

Health, Habitats and Medicinal Plant Use

Anthony B. Cunningham, Patricia Shanley and Sarah Laird

Medicinal plants are the roots of medical practice. Of the 12,807 species used in traditional Chinese medicine, for example, 11,146 are plant species (Zhao, 2004). Medicinal plant uses range from anti-microbial 'chewing sticks' for dental care and the treatment of internal parasites to symbolic uses. In fact, of the global total of 422,000 flowering plant species, more than 50,000 are used for medicinal purposes, with an estimated 2500 species of medicinal and aromatic plants traded worldwide, most still collected from wild sources (Schippmann et al, 2003).

Across all cultures, for most of human history, all doctors effectively were botanists, using medicinal plants as the primary source of medicines to treat disease. In Europe and North America, however, commercial pharmaceutical production since the 1950s, a medical 'effectiveness revolution' (Stevens and Milne, 1997) and randomized clinical trials have altered attitudes towards the botanical roots of medicine. Nevertheless, public health-care programmes involving traditional medicines and traditional healers have been implemented in many parts of the world (see Chapter 14, this volume). In China and Vietnam, for example, a long, well-documented history of medicine linked with significant policy support has resulted in public health programmes that use herbal treatments for many common illnesses (Wahlberg, 2006). These programmes often include collaborations with local universities and research institutes, which study and sometimes standardize traditional medicines (Balick et al, 1996). In Nigeria, collaborations between local universities, NGOs, traditional healers' associations and government have helped create the scientific and legal foundation for broader dissemination of traditional medicine as part of primary health care (Iwu and Laird, 1998). In the Caribbean, a programme called TRAMIL (Traditional Medicine in the Islands) has focused on medicinal plants used in households, promoting the safest and most significant species for primary health care (Lagos-Witte et al, 1997). In Brazil, primary health-care programmes are being developed using traditional medicines to meet the needs of communities that lack basic pharmaceutical medicines (Silva et al, 2005), and in the Peruvian Amazon, a regional indigenous federation known as FENAMAD is addressing local health-care needs (Alexiades and Lacaze, 1996). The legal and ethical implications of researching and commercializing traditional knowledge associated with medicinal plants have received extensive attention in recent years from indigenous peoples' groups, researchers, NGOs, governments and others, including as part of the policy process growing from the Convention on Biological Diversity (e.g., Posey, 1999; ten Kate and Laird, 1999; Laird, 2002). But it is beyond the scope of this chapter to review these issues here.

36 HUMAN HEALTH AND FORESTS

This chapter focuses on links between health care and medicinal plants, dealing with both demand and supply for herbal medicines. In terms of demand, we ask the following questions: What roles do herbal medicines play in public health-care systems? Do plants and their habitats have a role in psychosocial health? What about toxicity and adverse reactions to herbal medicines? Why do urban populations around the world continue to seek out herbal medicines, even when they have access to pharmaceuticals? We then deal with supply factors: What types of medicinal plants are most widely used, and which habitats are favoured sources of medicinal plants? Why should we worry about continued access to forests for slow-growing and more threatened medicinal species if weeds are such an important source of medicinally active ingredients? What role is played by 'conservation through cultivation'? And finally, what policy changes are needed?

DEMAND FOR MEDICINAL PLANTS

Herbal medicine in public health-care systems

Worldwide, the skewed distribution of medical doctors is a weakness in public health care. Typically, high numbers of medical doctors practise in the large cities of developed countries; few are found in the rural areas of developing countries (Wibulpolprasert and Pengpaibon, 2003). The situation in many developing countries offers little ground for optimism. First, the ratio of medical doctors, psychologists, dentists and midwives to total population is extremely low. Second, many skilled, locally trained medical personnel emigrate to Europe, North America or Australia (Hagopian et al, 2004). In sub-Saharan Africa, emigration has reduced the number of formally trained health professionals below the threshold needed to achieve the health-related Millennium Development Goals (United Nations, 2006). In the 1980s, the ratio of physicians to total population was 1:10,000, compared with a ratio of 1:110 for traditional healers to population (Green, 1985). In 1996, based on data in Padarath et al (2004), the physician-to-population ratio in Swaziland had increased to 1:6600. Access to medical doctors is often much worse. In Ghana, for example, the physician–population ratio was 1:16,100, and just 1:24,390 in Tanzania. Access to dentists is even more limited, but midwife numbers are better. In the mid-1990s, dentist–population ratios in Tanzania and Ghana, respectively, were 1:143,000 and 1:500,000 for dentists and 1:2230 and 1:1900 for midwives (Padarath et al, 2004). Equally scarce are psychologists with cross-cultural skills. As a result, traditional medicines continue to be the main form of health care for an estimated 80 per cent of people in developing countries (WHO, 2002).

In many developing countries, traditional birth attendants and traditional healers form important links in the chain of health personnel providing primary health care. Despite the establishment of hospitals and health centres, it is to these traditional healers and birth attendants that the majority of people turn in times of sickness and childbirth. It is therefore important that due regard be paid to the activities of these traditional practitioners.

Across the world, diverse local health-care systems to treat parasitic diseases and diarrhoea and improve oral hygiene have developed over hundreds or thousands of years. For example, in the Riau area of Sumatra, Indonesia, of the 114 medicinal plant species

used (from 51 plant families), 50 per cent were used to treat fevers, 33 per cent diarrhoea, and 31 per cent other gastrointestinal problems (Grosvenor et al, 1995). These are common ailments across the tropics. Use of medicinal plants is also widespread in developed countries. In Australia, for example, 48 per cent of the population use 'complementary and alternative medicine', and in the USA, 42 per cent of the population use it (Eisenberg et al, 1998), with use levels increasing significantly over the past decade (Pagán and Pauly, 2005).

Traditional healers also fill an important gap in psychological health-care systems where there are few psychologists with cross-cultural skills. Determining the perceived root causes of misfortune or conflict within communities and guarding against them is a role for the diviner rather than the herbalist, with diviners using plant and animal species for their symbolic value. In Tanzania (Rwiza et al, 1993) and Ethiopia (Alem et al, 1999), mental ill-health is widely considered to have supernatural causes that are best treated by traditional healers. In their study of epilepsy among rural Tanzanian residents, for example, Rwiza et al (1993) found that 36.8 per cent of respondents believed epilepsy could not be cured, and 17.1 per cent believed it could not even be controlled. On the other hand, 45.3 per cent believed epilepsy could be treated by traditional healers, and only 50.8 per cent believed hospital drugs were of any use.

Traditional treatment for parasitic diseases

In Tanzania, Gessler et al (1995) showed that most traditional healers were very familiar with the signs and symptoms relating to malaria, as defined by Western medicine. Many healers were aware of different manifestations of malaria and called them by different names; the types corresponded to the scientific terms describing the different types of *Plasmodium falciparum* malaria, such as cerebral malaria, clinical malaria or febrile type, and the gastrointestinal type.

The use of herbal medicines to treat parasitic diseases illustrates their importance in public health both locally and internationally. In tropical developing countries, parasitic diseases affect hundreds of millions of people (Tagboto and Townson, 2001), yet access to synthetic drugs is often difficult because of cost or remoteness. Best known of all treatments for parasitic disease is quinine, from *Cinchona* bark (Honigsbaum, 2002; Lee, 2002), but many other species are used locally. In Bolivia, for example, a bark extract of *Ampelocera edentula* (Ulmaceae) is used by the Chimanes Indians to treat cutaneous leishmaniasis (Fournet et al, 1994). Plants with insect-repellent properties are used preventively. Although inferior to the common synthetic repellent DEET (N,N-diethyl-3-methylbenzamide), andiroba oil, from the seeds of *Carapa guianensis* (Meliaceae), is an effective, low-cost and locally available mosquito repellent (Miot et al, 2004), widely used in South America. In West Africa, smoke from *Daniellia olivieri* (Caesalpinaceae) bark was shown to be more effective in reducing the incidence of malaria than the use of mosquito nets (Palsson and Jaenson, 1999).

Parasites also affect people's lives indirectly, by infesting their livestock. In some cases, the same herbal medicine species are used to treat both livestock and people, such as bark from the aptly named *Albizia anthelmintica*, which is effective against nematode parasites, such as *Haemonchus* and *Heligmosomoides*. Some parasitic diseases can also be controlled

38 HUMAN HEALTH AND FORESTS

through their hosts. In parts of the tropics where bilharzia parasites are common, there is considerable interest in herbal molluscides for controlling the snails that are the hosts for this parasitic disease: for example, preparations from *Phytolacca dodecandra*, *Warburgia salutaris* (Appleton et al, 1992), *Lawsonia inermis* (Singh and Singh, 2001) and *Azadirachta indica* (Osuala and Okwuosa, 1993).

Dentists are scarce in many parts of Africa, particularly in rural areas. Although diet plays a major role in the incidence of dental caries, the practice of dental hygiene is also important. Toothpaste use is low and chewing sticks are still in common use in many parts of Africa, particularly West Africa. In Nigeria, for example, most suburban children (72.5 per cent) used toothbrushes and toothpaste to clean their teeth, whereas in rural areas, 49.8 per cent used chewing sticks (Otuyemi et al, 1994), mostly from forest trees, with *Garcinia* species particularly favoured (Figure 3.1). In other areas, even if people prefer toothbrushes, high cost or remoteness prevents access to toothpaste and modern brushes (Figure 3.1).

Herbal medicines and health-seeking behaviour

Reasons for the use of traditional and alternative medicine include the perceived efficacy of traditional systems, the high cost of allopathic medical care, and cultural beliefs, as well as the lack of available medical doctors. The holistic, philosophical character of many medical systems strongly influences people's health-seeking behaviour, even when Western medicines are available. Good examples include the continued use of Chinese, South Asian (Ayurvedic and Unani), Thai, Tibetan and Vietnamese medical systems as well as diverse healing practices in Africa and Latin America. The continued importance of traditional medicine to the estimated 1.24 billion people in China is a well-known example, with herbal preparations accounting for 30–50 per cent of total medicinal consumption in China (WHO, 1996). Traditional medicine takes a holistic approach where disease or misfortune results from an imbalance between the individual and the social environment, whereas modern biomedicine takes a technical and analytical approach. This is also a reason behind the often-uneasy relationship between traditional and modern medicine. Both rural and urban patients commonly consult traditional healers before, after or simultaneously with consultation with medical doctors, often switching between different medical systems according to the ailment. In Guinea, West Africa, for example, 33 per cent of 397 diabetes patients surveyed used herbal medicine, motivated by factors that we suggest are also common in other countries: belief in the efficacy of herbal medicines (74 per cent), ease of access to medicinal plants (70 per cent), lower cost (48 per cent) and search for a complete cure (37 per cent). Hearing that others have had positive experiences using herbal medicines was a major factor, persuading 78 per cent of the respondents to use medicinal plants; 85 per cent of the users were satisfied with the results (Balde et al, 2006).

