p=0.0052$ ). Their greater collection time may reflect less efficient wood collection practices among girls. Although less efficient at wood collection than adult women, the contribution made by girls to the

wood supply of their natal homes appears to have a significant effect on the work loads of their mothers. Women having at least one daughter of wood collecting age (5 years or above) are found to spend significantly less time collecting wood than women without access to the labor of a daughter (Table 4). A regression model based on an analysis of variance was used to examine the effect of having a daughter of wood collecting age on women's wood collecting time, while controlling for household size and presence of an infant. The effect on women's wood collecting time remained significant (see Table 5). The model itself was not able to account for the variation in women's wood collecting time (adjusted R Square = 0.037,  $p = 0.192$ ).

Malawian women assisted by their daughters appear to bring back more wood in one trip than unassisted women would bring back in two trips (two mean sized bundles for an unassisted woman weigh 53.6 kg while the combined mean load for mother and daughter is 56.8 kg). However, this difference did not prove statistically significant (Mann Whitney U Test,  $U = 2635$ ,  $p = .236$  NS). The possibility that women assisted by their daughters would be able to reduce the frequency with which they collect firewood was also tested by comparing the mean number of days that had passed since the last wood collection trip for women, assisted and unassisted by their daughters. While the mean interval since the last wood collection trip was longer for women assisted by their daughters (4.2 days,  $n = 12$ ) than for unassisted women (3.8 days  $n = 166$ ), this difference was not significant (Mann Whitney U Test  $p = 0.5592$ ). However it may be that daughters do not accompany their mothers on all their wood collection trips and that some of the women classed as unassisted for this analysis do receive assistance.

Analysis of the residuals from the regression shown in Figure 1 indicates that Malawian households with and without daughters of wood collecting age do not differ significantly in mean per capita wood use (Mann Whitney U Test,  $U = 323$ ,  $p = .1295$  NS). This suggests that households with additional female labor do not use more firewood than those households without daughters of wood collecting age and therefore that the firewood gathered by daughters helps to reduce the maternal burden of wood collection.

Using the regression illustrated in Figure 1 it can be calculated that a Malawian girl remaining resident in her natal household until the age of 16, would consume 2479 kg of firewood (over-and-above that of her parents). Using the mean load size for girls of 25.7 kg, it would be necessary for her to make 96 wood collection trips in order to repay the wood she consumed during her period of residence. This is the equivalent of 16 wood collection trips per year from the age of 10 until the age 16. Women at Lake Malawi National Park undertake wood collection on average once every 4 days, the equivalent of 96 trips per year. Thus, a girl would have to accompany her mother on only 17% of firewood collection trips to ensure that her firewood costs are repaid.

The frequency with which daughters assist their mothers at Lake Malawi National Park was analyzed using records of assisted women for whom there is demographic data and who were tracked on two or more occasions (Table 6). These data are limited but suggest that girls collect wood with their mothers on about 50% of their trips; far more than the 17% needed to repay their own costs. Wood collection at these rates, if maintained over a six-year

period, would allow these girls to repay their own costs and those of two siblings while resident in the natal home.

In order to estimate the contribution to wood collection made by Maasai girls, the mean weights of wood collected daily by girls of any given age are calculated for each house for which a girl was observed collecting wood. The mean daily weight of wood collected is then calculated for each age. Three-point running means of these figures are used to estimate the daily weight of wood collected by a girl of any given age. These running means are shown in Figure 2.

The figures for mean daily per capita consumption (1.3 kg see above) and age specific production of wood are converted into figures for annual production and consumption. These figures are then summed across 16 years (the length of time which observations suggest a girl will spend in her natal home) to give figures for the cumulative production and consumption of wood for girls of any given age. The results are shown in Figure 3. From this figure it can be seen that a girl's cumulative production exceeds her cumulative consumption of wood by the age of 12. Her annual production exceeds her annual consumption from the age of 8, however she has, over that time, accumulated a wood-debt which is not repaid until she is 12. A summary of results is presented in Table 7 for comparison across the 2 study sites.

