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Adult Mortality and Natural Resource Use in Rural South Africa: Evidence From the Agincourt Health and Demographic Surveillance Site

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Abstract

There is little empirical evidence on the association between household experience with HIV/AIDS and shifts in the use of natural resources in developing countries, where residents of rural regions remain highly dependent on often-declining local supplies of natural resources. This study examines household strategies with regard to fuelwood and water among impoverished rural South African households having experienced a recent adult mortality and those without such mortality experience. Quantitative survey data reveal higher levels of natural resource dependence among mortality-affected households, as well as differences in collection strategies. Qualitative interview data provide insight into subtle and complex adjustments at the household level, revealing that impacts vary by the role of the deceased within the household economy. Resource management and public health implications are explored.

Keywords

Africa; Agincourt; fuelwood; HIV/AIDS; mortality; natural resources; resource collection; rural livelihoods; South Africa; water

The role of natural resources in household coping strategies, especially during times of crisis, and among the rural poor, has been noted in studies across the developing world (Eriksen et al. 2005; McSweeney 2004; Paumgarten 2005). However, little scholarly attention has been paid to the environmental dimensions of a particular household shock, namely, the death of a productive household member. Natural resources may be part of coping strategies, as lost wages may mean that households substitute collected goods (e.g., wild herbs/fruit) for those previously purchased (e.g., packaged foods) (e.g., Hunter et al. 2007). In addition, collection strategies themselves may be reshaped due to the loss of available labor. Still, there is little documentation of these effects, an important research gap in an era of rising prime-age adult mortality largely attributable to the HIV/AIDS pandemic.

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This research explores ways in which natural resource use in poor, rural regions of developing nations is being shaped by the loss of productive adult household members, with a particular focus on household strategies for fuelwood and water. Through both quantitative survey data and qualitative interview data, we explore two important questions. To first create an understanding of general patterns of natural resource use, we ask: (1) What are the associations between natural resource use strategies and household characteristics in rural South Africa? Then, to explore variation in these patterns across households with different adult mortality experience, we ask: (2) Beyond household characteristics, do adult mortality-impacted households exhibit different natural resource use strategies than households without such mortality experience?

Natural Resources and Rural Livelihoods in Southern Africa

Natural resources harvested around settlements play an important role in rural livelihoods across southern Africa by providing for household needs and also providing sources of income (Cavendish 2000; Shackleton and Shackleton 2000; Shackleton et al. 2001; Letsela et al. 2002; Twine et al. 2003a). The quantities of resources consumed domestically may be substantial. As an example, in their synthesis of South African studies spanning 14 villages, Shackleton and Shackleton (2004) found that rural households consumed an annual average of 5.3 tons of fuelwood. However, natural resource use is seldom the mainstay of rural livelihoods (Belcher et al. 2005). More typically, resource use supplements other livelihood strategies including agriculture and migrant labor (Shackleton et al. 2001). Access to natural resources thus allows diversification of rural livelihoods, thereby increasing resilience to shocks and distributing risk (Belcher et al. 2005).

Shackleton et al. (2007) estimated that the direct-use value and income generation from natural resources contribute roughly 20% of total household income in savanna regions of southern Africa (Shackleton et al. 2007). In addition, natural resources also serve as “safety nets” for rural households during times of hardship precipitated by shocks, such as crop failure, natural disasters, or the death of a breadwinner (Paumgarten 2005; Shackleton and Shackleton 2004). Resource-based coping strategies in times of crisis may include substituting previously purchased goods with wild equivalents or engaging in temporary sale of natural products to supplement household income (Shackleton and Shackleton 2004). The “safety net” function is particularly important for poor and vulnerable households (Shackleton and Shackleton 2004).

Below, following a short overview of African mortality trends, we present a typology of the ways in which these natural resource strategies might change following the death of a prime-age adult household member.

Mortality Trends and HIV/AIDS in Africa

HIV/AIDS is a leading cause of death in Africa and worldwide for individuals age 15 to 49 years (prime-age adults), and subsequent dramatic declines in life expectancy characterize the population of many African nations (Joint United Nations Programme on HIV/AIDS and WHO 2007). Globally, the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) estimate that 33.2 million individuals were living with HIV/AIDS in 2007. Sub-Saharan Africa, with 10% of the world’s population, is home to 35% of all people living with HIV/AIDS, 76% of HIV/AIDS deaths, and 68% of new infections (Joint United Nations Programme on HIV/AIDS and WHO 2007).