Medicinal plants and psychosocial health

Although this chapter concentrates on medicinal plant species used to treat topical diseases, two additional links to health are important: first, the wider cultural and psychosocial

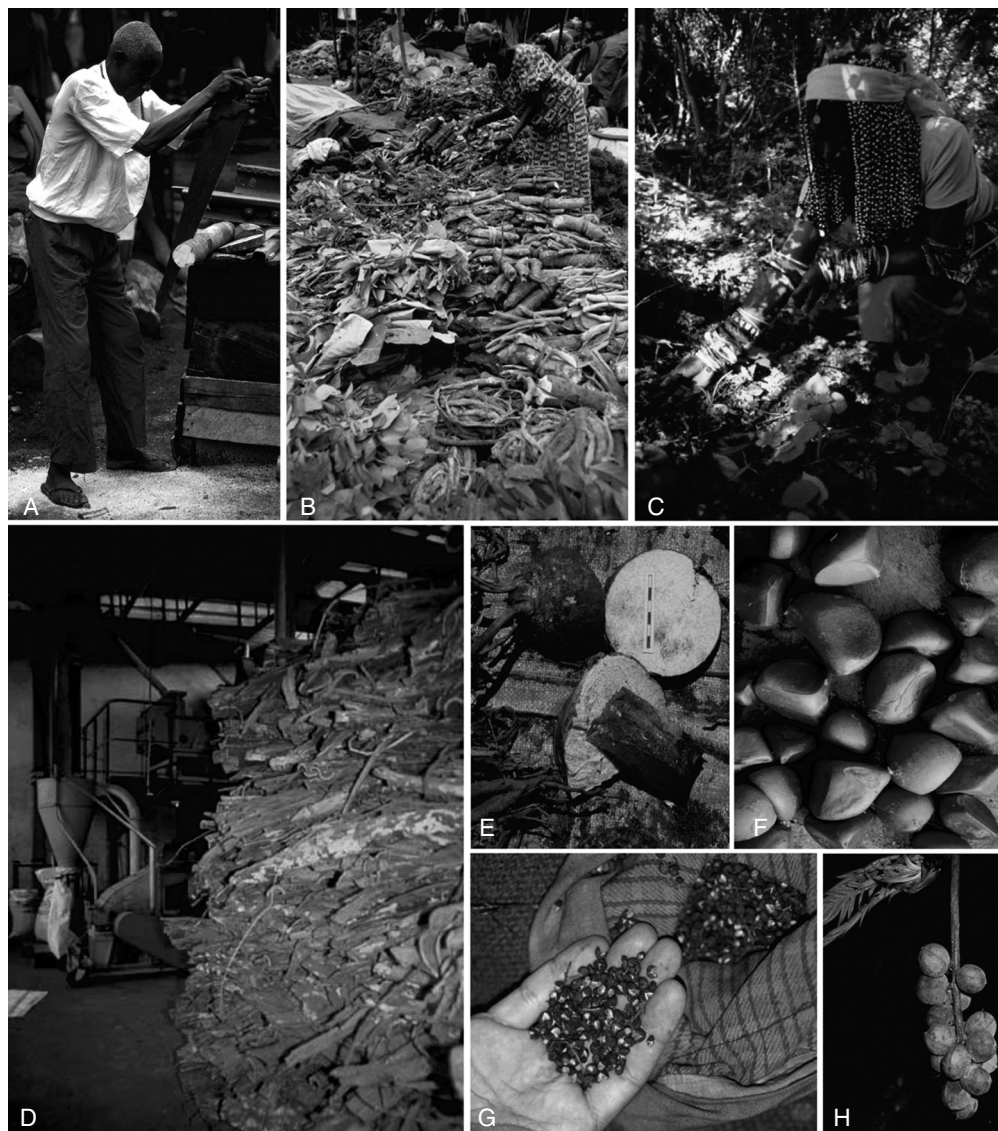


Figure 3.1 *Medicinal plants in trade*

a) Trunks of the forest tree *Garcinia* being sawn for processing into chewing sticks at a market occupied by 400 chewing-stick traders in Accra, Ghana. b) Traditional medicines, many of them from forest species, for sale at Bouake market, Côte d'Ivoire. c) *Plectranthus grillatus* being harvested by a Zulu diviner (*isangoma*), for whom forests play a crucial role as a source of 'wild power'. d) Yohimbe bark (*Pausinystalia johimbe*) being processed at a factory in Cameroon for export to Europe as an aphrodisiac. e) *Stangeria eriopus*, a 'living forest fossil' and the only living representative of its family (Stangeriaceae), highly threatened by the traditional medicines trade. f) Seeds from *Carapa* trees, the source of medicinal oil in both South America and tropical Africa. g) Seeds of 'Sichuan pepper', from *Zathoxylum yunnanensis*, a medicinal spice harvested from agroforestry systems and from wild populations. h) Seeds from *Hagenia abyssinica*, a montane forest tree, locally called *kosso* and used for their anti-parasitic activity; this is the top-selling medicinal in Ethiopian markets.

40 HUMAN HEALTH AND FORESTS

meaning of habitats and landscapes, and second, the symbolic and religious role of plants in psychosocial health.

Forests have complex cultural meanings that are directly linked to the wellbeing, culture and belief systems of forest peoples (Reichel-Dolmatoff, 1996; Posey, 1999). Forests can also be viewed as therapeutic landscapes, as in Japan, where *shinrin-yoku* (walking or staying in forests to promote health) is a major form of relaxation (Shirakawa, 2006). Similarly, in the 19th century, many urban parks and protected forests were established in industrializing countries because of the belief that trees and nature promoted a sense of tranquillity (Melnyk, 2001).

Plants are also used symbolically and for religious and cultural purposes, all of which are connected to psychosocial health. Worldwide, aromatic plants, many of them weedy species, are used to ward off misfortune. In Zulu and Xhosa homes in southern Africa, the plaited stems, leaves and flowers of *Helichrysum odoratissimum* (Asteraceae), known as *imphepho* (a word also used for incense burned in Christian churches), are widely burned as incense to honour ancestor spirits. Plants with red, black or white attributes – such as red or white sap or black fruits – are used symbolically because of the widespread importance of the colour triad red, white and black (see Jacobson-Widding, 1979).

Ritual use of psychoactive plants has been recently reviewed by Shepard (2005) and is summarized in Table 3.1. Here, it is sufficient to say that several species play pivotal cultural roles and can truly be considered ‘cultural keystone species’ (Garibaldi and Turner, 2004). They also have contemporary significance. In the western Pacific, kava (*Piper methysticum*) is a crucial component of community meetings. In South and Southeast Asia, betel (*Areca catechu*) ‘nuts’ are not only widely chewed, but, like kava, are also offered to ancestor spirits.

The most potent psychotropic plants are from forests in tropical Africa (*Tabernanthe iboga*), Mesoamerica (*Salvia divinorum*) and tropical South America (*Banisteriopsis caapi*, *Psychotria viridis*, *Brugmansia aurea* and *Virola*) (Table 3.1). Most widespread is the use of psychoactive infusions from a mix of the forest vine *Banisteriopsis caapi* (Malthigiaceae) with leaves from *Psychotria viridis* (Rubiaceae), commonly known as *ayahuasca*. The leaves are used as a religious sacrament in many Amerindian societies (Schultes and Raffauf, 1992) as well as by two syncretic religious groups, Santo Daime and União do Vegetal (which blend *ayahuasca* use with elements of Christianity) and the Afro-Brazilian church, Barquinha. Neither *ayahuasca* nor *Tabernanthe iboga* is a recreational drug. Instead, these are potent, purgative, psychoactive plants that cause profound insights, introspection and value change. Finding a spiritual turning point in life can play an important role in psychosocial health (Fiori et al, 2004), including people whose lives have been affected by addiction and substance abuse. In ceremonial context, potent psychoactive plants catalyse spiritual experience and behavioural change. Grob et al (1996) found that regular ceremonial *ayahuasca* use had helped União do Vegetal adherents overcome alcoholism and drug addiction. Similarly, ibogaine from *Tabernanthe iboga* root bark is effective in the treatment of heroin, cocaine and amphetamine addiction, a use that may be increasingly important in the future (Mash et al, 1998). In a global context, in line with the widespread Amerindian belief that *ayahuasca* communicates with people who have taken this sacrament, McKenna (2005) suggests that *ayahuasca* has an urgent message for all of us in terms of health and biodiversity links: the need to avoid global ecological catastrophe.

Table 3.1 *Leading psychoactive plant species in Africa, Latin America and Asia*

Scientific name, family	Common name	Life form, habitat and country	Part used traditionally	Source	Uses and trade
<i>Areca catechu</i> , Arecaceae	Betel nut	Palm, moist forest, South and SE Asia	Fruit, with admixture of lime and <i>Piper</i> <i>betel</i> leaves	Cultivated in agroforestry systems	Ritual and recreational use, widely traded
<i>Banisteriopsis</i> <i>caapi</i> , Malphiaceae	Ayahuasca, daime, hoasca, yage	Vine, tropical moist forest, South America	Stem, with admixture from <i>Psychotria</i> <i>viridis</i> or <i>Diplopterys</i> <i>cabrerana</i> .	Cultivated in home gardens and managed forests	Ritual, small-scale trade
<i>Boophae disticha</i> , Amaryllidaceae	Incotho	Geophyte, coastal renosterveld and montane grasslands, southern Africa	Corn	Wild harvest and cultivated by healers in home gardens	Divination and interpretation of dreams
<i>Cannabis sativa</i> , Cannabaceae	Cannabis	Shrub, disturbed areas, Himalaya	Seeds, resin	Widely cultivated	Recreational drug, fibre and pickled seeds as vegetable
<i>Catha edulis</i> , Celastraceae	Khat, qat, miraa	Tree, forest margins, Africa and Arabian peninsula	Leaves	Cultivated in agroforestry systems	Prevents fatigue, widely traded
<i>Duboisia hopwoodii</i> , <i>D. leichardtii</i> and <i>Nicotiana</i> <i>species</i> Solanaceae	Pituri	Shrub, desert, Australia	Resin, with <i>Acacia</i> ash admixture	Wild, but hybrid cultivated for commercial scopolamine production	Ritual (e.g. male puberty), widely traded
<i>Ephedra species</i> (<i>E. sinica</i> , <i>E. gerrardiana</i>), Ephedraceae	Ephedra	Shrub, semi-arid steppe and arid Himalaya	Stems	Wild harvest for international commercial trade	Harvested commercially (Pakistan, China). Colds, fatigue, high-altitude sickness
<i>Erythroxylum coca</i> , Erythroxylaceae	Coca	Shrub, Andean highlands, South America	Powdered or fresh leaves, with <i>Cecropia</i> leaf ash admixture	Cultivated, including in the Amazon	Prevents fatigue and high-altitude sickness. Illegal trade in processed form (cocaine)
<i>Mitragyna speciosa</i> , Rubiaceae	Kratom	Tree, moist tropical forest, SE Asia	Leaves	Wild harvest and home gardens	Prevents fatigue, treatment of morphine addiction
<i>Piper methysticum</i> , Piperaceae	Kava	Shrub, moist forest and agroforestry systems, western Pacific	Root	Cultivated, many varieties	Ceremonial and recreational use, widely traded
<i>Salvia divinorum</i> , Labiatae	Diviner's sage	Perennial herb, cloud forest, Mexico	Leaves	Cultivated, home gardens	Ritual use by Mazatec Indians, Mexico. Small- scale trade.
<i>Sceletium tortuosum</i> , Mesembryan- themaceae	Kanna, kougoed	Succulent, semi- desert, South Africa	Leaves	Wild harvest	Small-scale trade
<i>Synaptolepis kirkii</i> , Thymeleaceae	Uvuma- omhlophe	Scandent climber, dry coastal forest, southern Africa	Lignotuber	Wild harvest	Commercial trade in South Africa
<i>Virola species</i> , especially <i>V. theiodora</i> , Myristicaceae		Tree, moist tropical forest, South America	Resin from bark, with <i>Justicia pectoralis</i> leaves	Managed forests	Local use and barter

