

Forests and human health in the tropics: some important connections

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An overview of the state of human health in and around forests, and the causal links between forests and human health.

Why should foresters concern themselves with issues of human health? There are at least two important answers to this question. First, and perhaps most fundamental, forestry activities affect human health and human health affects forests. Second, the United Nations Millennium Development Goals (MDGs) (see Box), which the world's countries have committed to meet by 2015, reflect increasing global concern about human health. Four of the MDGs (1, 4, 5 and 6) address health directly. It can also be argued that improvements in human health (as part of human well-being) are a prerequisite for accomplishing the seventh goal, which is the most pertinent for foresters.

The second and third MDGs stress or imply gender equity. These goals also have fairly direct implications for human health, given the central role women typically play in family health maintenance. In most places it is women who

provide families with nutritious meals and maintain standards of hygiene. In forested areas, women's roles also involve interaction with forests and other natural resources (for non-wood forest products [NWFPs], clean and abundant water, forest agriculture, etc.). As the primary caretakers when other family members fall ill, women in forested areas often treat their family members with forest products. Finally, women are central players in decisions about family size; large families can adversely affect the health of both mother and offspring, and often adversely affect the health of forests as well.

Even the realization of the eighth MDG, related to global partnerships, could contribute to improved human and forest health.

As with many statistics pertaining to forests, global and regional statistics about the health of people living in forests are subject to some question. But a sense of the magnitude of both health problems for people and the links between forests and health can be grasped from the following sprinkling of statistics.

- Smoke from fuelwood and forest fires causes significant human respiratory problems. Smoke from simple biomass fuels may account for 1 million to 2 million premature deaths annually, mainly women and small children in developing countries (see Smith, this issue of *Unasylva*). Smoke plumes from forest fires can travel hundreds of kilometres, posing a great health risk; the extensive 1997 Indonesian forest fires caused an estimated 16 400 infant and foetal deaths

Millennium Development Goals

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

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Remote forested areas may have difficulty attracting doctors, nurses and health system administrators (a clinic in Mexico)

(Jayachandran, 2005) (see page 45 regarding health guidelines for fire events).

- Anyinam (1995) reports that in India alone, some 2 500 plants are used medicinally, and Shankar and Majumdar (1997) add that for 400 million to 500 million Indians, traditional medicine is the only option.
- Seventy to 80 percent of Africans consult traditional medical practitioners who often rely on medicinal plants. The United Republic of Tanzania, for instance, was reported to have 30 000 to 40 000 traditional practitioners compared with only 600 western doctors (Cunningham, 1993).
- US\$75 billion of pharmaceuticals of natural origin are sold each year (Kate and Laird, 1999).

The ubiquity of serious health problems, such as human immunodeficiency virus and acquired immunodeficiency syndrome (HIV and AIDS), Ebola and malaria, is counterbalanced by the (sometimes) recognized value of traditional knowledge and use of medicinal plants as alternatives to modern medicine.

Because forests, almost by definition, have lower population densities than urban areas or agricultural landscapes, people living in forest areas tend to be

disregarded in formal health care systems and research. They are often difficult to reach, and remote forested areas may have difficulty attracting doctors, nurses and health system administrators.

There are both ethical and practical reasons for reversing this trend. Justice demands greater attention to those with inequitable access to good health, by whatever means; and forest dwellers have knowledge and capabilities that can meaningfully contribute to improved forest management. This article identi-

fies four central links between forests and human health, focusing on two central questions:

- What are the human health conditions in and around forests?
- What are the causal links between forests and human health?

Finally, the article provides some policy recommendations targeted to specific actors such as health professionals or foresters.

The article draws heavily on recent research of the Center for International Forestry Research (CIFOR) (see Box). Much of this research concerns topics covered in depth in the other contributions in this issue; this article focuses on those topics that are less fully developed elsewhere in the issue. Most of the findings concern humid tropical forests, with lesser attention to dry forests, forest margins and previously forested areas.

HUMAN HEALTH–FOREST LINKS

Forests do not have the same importance in the daily life of all people living in and near the forest; their importance varies along a continuum from hunter-gatherers to swidden farmers, to recent in-migrants, to agriculturists, to urban dwellers (see Figure).

