Chapter 12

The Health Paradigm and Protected Areas: Linkages Between People and Their Livelihoods, Ecosystems and Natural Communities, and Health and Disease[1]

Michael D. Kock, WCS, Field Veterinary Program,
UC-Davis Wildlife Health Center Affiliate, Western Cape, RSA

Introduction – population and poverty

Issues at the interface between wild lands and people will become more critical as the world's population is expected to increase from 6.1 billion people in 2000 to 8.9 billion by the year 2050 (United Nations Population Information Network 2003). Population growth will place ever-increasing pressure on the world's natural resources and ecosystem services, as demand continues to grow for adequate nutrition and clean water, health care for all, and overall improvements in human livelihoods and well-being (Millennium Ecosystem Assessment 2003).

Poverty is probably the single most important constraint to development and protection of the environment in Africa. Over 24% of the world's poor who live below US $1 per day reside in sub-Saharan Africa. These individuals and families will through necessity prioritize their lives with regard to the following factors in descending order of importance:

- Food on the table
- Health
- Good social relations
- Promotion of culturally appropriate rural livelihoods, including livestock-keeping
- Desire for stability and security
- Environmental concerns

Environmental concerns will remain a luxury for the world's poor whilst poverty remains an issue, and protected areas in Africa will come under increasing pressure from illegal activities, livestock production, and political as well as socioeconomic pressures (Osofsky 1997, Millennium Ecosystem Assessment 2003, Kock and Kock 2003). Poverty is an integral part of the health paradigm: poverty leads to ill health, poor productivity, and little desire to address environmental issues. The key is to link poverty reduction to improved health of people and their livestock through the promotion of healthier ecosystems that include the wildlife that lives within these systems.

In balancing the needs and expectations of Africa's rural inhabitants with those of conservationists, it is necessary to consider how disease interactions influence human, livestock, and wildlife health (WCS 2003a, WCS 2003b, Kalema-Zikusoka 2005, Kock 2005, Bengis 2005) while keeping in mind that the role of wildlife health in conservation goes beyond the presence or absence of disease (Mainka 2001, Deem *et al*. 2001). Wildlife health, in the broadest sense, is a holistic concept with a focus on populations and the environments in which they live. This focus must of course include human populations and livelihood needs, especially at the wildlife/livestock interface. While some caution is merited to prevent making too simplistic a linkage between "ecosystem health" and "human health," potentially at the expense of wildlife and conservation funding (Osofsky *et al*. 2000), it is clear in Africa that a paradigm shift is needed. Health is the key linkage that can contribute to human well-being and, therefore, promote environmental stewardship and healthy ecosystems (Margoluis *et al*. 2001).

This paper will:

- Promote an ecosystem-based approach to health and disease issues;
- Argue that the biomedical professions have powerful tools that can assist other conservation practitioners in evaluating dysfunction in ecosystems;
- Emphasize that health and disease, in their broadest sense, are important issues in protected-area management and conservation practice; and
- Stress that healthy ecosystems contribute to sustainable development and human well-being and provide a *diverse* resource base that can be utilized on a sustainable basis to address poverty.

Epidemiology and disease control – the classic approach

In many instances, both historically and currently in Africa (Kock *et al*. 2002), disease control methods that have been adopted by veterinary and health authorities have been drastic, have had a significant negative impact on ecosystem health and biodiversity, and have rarely considered the broader issues surrounding and influencing health. Classic disease control methods include vaccination, test and slaughter, blanket slaughter, vector control, and movement

[1] See abstract on p.xxv.

controls including fencing. It is the latter that requires "out-of-the-box" thinking by traditional veterinary and animal health authorities. The indiscriminate use of fencing to control disease transmission between livestock and wildlife without considering connectivity and vital linkages between ecosystems is a cause for concern (Albertson 1998, Keene-Young 1999, Scott Wilson and EDG 2000, Thomson *et al*. 2003, Kock *et al*. 2002, Martin 2005). Addressing disease issues should be an integral part of protected-area planning and management and should involve veterinary and health authorities. This is crucial as the impact of emerging and re-emerging diseases on the health of people, their livestock, and wildlife is likely to constrain the maintenance and development of protected areas and compromise conservation initiatives into the future. The potential for spread of bovine tuberculosis (BTB) from Kruger National Park (NP) to surrounding human communities (Michel 2005) is a case in point.