South Africa, with a prevalence of 16.2% (in 2005), has the largest absolute number of HIV/AIDS infections in the world (Joint United Nations Programme on HIV/AIDS and WHO 2007). Within South Africa, the prevalence of the epidemic varies considerably between

provinces, from 15% in the Western Cape to 39% in the province of KwaZulu-Natal (Joint United Nations Programme on HIV/AIDS and WHO 2007). In the year 2000, in our study area, 21.5% of deaths were attributed to HIV/AIDS, and it was projected that by 2010 this will rise to 65% (Day and Gray 2003). Indeed, HIV/AIDS has become a challenging social problem in rural Africa with major implications for rural development (Rugalema and Khanye 2002). In all, the study area represents an appropriate and important context in which to examine the implications of prime-age adult mortality.

Mortality and Household Use of Natural Resources

Rural households undertake many unique and nuanced changes with regard to natural resources following the death of an adult member, depending upon a complex interaction of household characteristics and demographics as well as the social milieu and available natural resources. Following the lead of similar research (ABCG 2002; DAI 2003), we classify these many possible changes using four interrelated dimensions: *selection, use, acquisition*, and level of *consumption* of natural resources.

Natural resource selection strategies include household decisions involving what natural resource is to be used for a given purpose. For instance, afflicted households may turn to natural resources (e.g., wild foods) as alternatives to purchased items (ABCG 2002; Barany et al. 2001). More generally, more desirable products are replaced with those most readily available as households struggle to cope with diminished labor capacity and the resulting reallocation of money and time (ABCG 2002).

Natural resource use strategies are decisions regarding the purpose of the selected natural resources. For example, a household may use dung as fuel rather than as fertilizer or may sell natural resources it might otherwise consume in an effort to raise much-needed income (Cooke 1998). Reassessing whether to use land for income-generating or subsistence crops, as well as decisions to leave land fallow, would also be considered changes in natural resource use strategies (ABCG 2002).

Natural resource consumption strategies involve the quantities of resources consumed. Mutangadura et al. (1999) find that households generally reduce their overall consumption of natural resources in conjunction with related changes in natural resource selection and acquisition strategies. Of course, such reduced consumption may be less of a “strategy” than a necessity.

Lastly, *natural resource acquisition strategies* involve decisions about *where* natural resources are to be acquired, including water collection and harvesting from the local natural environment, as well as purchasing in formal and informal markets; who (in terms of household position) will do the collecting/harvesting; and what costs the household will pay in time, money, and/or bartered assets. For example, harvesting may take place within communal lands or within a homestead garden, or natural resources may be purchased or received as gifts.

The Africa Biodiversity Collaborative Group (ABCG) reports that throughout Sub-Saharan Africa, mortality-related changes in natural resource acquisition strategies may involve unsustainable harvesting practices and the deemphasizing of stewardship more generally (ABCG 2002). The death of a prime-aged adult also often represents the loss of a skilled natural resource harvester.

Questions regarding who in the household collects/harvests natural resources unavoidably raise the issue of opportunity costs. Children may spend time on resource collecting that they would otherwise spend in school or studying (DAI 2003); adults may be diverted from

income-generating activities (Cooke 1998). When collection from local sources is impossible, limited cash may be reallocated, or household assets liquidated, in order to purchase wood and/or water, or in order to cover medical and/or funeral costs (ABCG 2002; DAI 2003).

This research contributes to our understanding of the association between prime-age adult mortality (regardless of cause of death) and household coping strategies regarding natural resources. We do not aim to model causality since we are restricted to cross-sectional data; however, we contrast natural resource strategies between households with and without recent adult mortality experience.

The Agincourt Health and Demographic Surveillance Site

The fieldwork was undertaken in the MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt Unit) during May and June 2004, with the data available through the Agincourt Health and Demographic Surveillance System (AHDSS). The Agincourt Unit is in a rural region, formerly an Apartheid "home-land," in the extreme northeast of South Africa approximately 500 km northeast of Johannesburg (Figure 1). It encompasses 400 km^2, including 21 villages and more than 12,000 households. The area is semiarid (annual rainfall 550–700 mm) and relatively heavily populated (~170 persons/km^2). Household plots are generally too small to fully support subsistence agriculture, and residents are typically dependent upon communal land for cultivation, grazing livestock, and harvesting natural resources such as fuelwood, wild foods, thatching grass, construction timber, and other domestic products for household consumption and income generation (Shackleton 1996; Shackleton and Shackleton 2000).

Socioeconomically, the region is also highly dependent on remittances. Since formal-sector employment is limited, a large proportion of adults are migrant laborers, working on commercial farms and in mines, towns, and cities across the country. Among people between the ages of 30 and 49 years, 50% of males and 14% of females are migrant workers (Collinson et al. 2006; Collinson et al. 2007). In addition, a significant proportion of households depend on elderly residents' state pensions.