## **DISCUSSION**

The study focuses on three aspects of wood collection; the way in which care of infants is accommodated within wood collection, the influence of family size on demand for firewood and the level of assistance which women receive from their daughters in the provision of firewood.

### *Wood collection and the care of infants.*

Malawian women in the present study take their infants with them when foraging for firewood and integrate child-care into their labor. By feeding their infants during the rest periods associated with their work these women are able to assume normal workloads. This strategy is similar to that reported by Panter-Brick (1989) for Tamang women in Nepal. The Tamang combine child-care with many subsistence tasks by caring for infants during rest periods. The nursing activities of the Malawian women do not appear to affect the labor schedules of their foraging groups. No significant differences are found between the woodland residence times of groups with and without nursing women. Nursing women at Lake Malawi National Park appear as efficient as non-nursing women in foraging for wood. Their load sizes, travel and search times appear unaffected by the presence of their infants. This contrasts with the findings of Hurtado et al. (1985, 1992) who report reduced efficiency in foraging for food by Hiwi and Ache women in South America when these women are accompanied by their infants. Nursing Hiwi women are obliged to spend longer at foraging sites and women in both societies rely to some extent on provisioning by others.

Although living much closer to their sources of wood than women at Lake Malawi National Park, and facing no arduous climbs, the Simanjiro Maasai women were never seen to combine wood collection with child care. They never carried small children with them when they went to collect wood and they were very rarely accompanied by a daughter. It seems likely that the close proximity of the Maasai homes to their wood sources and the consequently short duration of wood collection trips allows infants to be left at home in the care of another individual. Living arrangements among the Maasai are also such that women have good access to potential baby-sitters not only amongst their own children but among their co-wives, the offspring of their co-wives, their in-laws and neighbors.

Maasai women were seen to combine child-care with a variety of other domestic, and also commercial, activities both inside and outside the home (Biran 1996). These activities, performed by women while holding a young child on their backs or laps, included trips to town for trading and grinding maize. Casual observation revealed that these trips involve journeys of up to 7 km carrying loads of up to 20 kg. It seems likely that, despite the loads and distances involved, women are obliged to combine these trips with child care because of the length of time for which they are absent from their homes. Panter-Brick (1989) reports that Tamang women, like the Maasai, combine child care with a number of subsistence activities, but tend to leave infants in the care of an older sibling when gathering firewood.

The wood foraging activities of women from the two societies in the present study do not appear to be constrained by the demands of caring for infants. However there are presumably hidden costs to the mother, such as the increased energetic expenditure of carrying an infant in addition to a wood bundle of the normal size in Malawi. The way in which infant care is accommodated within work activities varies across societies and also across tasks within societies. The decision to cache or carry an infant depends on a variety of factors including the nature and duration of the task. This probably includes an assessment of the environmental threats to which the infant would be exposed (Hurtado et al. 1992, Levine 1988), and the risks associated with leaving them for periods of time with other carers.

#### *Family size and firewood consumption.*

Changes in family size can affect demand for natural resources. The relationship between family size and demand for a resource is not necessarily linear. Economies of scale in firewood use have been noted previously (Fleuret and Fleuret 1978, Hosier 1984). Fleuret and Fleuret (1978) suggest that the inefficiency of semi-open, wood fires renders it more efficient to cook large quantities of food than small because the additional quantities are cooked by heat that would otherwise go to waste. Another contributory factor is that a minimum quantity of wood is required to establish a fire regardless of household size.

The present study finds that in Lake Malawi National Park, larger households consume less firewood per capita than smaller households. The observed mean family size of six people at the Malawi site appears an efficient unit for firewood consumption. The data shown in Figure 1 suggest that per capita firewood consumption begins to level off at less than 10 kg per week in households containing six or more people.