CIFOR and human health research

The Center for International Forestry Research (CIFOR) recognized the importance of human health in forest management in the mid-1990s. Some 20 interdisciplinary teams of researchers, working in ten countries in the developed and developing world, looking at forests managed for timber, plantations, and community use, all concluded that human health was an important element in sustainable forest management. Health professionals have also identified important links between the environment and health (e.g. Engelman, 1998; Gardner-Outlaw and Engelman, 1999; Walsh, Molyneux and Birley, 1993; Patz *et al.*, 2000; Patz and Wolfe, 2002).

In 2003, CIFOR initiated a review of the literature on human health and forests which included specialist workshops, interviews with experts, continuing field observations and the collection of over 600 studies and analyses. The full results are reported in Colfer, Sheil and Kishi (2006).

More information on CIFOR's work on human health is available at: www.cifor.cgiar.org/Research/Livelihoods/MainActivities/ForestHealth

Hunter-gatherers and swidden farmers depend on forests most fundamentally in terms of subsistence, health, income and culture; their total way of life may depend on the forest. They are likely to have useful stores of indigenous knowledge that can be tapped to improve forest management. Recent in-migrants may be just as dependent on forests for subsistence, but may have neither in-depth knowledge of local species, habitats and behaviour nor the associated symbolic and cultural ties and values that still enrich the lives of many forest dwellers. Settled farmers and urban dwellers may want to buy forest products or may depend on the forest for fuel or medicine, but are far less enmeshed in its sustainability or cultural significance.

To improve human health and forest sustainability, it is necessary to consider which categories local populations belong to and to assess how forest dwellers can contribute to improving forest management. It is also necessary to take note of variations in forest knowledge and use within forest communities (by age, gender, caste, etc.). As the articles in this issue show, interventions in forests, both harmful and benign, have implications for other populations, as has been dramatically and negatively shown in



*People residing in and near forests typically obtain a considerable, although variable, amount of nutritious foods from forests – with poor people generally more dependent on such food (children eating fruits of *Borassus aethiopium*, Senegal)*

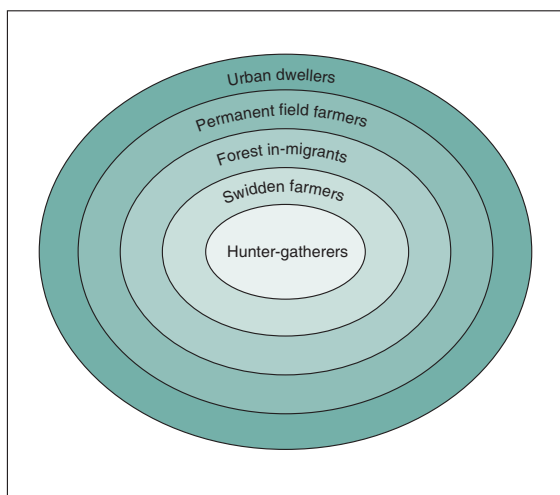
recent years with diseases emerging from forests such as severe acute respiratory syndrome (SARS).

Food and nutrition

Although the potential of forests for improving livelihoods may be small, forests serve as important safety nets. People residing in and near forests typically obtain a considerable, although variable, amount of nutritious foods from forests (see Dounias and Froment, this issue; Johns and Maundu, this issue). Poor people are disproportionately dependent

on such food. The adequacy of hunter-gatherers' access to nutrients from the forest and the nutritional value of many forest foods are still under investigation. It appears that no people on the planet are now wholly dependent on wild gathered forest products for their food; all cultivate, barter or trade to some degree. Nonetheless, wild foods continue to provide the major portion of the animal fats, proteins and minerals in the diets of millions of people.

Bennett and Robinson (2000) report that in 62 developing countries, people obtain more than 20 percent of their protein from wild meat and fish. People in the Congo Basin alone consume more than 1 million tonnes of wild meat yearly (equivalent to 4 million cattle) (Wilkie, 2001), while people in the Amazon Basin consume 67 000 to 164 000 tonnes per year (Bennett, Robinson and Eves, 2002). Wild forest-dwelling animals represent a mixed blessing, however,



Importance of forests for different groups of people living in or near them

with raids on crops counterbalancing ease of hunting.

