Introduction

Chapter 1 of
Section A, Overview
Book 15, Field Manual of Wildlife Diseases

Techniques and Methods 15–A1

U.S. Department of the Interior
U.S. Geological Survey

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By Milton Friend

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Section A, Overview
Book 15, Field Manual of Wildlife Diseases
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U.S. Geological Survey, U.S. Fish and Wildlife Service, and National Park Service

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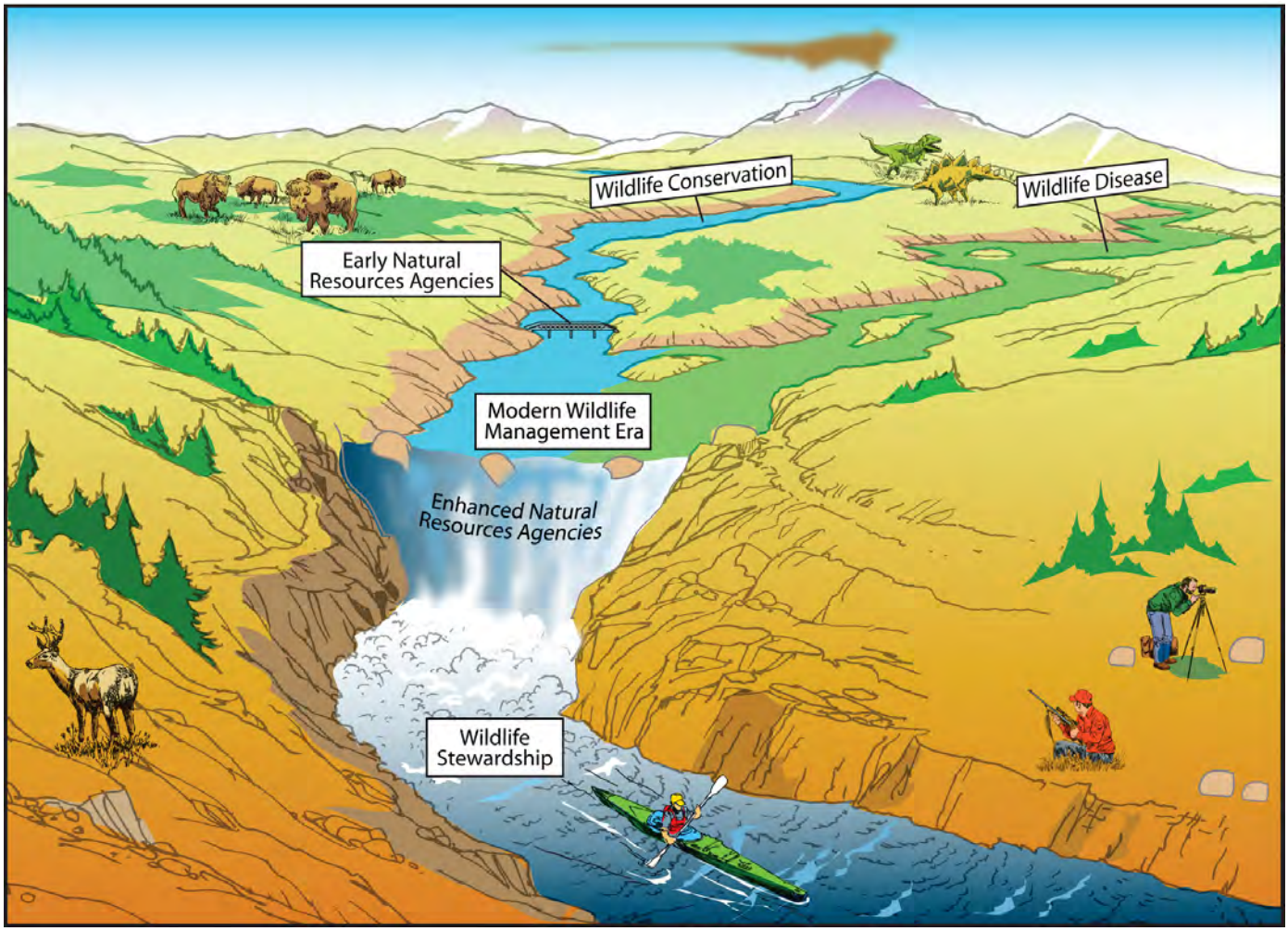
This is the third iteration of the National Wildlife Health Center's (NWHC) field guide developed primarily to assist field managers and biologists address diseases they encounter. By itself, the first iteration, "Field Guide of Wildlife Diseases: General Field Procedures and Diseases of Migratory Birds" (Friend, 1987), was simply another addition to an increasing array of North American field guides and other publications focusing on disease in free-ranging wildlife populations (table 1). Collectively, those publications were reflecting the ongoing transition in the convergence of wildlife management and wildlife disease as foundational components within the structure of wildlife conservation as a social enterprise serving the stewardship of our wildlife resources (fig. 1). For context, it is useful to consider those publications relative to a timeline of milestones involving the evolution of wildlife conservation in North America (tables 2, 3).

Table 1. Examples of wildlife disease manuals developed during the last half of the 20th century for use by the wildlife conservation community.