The findings of the current study are similar to those reported from a nation-wide survey of rural domestic energy consumption in Kenya (Hosier 1984). Hosier hypothesizes that there may be some fixed level of energy necessary to sustain a household under specific socio-economic conditions, such that each additional household member increases fuel consumption less than the previous member. Hosier suggests that economies of scale in firewood use may provide a motivation for maintaining large household sizes and could be a factor contributing to high fertility amongst rural populations. The pursuit of economies of scale in firewood use could, however, represent an organizational rather than a fertility decision. Co-operation between households could achieve the observed results as effectively as increasing household size through reproduction.

The data collected in the present study do not suggest any economy of scale for wood use among the households of the Simanjiro Maasai. This may be because the data reflect wood collection rates rather than true consumption rates. An alternative possibility is that the appropriate unit for measuring wood consumption among the Maasai exists at a multi-household level. The living and/or the polygynous marriage arrangements among the Maasai may lead to a greater degree of communality in resource use in this community.

*The contribution of dependent daughters to the household economy through firewood collection.*

Wood collection is an activity which, for females in both Lake Malawi National Park and Simanjiro, begins in childhood and is continued into adulthood. The earlier commencement of wood collection activities among Maasai girls (age 5 years compared with age 10 years for Malawian girls) may reflect the shorter and easier journeys from the Maasai homes to the wood sources. This fact may also allow Maasai girls to undertake wood collection without the supervision of an adult woman.

The loads of wood returned by girls are smaller in both societies than those returned by adult women although at Lake Malawi National Park this difference is not significant. At both study sites the labor of girls relieves their mothers of some of the burden of provisioning a family with firewood. Maasai women who have a daughter old enough to participate in wood collection devote significantly less time to this activity than women who do not have access to this source of labor. At Lake Malawi National Park, mother-daughter pairs collect more than double the quantity returned by unassisted women on a single trip. This may enable assisted women to collect wood less frequently.

The contributions to firewood collection made by girls at both study sites are similar to those reported by Kramer (2002) for subsistence tasks among girls in a Maya community in Mexico. Kramer used time allocation data to look at total production and consumption across a range of subsistence activities including wood collection. She found a sharp increase in production around the age of 10 and reports that girls become net producers at age 12. Among the Maasai and Malawi girls firewood collection increases sharply around the age of 10 and girls become net producers of this resource around the age of 12.

Our data suggest that the assistance provided to women by their dependent daughters can relieve these women of some of their wood collection duties. Over their period of residence in their natal households, daughters are able to collect wood surplus to their own needs. Having a daughter therefore need not represent a cost to a woman in terms of firewood and women may desire at least one daughter to offset some of the costs of provisioning sons. An apparent desire for at least one daughter has been found in previous studies in Bangladesh (Rahman and Da Vanzo 1993), and amongst Gabbra pastoralists in Kenya (Mace and Sear 1997), both of which are patrilineal societies. A woman may desire female offspring in order to mitigate the costs of male offspring. Such a process could contribute to the maintenance of high levels of fertility, in a similar way to that proposed for son preference (e.g. Belanger 2002, Mwangeni et al 2001). In Malawi, much of the community comes from matrilineal groups, who may also favor daughters over sons for other reasons, which complicates the analysis of direct comparisons of sex-preferences between the two sites described here.

It is possible that children's work loads simply reflect that of adults of their sex, and thus boys may be contributing in other subsistence spheres (on which we have no data), but it was not apparent that they were busy when young. Why boys do not help in women's subsistence tasks is not clear. One possibility is that parents make their children work for them as part of training to function as adults. In Malawi, it is likely that a young mother would have difficulty head loading the heavy wood bundles required to fuel her household unless she had practiced this task, and built up the necessary stamina, as a teenager. Girls in Malawi were sometimes seen to be given extra sugar in their tea (personal observation), compared to their brothers, perhaps reflecting the greater energetic demands that were being made of them.