Remaining forest habitats tend to be characterized by poor soils and plants whose defences make them unsuitable as food. However, forests are also important reservoirs of genetic resources which provide some foods at present and hold the potential to nourish a wider public in the future. The wild relatives of many common crops represent an important global heritage. Forests also supply numerous goods (and services) that indirectly support food provision, such as poles, beehives and fodder.

Commercialization often adversely affects the sustainability of plant and wildlife populations, spurred by the growth of markets in cities, entrance of loggers and others into forest areas, and improved weapons and transport (see Johns and Maundu, this issue). Sale of wildlife and other NWFPs represents a source of income for local families but sometimes takes food away from the kitchen. Seasonality results in serious hunger in some areas.

Landscape modification is often motivated by the need for food. Some manipulations maintain forest cover and increase food production at the same time. Changes in forest composition caused by logging, hunting and invasive species have diverse effects on food availability. Different stages of forest regrowth vary in food productivity.

The distribution of food within forest households can be inequitable, with women and girls particularly at risk. Forest (and other) diseases can adversely affect people's access to foods. Illness and death from HIV and AIDS, as well as care-giving responsibilities, reduce the effective working adult population – and thus family food supply (see Holding *et al.*, this issue). Food-related health problems that affect people living in forested areas include vitamin A and iodine deficiencies, mycotoxins and other toxins in foods, and viral diseases spread through contact with wildlife. Fuelwood is com-

monly used for cooking in forested areas and presents serious respiratory health hazards, particularly for women and children (see Smith, this issue).

Diseases

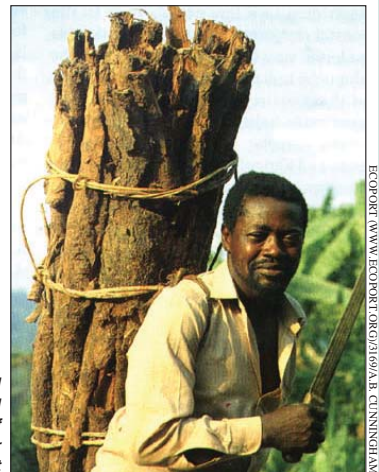
Deforestation, population growth, human movement, economics, power and disease are intimately interconnected, but predicting the impact of specific landcover changes on human health will require analysis of local conditions. Emerging viral diseases pose significant threats to human and wildlife populations (see Wilcox and Ellis, this issue). Vector-borne diseases are particularly likely to be implicated in forested areas. These ailments have varying relationships with deforestation, but in most cases deforestation appears to increase the disease load of local people.

Handling and consumption of bushmeat increase exposure to many viruses and may underlie the emergence of various diseases including HIV and Ebola. Forest animals and insects serve as hosts and vectors to a number of important diseases such as yellow fever, leishmaniasis and Chagas disease, among others. Land use changes affect various hosts and vectors differently, thus affecting human disease incidence. The threat of emergent diseases such as Lyme disease in the United States or Ebola in Central Africa is worsened by their capacity to spread beyond forests (see Wilcox and Ellis, this issue).

HIV and AIDS, conflict, nutrition and women's low status are intertwined in East and Central African forests. Globally, households affected by HIV and AIDS tend to enter a downward spiral of gender inequities, poor nutrition, cultural breakdown and more poverty and disease (see Holding *et al.*, this issue). Social inequities in access to resources, seasonal labour and separation of families all increase vulnerability to AIDS in (and outside) forested areas. Practical steps that could improve the situation include acknowledgement of the role of medicinal plants and forest foods in patient care, increased access to fuelwood (reducing labour requirements), development of woodland-based income-generating activities, and sharing of forest revenues to support local community initiatives to deal with HIV and AIDS (Anyonge, 2004). Indigenous knowledge has an important role in such efforts (Lengkeek, 2005).

Malaria is another major killer and factor in the burden of disease in and near forested areas, particularly in Africa. The causal links between deforestation and incidence of malaria are difficult to distinguish. Some logging processes can lead to standing water and increases in mosquito breeding sites. In a few places, such as Panama and the Terai region of

Many western pharmaceutical products derive from tropical forest species; shown, bark of *Prunus africana* destined for the European market



REPORT WWW.ECOPORT.ORG/1609/AB_CUNNINGHAM



*Traditional health care systems are based on significant local knowledge of medicinal plants; shown, a herbalist preparing medicine from the fruit of *Kigelia africana*, Uganda*

Nepal, forest clearing has allowed populations to enter areas that malaria had previously rendered uninhabitable. (In contrast, see page 19 for an example of how afforestation was used to help control malaria in Italy in the early twentieth century.) However, in other areas the movement of non-immune peoples into malarial areas where local people have some immunity has been connected with increased prevalence of the disease. The enormous variability and adaptability of mosquitoes contributes significantly to the difficulty in distinguishing causal factors and in developing effective health maintenance strategies.

