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**Adult Mortality and Natural Resource Use in Rural South Africa:
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Abstract: There is little empirical evidence on the association between HIV/AIDS and use of natural resources in developing countries although the HIV/AIDS pandemic continues while residents of rural regions remain highly dependent on the proximate natural environment. This study examines household strategies with regard to fuelwood and water use as related to prime-age adult mortality in rural South Africa. Survey data reveal higher levels of natural resource dependence among mortality-affected, impoverished households, as well as differences in collection strategies. Interview data provide insight into more subtle and complex adjustments at the household level, revealing that impacts vary by the role of the deceased within the household economy. Policy implications for both public health and environmental conservation are explored.

Keywords: Africa; South Africa; HIV/AIDS; Natural Resources; Rural Livelihoods

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The role of natural resources in household coping strategies during times of crisis, particularly among the rural poor, has been noted in studies across the developing world (Angelsen and Wunder 2003; Eriksen et al. 2005; Godoy et al. 1998; McSweeney 2004; Paumgarten 2005; Shackleton and Shackleton 2004; Takasaki et al. 2004). However, little scholarly attention has been paid to the environmental dimensions of a particular household shock which has serious ramifications for household livelihoods, namely the death of a productive household member. Indeed, there is very little empirical examination of this association published in the academic literature. This is an important research gap in an era of rising prime-age adult mortality largely attributable to the HIV/AIDS pandemic, particularly in sub-Saharan Africa. The analyses presented here contribute to our nascent understanding of the ways in which natural resource use in poor, rural regions of developing nations is being shaped, and reshaped, by the loss of productive adult household members. With a particular focus on household use and acquisition of fuelwood and water, and through examination of both quantitative and qualitative data, this research explores two important questions: *(1) What are the associations between natural resource use strategies and household characteristics of size, composition, and economic status in rural South Africa? (2) Beyond these household characteristics, how is adult mortality associated with these natural resource strategies?*

The manuscript is organized in the following manner: first, we offer a brief review of the literature on the centrality of natural resources in rural household livelihoods, and a concise look at mortality trends especially as related to HIV/AIDS. These two topics are then brought together in presentation of our research questions and consideration of the ways in which rural households' natural resource strategies might be altered by the death of an adult in the household. Next we discuss details of

the research setting, data collection, and analytical methods. Last we describe our findings, explicitly linking observed associations with policy implications.

Natural Resources and Rural Livelihoods in Developing Nations

Until relatively recently, the value of indigenous natural resources to rural livelihoods in the developing world was largely overlooked, prompting the description of common property natural resources as “invisible capital” (Cousins 1999). Across the developing world, natural resources play an important role in rural livelihoods by providing for household needs, providing sources of income, and serving as a ‘safety net’ in times of crisis (Kaimowitz 2003; Koziell and Saunders 2001; Shackleton and Shackleton 2004; Shackleton et al. 2001). These resources are usually harvested from communal forests and rangelands around rural settlements, and typically include fuelwood, wild foods, medicinal plants, fiber, and wood for carving, and construction material. The amounts consumed domestically may be substantial. For example, in their synthesis of South African studies spanning 14 villages, Shackleton and Shackleton (2004) found that rural households consumed a mean of 5.3 tons of fuelwood, 104 kg of edible wild fruit and 58 kg of wild spinaches annually. These patterns of domestic use of woodland resource are similar to those reported for other parts of southern Africa such as Zimbabwe (Campbell et al. 1997; Cavendish 2000). Despite the widespread reliance on the environment by rural households, natural resource use is seldom the mainstay of livelihoods, except for households specializing in resource-based enterprises, or those located in remote and isolated subsistence communities (Belcher et al. 2005). More typically, resource use is supplementary to a range of livelihood strategies including agriculture and migrant labor (Belcher et al. 2005; Quang and Anh 2006; Shackleton et al. 2001). Access to natural resources thus allows diversification of rural livelihoods, thereby increasing resilience to shocks and distributing risk (Angelsen and Wunder 2003; Belcher et al. 2005; Neumann and Hirsch 2000). Poor households have been shown to be more resource-dependent than wealthier households in two ways: 1) the relative contribution of natural resources to the household economy (Cavendish 2000; Quang and Anh 2006; Shackleton and Shackleton 2006) and 2) the per capita consumption of key

subsistence resources such as wild edible herbs (Shackleton and Shackleton 2006; Twine et al. 2003). Nevertheless, wealthier households often consume more natural resources in absolute terms (Cavendish 2000), although they more commonly buy these resources instead of harvesting themselves (Shackleton and Shackleton 2006). Income from the sale of raw or processed natural resources is usually modest (Angelsen and Wunder 2003; Belcher et al. 2005; Shackleton 2005), but nevertheless, can make an important contribution to total income at critical times of the year, especially for poor and vulnerable households (Angelsen and Wunder 2003; Shackleton 2005).