Note: Many of these plants are highly toxic and their mention here does not mean we advocate their use.

Sources: Kalix (1991), Schultes and Raffauf (1992), Smith et al (1996), unpublished data and Callaway et al (1999), de Rios and Stachalek (1999), Prisinzano (2005) and de Feo (2005)

Risks associated with herbal medicines

Herbal medicines have natural origins, but natural does not mean non-toxic. Like pharmaceutical drugs, herbal medicines need to be harvested, stored, prepared and prescribed with attention to safety, quality and efficacy. In rural areas where healthy stocks of favoured species remain, healers are able to harvest quality products locally. Safety, quality and efficacy are more difficult to achieve in urban areas, or where rural healers have to buy favoured species from traders. In Nigeria, for example, all herbal medicines tested contained heavy metals (Obi et al, 2006). A similar problem was found with Asian herbal medicines, which contained arsenic, lead and mercury at levels ranging from toxic (49 per cent) to levels higher than public health guidelines (74 per cent) (Garvey et al, 2001). High price and scarcity due to rarity or over-harvest pose additional problems, since substitution with similar-looking species with different properties becomes common.

In a recent literature review, Yang et al (2006) identified 32 pharmaceutical drugs that interacted with herbal medicines, primarily anti-coagulants, sedatives and anti-depressants, oral contraceptives, anti-HIV agents, cardiovascular drugs, immunosuppressants and anti-cancer drugs. Preventing these adverse reactions is important. Until South Africa's recent policy changes on supplying anti-retrovirals to HIV-positive people, use of herbal medicines such as *Hypoxis* and *Sutherlandia* were being promoted. The recent study by Mills et al (2005) showed that the use of these African herbal medicines might put patients at risk for drug toxicity, treatment failure or viral resistance.

Adverse reactions are not restricted to herbal medicines; they also occur with pharmaceuticals. In 1995, for example, the US Food and Drug Administration's surveillance system MedWatch recorded 6894 fatalities due to adverse drug reactions (Chyka, 2000). In France, a study of more than 300 'adverse drug events' by Queneau et al (2007) showed that 410 types of synthetic drugs were involved, most commonly psychotropic agents (20.5 per cent), diuretics (11.7 per cent), analgesics (13.9 per cent) and anti-coagulants (9.3 per cent) or other cardiovascular drugs (15.4 per cent). Strategies to avoid adverse reactions to herbal medicines can be developed, just as they can for pharmaceuticals. This includes understanding not only which pharmaceuticals interact with which herbal medicines, but also what drives demand for traditional medicines.

Urbanization, epidemiology and cultural preferences

In the past, sustainable harvest of medicinal plants was facilitated by several inadvertent or indirect controls and some intentional management practices. Taboos, seasonal and social restrictions on gathering medicinal plants, and the technology of harvesting equipment all served to limit medicinal plant harvesting. Before metal machetes and axes were widely available, plants were collected with a pointed wooden digging-stick or small axe, which limited the quantity of bark or roots gathered. Pressure on medicinal plant resources continues to remain low in remote areas without road access. In rural areas, medicinal plant use involves self-medication or traditional healers. In urban areas, however, the herbal medicines trade involves self-employed commercial harvesters and formal-sector traders who supply the large demand. As a result, herbal medicine trade is a booming business.

Rapid urbanization characterized the 20th century. In 1900, just 13 per cent (220 million people) of the world's population was urban, growing to 29 per cent in 1950, 49 per cent in 2005 and projected to reach 60 per cent (or 4.9 billion people) in 2030 (United Nations, 2006). Urbanization will be particularly rapid in developing countries and, combined with cultural preferences in health care, will continue to drive commercial trade in medicinal plants. It has not only changed patterns of where and how medicinal plants are sourced, but has also increased the incidence of lifestyle diseases, such as diabetes and hypertension, which in developing countries are often treated with herbal medicines. In South Asia, for example, the incidence of Type 2 diabetes, commonly treated with *Momordica charantia* (Curcubitaceae) (Saxena and Vikram, 2004) was higher in urban (11.6 per cent) than rural (2.4 per cent) populations (Ramachandran et al, 1999). In South Africa, a study of baTswana urban migrants similarly showed how hypertension increased because of factors associated with urbanization (van Rooyen et al, 2000). The epidemiology of insect-borne disease is also creating demand for herbal medicines. Belém, Brazil, where *Carapa guineensis* (andiroba) oil is used to prevent mosquito bites (Shanley and Luz, 2003), has seen an increase in malaria since the 1970s and the reappearance of *Anopheles darlingi* in the mid-1990s, thought to have been eradicated in 1968, probably because the city expanded into surrounding forest (Póvoa et al, 2003).

Urban markets create easy access to medicinal plants for city-dwellers, with cultural association coupled to commercial marketing fuelling demand (Figure 3.2). In addition, some native medicinal plants are considered powerful and effective in treating common and chronic diseases (Table 3.2) and have been widely commoditized. In India,

... market capitalism has shaped, constrained and transformed Indian traditional medicine over the last 25 years. ... nowadays approximately 90 per cent of the Ayurvedic and Unani formulas are over-the-counter brands that are marketed to urban middle-class consumers. The rise in the last decade of the 20th century of a relatively affluent urban consumer class of about 100 million people explains the proliferation of relatively expensive Ayurvedic and Unani brands. Because of their propagation in the public media, commoditized medicines increasingly determine image and substance of Ayurveda and Unani Tibb, India's largest medical traditions. For many Indians both forms of Indian medicine are no longer the tailor-made formulas made by humoral experts, the cheap alternatives of the poor and the medical betel nuts sold on city pavements, but modern looking medicines attractively packed and sold as remedies against common ailments, degenerative and chronic diseases and as important assets in fighting the stress of modern city life. (Bode, 2006)

A similar situation has developed in China, with many of the same high-altitude genera or species harvested from the Himalayas for trade to India, which like China is a major exporter and consumer of medicinal plants. Nepal exports between 7000 and 27,000 tonnes of medicinal plants a year, most of them to India, worth US\$7 million to 30 million per year (Olsen, 2005). At a global scale, China is the largest exporter of medicinal and aromatic plants, mainly to Hong Kong (140,500 tonnes), and is also a significant importer

44 HUMAN HEALTH AND FORESTS

Table 3.2 *The habitats, uses and main sources of the leading indigenous medicinal plant species in Latin America (eastern Brazil (moist forest), northeastern Brazil (caatinga)), North America (USA), Asia (China, Nepal) and Africa (South Africa, Ethiopia)*

<i>Scientific name, family</i>	<i>Common name</i>	<i>Life form, habitat and country</i>	<i>Part used</i>	<i>Source</i>	<i>Uses</i>
<i>Alepidea amatymbica</i> , Apiaceae	Ikhathazo	Perennial herb, montane grassland, South Africa	Rhizome	Wild	Coughs and colds
<i>Boweia volubilis</i> , Liliaceae	Igibisila	Perennial geophyte, montane grassland, South Africa	Bulb	Wild	Protective charm
<i>Carapa guianensis</i> , Meliaceae	Andiroba	Tree, moist forest, Brazil	Seed oil	Wild	Insect repellent, sprains, arthritis
<i>Copaifera reticulata</i> , Leguminosae	Copaíba	Tree, moist forest, Brazil	Oleoresin	Wild	Wounds, sore throat
<i>Echinacea angustifolia</i> , Compositae	Echinacea	Perennial herb, grasslands, USA	Root	Cultivated	Immuno-stimulant, wound healing
<i>Echinacea purpurea</i> , Compositae	Echinacea	Perennial herb, grasslands, USA	Root	Cultivated	Immuno-stimulant, wound healing
<i>Embelia schimperi</i> , Myrsinaceae		Scandent climber, forest margins, Ethiopia	Seeds	Wild	Anthelmintic
<i>Eucomis autumnalis</i> , Liliaceae	Umathunga	Perennial geophyte, montane grasslands, South Africa	Bulb	Wild	Enema preparation to cleanse colon
<i>Eucommia ulmoides</i> , Eucommiaceae	Duzhong	Tree, montane forests, western China	Bark	Cultivation, probably extinct in the wild	Dizziness due to hypertension
<i>Gastrodia elata</i> , Orchidaceae	Tianma	Perennial geophyte, southwest China	Tuber	Mainly from cultivation	Vertigo, dizziness, hypertension
<i>Ginkgo biloba</i> , Ginkgoaceae	Baiguo, ginkgo	Tree, temperate forest, China	Leaves, seeds	Cultivation	Cough, coronary heart disease, slows cognitive deterioration
<i>Hagenia abyssinica</i> , Rosaceae	Kosso	Tree, montane forest, Ethiopia	Seeds	Wild	Anthelmintic
<i>Himatanthus sucuuba</i> , Apocynaceae	Sucuúba	Tree, moist forest, Brazil	Bark/ exudate	Wild	Worms, herpes, uterine inflammation
<i>Hydrastis canadensis</i> , Ranunculaceae	Goldenseal	Perennial herb, deciduous temperate forest, Canada and USA	Root	Wild	Masks illicit drugs in urine, anti-diarrhoeal

Table 3.2 (cont'd)