## **CONCLUSIONS**

In both the Malawi and Tanzanian communities, wood collection was a female responsibility and an activity to which adult women made the greatest contribution. At both study sites wood collection had the potential to conflict with the demands on made by child-care on women's time and energy. Women at the two sites differed in their strategies for coping with this conflict and no impact on wood collection was evident in either case. Wood collection in Malawi was marked by longer journeys and heavier loads than at the Tanzanian site. This may have led to the observed participation in wood collection at a younger age by girls in the Tanzanian sample. While family size and structure appear to influence firewood consumption and acquisition, differences in the environment between the two sites may underpin much of the variation. The longer journey times, heavier loads and more infrequent journeys undertaken by Malawian women may reflect the environmental conditions. The steep terrain and risk of penalties associated with firewood collection within a national park in Malawi (Abbot and Mace 1999) may also explain why girls never collect unaccompanied.

Girls at both study sites are net producers of firewood over the time they reside in their natal homes and they thus help to offset the firewood costs of other household members. Although there are differences in the ecology, family structure and modes of subsistence between the two sites, the timing and extent of the contribution of dependent daughters to wood collection appear similar.

What is clear from the present study is that children are involved in essential subsistence activities that do not directly generate food or income. Such activities, which may largely be performed by girls, must be included when considering the costs and benefits which parents derive from children of each sex. This study has isolated one subsistence activity and examined how patterns are influenced by family size and structure, but there is a need to look more broadly across subsistence activities within a household and see how this varies by gender. Kramer (2002) has achieved this using time allocation data for Maya subsistence farmers. A different approach might be needed for a society like the Maasai that has a greater involvement in the cash economy and that uses livestock as a means of accumulating resources surplus to immediate subsistence needs.

Two further future areas of research are suggested by this study. First, is a study of the age at which women marry and leave their natal homes and how this is influenced by their production and consumption levels. This could be linked to a more explicit understanding of environmental conditions and how this influences decisions on the roles that children play in resource harvesting. A second area is to look at the collection and consumption of firewood (and other resources) in polygynous societies using units of analysis at both household and multi-household levels. This may help to establish at what levels economies of scale may be detected and contribute to understanding of co-operation in resource use in polygynous groups.

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Activity	Mean minutes per day women (n=52)	Mean minutes per day girls (n=17)
Animal care / milking	36	48
Child care	174	96
Domestic cleaning / maintenance	42	30
Food preparation / eating	108	108
Resting / socialising	168	300
Snuff making	6	0
Trips to town	66	0
Water collection	54	36
Wood collection	10	30
Total	664	648

**Table 1: Daytime activity budgets of Maasai women and girls.**

Women	Number of women	Number of focal groups	Mean body weight (kg)	Mean firewood weight (kg)	Mean wood collection time (min)	Mean woodland residence time (min)
Non-nursing	252	38	49.2	27.0	246	123
Nursing	12	7	58.3	31.1	261	112
U	/	/	657.5	1036.5	1328.0	1204.0
p	/	/	0.0009	0.0658	0.4762 NS	0.2330 NS

**Table 2: The wood collection activities of nursing and non-nursing women at Lake Malawi National Park.**

	Mean wood collection time (min)	Mean load size (kg)	Mean body weight (kg)	Mean woodland residence time (min)	Mean distance traveled (km)
Unassisted women	239	26.8	50.7	121	2.2
Assisted women	273	31.5	52.5	127	2.2
U	2174.5	2088.5	2527.5	2779.0	936.5
p	0.0110	0.0052	0.1329 NS	0.4456 NS	0.7802 NS

(n=196 unassisted women and 31 assisted women for all values except distance travelled where n=164 and n=12 respectively).

**Table 3: The wood collection activities of women who are assisted and unassisted by their daughters at Lake Malawi National Park.**

	n	Mean daily wood collection	Median daily wood collection	Std Dev
With daughter $\geq 5$ years	34	7 mins	0 mins	14.5 mins
No daughter $\geq 5$ years	18	15 mins	3 mins	21.1 mins

p=0.0342, U=216

**Table 4: Mean time spent daily in wood collection for Maasai women with and without a dependent daughter aged 5 years or more.**

Model	Beta	t	p
Constant	7.592	0.945	0.349
Household size	0.235	1.322	0.193
Presence of an infant	-0.007	-.043	0.966
Presence of a daughter aged $\geq 5$ years	-0.353	-2.111	0.04

Dependant variable: Woman's daily wood collection time.