Mortality experience, as well as other demographic characteristics of Agincourt households, was available through the AHDSS, which has collected census data at 12- to 18-month intervals from all subdistrict households since 1992. We used these data to identify households that had experienced the death of a household member aged 15–49 years during the 2 years before our fieldwork. Individuals within this age group are especially vulnerable to HIV/AIDS and also most likely to be economically productive and/or engaged in regular natural resource collection. In our study site, mortality among young adults (20–49 years) increased fivefold over the decade between 1992–1993 and 2002–2003, and this was attributed largely to the emerging HIV/AIDS pandemic (Kahn et al. 2007). Although admittedly imperfect, making use of prime-age adult mortality as a proxy for HIV/AIDS impacts is a common strategy (e.g., Yamano and Jayne 2004), given the emotional and ethical difficulties inherent in collecting information specifically on HIV/AIDS mortality. The ability to identify mortality-affected households, with additional information on gender and age of the deceased, represents a substantial strength of the demographic surveillance data. As such, the analyses presented here can offer an important foundation for future work exploring HIV/AIDS-related morbidity and cause-specific mortality as associated with natural resource strategies.

Data Collection and Analytical Methods

The survey included 241 households in eight villages in the central region of the study site, and the villages represented a range of environments along the region's east–west rainfall gradient. The sample was stratified by mortality experience: Half were randomly selected from households having experienced the death of a prime-age household member in the previous 2 years, and the other half were from households experiencing no such mortality. This examination is cross-sectional, examining differences in household natural resource strategies at a single point in time. The survey respondent was the individual within the household most responsible for the household's natural resource collection. In this way, we aimed to garner feedback from those most engaged on a daily basis with local environmental conditions.[1]

We examined households' *selection* of fuelwood for cooking fuel, as opposed to electricity, *uses* of fuelwood and water, and the quantity of fuelwood and water *consumed*. (Data collection took place in late autumn, a time when fuelwood consumption is experiencing slight increases from summer [Banks et al. 1996] but likely represents an annual mean.) We also asked about the households' *acquisition* strategies, including purchase and/or collection/harvesting efforts by specific household members. In models explaining these resource strategies, all 12 outcome variables, except quantities consumed, are coded as dummy variables with 1 representing "yes," and logistic regression is used. The outcomes are not mutually exclusive; for example, a household may be coded "1" for "purchases wood," while also being coded "1" for "the female head and/or daughter harvests wood."

Our primary predictor of interest was recent household adult mortality experience (1=affected by an adult death within the prior 2 years). An interaction term tempers the mortality estimate according to time since the death. An additional interaction term reflects variation in mortality impacts across households by socioeconomic status, as reflected by a possessions index created by the Agincourt Unit to reflect socioeconomic status (SES). The index ranges from 1 to 5 and is derived from an asset register including presence of a tap and toilet in the homestead, as well as ownership of appliances (e.g., radio) and equipment (e.g., wheelbarrow). The possessions index is included to reflect household economic well-being, and this approach has been used in similar contexts (Schellenberg et al. 2003).[2] While additional predictors related to household mortality experience (e.g., gender of deceased) were also explored, we present only the most robust and parsimonious models.

Our control variables include *household size* as a categorical variable, with categories based on preliminary analyses and chosen for ease of interpretation (categories reflect household size of 1, 2–5, 6–10, more than 10). *Sex ratio* is measured in standard demographic form as the ratio of male:female. A household is coded as young *age composition* if at least one-third of its members are under age 15 years, and as old if at least one-third of its members are over age 50 years.

We also include a categorical variable representing *village* to capture variation in environmental context since more detailed information on these contextual differences (e.g, availability of proximate natural resources) was unavailable. As such, there is no specific interpretation of this variable and it is intended only to broadly control for contextual variation.

[1] If the primary resource collector was unavailable, we queried as to their availability and made a return household visit. If the person was entirely unavailable, we spoke with another individual involved in natural resource collection. Nonresponse is extremely rare in this setting.

[2] Unfortunately, our data do not allow for disaggregation of the possessions index into its composite parts so the index is incorporated within our models as an additive value ranging from 1 to 5 with 3.2 as mean.