Several studies have calculated the direct-use value of natural resources consumed by rural households (e.g. Campbell et al. 1997; Cavendish 2000; Dovie et al. 2002; Letsela et al. 2002; Shackleton and Shackleton 2000; Twine et al. 2003). The review of South African studies by Shackleton and Shackleton (2004) suggests a mean annual gross value of R3854 (\$557/€93) per household per year, ranging from under R1000 (\$145/€102) to R12000 (\$1735/€225) per year. Such ‘environmental income’ could constitute as much as 40% of total household income (including cash and gifts/transfers) for poor households (Cavendish 2000). Because common property resources are inexpensive or free, these direct-use values constitute savings for the household that would otherwise have to pay for commercial alternatives (Shackleton and Shackleton 2004). This explains why after almost a decade of rural electrification, 90% of rural households in Bushbuckridge, South Africa, still cook with fuelwood (Madubansi and Shackleton 2006). These savings allow households to allocate scarce financial resources to other household needs, such as education (Shackleton and Shackleton 2004). Although such ‘environmental income’ plays an important role in subsidizing rural livelihoods, it typically escapes national economic accounting systems (Shackleton and Shackleton 2000) since natural resources are usually collected for domestic consumption and/or traded informally (Qureshi and Kumar 1998; Stiles 1994).

In addition to the day-to-day provisioning described above, natural resources serve as ‘safety nets’ for households during times of hardship precipitated by shocks, such as crop failure, natural

disasters such as floods, illness and/or the death of a breadwinner (Angelsen and Wunder 2003; Eriksen et al. 2005; Godoy et al. 1998; McSweeney 2004; Paumgarten 2005; Shackleton and Shackleton 2004; Takasaki et al. 2004). Shackleton and Shackleton (2004) refer to this as the ‘emergency net’ role of natural resources, to differentiate it from the ‘daily net’ role of improving livelihood security by meeting ordinary daily needs. 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 (Eriksen et al. 2005; McSweeney 2004; Shackleton and Shackleton 2004). The ‘safety net’ function is particularly important for poor and vulnerable households, such as those headed by single females (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 (prime-age adults), and dramatic declines in life expectancy, due primarily to HIV/AIDS, characterize the population of many African nations (UNAIDS and WHO 2007; UNAIDS undated(a)). Globally, the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) estimates that 33.2 million (30.6–36.1 million) individuals were living with HIV/AIDS in 2007. Despite the percentage prevalence having stabilized, and even declining in many places, continuing new infections (even at a reduced rate) make the 2007 estimate the largest ever (UNAIDS and WHO 2007, 5). Nearly 2.5 million (1.8–4.1 million) people were newly infected with HIV/AIDS during 2007, and nearly 2.1 million (1.9–2.4 million) died during that year (UNAIDS and WHO 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 (UNAIDS and WHO 2007).

Within sub-Saharan Africa, the southern region remains the most affected. This sub-region accounts for 35% of all people living with HIV/AIDS and 32% of all new infections and deaths in 2007. National HIV/AIDS prevalence exceeded 15% in Botswana, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe in 2005 (UNAIDS 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 (UNAIDS 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 (Department of Health South Africa, 2007 quoted in UNAIDS and WHO 2007). Our study area, while currently in the Mpumalanga Province was a part of the Limpopo Province at the time of our study. Limpopo Province was the most northerly of South Africa's nine provinces, where HIV-related tuberculosis and lower respiratory tract infections were among the leading causes of death (Thom 2004). Health indicators for Limpopo suggested that the impact of HIV/AIDS was only beginning to be felt (Johnson et al. 2003). In the year 2000, 21.5% of deaths were attributed to HIV/AIDS and it was projected that by 2010, this would rise to nearly 65% (Day and Gray 2003). Once a mainly urban phenomenon, HIV/AIDS has become a challenging social problem in rural Africa with major implications for rural development (Hargreaves and Pronyk 2003; Rugalema and Khanye 2002; Vogel 2002). In all, the study area represents an appropriate and important context in which to examine the implications of prime-age adult mortality.