**Table 5: Regression of household size, presence of an infant and presence of a daughter of wood collecting age onto woman's daily wood collection time.**

Focal Woman	Number of trips for which woman was observed	Number of trips on which woman was assisted by daughter	Percentage of trips on which woman was assisted by daughter
1	4	2	50%
2	3	2	67% <sup>1</sup>
3	6	3	50% <sup>2</sup>
4	2	1	50%
5	2	1	50%
TOTAL	17	9	52.9%

<sup>1</sup> a different daughter was present on each of the two trips on which 2 was tracked

<sup>2</sup> demographic records for this woman show that she has two daughters of appropriate age

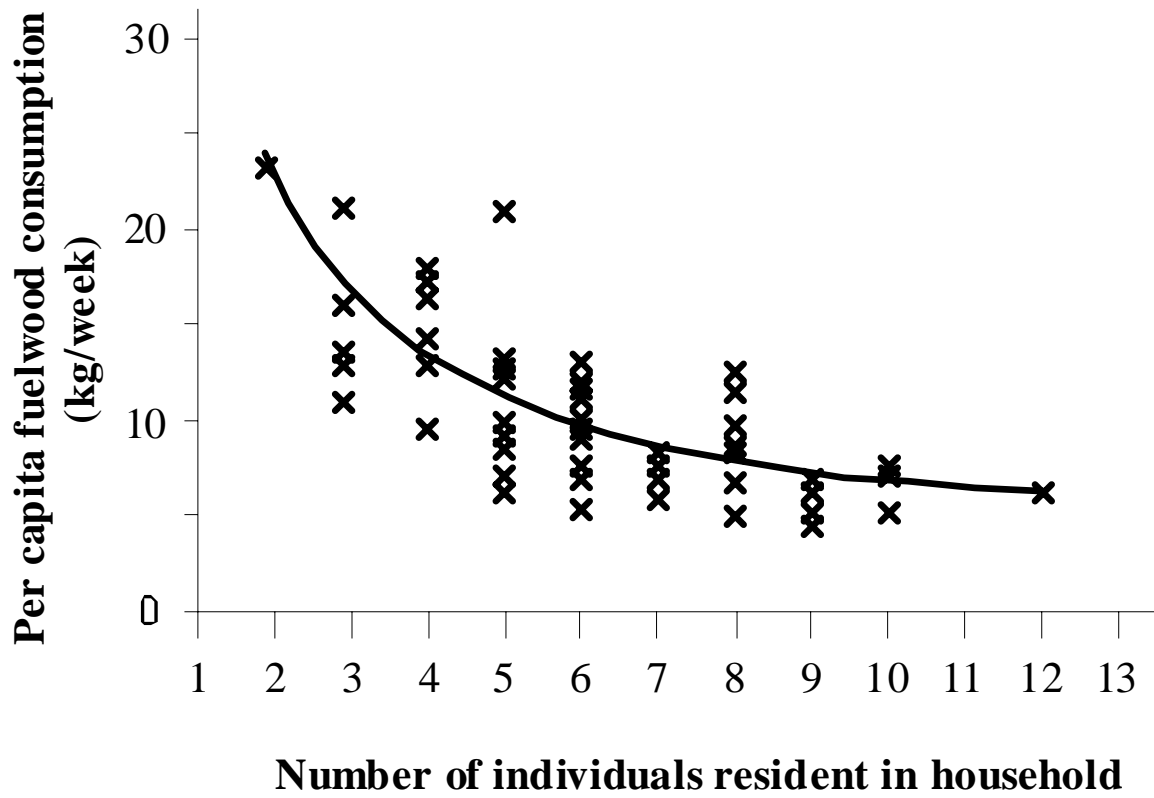
(10 & 14 years) but only the elder daughter was observed assisting her mother.