Mercury poisoning from consumption of contaminated fish is common in some forested areas. In the Amazon, gold mining and erosion (exacerbated by forest clearing) of soils containing naturally high levels of mercury have resulted in high levels of mercury in downstream waters. Exposure to mercury can lead to lowered resistance to disease, insanity, mental retardation and a number of less dramatic problems. Researchers and community members have worked together in some places to reduce exposure to mercury by altering local diets.

Medicinal products from forests

Many forest plants and animals produce poisons, fungicides, antibiotics and other biologically active compounds as defence mechanisms, and many of

these have medicinal uses. Compounds that have common medicinal uses such as cola nuts, caffeine, chocolate, chili peppers and cocaine are also found in forest areas. Many western pharmaceutical products derive from tropical forest species, e.g. quinine from *Cinchona* spp.; cancer-treating drugs from rosy periwinkle (*Catharanthus roseus*); treatments for enlarged prostate gland from *Prunus africana*; forskolin, which has a variety of medicinal uses, from the root of *Coleus forskohlii*; medicine for treating diabetes from *Dioscorea dumetorum* and *Harungana vismia*; and several medicines based on leaves of the succulents of the Mesembryanthemaceae family. Some of these products are now synthesized, but others are still collected from the wild. The economic value of traditional medicines is considerable; Achieng (1999), for instance, reported that the bark of *Prunus africana* alone was worth US\$220 million annually to the pharmaceutical industry.

Traditional health care systems are based on significant local knowledge of medicinal plants in all major tropical areas. These health care systems are important, particularly where formal health care services are absent (see Dounias and Froment, this issue). The market for traditional medicines is large and expanding, and much of it is in the hands of women, particularly that involving less commercially valuable

medicinal plants. There is also growing scientific evidence of the efficacy of some of these widely used traditional remedies.

At the same time, medicinal plants are threatened globally, via some of the same mechanisms outlined for forest foods (see Johns and Maundu, this issue). Some of the threats include slow growth patterns of desirable species, loss of traditional mechanisms that contributed to sustainable use, and competing uses of the same species, in tandem with growing commercialization and global markets. Certification of medicinal plants and better forest management techniques offer two possible partial solutions.

Pharmaceutical companies have sometimes been charged with reaping unacceptably large benefits from forest peoples' knowledge given the widespread poverty in forested areas. Issues relating to intellectual property rights, implications for cultural integrity, and amounts and recipients of benefits are complex. The Convention on Biological Diversity (CBD) aims to protect benefit-sharing rights, but adequate mechanisms for doing so are not in place, especially in many developing countries. Attempts to establish collaboration between the pharmaceutical industry and local communities in bioprospecting have had mixed results (Kate and Laird, 1999).

Cultural change and consequences of development

A sense of identity and community is central to the quality of all human life. It is increasingly recognized that culture greatly influences people's quality of life, sense of well-being and health. Among hunter-gatherers and many swidden farmers, the forest-health links are central. Important issues for those concerned with the health of forest people include the degree to which health beliefs and practices are integrated with other parts of cultural systems; differing philosophies about health and health care; and the variety of approaches to health

and illness that exist in the world's forests. A concern to maintain human health requires attention to the interconnectedness of forest peoples, their cultures and the forests. When people's food, rituals, health care, shelter and economic and political systems have always been intertwined with the forest, the loss of the forest has negative implications not only for their socio-economic status, but also for their mental health.

On a more global scale, protection of cultural diversity can serve as insurance against overdominance of western cultural models – which have often been characterized as stress-ridden and unhealthy, both physically and mentally (see O'Brien, this issue). Indigenous knowledge about foods and medicines can be assessed for its possible value to other cultures. It can also contribute to the self-confidence of forest peoples, with positive implications for mental health.