Scientific name, family	Common name	Life form, habitat and country	Part used	Source	Uses
<i>Nardostachys jatamansi</i> , Valerianaceae	Jatamansi	Perennial herb, montane pastures, Himalaya	Roots	Wild	Stomach ache, anorexia, toothache, essential oils
<i>Panax ginseng</i> , Araliaceae	Ginseng	Perennial herb, temperate forest, China	Root	Wild and cultivated	Cognitive function, endurance enhancement, anorexia
<i>Panax quinquefolius</i> , Araliaceae	American ginseng	Perennial herb, temperate forest, USA and Canada	Root	Wild	Cognitive function, endurance enhancement
<i>Parachornia fasciculata</i> , Leguminosae	Ipê roxo	Tree, moist forest, Brazil	Exudate	Wild	Respiratory illness
<i>Picrorhiza scrophulariiflora</i> , Scrophulariaceae	Huhuaglian, kutki	Montane Himalaya	Rhizomes	Wild	Fever, dysentery, conjunctivitis
<i>Rheum palmatum</i> , Polygonaceae	Wild rhubarb, dahuang	Montane pastures, Himalaya	Rhizome and roots	Wild	Dysentery, constipation, intestinal bleeding
<i>Scilla natalensis</i> , Liliaceae	Inguduza	Perennial bulb, montane grasslands, South Africa	Bulb	Wild	Enema preparation to cleanse colon
<i>Serenoa repens</i> , Areaceae	Saw palmetto	Palm savanna, Florida, USA	Fruits	Wild	Benign prostatic hypertrophy
<i>Siphonochilus aethiopicus</i> , Zingiberaceae	Indungulo, wild ginger	Montane grasslands, South Africa	Rhizome	Wild	Coughs and colds, supernatural protection
<i>Stryphnodendron barbatima</i> , Leguminosae	Barbatimão	Tree, moist forest, Brazil	Bark	Wild	Haemorrhage, uterine and vaginal infections
<i>Tabebuia impetiginosa</i> , Bignoniaceae	Pau d'arco	Tree, moist forest, Brazil	Bark	Wild	Inflammations, ulcers, skin ailments
<i>Terminalia chebula</i> , Combretaceae	Chebula	Tree, <i>terai</i> woodlands, lowland South Asia	Fruits	Wild	Diarrhoea, uterine bleeding
<i>Warburgia salutaris</i> , Canellaceae	Isibaha, pepper bark	Tree, forest/savanna ecotones, South Africa	Bark	Wild	Coughs, colds and opportunistic candida infections due to HIV

46 HUMAN HEALTH AND FORESTS



Figure 3.2 *China: The world's biggest medicinal trade*

a) Massive demand for herbal medicines in China is apparent in the bustling marketplaces like Hehuachi market, in Chengdu, China, which has an annual trade turnover of 1.2 billion yuan (around US\$148 million) in more than 200,000 tonnes of traditional medicine per year. b) Market values have encouraged cultivation of 25 to 30 per cent of Chinese medicinal species, including *Ginkgo biloba* (for seeds and leaves). c) Over-harvesting of wild populations of forest species, such as *Eucommia ulmoides*, a monotypic species, has forced a shift to plantation production. d) For women in ethnic minorities, such as Yao people, providing herbal-based health care is an important cross-cultural niche for their skills. e) Some species cannot be cultivated, however, such as this parasitic species, *Cynomorium songaricum* (Cynomoriaceae), from Xinjiang, China. f) To enhance production of *Ammorium tsao-ko*, forest trees are felled to keep the canopy open, affecting montane forests of northern Vietnam and southwestern China. g) Medicinal fungi, often from forests, are also highly valued, such as *Ganoderma* (chizi), which are traded internationally.

(80,550 tonnes) (Lange, 1998). According to a report published by Hong Kong Trade Development Council, the global sales for Chinese medicines have grown 8 per cent a year since 1994. In 2002, the total global sales of traditional Chinese medicines were US\$23.2 billion (Phillip Securities Research, 2003). Sales may increase even faster with the formal, industrialized production and export of traditional preparations. In Asia, particularly China, India, Pakistan and Vietnam, government support for the development and modernization of traditional medical systems is likely to increase harvest levels from wild stocks. In India, where the Ayurvedic industry is worth an estimated US\$1 billion per year, 7500 factories produce thousands of Ayurvedic and Unani formulas (Bode, 2006). In China, clinical trials for traditional preparations are now frequent (e.g., Cao et al, 2005; Qiong et al, 2005; Taixiang et al, 2005), and there are plans to establish standards for these products and a competitive, modern industry in traditional Chinese medicine. In Africa and South America, production is less formalized and branding is less sophisticated, yet the scale of the trade is nevertheless large. In South Africa, for example, 1.5 million informal traders sell about 50,000 tonnes of medicinal plants annually in a region with an estimated 450,000 traditional healers (Mander, 2004).

What is urgently needed is closer attention to the resource base of herbal health-care systems, because wild populations of medicinal plants remain the main sources of supply. The growing demand from urban areas, especially for the most favoured medicinal species, has catalysed the trade, drawing in remote resources to towns and cities (see Figure 3.2 a–d).

SUPPLY OF MEDICINAL PLANTS

Threats to continued availability

Poor people tend to rely on environmental services and harvested products that provide 'green social security'. As a result, they are particularly vulnerable to environmental degradation (Cavendish, 1999). The resource base of the herbal medicines trade is being affected by multiple factors simultaneously, at different spatial and time scales. The most serious of these are habitat loss and fragmentation, global climate change, species-specific over-exploitation and invasive species. Global projections of plant diversity loss show that the largest losses of habitat and diversity will occur in tropical ecosystems (forest, woodland, savannah), accounting for a projected loss of 25,000 to 40,000 plant species by 2050 (van Vuuren et al, 2006). In the African and Indo-Malayan tropics, regions where herbal medicines are extensively used, the worst losses in biodiversity are projected to occur primarily through loss of habitat. In contrast, it is climate change that will drive species loss in tundra, boreal forests and cool conifer forest (van Vuuren et al, 2006). What also needs to be taken into account in these global predictions is species-specific over-harvesting in what appears to be intact habitat.

Worldwide, it is estimated that of 422,000 flowering plants, 12.5 per cent (52,000) are used medicinally, and 8 per cent (4160 species) of these are threatened (Schippmann et al, 2003). Major biological factors that influence vulnerability or resilience include life form,

48 HUMAN HEALTH AND FORESTS

age to reproductive maturity, productivity, density, resprouting potential and plant part harvested. In general, species that are most susceptible to over-harvesting are habitat-specific, slow-growing and destructively harvested for their roots, bark or whole plant (Peters, 1994; Cunningham, 2001). Many wild species supplying medicinal plant markets show declining availability (Cunningham, 1991; 1993; Shanley and Luz, 2003; Botha et al, 2004). In South and Central America as well as tropical Africa, numerous valuable trees are 'conflict-of-use' species: trees with both a timber and a non-timber use. Eight of the most valuable fruit and medicinal species used and traded in eastern Amazonia, for example, are extracted as timber (Shanley and Luz, 2003). In Amazonia, two long-lived, low-density medicinal tree species, *Hymenaea courbaril* and *Tabebuia impetiginosa*, are particularly affected. The medicinal bark of *Tabebuia impetiginosa*, locally and internationally used for internal inflammations, skin diseases and tumors, is now collected as a by-product from sawmills. In Central America, *Metroxylon balsamum*, which is a favoured medicinal bark, is also heavily logged, as is *Prunus africana*, logged from Afromontane forests of West and East Africa. Ecological studies of both species indicate poor capacity for regeneration after logging, with some scientists recommending that like mahogany, these species merit listing by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Such a policy change has already occurred for *Prunus africana*, with mixed results (Cunningham, 2005).

Of most concern in terms of conservation, phytochemistry and health care are species that are not only slow-growing and vulnerable to over-harvesting but also phylogenetically distinctive – that is, just one species is the only living representative of an entire plant family or an entire genus (Table 3.3). The conservation of such monotypic species is important, compared with large medicinal plant genera, such as *Astragalus* (1750 species) and *Euphorbia* (2000 species), where many species share similar active ingredients.

At the local level, communities in the eastern Amazon that have experienced exploitative logging no longer have access to valuable barks or the medicinal oils from *Carapa guianensis* and *Copaifera* species, which are cut for timber. Certification of the timber of threatened medicinal bark species, such as *Tabebuia impetiginosa* and *Hymenaea courbaril*, and lively sales to 'green' consumers in the USA and Europe signify a substantial lack of understanding and communication regarding the livelihood benefits of species (Shanley et al, 2006).

In general, most botanicals companies are largely unaware of the sources of their raw material, including the geographic origins, production systems, and the social and environmental impacts. Many gatherers are poorly paid for their labour. King et al (1999) report that harvesters receive between US\$0.30 and \$0.65 per kilogram for raw cat's claw (*Uncaria* spp) in Peru, while the price of bulk, unprocessed cat's claw in the USA is US\$11 per kilogram. In part this is due to the common practice of sourcing raw material as a bulk commodity, and the physical and cognitive distance between most companies and their sources (Pierce and Laird, 2003; Laird et al, 2005).

At the same time, medicinal plants feed large international markets for botanical medicine, nutraceuticals, and personal care and cosmetic products, which are part of a larger 'supplement' market valued at more than US\$50 billion annually (*Nutrition Business Journal*, 2003). Medicinal plants and other natural products, like micro-organisms, insects and marine organisms, are also the basis of many of our pharmaceutical drugs (Farnsworth et al, 1985; Grifo et al, 1997; Laird and ten Kate, 2002; Newman et al, 2003; Cragg et al, 2005).