In addition to the survey and quantitative modeling, we present qualitative data from interviews in 31 randomly selected mortality-affected households from those surveyed. These interviews lasted 30 to 90 minutes, and we spoke with the household member most engaged in resource acquisition. The interviews explored topics such as resource collection strategies and the ways in which these strategies had changed since the household mortality experience; the conversations were very much focused on household changes. The interviews were conducted primarily by project investigators, with the assistance of a local translator. All interviews were translated and fully transcribed. For the purposes of this research, we carefully reviewed and analyzed the text of each conversation with an eye toward identifying (1) patterns related to the selection, use, acquisition, and level of consumption of wood and water within the household; and (2) changes in the strategies for selection, use, acquisition, and consumption of these resources following the death of an adult household member. The interview data offer an important complement to the survey results, providing a more nuanced understanding of the association between mortality and household management of natural resource use.

Sample Characteristics

Typical for the region, the vast majority of households use fuelwood, mostly for cooking and heating bath water (Table 1). It is far less common for households to use fuelwood to heat the home or brew traditional beer, so these are not presented as outcome variables in the multivariate models. Even with the high level of dependence on fuelwood, more than three-quarters of households use electricity for lighting. Nearly one-third use electricity for cooking, although clearly this is supplemental energy, given the high fuelwood use. There is wide variation in amount of fuelwood used, although—on average—only about 1.5 kg seasonal difference. Wood acquisition strategies are multifaceted, with nearly half of the households purchasing some wood, and harvesting undertaken mainly by the women.

There is universal use of water for drinking and cooking, and near universal use for bathing and washing. Water consumption is greater in summer, a logical pattern given seasonality of crop production and increased demands for drinking and bathing. Seasonal variation in water use is no doubt also shaped by climate, which is characterized by a wet summer and dry winter during which almost no rain falls and all but the largest rivers become dry. Very few households purchase water, suggesting that nearly all households experience some opportunity cost of time allocated to water collection, although the time required to collect water ranges from only 1 minute to nearly 7 hours. Collection is undertaken mainly by particularly female heads/wives and daughters.

Quantitative Survey Results

Our first research question sets the stage for examination of mortality impacts by initially exploring how other household factors are associated with resource selection, use, consumption, and acquisition. Bivariate results reveal little statistical or substantive significance, so we begin with a review of multivariate estimates first for fuelwood (Table 2), then water (Table 3). Each table of results has two sections in direct relation with the two questions posed at this paper's outset. The top half, labeled "Research Question 1," presents the associations between natural resource strategies and household characteristics. The bottom half, labeled "Research Question 2," presents mortality's association with household natural resource strategies net of the household characteristics. Although changed slightly, estimates for the household variables are not replicated in the table's bottom half due to space constraints.

In our study site, household composition and socioeconomic status have little significant association with the selection of fuelwood versus electricity, a fairly common alternative for cooking and lighting. Electricity is less often used for cooking by larger households, which have more individuals for whom to provide and more hands available for fuelwood collection. In general, however, the surveys and interviews reveal little variation in energy used, with nearly all households using fuelwood as primary source.

Among the specific uses of fuelwood, cooking and heating water are nearly universal, and household characteristics (specifically SES) are significantly associated only with the use of fuelwood for heating water. Few of the household characteristics are associated with energy use.

Even with household size controlled, households with relatively more men and/or older age structure tend to have higher wood consumption levels in both summer and winter. In addition, households with higher SES tend to use slightly more wood, particularly in the summer. The interviews suggest that households are clearly very conservative in their resource use, as daily homestead fires are carefully tended, burning only the requisite amount of wood. Yet, curiously, the survey data reveal a wide variation in level of use, ranging from 1 kg to more than 20 kg daily.

With regard to acquisition strategies, the regression results suggest that household composition had limited, but statistically significant, associations with who harvested fuelwood. In particular, larger households are more likely to have a male head who harvested. As would be expected, female heads are less likely to harvest wood in households with relatively more male members. Interestingly, socioeconomic status does not influence whether a household buys fuelwood.

The bottom of Table 2 addresses our second research question on the association of adult mortality and natural resource strategies. Recent adult mortality experience is associated with a greater likelihood that a household will use wood, although the negative coefficient for the interaction between mortality and SES suggests this association is weaker for households of higher SES. The same pattern is demonstrated by the positive coefficients suggesting that mortality-affected households are more likely to use wood for cooking and heating bath water, with a lesser association for households of higher SES. We also queried as to seasonal resource use since seasonal variation could potentially mask mortality impacts. More specifically, mortality experience may be only manifest in summer, when fuelwood is relatively abundant—as opposed to winter, when scarcity decreases fuelwood use by all households regardless of adult mortality experience. Still, we find that prime-age adult mortality is not associated with level of household fuelwood use in either summer or winter, thereby suggesting the lack of mortality effect is not due to variation in fuelwood availability.