It is well known that HIV/AIDS disproportionately kills adults in their prime economic and parenting years (de Waal and Whiteside 2003; Haddad and Gillespie 2001). And, as Hargreaves and Pronyk (2003, 94) note, "rural households are highly vulnerable to the multiple impacts of the illness and death of a household member." It is the intersection of the demographic, cultural, and economic characteristics of HIV/AIDS that makes it such a devastating shock not only for afflicted households, but also more generally for communities, organizations, institutions, and even entire societies. As Beresford notes, "HIV/AIDS damages society just as it does the human body: it begins by killing those

parts responsible for building society, the women and breadwinners who sustain and safeguard the community as a whole” (2001, 19).

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. Following the lead of similar research (ABCG 2002; DAI 2003), we classify these many possible changes using four interrelated dimensions: selection, use, level of consumption, and acquisition 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). For example, women in rural India have been observed using bamboo as fuelwood despite its low sustained heat, fast burn rate, and excessive smoke, because of “extreme difficulties” in obtaining preferred species of fuelwood (TERI 1994).

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 may change 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” and more of 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, and/or natural resources may be purchased or received as gifts. Filmer and Pritchett (1996) provide a particularly salient example of the importance of acquisition strategies. Their research from Pakistan suggests that fertility rates may rise in response to resource scarcity because of an increase in the relative value of children as resource collectors. After all, “little hands help” (Dasgupta 1995). Still, the subsequent rise in population can further contribute to natural resource scarcity, creating a “vicious circle” (Filmer and Pritchett 1996).

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 and knowledgeable natural resource harvester. In contrast, children and inexperienced collectors are more likely to employ unsustainable harvesting practices owing to a lack of (often traditional) knowledge (ABCG 2002; DAI 2003).

Questions of *who* in the household collects/harvests natural resources unavoidably raise the issue of opportunity costs. Increases in total time spent on natural resource harvesting as a result of a skilled adult collector’s death represent only a part of households’ collection costs. Children may spend on resource collecting time 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 (ABCG 2002).¹ Additionally, research reveals increases in begging and a greater reliance on family and charitable organizations after the death of a household member (Mutangadura et al. 1999). Overall, this research is designed to contribute to our understanding of the association between prime-age adult mortality and household coping strategies particularly regarding natural resources.

Study Context and Methods

The fieldwork for this project was undertaken in the Agincourt Health and Demographic Surveillance Site (AHDSS) of the MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt Unit) during May-June 2004. The study site is in a rural region in the extreme northeast of South Africa approximately 500 km. northeast of Johannesburg (see Figure 1). It encompasses 400 km², including 21 villages and over 12,000 households. The area is semiarid (annual rainfall 550-700 mm) and relatively heavily populated (~170 persons per km²). Household plots are generally too small to fully support subsistence agriculture. The settlement pattern is fairly typical of rural communities across South Africa, and socioeconomically the region is characterized by a high reliance on both natural resources and remittances. Because there is limited formal sector employment, a large proportion of adults are migrant laborers, working on commercial farms and in towns and cities across the country. Of all males between the ages of 30 and 49, 50% are migrant workers, as are 14% of females of the same age group (Collinson et al. 2006a; Collinson et al. 2006b; Collinson et al. 2007). In addition, a significant proportion of households depend on an elderly resident's state pension as the only reliable source of household income. Residents of these rural communities are typically dependent on the natural environment for a range of resources, including the grazing of livestock and the collection of fuelwood, wild foods, thatching grass, construction timber, and other domestic products that are used both for household consumption and for generating income (Shackleton 1996; Shackleton and Shackleton 2000).

¹ This is a common strategy to cover medical and/or funeral costs as well (ABCG 2002; DAI 2003; Mutangadura et al. 1999).

(Figure 1 about here)

Information on the incidence of mortality, as well as other demographic characteristics of Agincourt households, was available through the demographic surveillance system of the Agincourt Unit. Since 1992, the Agincourt Unit has collected census data at 12-18 month intervals from all subdistrict households. Given the importance of HIV/AIDS in shaping contemporary mortality patterns, this study focuses on households that had experienced the death of a household member aged 15-49 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. Although admittedly imperfect, making use of prime-age adult mortality as a proxy for AIDS impacts is a frequently used strategy (e.g. Yamano and Jayne 2004) especially given the emotional and ethical difficulties inherent in collecting information on AIDS. Another limitation of the focus on prime-age adult mortality is our inability to identify impacts associated with the preceding period of illness. Even so, although unable to disentangle morbidity effects, we argue that 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 AIDS-related morbidity and cause-specific mortality as associated with natural resource strategies.