Table 3.3 *Examples of commercial medicinal plants with high conservation values*

<i>Phylogenetic distinctiveness, family</i>	<i>Scientific name</i>	<i>Common name, life form, part used, main use</i>	<i>Geographic region and comments on conservation status</i>
<i>MONOTYPIC FAMILIES</i>			
Eucommiaceae	<i>Eucommia ulmoides</i>	<i>Duzhong</i> , tree, bark, hypertension	China , endemic family to China. Very rare (or possibly extinct) in the wild (montane forest, western China). Rare/endangered in Sichuan (Zhang and He, 2002) and Rare (Walter and Gillet, 1998).
Ginkgoaceae	<i>Ginkgo biloba</i>	<i>Yinxingye</i> (leaves), <i>baiguo</i> (seeds), tree	China , endemic family to China. Very rare in the wild. Dioecious. Rare/endangered in Sichuan (Zhang and He, 2002) and Rare (Walter and Gillet, 1998). Widely cultivated for ornamental and medicinal purposes.
Stangeriaceae	<i>Stangeria eriopus</i>	<i>Imfingo</i> , protective charm in Zulu traditional medicine	South Africa . 1 species, endemic to South Africa. Dioecious. Wild harvest from forest or forest margin grasslands.
<i>MONOTYPIC GENERA</i>			
Ranunculaceae	<i>Circaea agrestis</i>	Perennial herb, roots, Chinese traditional medicine	NW Himalayan region , endemic to W and NW China. Rare/endangered in Sichuan (Zhang and He, 2002).
Ranunculaceae	<i>Hydrastis canadensis</i>	Perennial herb, herbal antibiotic, inflammation	Eastern North America , endemic. Temperate forests.
Ranunculaceae	<i>Kingdonia uniflora</i>	Perennial herb, roots, Chinese traditional medicine	China . Rare/endangered in Sichuan (Zhang and He, 2002).
Asteraceae	<i>Lamprachaenium microcephalum</i>	Perennial herb, Chinese traditional medicine	India , endemic. Considered vulnerable.
Valerianaceae	<i>Nardostachys grandiflora</i>	<i>Jatamansi</i> , perennial herb, roots, stomach ache, vomiting and massage oils	Himalayan endemic, monotypic genus. High-altitude yak pastures and mountain slopes.
Scrophulariaceae	<i>Neopicrorhiza scrophulariiflora</i>	<i>Kutki</i> , perennial herb, roots, fever, dysentery, diarrhoea	W. Himalayan endemic. 1 species. High-altitude yak pastures and mountain slopes. Wild harvest. Rare/endangered in Sichuan (Zhang and He, 2002).

50 HUMAN HEALTH AND FORESTS

Table 3.3 (cont'd)

Phylogenetic distinctiveness, family	Scientific name	Common name, life form, part used, main use	Geographic region and comments on conservation status
MONOTYPIC GENERA			
Monimiaceae	<i>Peumus boldus</i>	<i>Boldo</i> , small tree, leaves, antioxidant, rheumatism	Chile , endemic. 1500 tonnes of leaves exported, 80% within Latin America (Argentina, Brazil), 18% Europe (France, Germany).
Dioscoreaceae	<i>Trichopus zeylanicus</i>	<i>Arogya pacha</i> , perennial herbs, fruits, anti-fatigue, anti-microbial.	Indo-Malayan region , considered critically endangered in South India.
Asclepiadaceae	<i>Utleria salicifolia</i>	Perennial herb, rhizomes, anti-ulcer	South India , endemic, considered critically endangered in South India.

Note: These species are the only representatives of their families, or should be rated highly for conservation action because of their phylogenetic (and in many cases, phytochemical) distinctiveness.

These drugs now contribute significantly to pharmaceutical company revenues and make up a significant portion of top-selling drugs, particularly in categories like infectious disease and cancer (Newman and Laird, 1999; Newman et al, 2003). Industry interest in natural products is a response to technological, scientific, legal and market developments, and as such is cyclical and constantly changing. Industry continues to return to natural products as a source of novelty and diversification, as today's surging interest in micro-organisms and species from extreme environments attests (Laird and Wynberg, 2005).

Favoured medicinal plant habitats

The origins and management of species used in health care can inform our understanding of the relationship between biodiversity, medicinal plants and health. Old-growth tropical forests are widely considered the most important source of medicinal plants because of their diversity and the occurrence of plant families rich in active ingredients (such as the Apocynaceae and Menispermaceae). In other areas, secondary or disturbed habitats are preferred. In Ghana, for example, Falconer (1990; 1994) found that primary forest was not the main source of plant medicines for households (in terms of the percentage of species used), and that fallow areas and the village periphery are the most important sources. Of those interviewed, 82 per cent gathered their own medicines from these areas, with 12 per cent from the forest, 65 per cent from farm fallow and 46 per cent from village areas. However, healers make greater use of forest species, even if many are sourced from disturbed habitats or planted in compounds. Laird et al (2007) similarly found that indigenous Bakweri healers around Mount Cameroon use significantly more medicinal forest species than most members of communities, and that many forest species are transplanted from the forest into healers' home gardens. As a result, the location of species collections is not necessarily an

indication of the conservation value of the species or of the value of forest to local communities. In addition, forest species are often considered the most powerful and used to treat the most severe problems. Although disturbed sites (e.g., village, farm, fallow and secondary forest areas) offer a wide range of species, forest species are critical to the specialist medicine practised by healers. Healers also collect almost six times the number of native and wild medicinal species as the village average, followed by hunters.

Introduced weeds are widely adopted into local pharmacopoeia. In a thought-provoking paper, Stepp (2004) pointed out that many indigenous peoples harvest medicinal plants from non-forested, disturbed habitats, and that 36 of the 101 plant species from which 119 contemporary pharmaceuticals are derived come from plants that could be classed as weeds. This analysis was not focused solely on short-lived, annual weeds of disturbed areas, but also included forest trees, such as *Taxus brevifolia* (the source of taxol), and long-lived clonal species, such as *Convallaria majalis* (whose individuals can live longer than 670 years). In the *caatinga* dry forests of northeastern Brazil, for example, only 56 per cent of the medicinal species used are native (de Albuquerque, 2006).

There are also significant differences between communities that have resided in a forest area for many generations and continue to rely on the forest, and those that recently arrived in an area or live more independently of forest resources. In Cameroon, Laird et al (2007) found that of the more than 400 useful plant species documented in Bakweri villages around Mount Cameroon, a quarter had been introduced. The indigenous Bakweri communities in this area have long histories of contact with outside groups and have incorporated many introduced species into their livelihoods. However, total livelihood contributions from native and wild species to indigenous households are more than five times the contribution of native and wild species to migrant households; this includes their use of medicinal species.

In some cultural situations, habitat selection is also influenced by the gender of the traditional healers. Among many African farming societies, it is more acceptable for men (as hunters) to spend time on their own in old-growth forests, and less so for women. In interview surveys with 714 healers using 295 plant species in southwestern Uganda, Kyashobire (1998) found that men (herbalists and non-specialists who collected plants for home remedies) used the forest more extensively than women (both traditional birth attendants and female herbalists) (Table 3.4). Men also used more bark and roots; for women, leaves were the common plant part most commonly used.

Table 3.4 *Habitats of plant species collected in or around Bwindi forest, Uganda*

<i>Herbalist category</i>	<i>Garden</i>	<i>Early fallow</i>	<i>Mature fallow</i>	<i>Bushy thicket</i>	<i>Forest</i>	<i>Healers interviewed (n)</i>
Traditional birth attendant	9.5%	22.7%	24.8%	21.3%	21.7%	184
Female herbalist	8.6%	23.2%	24.1%	24.1%	20.0%	179
Male herbalist	9.4%	18.0%	21.1%	22.8%	28.7%	258
Male, non-specialist	3.9%	18.1%	15.2%	25.0%	37.8%	93

Note: Some 295 plant species are used in this area.

Source: Kyashobire, 1998

Cultivation of medicinal plants

'Conservation through cultivation' has long been promoted as a means of ensuring future supplies of medicinal plants (e.g., Cunningham, 1993), yet most medicinal plants are still harvested from wild populations. Based on figures from Europe, China and India, the number of medicinal and aromatic species cultivated worldwide does not exceed a few hundred (Schippmann et al, 2003). From an economic perspective, cultivation can be desirable, guaranteeing a regular supply and adherence to quality standards (Pierce et al, 2002). What is needed is an objective assessment of where and why conservation through cultivation has been successful (or not).

For the rural poor without land or livestock, harvesting of wild plant resources, including medicinal plants, is a common option, particularly in ecosystems with low arable potential. In theory, medicinal plant cultivation also offers an economic opportunity for rural smallholder farmers and an answer to declining wild stocks. Cultivation of medicinal species for illegal but lucrative processing for the drug trade certainly takes place: examples include *Cannabis sativa* (Australia, Africa, Asia, North America), *Catha edulis* (Ethiopia, Kenya, Yemen), *Erythroxylon coca* for cocaine (South America) and opium from *Papaver somniferum* (Afghanistan and Southeast Asia).

In practice, economically viable, legal production of medicines is difficult to achieve on a large enough scale to meet commercial demand. Small-scale producers commonly face high risks and transaction costs, and lack guaranteed markets and trust among different actors along the value chain (van de Kop et al, 2006). In Africa, *Prunus africana* is a good example of the failure of cultivated production to date. Bark production can be an economic proposition (Cunningham et al, 2002), and plantation trials were implemented in Kenya as early as 1920. In northwestern Cameroon, an estimated 3200 farmers grow *Prunus africana* in small-scale agroforestry systems, yet export continues to be based on wild harvest, with many populations over-exploited (Cunningham, 2005). There have been successes elsewhere, such as in China, where a much higher proportion of medicinal plants (10 to 25 per cent, or 100 to 250 of the estimated 1000 commonly traded species) are cultivated, compared with less than 1 per cent of medicinal plants sourced from cultivation globally. We suggest that cultivation in China has been a response to several factors, including price increases linked to major declines in wild stocks and the attraction of conservation through cultivation from a policy perspective. Progress towards policy goals, for example, is evaluated in China according to targets, which are usually set by the next-highest level of the Communist Party (for party leaders) or government (for government officials). A target of a certain area of a medicinal plant species under cultivation is much easier to measure than sustainable harvest of dispersed, wild populations.

In Peru, the realized or expected increases in demand for such plants as camu-camu (*Myrciaria dubia*) and cat's claw (*Uncaria guianensis*) have led state agencies and NGOs to promote the cultivation or intensification of the production system through direct intervention, technical assistance or subsidies (Panduro and de Jong, 2004; Nalvarte and de Jong, 2004). In Brazil, demand has catalysed innovation that favours sustainable practices, especially in cases where land tenure is clear. Particularly in peri-urban areas close to markets, demand has encouraged farmer-led innovations not only in palms (Anderson

and Jardim, 1989) but also in long-lived exudate-producing species. Local management practices leading to improved production in peri-urban areas include germplasm selection, selective weeding of fallows and enrichment planting. Results illustrate that species useful for nutritional fruits, medicinal exudates and roots are more likely to be managed than long-lived species used for medicinal bark. For example, in areas close to markets in the eastern Amazon of Brazil, demand has encouraged farmer-led innovations in the management of *Parabancornia fasciculata* (amapa). The latex is used for respiratory diseases and to fortify the body after malaria. Farmers are currently experimenting with extraction techniques and incipient attempts at enriching forests with seedlings. Where land tenure is clear, innovations of sustainable practices are incipient, whereas on communal or invaded private properties, exploitative practices are widespread.