Development projects have often had adverse as well as beneficial effects on people's health, for example by reducing subsistence access to forest lands and foods and bringing indigenous people into contact with new diseases and cultures. For example, increases in leishmaniasis have been linked with deforestation, migration and agricultural development in the regions of the Amazon and the Nile (Patz *et al.*, 2000); a dramatic increase in schistosomiasis was observed in Ghana immediately following the construction of 164 dams (Hunter, 2003); HIV and AIDS exposure increased along the Nigerian highway system (Orubuloye, Caldwell and Caldwell, 1993); and worrying levels of mercury were reported in children living near a gold mining area in the Philippines (Akagi *et al.*, 2000). Nutritional status in East Kalimantan, Indonesia has repeatedly declined when "development" has arrived (Colfer, 1981; Dounias and Froment, this issue). Exposure to alien cultures has sometimes brought social problems such as prostitution, alcoholism, stress and dietary

disorders (e.g. Natshara and Ohsuka, 1999; Gracey, 2000).

CONCLUSIONS AND WAYS FORWARD

The CIFOR review produced many specific recommendations for those on the ground: health professionals, foresters, development personnel, natural resource managers, administrators, industry (especially logging, pharmaceuticals, mining) and civil society (Colfer, Sheil and Kishi, 2006). Broader conclusions are given here.

What specifically has been learned about the two issues addressed – the state of people's health in and around forests, and the causal links between forests and human health? Looking at the condition of people's health in and around forests, there are some notable examples of increased health threats such as Ebola from forests. But tropical forests also provide essential foods, medicines, health care and mental health benefits to people all over the world. The amount of these benefits generally increases with proximity to the forest. However, forest communities, and those adjacent to forests, are not high on the agenda of most governmental health care institutions, often because the populations involved are small and the logistics of serving them are formidable. Although there is some evidence that some of the most forest-dependent people (hunter-gatherers) may have better health than other rural peoples (e.g. Melnyk, 1995; Santos and Coimbra, 1996; Koppert *et al.*, 1993), many people in and around forests suffer from a variety of debilitating and fatal ailments, including many of the same ones that beset non-forest dwellers in developing countries. There is also significant evidence that, in many cases, activities intended to promote economic development, such as construction of dams, roads and mines and other activities which may lead to deforestation, have worsened the health of those living near forests.

Although technical understanding of pathology, nutrition, pharmacology and epidemiology is crucial to making the links more positive and must be encouraged, it is not enough. There is a pressing need to fashion innovative solutions to the health care needs of forest people. Experience with adaptive collaborative management with communities (e.g. Colfer, 2005) suggests that the most direct and cost-effective way to do this is to use participatory, interdisciplinary approaches. In communities around the world, people have been ready and willing to work with CIFOR on health issues – for example, on medicinal plants in the Philippines (Hartanto *et al.*, 2003), Indonesia and Brazil (Shanley and Luz, 2003) and on monitoring of health status in various contexts (Dounias *et al.*, 2004); but so far funding has been insufficient to implement these ideas fully.

Participatory approaches make it possible to build on the biological and cultural diversity of forests and forest peoples. They allow the world to make benign and appropriately compensated use of local people's indigenous knowledge and natural resources and take into account the logistical problems of formal health care delivery systems, which cannot supply trained medical doctors and public health personnel to every village. The wider underlying goal must be a more equitable global system in which forest dwellers do not pay the costs of supporting the lifestyles of the better off.

Regarding the impacts of these links, effects of forest loss on the health of people living in and around forests vary but are often negative. Nutritional status has often declined with the arrival of "development"; new diseases have arrived and old ones have become more virulent; exposure to alien cultures has sometimes brought social problems such as alcoholism and stress. Diseases originating in forests can spread to neighbouring habitats and even around the world. The diversity of forest types,

wildlife, disease vectors, human populations and cultures, and interactions among these factors, all affect human health. It has been projected that as the climate changes, disease incidence in forested areas and elsewhere may increase (Chivian, 1997; Patz and Wolfe, 2002).

There has been little explicit analysis of the effects of human health or ill health on forests, beyond an occasional reference to the spread of human disease to forest animals. AIDS has caused a reduction in trained forest managers in parts of Africa, with probable negative consequences for forests. And forest degradation can in some cases be traced back to high population growth, which is part of a complex set of interrelated factors that are likely to include women's low status, social inequity, high infant and child mortality, low nutritional status, high disease loads and general poor health.