We undertook a natural resource survey of 241 households in 8 villages in the central region of the study site.² The sample was stratified by mortality experience: half of the survey households were randomly selected from households having experienced the death of a household member aged 15-49 in the previous 2 years, and the other half from households experiencing no such mortality. The survey

² Geographic restrictions were due to logistical and budgetary considerations. Nonetheless, the study villages were chosen to represent a range of environments along the region's east-west rainfall gradient.

focused on both fuelwood and water, and asked about household selection, use, acquisition, and consumption.

Quantitative modeling of the survey data makes use of information gathered on households' selection of fuelwood as opposed to electricity. We asked about the households' uses of fuelwood and water (e.g., for cooking, heating bath water, heating the home, and/or brewing traditional beer), as well as the quantity of fuelwood and water consumed. Lastly, we asked about the households' acquisition strategies, including purchase and/or collection/harvesting efforts by specific household members. In the analyses that follow, all outcome variables, except quantity of wood and water consumed, are coded as dummy variables with 1 representing "yes." Importantly, the outcomes are not mutually exclusive; a household may be coded "1" for "purchases wood," while also being coded "1" for "the female head and/or daughter harvest wood."

Our primary predictors of interest reflect household experience with adult mortality in the two years before the survey. A dummy variable reflects households affected by an adult death, while 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.³ Importantly, the examination presented here is cross-sectional, and as such, we examine differences in household natural resource strategies by adult mortality experience at a single point in time. Any variation across households in resource strategies are not necessarily longer-term, but more likely to represent a snapshot of the dynamic nature of household coping strategies. Again we contend that such a window into household impacts of prime-age adult mortality is of particular importance in the contemporary era of HIV/AIDS.

Our controls include household size as a categorical variable, with categories based on preliminary analyses and chosen for ease of interpretation (categories reflect household sizes of 1, 2-5,

³ We explored additional predictors related to household mortality experience (e.g., gender of deceased, nonlinear representation of time since mortality), but we present here only the most robust and parsimonious models.

6-10, greater than 10). Three variables reflecting household sex and age composition are also included. Sex ratio is measured in standard demographic form as the ratio of male:female. A household is coded as young if at least one-third of its members are under age 15, and as old if at least one-third of its members are over age 50. Finally, a “possessions index” has been created by the Agincourt Health and Population Unit to reflect socioeconomic status. The index ranges from 1 to 5 and is derived from an AHDSS 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). Within this setting, the possessions index is often used as an indicator of household economic well-being, and this approach has been used by others in similar contexts (Schellenberg et al. 2003).

Table 1 presents a descriptive profile of the study’s survey sample with regard to wood and water use as well as sociodemographic characteristics. As in the study region generally, the vast majority of households use fuelwood, with most using wood for cooking and heating bath water. 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, most households are electrified, as over three-quarters use electricity for lighting. Nearly one-third use electricity for cooking, although clearly this is supplemental energy given the high level of fuelwood use. There is wide variation across households in amount of fuelwood used, although only about 1.5 kg seasonal difference. On average, households use nearly 9 kg of wood daily in the summer and just over 10 kg in the winter. The descriptive profile suggests that wood acquisition strategies are multifaceted, with nearly half of the households purchasing some wood, and harvesting undertaken mainly by the household’s women.

(Table 1 about here)

There is universal use of water for drinking and cooking, and near universal use for bathing and washing. Nearly one-third of households use water for plants, while fewer use it for making bricks, watering animals, and brewing traditional beer. The level of water consumption is higher in summer, a logical pattern given seasonality of crop production and increased consumption 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. These opportunity costs vary dramatically however since the time required to collect ranges from only 1 minute to nearly 7 hours. As for wood, collection is primarily a woman's job, with high levels of engagement especially by female heads/wives and daughters.

Among predictor variables, household size ranges from 1 to 21, with the average just under seven. The mean sex ratio of 0.81 is consistent with the slightly higher incidence of male migration for economic purposes. Many more households have a young age structure than an older one: people under age 15 constitute at least one-third of household members in over 70% of the study households, while only 10% of the households have a third of their members over 50 years of age. Finally, on the socioeconomic status (SES) scale of 1 to 5, households sampled for the survey register a mean value of 3.19.