Male heads are clearly more likely to harvest wood in mortality-affected households than in unaffected ones. Upon further analyses, we found that among households with a male head harvesting fuelwood, the deceased person is equally likely to be male or female. It is possible, then, that male heads are called to harvesting duty in households in crisis. This is further suggested by the negative coefficient estimate for years since mortality, as the likelihood of male heads harvesting wood declines as time passes.

For water strategies, we model only those uses that vary substantially across households (Table 3). We expected, and found, universal use of water for basic domestic consumption, and water is generally used sparingly for these purposes because it is difficult to obtain. Interestingly, household sociodemographic characteristics exhibit little association with

household water uses: brewing traditional beer, watering plants, watering animals, and making bricks.

On level of water consumption, a significant and puzzling negative association exists between SES and daily winter consumption of water. It is possible that this reflects greater use of water by more disadvantaged households for watering food grown in homestead gardens as a substitute for purchased food. Village is a significant discriminator of daily water consumption in both summer and winter, highlighting the important variation in water availability between villages. Indeed, the pattern of statistical significance demonstrated within Table 2 suggests that the substantial variation in daily consumption, ranging from 3 to 225 L, appears to be primarily a function of village water supply and household SES.

As with wood, water acquisition strategies represent an important dimension of household decision making in that collection often requires a substantial time investment. Here, we predict how many minutes were required to collect water and who in the household collects. Household composition and socioeconomic status both have limited but statistically significant effects on who collects water. The male head is more likely to collect water in larger households and in those with more men. As would be expected, female heads are less likely to collect water in households with relatively more male members. Finally, higher SES is associated with a decreased likelihood of a daughter collecting. Households spend, on average, 54.1 minutes per day collecting water. This figure doubles if the female head collects the water.

The bottom of Table 3 shows little association between water use strategies and household mortality experience. The only significant effect is that men are less likely to collect water as time passes since the death. As with wood, male heads appear more likely to collect water in mortality-affected households, but the likelihood of this activity decreases with time.

Qualitative Interview Outcomes

The interview data reveal additional complexity regarding resource strategies within mortality-impacted households related to the gender, age, and household role of the deceased in the household economy. If the deceased was a resource collector/harvester, for example, but did not engage in income-generating work outside the household, his/her resource harvesting duties are typically taken on by other household members. For example, George's (pseudonyms used) deceased wife "used to collect fuelwood in the bush … . She was responsible for household duties like cleaning and other things." George now stays with his sister's daughter, who "performs those duties now." Hope's story is also instructive. Both of Hope's deceased parents had previously assisted in their household's resource harvest. Hope explained that her mother "used to do" the cooking, but now "I do it myself." Hope also harvests fuelwood and water; as she says, "I have to do a lot of things by myself now." As a result, Hope no longer has time to tend the garden. "I used to have a garden and I could go out to collect water to water my plants … . But I buy now [what I used to grow]."

George's story reveals that the responsibilities of a deceased resource collector are spread across other family members, and other data suggested children often play an important role. In several households, children spend considerable time collecting natural resources. As Sibongile explains, "we get [wood] from the bush next to the mountains … it's not easy to find them and we get them from far and we take a long time." Her household did not purchase fuelwood, since their only source of income was a very small and irregular contribution from her mother's old-age pension. Sibongile would like to buy natural resources, as opposed to collecting: "If we had money we were going to purchase fuelwood or hire someone to collect water because sometimes you feel tired but with no option."

Although such shifts in time allocation are clearly important, the most significant changes in the household economy are felt when the deceased had contributed wages. In these cases, impacts involving natural resource selection, use, consumption, and acquisition strategies vary greatly. In some cases, the lost income had been used to purchase fuelwood and water, with household members subsequently being forced to harvest wood and water on their own. Trezia's deceased father worked as a gate keeper at a local game reserve and contributed important income to the household. Trezia reports that "there are lot of changes like I did not have to collect fuelwood … but now I need to do that on my own." Lucille's husband had been engaged in hard labor but during his illness he was cared for by a traditional healer, and Lucille took a job as domestic worker. Since Lucille was then less available for household tasks, the children took primary responsibility for resource harvesting "because they also needed to do the things I used to do." After her husband's death, Lucille became ill; she too was no longer able to work and had to rely completely on her children for performance of household tasks and modest contributions of income. Overall, Lucille's story reveals a complex array of task reassignments to manage daily living in the context of illness and uncertainty.