In other cases, cultivation can worsen the situation by contributing to habitat destruction. In southwestern China, for example, cultivation of commercially traded medicinal plants, such as *Ammomum villosum* (sharen), prevents lowland rainforest regeneration (Liu et al, 2006). The area of *Ammomum villosum* cultivation in Xishuangbanna, Yunnan, is now 58km², much of it within conservation areas (Liu et al, 2006). Similarly, cultivation of *Ammomum tsao-ko* (caoguo) (Figure 3.2f) is affecting montane forest conservation areas of high conservation priority, such as forests in Fengshuiling Nature Reserve, Yunnan, and the cross-border area in northern Vietnam. After the understorey is cleared, the *Ammomum* plants that are cultivated underneath canopy trees create intense shade that suppresses forest regeneration.

Despite an economic rationale, consumer preferences for wild-harvested material are widespread (Cunningham, 1993; Pierce et al, 2002). Cultivation is expensive, not always feasible and can take a long time (Schippmann et al, 2003). For families without land and with few livelihood options, wild-harvesting is a safety net. Large and medium-scale plantations generally favour elites, excluding small farmers and those without access to farmland (Scheffer, 2004). Public-private partnerships similar to those implemented in India for *Neopicrorhiza kurroa* cultivation are likely to support small-scale producers in the future (van de Kop et al, 2006).

POLICY RECOMMENDATIONS

As Bodeker and Kronenberg (2002) point out, the Traditional Medicines Strategy (WHO, 2002) focuses on four areas that need implementation to get the best public health benefits from the use of traditional, and complementary and alternative medicine:

- 1 policy changes leading to better recognition of non-Western medicine and its integration into health-care systems;
- 2 attention to safety, efficacy and quality of medicinal plant use;
- 3 improved access to traditional medicine, including sustainable harvesting of materials, which in turn affects access issues such as cost, since resource depletion of popular species leads to price increases and scarcity; and
- 4 improving the quality of information on the rational use of traditional medicine.

54 HUMAN HEALTH AND FORESTS

These areas of focus raise questions:

- How can empirical knowledge of medicinal plant uses, often held by an older generation of healers in remote areas, be accumulated, stored and transmitted to next generations without compromising their intellectual property rights?
- How can the providers of medicine, the innovators of the trade and the transmitters of knowledge be adequately compensated?
- How can consumers be protected from false information or the use of products with negative side-effects?
- How can sustainable wild sourcing be implemented – or the medicinal plants be ‘domesticated’ – to secure supplies of quality products before the over-harvesting of wild stocks depletes the resource?

For this last question, policy changes are needed on several fronts: first, the implementation of recent recommendations for sustainable wild harvest made by Schippmann et al (2003), and second, development of public–private partnerships for smallholder cultivation that follow initial successes in India (van de Kop et al, 2006). Sustaining supplies of slow-growing medicinal plants is difficult to achieve but essential for the achievement of the other goals of the Traditional Medicines Strategy, since declining wild stocks are accompanied by adulteration and species substitutions, which in turn reduce efficacy, quality and safety. In India, for example, scarcity and high prices result in *Podophyllum hexandrum* (Araliaceae) roots being substituted or adulterated by *Ainsliaea latifolia* (Asteraceae) roots (Shah, 2006).

Practical steps include the following:

- Develop risk management strategies to prevent adverse reactions to herbal medicines by identifying safe species (as TRAMIL has done) and adverse reactions with pharmaceuticals (Yang et al, 2006).
- Sustain wild harvests. Several approaches can be taken:
 - Develop management plans that link traditional ecological knowledge and sustainable harvest methods, such as those already developed for non-timber forest products (Peters, 1994; Cunningham, 2001).
 - Strengthen capacity through recognizing the skills of knowledgeable local people in conducting inventories, and monitoring and assessing the effects of medicinal plants, as has been done in northwestern Nepal for management of *Nardostachys grandiflora* and *Neopicrorhiza scrophulariiflora* (Ghimire et al, 2004).
 - Provide international and national support for regional training courses and curriculum development in applied ethno-botany and resource management.
- Develop appropriate certification systems. For medicinal plants to be certified in developing countries, producers must weigh the costs and benefits of different certification schemes and decide whether a particular set of standards is a good fit for their product, consumer market, budget and organizational capacity. Several schemes are available:
 - wild harvest certification: the International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants (ISSC-MAP) is the most recent initiative (Patzold et al, 2006);

- good agricultural and collection practices: established guidelines that set standards for the proper handling and sanitation of products during harvest, storage and shipping;
 - good manufacturing practices: guidelines for infrastructure, staff and processing procedures, including for food and herbal products;
 - organic certification; and
 - certification of geographic origin, which has potential for application to some medicinal plant species under an approach termed Appellation Origine Protégée, adopted by the European Union in 1992, which includes protection not only of the product and the know-how related to it, but also the conservation of its habitat.
- Develop marketing networks so that certified producer associations or companies can capitalize on certification, including ‘matchmaking’ between producer associations and industry partners committed to buying sustainable harvested or high-quality cultivated products at fair prices to producers.
 - Lower the barriers to smallholder cultivation on a larger scale, following recommendations made by van de Kop et al (2006).
 - Expand medicinal plant domestication programmes based on policy agreements between ‘range states’, the countries in which a species commonly grows; such programmes build up provenance collections for regional benefit that take advantage of the genetic and chemical diversity within a species over its distribution range.
 - Develop secure *ex situ* field gene banks for the conservation of high-priority species.

CONCLUSIONS

Tropical ecosystems (forests and woodlands) and high mountain areas are major harvesting areas for the leading medicinal plants in Ayurvedic, Chinese, Tibetan, Unani and diverse African and Latin American health systems. Many of these favoured medicinal plants are long-lived, often habitat-specific perennial species. These species are threatened by habitat loss, climate change, and species-specific, multipurpose over-harvesting and logging. Thus the resource base for traditional health-care systems used by at least 2 billion people is also threatened. Stepp (2004) correctly concluded that many weeds in degraded habitats contain medically active ingredients, but this should not distract attention from chemically and phylogenetically distinctive medicinal species in tropical forests. The world’s major psychotropic plants (e.g., *Banisteriopsis caapi*, *Psychotria viridis*, *Tabernanthe iboga*), which come from forests, are central to ancient cultural rituals but also have contemporary significance. It is also in forest and montane ecosystems that medicinal species occur in monotypic families (Eucommiaceae, Ginkgoaceae, Stangeriaceae), monotypic genera (*Peumus*, *Neopicrorhiza*) and very small genera of two to five species (*Ekmanianthe*, *Holostemma*, *Notopterygium*, *Podophyllum*, *Warburgia*). These habitats need to be the focus of improved policy and practice for medicinal plant conservation and resource management.

REFERENCES

- Alem, A., Jacobsson, L., Araya, M., Kebede, D. and Kullgren, G. (1999) 'How are mental disorders seen and where is help sought in a rural Ethiopian community? A key informant study in Butajira, Ethiopia', *Acta Psychiatrica Scandinavica (Supplement)*, 397: 40–47 [abstract only]
- Alexiades, M. and Lacaze, D. (1996) 'FENAMAD's program in traditional medicine: An integrated approach to health care in the Peruvian Amazon', in M.J. Balick, E. Elisabetsky and S.A. Laird (eds) *Medicinal Resources of the Tropical Rainforest*, Columbia University Press, New York, NY, pp341–365
- Anderson, A.B., and Jardim, M.A.G. (1989) 'Costs and benefits of floodplain forest management by rural inhabitants in the Amazon estuary: A case study of açai palm production', in J.O. Browder (ed) *Fragile Lands in Latin America: The Search for Sustainable Uses*, Westview Press, Boulder, CO
- Appleton, C.C., Drewes, S.E. and Cunningham, A.B. (1992) 'Observations on the molluscicidal properties of (-) warburganal South African *Bulinus africanus*', *Journal of Applied and Medical Malacology* 4: 37–40
- Balde, N.M., Youla, A., Balde, M.D., Kake, A., Diallo, M.M., Balde, M.A. and Maugendre, D. (2006) 'Herbal medicine and treatment of diabetes in Africa: An example from Guinea', *Diabetes and Metabolism* 32(2): 171–175
- Balick, M.J., Elisabetsky, E. and Laird, S. (1996) *Medicinal Resources of the Tropical Forest: Biodiversity and its Importance to Human Health*, Columbia University Press, NY
- Bode, M. (2006) 'Taking traditional knowledge to the market: The commoditization of Indian medicine', *Anthropology & Medicine* 13: 225–236
- Bodeker, G. and Kronenberg, F. (2002) 'A public health agenda for traditional, complementary, and alternative medicine', *American Journal of Public Health* 92: 1582–1591
- Botha, J., Witkowski, E.T.F. and Shackleton, C.M. (2004) 'The impact of commercial harvesting on *Warburgia salutaris* ("pepper-bark tree") in Mpumalanga, South Africa', *Biodiversity and Conservation* 13: 1675–1698
- Cao, Y., Yinyu Shi, Yuxing Zheng, Meiyu Shi and Sing Kai Lo (2005) 'Blood-nourishing and hard-softening capsule costs less in the management of osteoarthritic knee pain: A randomized controlled trial', *eCAM* 2(3): 363–368
- Callaway, J.C., McKenna, D.J., Grob, C.S., Brito, G.S., Raymon, L.P., Poland, R.E., Andrade, E.N., Andrade, E.O. and Mash, D.C. (1999) 'Pharmacokinetics of *Hoasca* alkaloids in healthy humans', *Journal of Ethnopharmacology* 65: 243–256
- Cavendish, W. (1999) 'Empirical regularities in the poverty–environment relationship of African rural households', Working Paper No. WPSS 99-21, Centre for the Study of African Economies, Oxford University, Oxford
- Chyka, P.A. (2000) 'How many deaths occur annually from adverse drug reactions in the United States?', *American Journal of Medicine* 109(2): 122–130
- Cragg, G.M., Kingston, D.G.I. and Newman, D.J. (eds) (2005) *Anticancer Agents from Natural Products*, CRC Press, Boca Raton, FL
- Cunningham, A.B. (1991) 'Development of a conservation policy on commercially exploited medicinal plants: A case study from southern Africa', in V. Heywood, H. Synge and O. Akerele (eds) *Conservation of Medicinal Plants*, Cambridge University Press, Cambridge, pp337–358
- Cunningham, A.B. (1993) 'African medicinal plants: Setting priorities at the interface between conservation and primary health care', People and Plants Working Paper No. 1: 1–50, UNESCO, Paris