In addition to the survey and quantitative modeling, we present qualitative data from interviews in 31 of the mortality-affected households surveyed. These interviews ranged in length from 30 to 90 minutes, and we spoke with the household member most engaged in resource acquisition. 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 manuscript, 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.

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. We review results with regard first to fuelwood (Table 2), then to water (Table 3).

The results of the multivariate regression analysis suggest that in our rural South African study site, household composition and socioeconomic status have few significant effects on the selection of fuelwood vs. 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 wood collection. Table 2 also reveals that SES and village context make a difference in the use of electricity for cooking and/or lighting. A preliminary exploration of specific village locations as related to electricity use suggested that households in villages with relatively fewer nearby fuelwood sources are more likely to make use of electricity; this association is the subject of ongoing analyses. The qualitative interview data also suggest that some households manage to make use of electricity. In general, however, the surveys and interviews reveal little variation in type of energy used, with nearly all households using fuelwood as the primary source. The principal factors shaping the use of alternatives are village context and socioeconomic status, with higher income often allowing for the purchase of electricity.

(Table 2 about here)

Among the specific uses of fuelwood, cooking and heating water are nearly universal, and household characteristics (specifically SES) significantly affect only decisions with regard to heating water. Few of the household characteristics we measured affect energy use, and the interviews also reveal little variation across households in use of wood. Only a handful of households brew traditional beer or heat the home with wood.

Even when household size is 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 show 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 fairly wide variation in level of use, ranging from a minimum of 1 kg daily to over 20 kg daily.

With regard to acquisition strategies, the results of the regression models suggest that household composition and socioeconomic status both have limited, but statistically significant effects on who in the household harvests fuelwood. In particular, larger households are more likely to have a male head who harvests wood. 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, which focuses on the association of adult mortality and natural resource strategies. Recent adult mortality experience is associated with an increased likelihood that a household will use wood, although the negative coefficient for the interaction between mortality and SES suggests that this association is weaker for households of higher socioeconomic status. 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. In addition, the negative estimates for years since mortality nearly reach statistical significance, with $p < 0.08$ for prediction of cooking with wood and

$p < 0.07$ for prediction of heating water with wood. Although not reaching the $p < 0.05$ threshold, these results suggest that the association between these outcomes and adult mortality experience may lessen with the passing of time.

Male heads are clearly more likely to harvest wood in mortality-affected households than in unaffected ones. Among households with a male head harvesting fuelwood, the deceased person is equally likely to have been 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 varied substantially across households (Table 3). We expected, and found, universal use of water for basic domestic consumption, and water was generally used sparingly for these purposes because it was difficult to obtain. Interestingly, household sociodemographic characteristics have relatively little impact on other household uses of water: 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, and used as substitute for purchased food, in the dry winter months. 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 substantial variation in daily consumption, ranging from 3 to 225 litres, 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 are required to collect water, and who in the household collects. The results suggest that less time is required to collect water in households with higher SES, likely because of better access, usually from a tap in the yard. 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 spent, on average, 54.1 minutes per day collecting water. This figure doubles if the female head collects the water (mean of 105 minutes).

The bottom of Table 3 shows little association between water use strategies and household mortality experience. In fact, the only significant coefficient is the one for the decrease in probability that a male head will 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.

The interview data reveal additional complexity as they offer a more nuanced perspective on resource strategies within mortality-impacted households. These qualitative data reveal that household impacts are clearly shaped by the gender, age, and household role of the deceased. Specifically, patterns of change in resource selection, use, consumption, and acquisition in households experiencing an adult death are clearly related to the deceased's role 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 or 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."* George was laid off from his job several months ago, and they stopped regularly purchasing food: *"sometimes we buy, but most of the time we rely on the garden."* Both of Hope's deceased parents had previously assisted in their household's resource harvest. Hope explains 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 appear to spread across other family members, and other data suggest that children often play an important role. In several households, children spent considerable time collecting natural resources, often at the expense of their studies. Indeed, households without regular income may have no option but to acquire scarce fuelwood through harvesting. 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 does not purchase fuelwood, since their only source of income is a very small and irregular contribution from her mother’s old age pension. This cash is *“used to buy mealie meal (maize meal, a staple grain) and other groceries. But because we are many at home, the money becomes too little, and she also uses it for the funeral insurance.”* 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 were felt when the deceased had contributed wages. In these cases, impacts involving natural resource selection, use, consumption, and acquisition strategies varied 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, and he used to buy groceries, but now I need to do that on my own.”* Trezia has not been successful in her search for employment, and the household’s income had yet to be replaced at the time of the interview. Lucille’s husband had been engaged in hard labor, *“piece jobs like brick making and digging toilet holes.”* 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 now 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 including reeds for mats, marula nuts for jam, and fruits and vegetables. They also collect locusts, although as Asnara explains, *“we don’t go out to look for them but catch those which are attracted by light in the evening.”* The water source is unreliable, and *“sometimes we spend 2-3 days without water.”* The children harvest fuelwood, which, as she explains *“is difficult to get ...because there are no longer trees around.”* 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.”*