Also complex is the reconfiguration of household tasks following the death of Asnara's sister, who worked as a waitress at a local game reserve and made important financial contributions to their household. Now,the household survives on very low income, with the only regular source being the government disability grant paid to her mother, who is the victim of a stroke. In addition to her disabled mother, Asnara takes care of her two sons, her sister's child, and her elderly grandmother. The household makes use of a wide variety of natural resources, such as reeds for mats and marula fruit for jam. Asnara is looking for a job, and if she finds one, "I would reduce the boys' responsibilities since I will buy fuelwood. But with water, they would have to collect." She would prefer that "these boys would collect sand for … bricks" to sell for income and also for expansion of their home.

Households that lose adult wage-earners shift time allocation much like those that lost resource collectors. As revealed by Asnara's story, however, the tasks are not simply reassigned, but rather, households stop purchasing resources and begin collecting alternative natural resources. The death of Lenia's wage-earning husband "brought a lot of changes, the first thing being changes in the diet, the second thing is that we are no longer able to buy fuelwood and water, so it requires us to do that by our own hands." Similar impacts are described by Tara. Although in the past Tara's household hired someone to collect fuelwood, since her husband's death "we depend more now on the field."

Discussion, Implications, and Conclusion

The environmental dimensions of prime-age adult mortality are centrally important to the sustainability of the livelihoods of many rural households and communities in Sub-Saharan Africa, particularly in the contemporary era of HIV/AIDS. Both quantitative survey data and qualitative interview data suggest that the recent loss of an adult household member may shape households' resource strategies, primarily with regard to fuelwood. Mortality-affected households are more likely to use wood in general, as well as more likely to use wood specifically for cooking and for heating water. Further, poverty shapes resource strategies since the higher levels of wood use by mortality-affected households is tempered by socioeconomic status and years since death suggesting that substitution is especially important for households particularly vulnerable in times of crisis.[3]

[3]It is important to note, however, that the overall explanatory power of the estimated models remains quite low—ranging from only 0.01 to 0.26. As such, factors not included within our analyses account for the bulk of variation in natural resource use and strategies within this study setting.

The loss of household members responsible for natural resource collection affects the time allocation of others, particularly if there is insufficient household income to consider purchasing the required resources. The survey data suggest that male household heads pick up collection duties, for both wood and water, in the crisis period after an adult household member dies. Interview data further reveal important impacts on time allocation. The mortality effects revealed in the quantitative data exhibit substantial variation across households, and this conclusion is reinforced by the qualitative data. The in-depth interviews give clear "voice" to households living the experience of adult mortality combined with high levels of dependence on natural resources. These findings correspond with similar research demonstrating the importance of the "buffer" offered by natural resources to households impacted by an adult mortality (Hunter et al. 2007). Our findings highlight the importance of the role of the deceased in the household economy in this regard.

Because they included mortality from any cause, our survey data do not allow for specific identification of cause of death. Also, because they report natural resource strategies at the time of the survey, they do not they allow for examination of changes in household resource use strategies that may be related to a prolonged period of illness that may precede adult death particularly as related to HIV/AIDS. In these ways, it is likely that our measures actually underestimate mortality effects, due to two factors. First, the stigma associated with AIDS may make it less likely that households receive outside support in times of crisis (Skinner and Mfecane 2004). As such, if we had been able to identify AIDS-specific mortality we might have observed more substantial mortality impacts. Second, household natural resource shifts may actually take place during a period of protracted illness prior to adult death. In this way, our mortality indicator may understate household adjustments by not capturing shifts occurring during an earlier illness period.

This study yields implications for the sustainability of common-property natural resources. These resources are coming under increasing pressure in rural South Africa due to socioeconomic factors such as high human population densities, poverty, and the weakening of the traditional authorities historically responsible for controlling access (Giannecchini et al. 2007; Kirkland et al. 2007). With regard to poverty, a shortage of financial resources reduces many households' options for substituting natural resources with commercial alternatives. Poverty may also promote resource-based market activities, such as the sale of firewood, which further increase local demand for resources (Giannecchini et al. 2007). This points to a tension between the beneficial "safety net" role of natural resources (Shackleton and Shackleton 2004) and considerations of environmental sustainability. On institutional change, the waning effectiveness of local traditional authorities in managing common property resources has been noted in communities across South Africa (Twine et al. 2003b; Kirkland et al. 2007) and can effectively lead to open-access resource use systems, which further undermines sustainability, especially in the face of high demand for local resources. Indeed, the observed interactions between environmental and socioeconomic change in open-access systems can threaten resilience of both ecosystems and rural livelihoods (Giannecchini et al. 2007).