Infectious and noninfectious diseases are increasingly being recognized as important "emerging issues" by health specialists, disease ecologists, conservation biologists, wildlife managers, and protected area planners (Meffe 1999, Deem *et al*. 2001, Lafferty and Gerber 2002, Aguirre *et al*. 2002, Daszak and Cunningham 2002, Graczyk 2002, WCS 2003b, Kalema-Zikusoka 2005, World Parks Congress Outputs 2003). There are numerous examples of emerging diseases that are impacting on human health and biodiversity. For example, from 2001 to 2003 the Ebola virus killed dozens of people and wiped out hundreds of gorillas in central Africa (WCS 2003a); West Nile virus has afflicted a wide range of domestic and wild animals and people in North America; the deadly severe acute respiratory syndrome (SARS) virus that affected people worldwide is potentially epidemiologically linked to wild species in markets in China; BTB has been reported in buffalo, lion, and other species in Kruger NP (Clifton-Hadley *et al*. 2001, Bengis 2005, Michel 2005); brucellosis is compromising bison populations in North America (Bienen 2002, Gillin *et al*. 2002); and foot and mouth disease outbreaks in southern Africa have affected livestock and wildlife (Thomson *et al*. 2003). It is clear from these examples that the issues of health and disease need to be brought into the conservation mainstream (Deem *et al*. 2001, WCS 2003a).

Livestock and natural resources in Africa – subsistence and poverty

There are over 77 million cattle in Africa (Kock 2005), and they represent a key factor in rural livelihoods and human well-being, disease control strategies, and the future health of ecosystems and the services they provide. It is a concern that large donors' attempts to reduce poverty in Africa often focus on livestock production (Perry *et al*. 2003, DFID 2002) at the expense of wildlife and natural resources and with little consideration for alternative land-use options. Livestock production is both unsustainable (without subsidies) and a poor land-use option in many semi-arid areas of the continent (Barnes *et al*. 2003, R.B. Martin personal communication 2003, Child 1995). This focus on "livestock as livelihood" is reflected in the funding allocated by many governments, trusts, foundations, and nongovernmental organizations. The negative impacts of subsidized livestock production on ecosystem health benefit nobody. The continued dependence on livestock in semi-arid areas of Africa is likely to keep rural people poor. What is needed to reduce poverty, lift rural communities beyond subsistence living, and promote environmental stewardship is a diversification of rural livelihoods to include both sustainable livestock production and natural resources management, as well as support for existing indigenous systems such as pastoralism (Kock 2005, Grahn and Leyland 2005).

Protected area management – aquatic and terrestrial areas

Historically, protected areas in Africa have been managed without due concern for the communities that live close to these areas. This "hard edge" approach has done little to foster support for conservation and environmental issues, and this legacy can be seen in the lukewarm response that the wildlife industry receives from politicians and other decision-makers in many parts of postcolonial Africa. In southern Africa, the adoption of community-based approaches to resource management, such as CAMPFIRE (Communal Areas Management Program For Indigenous Resources), softened the hard edge and allowed communities to benefit from protected areas, be they national parks, game reserves, safari areas, or private conservation initiatives (Child 1995). Community-Based Natural Resource Management (CBNRM) programs continue to be developed and evaluated in southern Africa (Murphree 2000, DFID 2002, Weaver and Skyer 2005, D. Cumming, personal communication 2004, Murphree 2005, Lewis 2005).

In the 21st century, management of protected areas needs to go beyond just concern for improved relationships with communities through benefits such as cash returns related to CBNRM. It must consider the health of the overall ecosystem, including people, their livestock, and the flora and fauna that are part of the larger community. Additionally, management of a protected area and the communities that are terrestrially based must consider their activities in terms of their impacts on adjacent water bodies, including marine-protected areas. Runoff from land can carry undesirable contaminants and pathogens into marine and freshwater environments with potentially negative impacts on biodiversity (Miller *et al*. 2002, Lafferty and Gerber 2002, Daszak and Cunningham 2002).

The health paradigm: What is health? What is an ecosystem?