- Cunningham, A.B. (1997) *The 'Top 50' Listings and the Medicinal Plants Action Plan*, IUCN/SSC Medicinal Plant Specialist Group, Bonn, Germany
- Cunningham, A.B. (2001) *Applied Ethnobotany: People, Wild Plant Use and Conservation*, Earthscan, London
- Cunningham, A.B. (2005) 'CITES significant trade review of *Prunus africana*', PC16 Doc. 10.2, CITES Management Authority, Geneva, Switzerland
- Cunningham, A.B., Ayuk, E., Franzel, S., Duguma, B. and Asanga, C. (2002) 'An economic evaluation of medicinal tree cultivation', People and Plants Working Paper No. 10, UNESCO, Paris
- de Albuquerque, U.P. (2006) 'Re-examining hypotheses concerning the use and knowledge of medicinal plants: A study in the Caatinga vegetation of NE Brazil', *Journal of Ethnobiology and Ethnomedicine* 2(30): 1–10
- de Feo, V. (2005) 'The ritual use of *Brugmansia* species in traditional Andean medicine in northern Peru', *Economic Botany* 58: 221–229
- de Rios, M.D. and Stachalek, R. (1999) 'The *Duboisia* genus, Australian aborigines and suggestibility', *Journal of Psychoactive Drugs* 31(2): 155–161
- Eisenberg, D.M., Davis, R.B., Ettner, S.L., Appel, S., Wilkey, S., van Rompay M. and Kessler R.C. (1998) 'Trends in alternative medicine use in the United States 1990–1997: Results of a follow-up national survey', *JAMA* 280: 1569–1575
- Falconer, J. (1990) *The Major Significance of 'Minor' Forest Products: The Local Use and Value of Forests in the West African Humid Forest Zone*, FAO, Rome
- Falconer, J. (1994) *Non-timber Forest Products in Southern Ghana*, Overseas Development Administration, UK/Forestry Department, Republic of Ghana/Natural Resources Institute, UK
- Farnsworth, N.R., Akerele, O., Bingel, A.S., Soejarto, D.D. and Guo, Z. (1985) 'Medicinal plants in therapy', *Bulletin of the World Health Organization* 63: 965–981
- Fiori, K.L., Hays, J.C. and Meador, K.G. (2004) 'Spiritual turning points and perceived control over the life course', *International Journal of Ageing and Human Development* 59(4): 391–420
- Fournet A., Barrios, A.A., Munoz, V., Hocquemiller, R., Roblot, F. and Cave, A. (1994) 'Antileishmanial activity of a tetralone isolated from *Ampelocera edentula*, a Bolivian plant used as a treatment for cutaneous leishmaniasis', *Planta Medica* 60(1): 8–12
- Garibaldi, A. and Turner, N. (2004) 'Cultural keystone species: Implications for ecological conservation and restoration', *Ecology and Society* 9(3): 1, www.ecologyandsociety.org/vol9/iss3/art1
- Garvey, G.J., Hahn, G., Lee, R.V. and Harbison, R.D. (2001) 'Heavy metal hazards of Asian traditional remedies', *International Journal of Environmental Health Research* 11: 63–71
- Gessler, M.C., Msuya, D.E., Nkunya, M.H., Schar, A., Heinrich, M. and Tanner, M. (1995) 'Traditional healers in Tanzania: The perception of malaria and its causes', *Journal of Ethnopharmacology* 3(48): 119–130
- Ghimire, S., McKey, D. and Aumeeruddy-Thomas, Y. (2004) 'Heterogeneity in ethnoecological knowledge and management of medicinal plants in the Himalayas of Nepal: Implications for conservation', *Ecology and Society* 9(3): 6, www.ecologyandsociety.org/vol9/iss3/art6/
- Green, E.C. (1985) 'Traditional healers, mothers and childhood diarrhoeal disease in Swaziland: The interface of anthropology and health education', *Social Science and Medicine* 20: 277–285
- Grifo, F., Newman, D., Fairfield, A.S., Bhattacharya, B. and Grupenhoff, J.T. (1997) 'The origins of prescription drugs', in F. Grifo and J. Rosenthal (eds) *Biodiversity and Human Health*, Island Press, Washington, DC

58 HUMAN HEALTH AND FORESTS

- Grob, C.S., McKenna, D.J., Callaway, J.C., Brito, G.S., Neves, E.S., Oberlander, G., Saide, O.L., Labigalini, E., Tacla, C., Miranda, C.T., Strassman, R.J. and Boone, K.B. (1996) 'Human psychopharmacology of Hoasca, a plant hallucinogen used in ritual context in Brazil', *Journal of Nervous and Mental Disorders* 184(2): 86–94
- Grosvenor, P.W., Gothard, P.K., McWilliam, N.C., Supriono, A. and Gray, D.O. (1995) 'Medicinal plants from Riau province, Sumatra, Indonesia. Part 1: Uses', *Journal of Ethnopharmacology* 45: 75–95
- Hagopian, A., Thompson, M.J., Fordyce, M., Johnson, K.E. and Hart, L.G. (2004) 'The migration of physicians from sub-Saharan Africa to the United States of America: Measures of the African brain drain', *Human Resources for Health* 2(17): 1–10
- Honigsbaum, M. (2002) *The Fever Trail: In Search of the Cure for Malaria*, Farrar Straus & Giroux, New York, NY
- Iwu, M. and Laird, S.A. (1998) 'The International Cooperative Biodiversity Group: Drug development and biodiversity conservation in Africa', case study of a benefit-sharing plan, UNEP, Nairobi
- Jacobson-Widding, A. (1979) *Red-White-Black as a Mode of Thought: A Study of Triadic Classification by Colours in the Ritual Symbolism and Cognitive Thought of the Peoples of the Lower Congo*, Almqvist & Wiksell, Uppsala, Sweden
- Kalix, P. (1991) 'The pharmacology of psychoactive alkaloids from ephedra and catha', *Journal of Ethnopharmacology* 32(1–3): 201–208
- King, S.R., Meza, E.N., Carlson, T.J.S., Chinook, J.A., Moran, K. and Borges, J.R. (1999) 'Issues in the commercialisation of medicinal plants', *Herbalgram* 47: 46–51
- Kleinman, A., Eisenberg, L. and Good, B. (1978) 'Culture, illness, and care: Clinical lessons from anthropologic and cross-cultural research', *Annals of Internal Medicine* 88: 251–258
- Kyashobire, M. (1998) 'Medicinal plants and herbalist preferences around Bwindi Impenetrable Forest, Uganda', MSc thesis, Department of Botany, Makerere University, Kampala
- Lagos-Witte, S., Germosén-Robineau, L. and Weniger, B. (1997) 'Rol actual de la fitomedicina en el caribe. presentacion de la farmacopea vegetal Caribeña (TRAMIL)', *ISHS Acta Horticulturae* 503: II WOCMAP Congress Medicinal and Aromatic Plants, Part 4: Industrial Processing, Standards & Regulations, Quality, Marketing, Economics
- Laird, S.A. (2002) *Biodiversity and Traditional Knowledge: Equitable Partnerships in Practice*, Earthscan, London
- Laird, S.A. and ten Kate, K. (2002) 'Linking biodiversity prospecting and forest conservation', in S. Pagiola, J. Bishop and N. Landell-Mills (eds) *Selling Forest Environmental Services: Market-Based Mechanisms for Conservation and Development*, Earthscan, London, pp151–172
- Laird, S.A. and Wynberg, R. (2005) *The Commercial Use of Biodiversity: An Update on Current Trends in Demand for Access to Genetic Resources and Benefit-Sharing, and Industry Perspectives on ABS Policy and Implementation*, UNEP, Nairobi
- Laird, S.A., Pierce, A.R. and Schmitt, S.F. (2005) 'Sustainable raw materials in the botanicals industry: Constraints and opportunities', *Acta Horticulture* 676: 111–117
- Laird, S.A., Awung, G.L. and Lysinge, R.J. (2007) 'Cocoa farms in the Mount Cameroon region: Biological and cultural diversity in local livelihoods', *Biodiversity and Conservation* 16: 2401–2427
- Lange, D. (1998) *Europe's Medicinal and Aromatic Plants: Their Use, Trade and Conservation*, TRAFFIC International, Cambridge
- Lee, M.R. (2002) 'Plants against malaria, Part 1: Cinchona or the Peruvian bark', *The Journal of the Royal College of Physicians of Edinburgh* 32: 189–196

- Liu, H., Lei, G., Zheng, Z. and Feng, Z. (2006) 'The impact of *Amomum villosum* cultivation on seasonal rainforest in Xishuangbanna, southwest China', *Biodiversity and Conservation* 15: 2971–2985
- McKenna, D.J. (2005) 'Ayahuasca and human destiny', *Journal of Psychoactive Drugs* 37: 231–234
- Mander, M. (2004) 'Phytomedicines industry in southern Africa', in N. Diederichs (ed) *Commercialising Medicinal Plants: A Southern African Guide*, African Sun Media, Pretoria, South Africa
- Mash, D.C., Kovera, C.A., Buck, B.E., Norenberg, M.D., Shapshak, P., Hearn, W.L. and Sanchez-Ramos, J. (1998) 'Medication development of ibogaine as a pharmacotherapy for drug dependence', *Annals of the New York Academy of Sciences* 44: 274–292
- Melnyk, M. (2001) 'Community health and conservation: A review of projects', unpublished report, Biodiversity Support Program, Washington, DC
- Mills, E., Foster, B.C., van Heeswijk, R., Phillips, E., Wilson, K., Leonard, B., Kosuge, K. and Kanfer, I. (2005) 'Impact of African herbal medicines on antiretroviral metabolism', *AIDS* 19(1): 95–97.
- Miot, H.A., Batistella, R.F., Batista Kde, A., Volpato, D.E., Augusto, L.S., Madeira, N.G., Haddad, V. and Miot, L.D. (2004) 'Comparative study of the topical effectiveness of the Andiroba oil (*Carapa guianensis*) and DEET 50 per cent as repellent for *Aedes* sp', *Revista do Instituto de Medicina Tropical de São Paulo* 46(5): 253–256
- Nalvarte, W and de Jong, W. (2004) 'Uña de gato (*Uncaria tomentosa* (Willd ex Roem & Schult) DC y *Uncaria guianensis* (Aubl.) Gmel.): Potencial y esperanzas de un bejuco Amazónico del Perú', in M.N. Alexiades and P. Shanley (eds) *Productos forestales medios de subsistencia y conservación: Estudios de caso sobre sistemas de manejo de productos forestales no maderables Volumen América Latina*, Centro para la Investigación Forestal Internacional (CIFOR), Bogor, Indonesia
- Nantel, P., Gagnon, D. and Nault, A. (1996) 'Population viability analysis of American ginseng and wild leek harvested in stochastic environments', *Conservation Biology* 10: 608–621
- Newman, D.J., Cragg, G.M. and Snader, K.M. (2003) 'Natural products as sources of new drugs over the period 1981–2002', *Journal of Natural Products*, 66: 1022–1037
- Newman, D.J. and Laird, S.A. (1999) 'The influence of natural products on 1997 pharmaceutical sales figures', in K. ten Kate and S.A. Laird (eds) *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit Sharing*, Earthscan, London
- Nutrition Business Journal* (2003) *NBJ's Supplement Business Report 2003*, Penton Media Inc, San Diego, CA
- Obi, E., Akunyili, D.N., Ekpom, B. and Orisakwe, O.E. (2006) 'Heavy metal hazards of Nigerian herbal remedies', *The Science of the Total Environment* 69(1–3): 35–41
- Olsen, C.S. (2005) 'Valuation of commercial central Himalayan medicinal plants', *Ambio* 34: 607–610
- Osuala, F.O. and Okwuosa, V.N. (1993) 'Toxicity of *Azadirachta indica* to freshwater snails and fish, with reference to the physicochemical factor effect on potency', *Applied Parasitology* 34(1): 63–68
- Otuyemi, O.D., Abidoye, R.O. and Dada, D. (1994) 'Oral health knowledge, attitude and behaviour of 12-year-old suburban and rural school children in Nigeria', *African Dentistry Journal* 8: 20–25
- Padarath, A., Chamberlain, C., McCoy, D., Ntuli, A., Rowson, M. and Loewenson, R. (2004) 'Health personnel in Southern Africa: Confronting maldistribution and brain drain', Equinet Discussion Paper No. 3, www.queensu.ca/samp/migrationresources/braindrain/documents/equinet.pdf (accessed 25 October 2007)