Households that lose adult wage-earners shift time allocation much like those losing resource collectors. As revealed by Asnara’s story, however, the tasks are not simply reassigned, but rather, households stop purchasing resources and start collecting alternative natural resources. The death of Lenia’s wage-earning husband *“brought a lot of changes, the first thing being changes on 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 in the field.”* He worked at the Kruger National Park. She says, *“yes, there are definitely changes.”*

Discussion

Although little explored, 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. Results from both survey and interview data from rural South Africa suggest that the recent loss of an adult household member shapes 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 socio-economic status and years since death.

Of course, 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.

Our survey data do not allow for specific identification of cause-of-death, nor do 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 (UNAIDS undated(b)). As such, the ability to identify AIDS-specific mortality may actually reveal more substantial mortality impacts. We consider all causes of prime-age adult mortality together, thereby potentially weakening the mortality effect as compared to AIDS-only deaths. Second, household shifts in natural resource strategies 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 period of illness. These limitations suggest that the revealed mortality effects

do, in fact, represent substantial variation across households, particularly when interpreted in combination with the qualitative data. Indeed, 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 past research demonstrating the importance of natural resources as a buffer with regard to household shocks such as an HIV/AIDS-related death (Hunter et al. 2007). Indeed, the vast majority of rural households depend heavily on natural resources as both a buffer against poverty and a means of generating income (Cunningham 1988; Shackleton 1996; Shackleton and Shackleton 2000).

Analyses of the effect of adult mortality on household natural resource strategies yield policy implications for the management of common property natural resources. As noted by the United Nations Environmental Programme (UNEP), over the past 30 years, the environment in Africa has continued to deteriorate, resulting in environmental change which is making more and more people in the region vulnerable due to increased risk and inadequate coping strategies (SADC 2002). Rural communities in South Africa depend greatly on indigenous natural resources that are coming under increasing pressure due to poverty, high human population densities, and the weakening of the traditional authorities historically responsible for controlling access (Giannecchini et al. 2007; Kirkland et al. 2007). Current extraction rates may be unsustainable in some cases (Banks et al. 1996).

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. There has been a dramatic increase in the pace of rural electrification in more recent years, but our data show that this alone will not solve the problem in the short to medium term, because of the economic obstacles facing the rural poor, including those affected by adult mortality. This is supported by Madubansi and Shackleton (2006) who showed that fuelwood is still the dominant thermal energy source used by households across five rural villages in the study region, despite widespread access to electricity and declining fuelwood stocks. The increasing risk of adult

mortality due to HIV/AIDS puts additional stress on marginal households dealing concurrently with decline in the local stocks of essential natural resources. Because of the important role of natural resources as a buffer for households in times of 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 property rights and more effective local institutions for the management of common property natural resources are therefore desperately needed. More specific interventions might encourage the establishment 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 be necessary.

In closing, we must revisit an important limitation of these analyses. Our methodology did not allow for identification *a priori* of households experiencing only HIV/AIDS mortality. Rather, our focus was on households experiencing the death, for any reason, of an adult household member in the prime working years. However, past scholarship suggests that nearly half of these deaths are likely due to HIV/AIDS. The lack of integration of environmental dimensions within AIDS scholarship necessitates such broad analyses as a first step; our ongoing efforts are designed to distinguish specifically across causes of death in order to reveal a more nuanced story with regard to the environmental dimensions of HIV/AIDS.

That said, our evidence does suggest that increased adult mortality and increased environmental scarcity are indeed shaping and reshaping household strategies with regard to natural resource use and collection. Importantly, the survey data reveal interactions between poverty and village location in determining household coping strategies. Combined with the interview data, the results reveal subtle and complex shifts at the household level. Understanding these shifts is central to the design of policy aimed at supporting impoverished, natural-resource dependent rural households that have lost adult members to the HIV/AIDS pandemic.