Human well-being and progress towards sustainable development are vitally dependent upon improving the management of the earth's ecosystems to ensure conservation and sustainable use (Millennium Ecosystem Assessment 2003). The World Health Organization (WHO) defines health as a state of complete physical, mental, and social well-being and not just the absence of disease and infirmity (Deem *et al*. 2001, Last 1983). Within the broader context of health, this is very much a human-focused definition and cannot be applied to wildlife or ecosystems. An ecosystem is a dynamic complex of plant, animal, and micro-organism communities and the nonliving environment interacting as a functional unit (Millennium Ecosystem Assessment 2003). People and their livelihoods are an integral part of ecosystems. Ecosystems of course vary enormously in size and composition, from a small city park to a forested basin extending over several thousand square kilometres.

An ecosystem should be viewed as a patient (Rapport 1998) and can be evaluated in terms of objective standards that relate to the system's capacity for organization, vigour, and resilience. Ecosystem *services* are the benefits people and animals obtain from ecosystems and are vital to ecosystem stability. The state of health of an ecosystem can be judged by criteria very similar to those for a person or animal, namely:

- Homeostasis (having balance between system components)
- Absence of disease
- Diversity and complexity
- Stability and resiliency
- Vigour and scope for growth

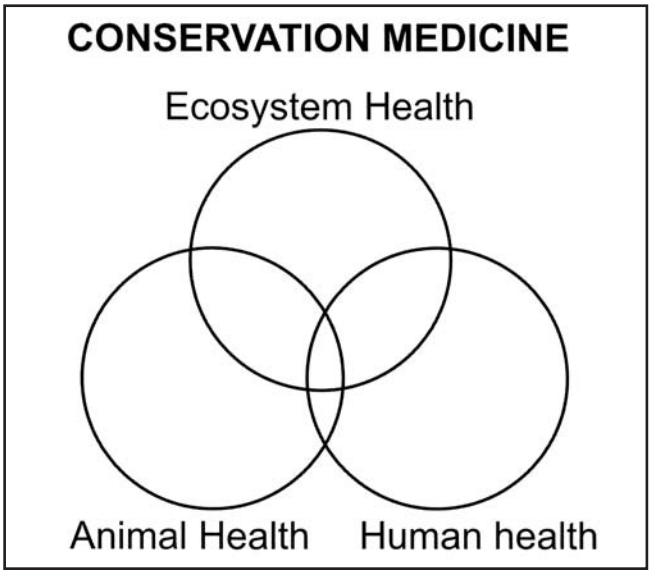
Widespread social inequities, ecological dysfunction, and climate instability are all contributing to the emergence, resurgence, and redistribution of infectious diseases on a global scale (Epstein 1998); therefore, there is an increasing need for a transdisciplinary approach to examining ecosystem health and to developing ways to assess health more broadly and objectively.

Just as conservation practitioners without a health background need to understand that health matters when considering biodiversity and protected area planning, so should veterinary and other health authorities recognize that ecosystems and their services are important and that many rural people rely on natural resources for a living.

Conservation medicine, ecosystem health, and preventive medicine

The concept of "one health" and the interface between veterinary medicine, human medicine, and public health is not a new concept. During the 1960s and 1970s visionary attempts were made to construct a bridge between medicine and agriculture by veterinarians such as Professor Calvin Schwabe. Discussions on medical ecology and zoology, animal monitors of the environment, and comparative biology and medicine were the precursors to a more holistic approach to animal and human health (Schwabe 1984). This concept has been further developed through programs such as Envirovet (Beasley 1993) and the development of ecosystem health as an integrative science (Rapport *et al*. 1998).

Fig. 1. Conservation medicine is at the nexus of the fields of human health, animal health, and ecosystem health.



Reprinted with permission from Tabor 2002.

The "one health" concept takes *conservation medicine* a step further by including a broader socioecological definition of health (Kock 1996); and conservation medicine's primary goal is the pursuit of ecological health – the health of ecosystems and the species that live within these systems (Fig. 1) (Else and Pokras 2002, Tabor 2002). Conservation medicine attempts to bring together many disciplines, including human and public health, epidemiology, veterinary medicine, toxicology, ecology, and conservation biology (Meffe 1999). Adopting an ecosystem approach to health issues related to protected areas and the communities that live close to or in these areas represents an attempt to bridge the gaps that exist between the different disciplines and create an enabling environment for a win-win situation. Conservation medicine encourages practitioners to look upstream as well as downstream, e.g., for potential environmental impacts of land uses and activities (Tabor 2002). Powerful biomedical tools are available to address these complex issues and develop preventive approaches.