Our results suggest that the economic impacts of adult mortality due to AIDS may increase the demand for key natural resources such as fuelwood, or at least retard the rate of transition from the use of biomass energy to electricity. Although there has been a recent dramatic increase in the pace of electrification in rural South Africa, our data suggest that this will not halt fuelwood use because of the economic obstacles facing the rural poor, including those affected by adult mortality. This is supported by Madubansi and Shackleton (2006), who found that fuelwood remains the dominant thermal energy source used by households among five rural villages in the study region, despite widespread electricity

access. Fuelwood use is ascribed primarily to the prohibitive costs of cooking appliances and the required electricity.

The sustainability of current fuelwood extraction rates in the region varies between communities and depends on local environmental and socioeconomic conditions (Banks et al. 1996). However, general increases in collection times, numbers of species used, and declines in households purchasing fuelwood over the decade 1991–2002 all point to declining fuelwood stocks (Madubansi and Shackleton 2006, 2007). The increasing risk of adult mortality due to HIV/AIDS thus puts additional stress on marginal households dealing concurrently with declines in the local stocks of essential natural resources—intensifying vulnerability among already-vulnerable rural households.

Because of the important role of natural resources as a buffer for households in crisis, such as after an adult death, greater attention should be given to interventions aimed at the effective management of local natural resources. Critical consideration of common property rights and more effective local institutions for the management of common-property natural resources are therefore desperately needed. Issues to be addressed include (1) the legitimacy, accountability, capacity, mandate, and legislative support for current local resource management institutions; (2) the level of community participation in resource management; and (3) the extent to which national and provincial government departments should be involved in local resource management, or provide logistical and technical support for local institutions. More specific interventions might encourage the establishment of homestead fuelwood plots, use of fuel-efficient stoves, and cultivation of wild indigenous food products. Additional government interventions, such as increasing the free basic household electricity allowance (currently 50 kWh per household per month), may also be necessary.

In closing, our evidence suggests that the intersection between adult mortality and environmental scarcity is indeed shaping and reshaping household strategies with regard to natural resource use and collection. Combined with the interview data, the results reveal subtle and complex shifts at the household level in resource strategies associated with adult mortality. Understanding these shifts is central to the design of policy aimed at supporting impoverished, natural resource–dependent rural households in this contemporary era of HIV/AIDS.

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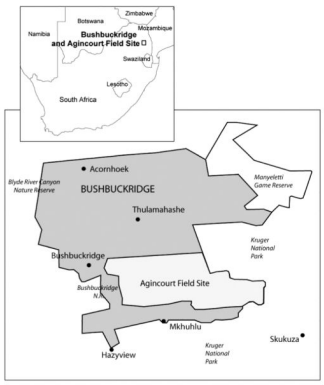

Figure 1.
Study area, Agincourt Health and Demographic Surveillance Site, Mpumalanga Province, South Africa.

Table 1

Descriptive profiles of household variables incorporated in the multivariate models

	Percentage or mean	Min	Max	*n*
Fuelwood				
Use wood for fuel (%)	92.8%			241
Wood uses				
Cooking	90.8%			227
Heating water for bathing	85.4%			225
Heating house	1.3%			227
Brewing traditional beer	3.3%			227
Alternative fuels				
Electricity for cooking	31.3%			241
Electricity for lighting	82.5%			241
Level of use				
Wood per day in summer (kg)	8.7	0	22	171
Wood per day in winter (kg)	10.4	0	29	171
Acquisition strategies				
Purchases wood	44.6%			241
Male head harvests	13.8%			241
Female head or wife harvests	36.2%			241
Son harvests	7.9%			241
Daughter harvests	34.6%			241
Other female harvests	14.1%			241
Water				
Water uses				
Drinking	100.0%			248
Cooking	100.0%			248
Bathing	97.6%			248
Washing	98.4%			248
Water for plants	29.8%			248
Water for making bricks	18.2%			248
Water for animals	8.9%			248
Brewing traditional beer	6.1%			248
Level of use				
Water per day in summer (L)	82.7	10	225	236
Water per day in winter (L)	69.7	3	225	235
Acquisition details				
Purchases water	0.4%			248
Minutes to collect	50.9	1	420	201
Male head collects	15.7%			248
Female head or wife collects	43.6%			248
Son collects	23.0%			248

	Percentage or mean	Min	Max	*n*
Daughter collects	50.8%			248
Other	10.1%			248
Sociodemographic characteristics				
Composition				
Sex ratio (male:female)	0.8	0	4	241
Young age structure	70.5%			241
Older age structure	9.5%			241
Socioeconomic status				
Possessions Index	3.2	1	5	239

Table 2

Multivariate estimation of household fuelwood strategies, Agincourt Site, Mpumalanga Province, South Africa