The CIFOR review showed that there is a significant, if dispersed, body of knowledge on this topic for use by foresters and others. However, communication of this knowledge needs to be strengthened:

- between researchers, practitioners and policy-makers on the one hand and local communities (or segments thereof) on the other, since the complexity of health/forest interactions means that no single external party is likely to be able to make appropriate plans for any given locale without the direct involvement of the people who live there;
- among disciplines, since forests, cultures and diseases all represent complex systems requiring diverse expertise;
- between researchers and policy-makers, so that research findings can be more quickly available and more effectively used.

The most fundamental conclusion, for those concerned with improving human health and forest management, is the need for various groups to work

together better. Foresters, health professionals and communities need to work together in identifying opportunities and addressing problems; but they also need the help of government agencies whose policies and procedures have an impact on forest peoples' lives. One impediment to progress has been the general view that the concerns expressed in this review were someone else's problem. All groups with activities, responsibilities and resources in forested areas are urged to take on the difficult but important challenges of promoting good health in forest areas. ♦



Bibliography

- Achieng, J.** 1999. *African medicinal tree threatened with extinction*. Third World Network. Internet document. Available at: www.twinside.org.sg/title/1903-cn.htm
- Akagi, H., Castillo, E.S., Cortes-Maramba, N., Francisco-Rivera, A.T. & Timbang, T.D.** 2000. Health assessment for mercury exposure among schoolchildren residing near a gold processing and refining plant in Apokon, Tagum, Davao del Norte, Philippines. *The Science of the Total Environment*, 259(1-3): 31-43.
- Anyinam, C.** 1995. Ecology and ethno-medicine: exploring links between current environmental crisis and indigenous medical practices. *Social Science and Medicine*, 40(3): 321-329.
- Anyonge, C.H.** 2004. HIV/AIDS and national forest programmes. *ETFRN News*, 41/42: 40-42. Available at: www.etfrn.org/ETFRN/newsletter/news4142/index.html
- Bennett, E.L. & Robinson, J.G.** 2000. *Hunting of wildlife in tropical forests: implications for biodiversity and forest peoples*. Washington, DC, USA, World Bank.
- Bennett, E.L., Robinson, E.S. & Eves, H.** 2002. The scale of hunting and wild meat trade in tropical forests today. Presented at the Society for Conservation Biology Symposium on Mitigating Unsustainable Hunting and the Bushmeat Trade in Tropical Forest Countries: Using Science to Change Practices, Canterbury, UK, 18 July.
- Chivian, E.** 1997. Global environmental degradation and biodiversity loss: implications for human health. In F. Grifo & J. Rosenthal, eds. *Biodiversity and human health*, pp. 7-38. Washington, DC, USA, Island Press.
- Colfer, C.J.P.** 1981. Home gardening... not so easy. *Agenda*, 4(8): 8-11.
- Colfer, C.J.P.** 2005. *The complex forest: community, uncertainty and adaptive collaborative management*. Washington, DC, USA, Resources for the Future/CIFOR.
- Colfer, C.J.P., Sheil, D. & Kishi, M.** 2006. *Forests and human health: assessing the evidence*. CIFOR Occasional Paper No. 45. Bogor, Indonesia, CIFOR. Available at: www.cifor.cgiar.org/scripts/news/scripts/publications/detail.asp?pid=2037
- Cunningham, A.B.** 1993. *African medicinal plants: setting priorities at the interface between conservation and primary healthcare*. People and Plants Working Paper No. 1. Paris, France, United Nations Educational, Scientific and Cultural Organization (UNESCO).
- Dounias, E., Kishi, M., Selzner, A., Kuniawan, I. & Levang, P.** 2004. No longer nomadic: changing Punan Tubu lifestyle requires new health strategies. *Cultural Survival Quarterly*, 28(2): 1-6. Available at: www.cifor.cgiar.org/publications/pdf_files/research/forests_health/21.pdf
- Engelman, R.** 1998. *Plan and conserve: a source book on linking population and environmental services in communities*. Washington, DC, USA, Population Action International. Available at: www.populationaction.org/resources/publications/archive.htm
- Gardner-Outlaw, T. & Engelman, R.** 1999. *Forest futures: population, consumption and wood resources*. Washington, DC, USA, Population Action International. Available at: www.populationaction.org/resources/publications/archive.htm
- Gracey, M.** 2000. Historical, cultural,