Biodiversity and health assessment

Just as the conservation importance of an area is typically determined by assessing its biodiversity (Sutherland 2000), so can veterinarians and conservation biologists apply similar techniques using biomedical tools to assess the health of the area and all its components (Rapport 1998). The "ecosystem as patient" metaphor can also help shape our overall approach: "Critical clinical problems mandate a rigorous

diagnostic plan, a multifaceted therapeutic plan, clear communication, and short- as well as long-term monitoring. Critical conservation problems deserve no less." (Osofsky 1997). Biodiversity assessment is essential with any conservation planning effort: if you do not know what you have, how can you determine what has been lost and identify any problems? Without baseline data on species present and their abundance it would be difficult to develop conservation priorities. Fig. 2 outlines a logical approach for organizing conservation work. The health paradigm fits neatly into this schematic because just as biodiversity needs to be assessed, so does the health status of the living components of the system, e.g., the presence or absence of disease (Fig. 3). Identification and diagnosis of problems and the application of solutions along with biodiversity assessment and monitoring is similar to the approach to ecosystem health care. In biomedical terms this would be achieved through detection, diagnosis, prognosis, treatment, and prevention. In the case of ecosystem health, the precautionary principle is supportive of an approach based on the tenets of preventive medicine – anticipatory action to protect the environment from possible or irreversible harm (Calver 2000). A preventive medicine approach allows for action to be taken without a causal relationship being proved but only suspected, thus lessening the risks of uncertainty.

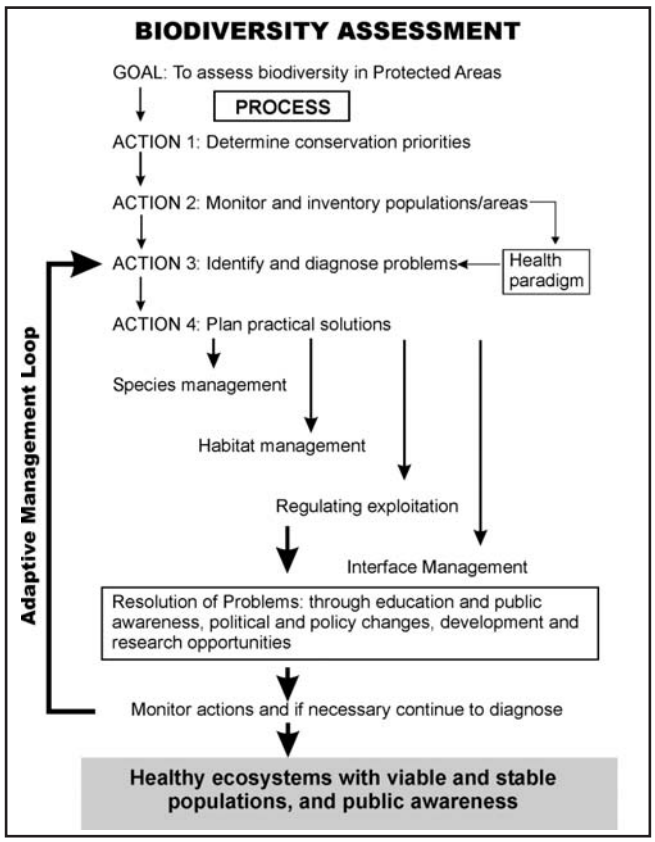
Biomedical tools and ecological condition monitoring

Ecosystems provide vital services to human and animal communities, e.g., by providing natural filtering systems, sources of food and fibre, and water (Rapport 1998). Disruption of some of these natural services will have impacts on air, water, and other renewable resources and thus health. Pathogen pollution in water systems can be attributed in some instances to the disappearance of natural filtering systems such as marshes and swamps (Miller *et al*. 2002).

Ecosystems are constantly in a state of flux related to land ownership and management, water and air quality, plant and animal diversity, threatened and endangered species, exotic and invasive species, and human recreation. An adaptive approach to monitoring needs to be adopted to deal with these uncertainties and changes (Figs. 2 and 3) (Sutherland 2000, Salafsky *et al*. 2001).