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

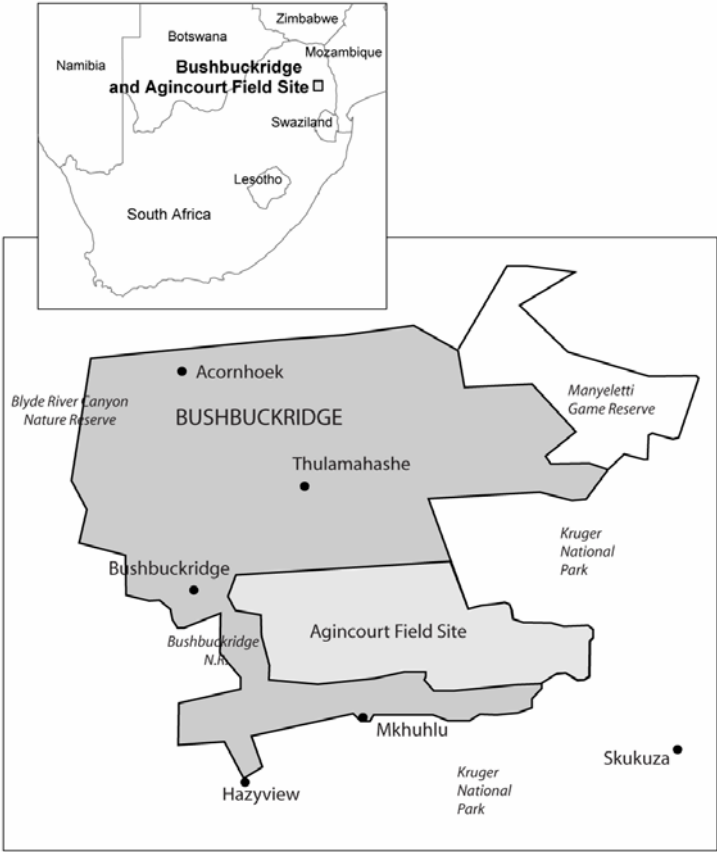


Table 1: Descriptive Profiles of Household Variables Incorporated in the Multivariate Models.

	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 (in kg)	8.7	0	22	171
Wood per day in winter (in 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 (in litres)	82.7	10	225	236
Water per day in winter (in litres)	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
Daughter collects	50.8%			248
Other	10.1%			248
Socio-Demographic 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 Health and Demographic Surveillance Site, Mpumalanga Province, South Africa

	<u>Use Wood</u>	<u>Alternative Energy</u>		<u>Uses of Wood</u>		<u>Level of Use</u>		<u>Acquisition Strategies</u>			
	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
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
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
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
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
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
Village	-0.04	-0.06 *	-0.25 **	-0.04	-0.09	-0.01	-0.02	-0.01	-0.01	-0.01	0.02
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
Mortality*SES	-0.83 *	0.09	-0.19	-0.69 *	-0.64 **	-1.21	0.61	0.05	-0.36	-0.05	0.64
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
Constant	2.32 *	-0.09	3.68	2.15 *	2.19 **	4.12	9.05	0.19	-3.79 **	0.64	-1.27
R²	0.08	0.06	0.20	0.08	0.10	0.11	0.09	0.01	0.11	0.04	0.08
N	239	239	239	239	239	169	169	239	239	239	239

*p<0.05;**p<0.01

1: Data Source: Agincourt Health and Demographic Surveillance Site, Population & Environment Survey, June 2004.

Table 3: Multivariate Estimation of Household Water Strategies, Agincourt Health and Demographic Surveillance Site, Mpumalanga Province, South Africa

	<u>Uses for Water</u>				<u>Level of Use</u>		Minutes to Collect	<u>Acquisition Strategies</u>			
	Brewing Beer	Water for Plants	Water for Animals	Water for Making Bricks	Daily Consumption summer, liters	Daily Consumption winter, liters		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
R²	0.091	0.039	0.05	0.07	0.007	0.06	0.037	0.114	0.035	0.028	0.26
N	240	240	240	240	228	227	195	240	240	240	240

*p<0.05;**p<0.01

1: Data Source: Agincourt Health and Demographic Surveillance Site, Population & Environment Survey, June 2004.