- political, and social influences on dietary patterns and nutrition in Australian Aboriginal children. *American Journal of Clinical Nutrition*, 72(5): 1361S–1367S.
- Hartanto, H., Lorenzo, C., Valmores, C., Arda-Minas, L. & Burton, E.M.** 2003. *Adaptive collaborative management: enhancing community forestry in the Philippines*. Bogor, Indonesia, CIFOR.
- Hunter, J.M.** 2003. Inherited burden of disease: agricultural dams and the persistence of bloody urine (*Schistosomiasis hematobium* [sic]) in the Upper East Region of Ghana, 1959–1997. *Social Science and Medicine*, 56(2): 219–234.
- Jayachandran, S.** 2005. *Air quality and infant mortality during Indonesia's massive wildfires in 1997*. Bureau for Research in Economic Analysis of Development (BREAD) Working Paper No. 95. Cambridge, Massachusetts, USA, BREAD. Available at: www.cid.harvard.edu/bread/papers/working/095.pdf
- Kate, K.T. & Laird, S.A.** 1999. *The commercial use of biodiversity: access to genetic resources and benefit sharing*. London, Earthscan.
- Koppert, G.J.A., Dounias, E., Froment, A. & Pasquet, P.** 1993. Food consumption in three forest populations of the southern coastal area of Cameroon: Yassa, Mvae, Bakola. In C.M. Hladik, A. Hladik, O.F. Linares & H. Pagezy, eds. *Tropical forests, people and food: biocultural interactions and applications to development*, pp. 295–310. Paris, France, UNESCO/Parthenon Publishing Group.
- Lengkeek, A.** 2005. Trees on farm to mitigate the effects of HIV/AIDS in SSA. *The Overstory*, 152: 1–7.
- Melnyk, M.A.** 1995. *The contributions of forest foods to the livelihoods of the Huottuja (Piaroa) people of southern Venezuela*. London, UK, University of London, Centre for Environmental Technology.
- Natsuhara, K. & Ohtsuka, R.** 1999. Nutritional ecology of a modernizing rural community in Papua New Guinea: an assessment from urinalysis. *Man and Culture in Oceania*, 15: 91–111.
- Orubuloye, I.O., Caldwell, J.C. & Caldwell, P.** 1993. The role of high-risk occupation in the spread of AIDS: truck drivers and itinerant market women in Nigeria. *International Family Planning Perspectives*, 19(2): 43–48, 71.
- Patz, J.A., Graczyk, T.K., Geller, N. & Vittor, A.Y.** 2000. Effects of environmental change on emerging parasitic diseases. *International Journal for Parasitology*, 30: 1395–1405.
- Patz, J.A. & Wolfe, N.D.** 2002. Global ecological change and human health. In A. A. Aguirre, R. S. Ostfeld, G. M. Tabor, C. House & M. C. Pearl, eds. *Conservation Medicine*, pp. 167–181. Oxford, UK, Oxford University Press.
- Santos, R.V. & Coimbra, C.E.A.** 1996. Socioeconomic differentiation and body morphology in the Surui of southwestern Amazon. *Current Anthropology*, 37(5): 851–856.
- Shankar, D. & Majumdar, B.** 1997. Beyond the biodiversity convention: the challenges facing the bio-cultural heritage of India's medicinal plants. In G. Bodeker, K.S.S. Bhat, J. Burley & P. Vantomme, eds. *Medicinal plants for forest conservation and health care*, pp. 87–99. Rome, FAO.
- Shanley, P. & Luz, L.** 2003. The impacts of forest degradation on medicinal plant use and implications for health care in eastern Amazonia. *BioScience*, 53(6): 573–584.
- Walsh, J.F., Molyneux, D.H. & Birley, M.H.** 1993. Deforestation: effects on vector-borne disease. *Parasitology*, 106: S55–S75.
- Wilkie, D.S.** 2001. Bushmeat hunting in the Congo Basin—a brief review. In M. I. Bakarr, G.A.B. da Fonseca, R.A. Mittermeier, A.B. Rylands & K.W. Painemilla, eds. *Hunting and bushmeat utilization in the African rain forest*. Washington, DC, USA, Conservation International. ♦