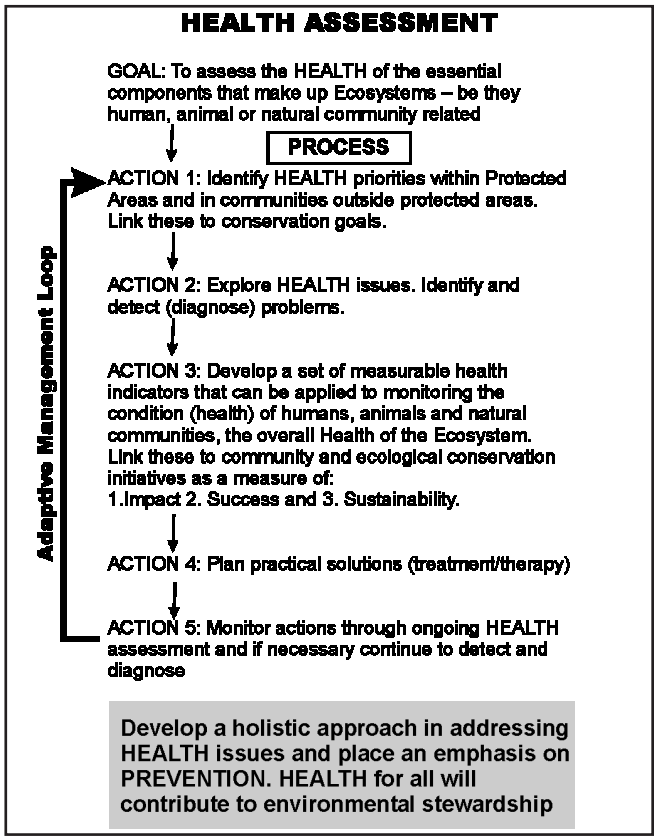
The development of ecological indicators can provide powerful tools that can generate scientific information on the status or trends of important ecosystem health parameters (Sayre *et al*. 2000). In parallel, epidemiological tools such as disease surveillance and monitoring can be linked to various indicators in terms of disease and health impacts. The use of indicators will help simplify data for decisionmakers and provide a focal point for strategic planning, policy formulation, resource allocation, and specific management actions (Boyce 2003).

Fig. 2. Logical process for organizing conservation work



Reprinted with permission from Sutherland 2000.

Fig. 3. Logic for health assessment of an ecosystem



Adapted with permission from Sutherland 2000.

Boyce (2003) describes a conceptual model that demonstrates how and why indicators are useful. The model assumes a causal relationship between the following factors:

- Stresses placed on the environment by people or natural causes (*pressures*)
- Changes in the state or condition of the environment (*state*)
- Changes in ecological health caused by changes in environmental conditions (*effects*)
- Actions taken by authorities and stakeholders (*responses)*

For example, the introduction of an exotic and invasive plant species such as Port Jackson (*Acacia saligna*) into the Western Cape of South Africa exerts *pressures* on the environment. These pressures alter the *state* or condition of the environment, such as impacting on the water table. The change in the water table has adverse *effects* on native species by reducing water availability. Government and managers *respond* by implementing a "Working for Water Campaign" with removal of invasive species.

The following is a conceptual and hypothetical presentation of a set of ecosystem health issues (ecosystems being wild *and* human derived) and ecological and health indicators that might be used to address the issues (detect, diagnose, and treat/prevent) and monitor them.

Tuberculosis and human immunodeficiency virus/ acquired immune deficiency syndrome (HIV/AIDS) in the greater Kruger NP area: Unhealthy ecosystem because of introduction of BTB (*Mycobacterium bovis*) into buffalo, negative impact on other species, especially predators, and potential for spread to immunocompromised individuals living in human communities bordering the Park.

Desired Conditions

- Intact ecological processes and biological diversity within the park, i.e., healthy ecosystems
- Freedom from BTB or reduced prevalence of the disease (assuming chronic state)
- Reduced prevalence of HIV infection in the human communities and absence of BTB in both people and their livestock

Stressors

- Chronic BTB infection in buffalo, continued spread of the disease, and spill over into other species within the ecosystem and beyond
- Drought and other environmental stressors; focal water points
- Increasing human population around the Kruger NP
- Attitude – lack of knowledge on the means to prevent HIV-AIDS
- High HIV prevalence and full-blown AIDS cases: immunocompromised individuals
- Increasing opportunities for human-buffalo contact through illegal activities or infection of cattle through buffalo contact or drought-induced incursions by cattle into the Park