60 HUMAN HEALTH AND FORESTS

- Pagán, J.A. and Pauly, M.V. (2005) 'Access to conventional medical care and the use of complementary and alternative medicine', *Health Affairs* 24: 255–262
- Palsson, T and Jaenson, W.G. (1999) 'Comparison of plant products and pyrethroid-treated bed nets for protection against mosquitoes (Diptera: Culicidae) in Guinea Bissau, West Africa', *Journal of Medical Entomology* 36(2):144–8.
- Panduro, M.P. and de Jong, W. (2004) 'Camu-camu (*Myrciaria dubia* McVaugh H.B.K.), Arbusto Amazónico de Áreas Inundables con Alto Contenido de Vitamina C', in M. Alexiades and P. Shanley (eds) *Productos forestales, medios de subsistencia y conservación, Volumen 3: America Latina*, CIFOR, Bogor, Indonesia
- Patzold, B., Leaman, D. and Honnef, S. (2006) 'Sustainable wild collection of medicinal plants: The need for an international standard', *TRAFFIC Bulletin* 21: 41–45
- Peters, C.M. (1994) *Sustainable Harvest of Non-timber Plant Resources in Tropical Moist Forest: An Ecological Primer*, WWF, Washington, DC
- Phillip Securities Research (2003) *Stock Update*, Eu Yan Sang International, 17 January, pp1–3
- Pierce, A.R. and Laird, S.A. (2003) 'In search of comprehensive standards for non-timber forest products in the botanicals trade', *International Forestry Review* 5(2): 138–147
- Pierce, A.R., Laird, S.A. and Malleson, R. (2002) *Annotated Collection of Guidelines, Standards, and Regulations for Trade in Non-timber Forest Products and Botanicals*, Rainforest Alliance, New York
- Posey, D.A. (1999) *Cultural and Spiritual Values of Biodiversity: A Complementary Contribution to the Global Biodiversity Assessment*, UNEP, Nairobi
- Póvoa, M.M., Conn, J.E., Schlichting, C.D., Amaral, J.C.O.F. and Segura, M.N.O. (2003) 'Malaria vectors, epidemiology, and the re-emergence of *Anopheles darlingi* in Belém, Pará, Brazil', *Journal of Medical Entomology* 40: 379–386
- Prisinzano, T.E. (2005) 'Psychopharmacology of the hallucinogenic sage *Salvia divinorum*', *Life Sciences* 78(5): 527–531
- Qiong, W., Yiping, W., Jinlin, Y., Tao, G., Zhen, G. and Pengcheng, Z. (2005) 'Chinese medicinal herbs for acute pancreatitis', *The Cochrane Database of Systematic Reviews*, Issue 1, Art. No. CD003631 1–14
- Queneau, P., Bannwarth, B., Carpentier, F., Guiliana, J.M., Bouget, J., Trombert, B., Leverage, X., Lapostolle, F., Borron, S.W. and Adnet, F. (2007) 'Emergency department visits caused by adverse drug events: Results of a French survey', *Drug Safety* 30(1): 81–88
- Ramachandran, S.C., Latha, E. and Manoharan, M. (1999) 'Impacts of urbanisation on the lifestyle and on the prevalence of diabetes in native Asian Indian population', *Diabetes Research and Clinical Practice* 44(3): 207–213
- Reichel-Dolmatoff, G. (1996) *The Forest Within: The World-view of the Turkano Amazonian Indians*, Themis Books, Dartington, Devon
- Rwiza, H.T., Matuja, W.B., Kilonzo, G.P., Haule, J., Mbena, P., Mwang'ombola, R. and Jilek-Aall, L. (1993) 'Knowledge, attitude, and practice toward epilepsy among rural Tanzanian residents', *Epilepsia* 34(6): 1017–1023
- Saxena, A. and Vikram, N.K. (2004) 'Role of selected Indian plants in management of type 2 diabetes: A review', *Journal of Complementary and Alternative Medicine* 10: 369–378
- Scheffer (2004) 'Produção de espinheira-santa (*Maytenus ilicifolia* Mart. ex Reiss) na região metropolitana de Curitiba, Paraná Brasil', in M. Alexiades and P. Shanley (eds) *Productos Forestales, Medios de Subsistencia y Conservación. Vol. 3 – America Latina*, CIFOR, Indonesia
- Schippmann, U., Leaman, D.J. and Cunningham, A.B. (2003) 'Impact of cultivation and gathering of medicinal plants on biodiversity: Global trends and issues', in *Biodiversity and the Ecosystem Approach in Agriculture, Forestry and Fisheries*, FAO, Rome
- Schultes, R.E. and Raffauf, R.F. (1992) *Vine of the Soul*, Synergetic Press, Oracle, AZ

- Shah, N.C. (2006) 'Podophyllum hexandrum and its conservation status in India', *Medicinal Plants Conservation* 12: 42–46
- Shanley, P. and Luz, L. (2003) 'The impacts of forest degradation on medicinal plant use and implications for health care in Eastern Amazonia', *BioScience* 53: 573–584
- Shanley, P., Pierce, A. and Laird, S. (2006) *Alem de Madeira: A Certificação de Produtos Florestais Não-Madeireiros*, CIFOR/Forest Trends, Belem, Brazil
- Shepard, G. (2005) 'Psychoactive botanicals in ritual, religion and shamanism', in E. Elisabetsky and N. Etkin (eds) *Ethnopharmacology*, UNESCO/Eolss Publishers, Oxford, UK, Chapter 18
- Shirakawa, T. (2006) 'Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction', *Public Health*, 19 October [abstract only]
- Silva, M.I., Sousa, F.C. and Gondim, A.P. (2005) 'Herbal therapy in primary health care in Maracanaú, Ceará, Brazil', *Annals of Pharmacotherapy* 39: 1336–1341 [abstract only]
- Singh, A. and Singh, D.K. (2001) 'Molluscicidal activity of *Lawsonia inermis* and its binary and tertiary combinations with other plant derived molluscicides', *Indian Journal of Experimental Biology* 39(3): 263–268
- Smith, M.T., Crouch, N.R., Gericke, N. and Hirst, M. (1996) 'Psychoactive constituents of the genus *Sceletium* N.E.Br. and other Mesembryanthemaceae: A review', *Journal of Ethnopharmacology* 50: 119–130
- Stepp, R. (2004) 'The role of weeds as sources of pharmaceuticals', *Journal of Ethnopharmacology* 92: 163–166
- Stevens, A. and Milne, R. (1997) 'The effectiveness revolution and public health', in G. Scalley (ed) *Progress in Public Health*, Royal Society of Medicine Press, London, pp197–225
- Tagboto, S. and Townson, S. (2001) 'Antiparasitic properties of medicinal plants and other naturally occurring products', *Advances in Parasitology* 50: 199–295
- Taixiang, W., Munro, A.J. and Guanjian, L. (2005) 'Chinese medical herbs for chemotherapy side effects in colorectal cancer patients', *The Cochrane Database of Systematic Reviews*, issue 1, art. no. 4540, 1–21
- ten Kate, K. and Laird, S.A. (1999) *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit Sharing*, Earthscan, London
- United Nations (2006) *International Migration and the Achievement of MDGs in Africa*, United Nations Secretariat, Turin
- van de Kop, P., Ghayur, A. and de Steenhuijsen Pijters, B. (2006) 'Developing a sustainable medicinal-plant chain in India: Linking people, markets and values', in R. Ruben, M. Slingerland and H. Nijhoff (eds) *Agro-food Chains and Networks for Development*, Springer, The Hague, pp191–202
- van Rooyen, M., Kruger, H.S., Huisman, H.W., Wissing, M.P., Margetts, B.M. and Venter, C.S. (2000) 'An epidemiological study of hypertension and its determinants in a population in transition: The THUSA study', *Journal of Human Hypertension* 14: 779–787
- van Vuuren, D.P., Sala, O.E. and Pereira, H.M. (2006) 'The future of vascular plant diversity under four global scenarios', *Ecology and Society* 11(2): 25
- Wahlberg, A. (2006) 'Bio-politics and the promotion of traditional herbal medicine in Vietnam', *Health* 10: 123–147
- Walter, K.S. and Gillet, H.J. (1998) *The 1997 IUCN Red List of Threatened Plants*, compiled by the World Conservation Monitoring Centre, IUCN, Gland, Switzerland
- Wibulpolprasert, S. and Pengpaibon, P. (2003) 'Integrated strategies to tackle the inequitable distribution of doctors in Thailand: Four decades of experience', *Human Resources for Health* 1: 12 [abstract only]

62 HUMAN HEALTH AND FORESTS

- WHO (1996) World Health Organization Fact Sheet No. 134, www.who.int/intfs/en/fact134.html
- WHO (2002) 'Traditional medicine strategy 2002–2005', www.who.int/medicines/library/trm/trm_strat_eng.pdf
- Yang, X.X., Hu, Z.P., Duan, W., Zju, Y.Z. and Zhou, S.F. (2006) 'Drug-herb interactions: Eliminating toxicity with hard drug design', *Current Pharmaceutical Design* 12(35): 4649–4664
- Zhang, Q-Y. and He, X-J. (2002) 'Conservation of rare and endangered plants in Sichuan', *Journal of Wuhan Botanical Research* 20: 387–394 [in Chinese]
- Zhao, Z. (2004) *An Illustrated Chinese Materia Medica in Hong Kong*, Chun Hwa Book Company, Hong Kong