		Alternative energy		Uses of wood		Level of use		Acquisition strategies				
	Use wood, yes=no	Electricity for cooking	Electricity for lighting	Cooking	Heating water	Wood per day (kg, summer)	Wood per day (kg, winter)	Buy wood	Male head harvests	Female head, wife harvests	Son harvests	Daughter harvests
Research question #1: *What are the associations between natural resource use, household size, composition, and economic status?*												
Household size	−0.01	−0.10*	0.03	0.03	0.09	0.04	0.10	−0.01	0.18**	−0.03	−0.08	0.03
Household composition												
Sex ratio	−0.41	0.20	0.07	−0.33	−0.49	1.92**	1.93**	0.10	0.35	−0.42*	0.07	0.07
Young age structure	−0.67	0.20	−0.70	−0.63	−0.34	0.48	−1.80	−0.22	−0.51	−0.26	−0.55	0.07
Older age structure	0.15	−1.27	−0.70	0.50	1.38	2.64*	3.67	0.06	0.89	0.25	−0.99	0.18
SES												
Possessions Index	0.50	0.11	0.19	0.33	0.14**	0.99*	0.61	−0.06	0.18	−0.10	−0.05	−0.12
Village	−0.04	−0.06*	−0.25**	−0.04	−0.09	−0.01	−0.02	−0.01	−0.01	−0.01	0.02	−0.07
Research question #2: *Beyond these household characteristics, how is mortality experience associated with natural resources?*												
Adult mortality												
within past 2 years	3.39*	−1.27	0.28	3.48**	3.02**	3.47	−0.17	0.01	2.84*	−0.54	−1.89	1.20
Mortality×SES	−0.83*	0.09	−0.19	−0.69*	−0.64**	−1.21	0.61	0.05	−0.36	−0.05	0.64	−0.30
Years since mortality	−0.40	0.36	0.13	−0.56	−0.49	0.13	0.61	−0.14	−0.89**	0.23	−0.59	−0.05
Constant	2.32*	−0.09	3.68	2.15*	2.19**	4.12	9.05	0.19	−3.79**	0.64	−1.27	−0.17
R^2	.08	.06	.20	.08	.10	.11	.09	.01	.11	.04	.08	.04
n	239	239	239	239	239	169	169	239	239	239	239	239

*Note. Statistical significance indicated by $p<.05$;

**$p<.01$.

Data Source: MRC/Wits Rural Public Health and Health Transitions Unit.

Table 3

Multivariate estimation of household water strategies, Agincourt Site, Mpumalanga Province, South Africa

	Uses for Water				Level of use		Acquisition strategies				
	Brewing beer	**Water for plants**	**Water for animals**	**Water making bricks**	**Daily consumption summer, L**	**Daily consumption winter, L**	**Minutes to collect**	**Male head collects**	**Female head collects**	**Son collects**	**Daughter collects**
Research question #1: *What are the associations between natural resource use, household size, composition and economic status?*											
Household size	0.12	−0.04	0.05	−0.10	0.33	1.20	0.92	0.13*	−0.05	−0.09	0.01
Household composition											
Sex ratio	−0.35	86.00	0.14	0.00	0.22	2.12	7.26	0.53**	−0.37*	0.08	0.12
Young age structure	−0.05	−0.43	0.26	−0.25	5.91	7.51	10.86	0.21	−0.04	0.07	−0.16
Older age structure	0.57	−0.12	−0.50	0.84	5.27	8.91	−2.34	0.99	−0.16	−0.62	0.27
SES											
Possessions index	−0.40	0.00	−0.01	0.09	−3.30	−6.24***	−11.28	0.12	−0.13	0.12	−0.26**
Village	−0.03*	−0.10*	−0.06	0.03	−1.71*	−2.22***	0.83*	−0.01	−0.04	−0.02	−0.04
Research question #2: *Beyond these household characteristics, how is mortality experience associated with natural resources?*											
Adult mortality											
within past 2 years	2.39	0.27	0.92	0.33	−10.87	2.12	−36.46	0.21	−0.38	−0.06	0.78
Mortality×SES	−0.43	0.01	−0.05	−0.37	3.78	1.28	8.82	0.20	0.04	0.13	−0.18
Years since mortality	−0.10	−0.18	−0.66	0.22	3.58	1.84	12.36	−0.70*	0.08	−0.32	−0.01
Constant	−2.78*	0.43	−2.30*	−1.72	98.46***	87.43	67.41*	0.97***	1.25*	−0.65	0.78
Goodness of fit[a]	93.75	70.42	90.83	83.33	.01	.06	.04	83.75	60.00	76.67	56.67
n	240	240	240	240	228	227	195	240	240	240	240