Indicators

- Abundance of buffalo
- Distribution of buffalo
- Survivorship of adult buffalo
- Cause-specific mortality in buffalo
- Presence or absence of disease in live buffalo (BTB testing using skin test and/or blood test)
- Abundance of lion
- Distribution of lion
- Survivorship of adult lion
- Cause-specific mortality in lion
- Survivorship of people bordering the Park
- Cause-specific mortality in the human community bordering the Park (AIDS-related diseases)
- Response to educational programs, e.g., use of condoms
- HIV prevalence in local communities
- Detection and/or monitoring of BTB either in human communities or their livestock, or both

The use of an ecosystem health paradigm with ecological and health indicators would provide for an integrated approach to the issues affecting both human and animal communities living within the greater Kruger NP/Great Limpopo Transfrontier Conservation Area (involving South Africa, Mozambique, and Zimbabwe). This holistic approach should also result in improved public relations and attitudes towards park management programs and broader environmental issues.

The health umbrella

In 1933, Aldo Leopold (Leopold 1933) stated, "The role of disease in wildlife conservation has probably been radically underestimated." Despite this recognition early in the 20th century, conservation efforts worldwide are still being hampered because of a critical flaw in the overall approach: the failure to recognize the critical role that health plays in animal population dynamics, species survival, and the follow-on impacts on the human condition. Improving the health of people and their domestic animals is not only a key step to raising living standards and livelihood security, it is the single most effective way to reduce the incidence of disease transmission to highly susceptible wildlife populations (WCS 2003c).

Recognition of the "ecological" context of health has been significantly boosted by the World Parks Congress "Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/ Livestock Interface: Implications for Wildlife, Livestock, and Human Health," held in Durban, South Africa, in 2003. An official output from the Congress was an "Emerging Issues" declaration, and within the "Building Broader Support for Protected Areas" stream, the issue of "Disease and Protected Area Management" was recognized as one of the key emerging

issues requiring attention (World Parks Congress Outputs 2003).

The World Parks Congress has acknowledged the "one health" paradigm and how this interfaces with protected areas, as well as how healthy ecosystems can contribute to sustainable development and human well-being. People, their animals, and the flora and wild fauna on planet Earth totally depend on a flow of services that are provided by healthy ecosystems; unhealthy ecosystems are by definition more likely to harbour pathogens, pollutants, and toxins. Broader support for protected areas through application of the health sciences, with their clear link to human well-being, will provide impetus for enhancing conservation success and the sustainability of these areas in a turbulent, ever-changing world.

References

Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice.* New York, USA: Oxford University Press; 2002. 407pp.

Albertson A. *Northern Botswana veterinary fences: critical ecological impacts*. Maun, Botswana: Okavango Peoples Wildlife Trust; 1998. Accessed March 2004 at http://www.stud.ntnu.no/~skjetnep/owls/fences/index.html#impact

Barnes J, Boyd C, Cannon J. 2003. Economic incentives for rangeland management in northern Botswana: implications for biodiversity. *Proceedings VIIth International Rangelands Congress*. Durban, South Africa, 26 July–1 August: pp.203–212.

Beasley V. Ecotoxicology and ecosystem health: roles for veterinarians; goals of the Envirovet program. *J Am Vet Med Assoc.* 1993;203:617–628.

Bengis RG. Transfrontier conservation area initiatives in sub-Saharan Africa: some animal health challenges. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Bienen L. 2002. Conservation corridors and the spread of infectious disease. *Conserv Pract*. 2002;3:11–17.

Boyce W. *Ecological Monitoring in the Anza Borrego/Cuyamaca Region.* Report prepared for California State Parks. Davis, California, USA: Wildlife Health Center, University of California; 2003.

Calver MC. Lessons from preventive medicine for the precautionary principle and ecosystem health. *Ecosystem Health*. 2000;6:99–107.

Child G. *Wildlife and People: the Zimbabwean Success*. Harare, Zimbabwe, and New York: Wisdom Foundation; 1995.

Clifton-Hadley RS, Sauter-Louis CM, Lugton IW, Jackson R, Durr PA, Wilesmith JW. *Mycobacterium bovis* infections. In: Williams ES, Barker IK (eds). *Infectious Diseases of Wild Mammals*. 3rd ed. London, UK: Manson Publishing/The Veterinary Press; 2001. pp.340–371.

Daszak P, Cunningham AA. Emerging infectious diseases: a key role for conservation medicine. In: Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice.* New York, USA: Oxford University Press; 2002. pp.40–61.