**Table 6. Frequency with which daughters assist their mothers in firewood collection.**

	Lake Malawi (95% CI)	Simanjiro Maasai (95% CI)
<i>Background</i>		
Subsistence	Subsistence agriculture / fishing	Agro-pastoralist
Marriage system	Monogamous	Polygynous
<i>Wood collection</i>		
Terrain	Steep hills	Gently undulating
Age at which girls begin wood collection	10 years	5 years
Girls' wood collection	Girls accompany mothers	Girls collect alone or with peers
Infant care during wood collection	Accompany mothers	Left with allo-parent
Mean distance to wood	2.1km (1.8 - 2.5km)	1.1km (0.9-1.3km, n=11 homesteads)
Mean trip length women	241 mins.	90 mins.
Mean trip length girls	241 mins.	114 mins.
Mean daily wood collection time women	63 mins.	10 mins. (5-14mins. n=52)
Mean daily wood collection time girls	63 mins.	30 mins (8-52 mins., n=17)
Mean load size women	27.0kg (25.9 – 28.1, n = 227)	19kg (17-22kg, n = 29)
Mean load size girls	25.3kg (21.6 – 29.0, n = 31)	All girls: 13kg (11-16kg, n = 21) Age ≥ 10 years: 15kg (12-18kg, n = 15)
Mean body mass women	49.2 kg (48.2 – 50.2, n = 227)	51kg (n = 29)
Mean body mass girls	36.9kg (35.3 – 38.4, n= 31)	No Data
<i>Wood use</i>		
Purposes for which wood used	Cooking & lighting	Cooking, lighting and heating (seasonally)
Mean weekly wood use per capita	10.1kg	9kg
Influence of household size	Economy of scale	No relationship with household size.

**Table 7: Summary of results at the two study sites.**

Figure 1: Per capita firewood consumption and household size in Malawi.



**Figure 2: Three-point, running means of daily wood collection by Maasai girls.**

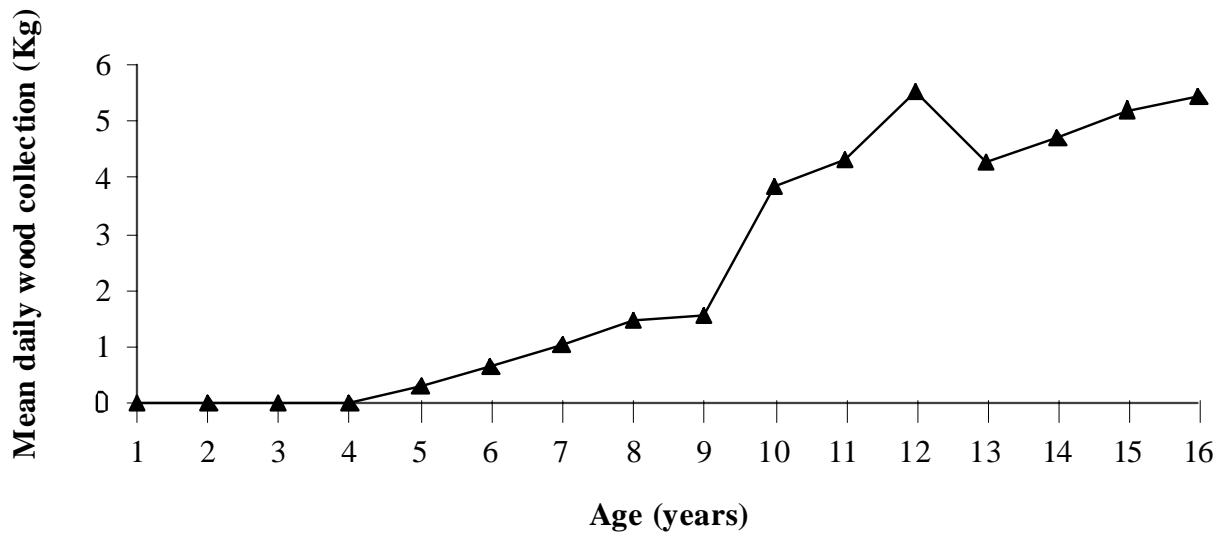


Figure 3: Cumulative wood collection and use by Maasai girls.