Deem SL, Karesh WB, Weisman W. Putting theory into practice: wildlife health in conservation. *Conserv Biol.* 2001;15:1224–1233.

Department For International Development (DFID). *Wildlife and Poverty Study*. Report prepared by the Livestock and Wildlife Advisory Group, DFID's Rural Livelihoods Department. London, UK: DFID; 2002. 80pp.

Else, JG, Pokras MA. Introduction. In: Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice.* New York, USA: Oxford University Press; 2002. pp.3–7.

Epstein PR. Integrating health surveillance and environmental monitoring. In: Rapport D, Costanza R, Epstein PR, Gaudet C, Levins R (eds). *Ecosystem Health*. Oxford, UK: Blackwell Science; 1998. pp.154–177.

Gillin CM, Tabor GM, Aguirre AA. Ecological health and wildlife disease management in national parks. In: Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice.* New York, USA: Oxford University Press; 2002. pp.253–264.

Graczyk TK. Zoonotic infections and conservation. In: Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice*. New York, USA: Oxford University Press; 2002. pp.220–228.

Grahn R, Leyland T. Complementarity between community-based animal health delivery systems and community-based wildlife management? An analysis of experiences linking animal health to conflict management in pastoralist areas of the Horn of Africa. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L,

Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Kalema-Zikusoka G. Protected areas, human livelihoods and healthy animals: ideas for improvements in conservation and development interventions. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Keene-Young R. A thin line: Botswana's cattle fences. *Afr Environ Wildl.* 1999;7:71–79.

Kock MD. Wildlife, people and development: veterinary contributions to wildlife health and resource management in Africa. *Trop Anim Health Prod.* 1996;28:68–80.

Kock MD, Mullins GR, Perkins JS. Wildlife health, ecosystems, and rural livelihoods in Botswana. In: Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice*. New York, USA: Oxford University Press; 2002. pp.265–275.

Kock MD, Kock RA. Softly, softly: veterinarians and conservation practitioners working in the developing world. *J Zoo Wildl Med.* 2003;34:1–2.

Kock RA. What is this infamous "wildlife/livestock disease interface?" A review of current knowledge for the African continent. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Lafferty KD, Gerber LR. Good medicine for conservation biology: the intersection of epidemiology and conservation theory. *Conserv Biol.* 2002;16:593–604.

Last JM. *A Dictionary of Epidemiology*. New York: Oxford University Press; 1983.

Leopold A. *Game Management*. New York, USA: Charles Scribner's Sons; 1933. Reprinted: Madison, USA: University of Wisconsin Press; 1986.

Lewis D. Synergies between animal husbandry and wildlife conservation: perspectives from Zambia. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Mainka SA. The veterinarian's role in biodiversity conservation. *J Zoo Wildl Med.* 2001;32:165–167.

Margoluis R, Myers S, Allen J, Roca J, Melnyk M, Swanson J. *An Ounce of Prevention: Making the Link Between Health and Conservation*. Biodiversity Support Program; Washington, DC, USA: World Wildlife Fund; 2001. 58pp.

Martin RB. The influence of veterinary control fences on certain wild large mammal species in the Caprivi, Namibia. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Meffe GK. Conservation medicine. *Conserv Biol.* 1999;13:953–954.

Michel AL. Tuberculosis – what makes it a significant player at the wildlife/livestock/human interface? In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Millennium Ecosystem Assessment. *Summary. Ecosystems and Human Well-being: a Framework for Assessment.* 2003. 25pp. Accessed March 2004 at http://www.millenniumassessment.org/en/products

Miller MA, Gardiner IA, Kreuder C, Paradies DM, Worcester KR, Jessup DA, Dodd E, Harris MD, Ames JA, Packham AE, Conrad PA. Coastal freshwater runoff is a risk factor

for *Toxoplasma gondii* infection of southern sea otters (*Enhydra lutris nereis*). *Int J Parasitol.* 2002; 32:997–1006.

Murphree MW. Community-based conservation: old ways, new myths and enduring challenges. *Proceedings of the Conference on African Wildlife Management in the New Millennium*, 13–15 December 2000. Mweka, Tanzania: College of African Wildlife Management; 2000. 16pp.

Murphree M. "Counting sheep": the comparative advantages of wildlife and livestock – a community perspective. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East Africa Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Osofsky SA. Think link: critically evaluating linkages between conservation projects and development. *J Zoo Wildl Med.* 1997;28(2):141–143.

Osofsky SA, Karesh WB, Deem SL. Conservation medicine: a veterinary perspective. *Conserv Biol*. 2000;14:336–337.

Perry BD, Randolph TF, Ashley S, Chimedza R, Forman T, Morrison J, Poulton C, Sibanda L, Stevens C, Tebele N, Yngstrom I. *The Impact and Poverty Reduction Implications of Foot and Mouth Disease Control in Southern Africa, with Special Reference to Zimbabwe*. Nairobi, Kenya: International Livestock Research Institute (ILRI); 2003. 137pp.

Rapport D. Defining ecosystem health. In: Rapport D, Costanza R, Epstein PR, Gaudet C, Levins R (eds). *Ecosystem Health*. Oxford, UK: Blackwell Science; 1998. pp.18–33.

Salafsky N, Margoluis R, Redford K. *Adaptive Management: A Tool for Conservation Practitioners.* Washington, DC, USA: Biodiversity Support Program; 2001. 100pp.

Sayre R, Roca E, Sedaghatkish G, Young B, Keel S, Roca R, Sheppard S. *Nature in Focus: Rapid Ecological Assessment*. Washington, DC, USA: Island Press; 2000. 182pp.

Schwabe CW. *Veterinary Medicine and Human Health*, 3rd ed. Baltimore, USA: Williams & Wilkins; 1984. 680pp.

Scott Wilson and the Environment and Development Group (EDG). *Environmental Assessment of Veterinary Fences in Ngamiland: Summary Report*. Edinburgh and Oxford, UK: Scott Wilson and EDG; 2000. 106pp.

Sutherland WJ. *The Conservation Handbook: Research, Management and Policy*. London, UK: Blackwell Science; 2000. 278pp.

Tabor GM. Defining conservation medicine. In: Aguirre AA, Ostfeld RS, Tabor GM, House C, Pearl MC (eds). *Conservation Medicine: Ecological Health in Practice.* New York, USA: Oxford University Press; 2002. pp.8–16.

Thomson GR, Vosloo W, Bastos ADS. Foot and mouth disease in wildlife. *Virus Res.* 2003;91:145–161.

United Nations Population Information Network. *World Population Prospects: The 2002 Revision (Population Division).* 2003. Accessed March 2004 at http://www.un.org/popin/data.html.

Weaver LC, Skyer P. Conservancies: integrating wildlife land-use options into the livelihood, development and conservation strategies of Namibian communities. In: Osofsky SA, Cleaveland S, Karesh WB, Kock MD, Nyhus PJ, Starr L, Yang A (eds). *Proc. Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. AHEAD (Animal Health for the Environment And Development) Forum*. IUCN Vth World Parks Congress, Durban, South Africa, 14–15 Sep 2003. IUCN/SSC Veterinary Specialist Group, Southern Africa Sustainable Use Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 2005 (this volume).

Wildlife Conservation Society (WCS), The Field Veterinary Program (FVP). 2003a. *Animal Health Matters: Improving the Health of Wild and Domestic Animals to Enhance Long-Term Development Success in USAID-Assisted Countries.* RFA USAID/G/ENV/ENR 99–1 Technical Application Report. Wildlife Conservation Society, Bronx, New York, USA. Accessed March 2004 at http://wcs.org/sw-high_tech_tools/ wildlife healthscience/fvp/168570/168612/animalhealthmatters

Wildlife Conservation Society (WCS), The Field Veterinary Program (FVP). 2003b. *Livestock and Wildlife Health. Wildlife Health: Disease – A Growing Threat to Wildlife Conservation*. Accessed October 2004 at http://wcs.org/ sw-high_tech_tools/wildlifehealthscience/fvp/167670

Wildlife Conservation Society (WCS), The Field Veterinary Program (FVP). 2003c. *Gorilla and Human Health. Wildlife Health: Disease – A Growing Threat to Wildlife Conservation*. Accessed October 2004 at http://wcs.org/ sw-high_tech_tools/wildlifehealthscience/fvp/167670

World Parks Congress Outputs. Vth World Parks Congress Emerging Issues. 2003. Accessed December 2004 at http://www.iucn.org/themes/wcpa/wpc2003/english/outp uts/durban/eissues.htm#3