Title	Author(s) and date of first publication	Description
Disease of Wildlife in Wyoming	Honess and Winter, 1956	This 279-page publication of the Wyoming Game and Fish Commission was the first such publication encountered during my career and has remained on my bookshelf since then. Parasites are the primary pathogens addressed. The second edition (1982) reflects the expanded occurrence of nonparasitic infectious diseases in wildlife as evident by about one-third of the 353 pages in this larger format edition pertaining to those diseases.
Manual of Common Parasites, Disease and Anomalies of Wildlife in Ontario	Fyvie, 1964	A pocket-sized (6-by-8 inch) ring binder intended to be taken into the field. Color photographs of gross lesions are accompanied by a brief description of the disease, one to three selected references for more detailed information, and a form for documenting occurrences of each disease. An expanded second edition was published in 1969.
Manual of Common Wildlife Diseases in Colorado	Adrian, 1981	Similar size and basic content as the Ontario and Southeastern United States field manuals (see below).
Alaskan Wildlife Diseases	Dieterich, 1981	A 542-page photocopy publication with photographic inserts and a cross-reference index in an attached book jacket that identifies which diseases appear in which species. Diseases in wild birds, mammals, fish, and invertebrates are all addressed.
Handbook of Diseases of Saskatchewan Wildlife	Wobeser, 1985	Addresses causative agent, species affected, occurrence in Saskatchewan, general ecology, clinical disease, pathology, specimens for diagnosis, and general significance for wildlife. Color photographs illustrate each disease.
Field Guide to Wildlife Diseases: General Field Procedures and Diseases of Migratory Birds	Friend, 1987	A highly illustrated guide written for field biologists. Tables synopsize information. The first part of the book addresses field procedures for combating disease. The remainder of the text is disease specific and addresses synonyms, cause, species affected, geographic distribution of disease, seasonality, field signs, gross lesions, diagnosis, control, and human health considerations.
Field Manual of Wildlife Diseases in the Southeastern United States	Davidson and Nettles, 1988	Highly popular publication. Information is arranged by species and then disease. Color photographs illustrate the disease condition/parasite. Information is arranged by causative agent, clinical signs, lesions, hosts, diagnosis, ecology, wildlife management significance, and public health implications. An expanded second edition was published in 1997 and further expansion was included in the third edition published in 2006.
Field Manual of Wildlife Diseases: General Field Procedures and Diseases of Birds	Friend and Franson, 1999	An expanded revision of the 1987 field guide that incorporates additional diseases. The basic format and type of information presented is similar to the 1987 field guide; available online at http://www/nwhc.usgs.gov/.



(Illustration by John Evans)

Figure 1. Wildlife have been confronted by disease throughout their evolution; however, the convergence of disease as a factor to be addressed in wildlife conservation did not occur until the advent of modern wildlife management. Disease is now one of many increasing problems faced by natural resource agencies as they struggle to provide adequate wildlife stewardship.

Table 2. Pre-21st century United States wildlife management milestones.

[See also Friend (2012)]

Event	Date
Overexploitation and destruction by other means impoverishes much of the previously abundant natural resources in the colonies.	1620
The Division of Biological Survey (BBS) is elevated to Bureau status within the U.S. Department of Agriculture (USDA); the BBS serves as the Federal wildlife conservation agency.	1905
President Theodore Roosevelt issues the Roosevelt Conservation Doctrine; that document established the start of the modern era for wildlife conservation.	1908
American Game Policy emerges and calls for establishment of a wildlife profession.	1930
Aldo Leopold publishes "Game Management." This foundational publication provides the bedrock for wildlife management as a profession.	1933
The University of Wisconsin–Madison offers the first advanced degree program in wildlife management, with Aldo Leopold serving as the Chair of Game Management within the Department of Agricultural Economics before advancing to Chairman of a new Department of Wildlife Management in the College of Agriculture. The first graduate student enters that program in 1934.	1933
President Franklin D. Roosevelt calls for the first North American Wildlife Conference to meet in Washington, D.C., as a means "to bring together individuals, organizations, and agencies interested in the restoration and conservation of wildlife resources." The hope is that constructive proposals for concrete action would result, that through the proposals the existing State and Federal government agencies and conservation groups could engage in cooperative efforts for the common good (Silcox, 1936).	1936
The Wildlife Society and "The Journal of Wildlife Management" become components of the North American wildlife conservation movement at the second North American Wildlife Conference in St. Louis, Missouri.	1937
The Pitman-Robertson Act is passed. That act earmarks the revenue from the manufacturers' excise tax on sporting arms and ammunition to be used as allocations to the states for wildlife conservation projects.	1937
President Franklin D. Roosevelt establishes the Patuxent Research Refuge in Maryland as the first national wildlife refuge designated for research.	1939
The BBS is transferred from the USDA to the U.S. Department of the Interior, where it is merged with the Bureau of Fisheries from the Commerce Department and renamed the U.S. Fish and Wildlife Service (FWS).	1939
First Conservation Biology Conference speaker Robert May reaffirms Leopold's contention (1933) that the impacts from wildlife disease are radically underestimated.	1986

Table 3. Pre-21st century wildlife disease milestones.

[See also Friend (2012)]

Event	Date
An undiagnosed mass dieoff of pelicans occurs in the West Indies: first record of a wildlife epizootic in the Americas.	1656
Rabies is common in dogs on the East Coast of America; a 1785 epizootic involves wolves and other wildlife carnivores; the disease is first diagnosed on the West Coast in the 1860s.	1750s
Plague in wild rodents appears in America; the first laboratory-confirmed diagnosis of tularemia in wildlife follows in 1914.	1908
Collaborative investigations by the California Department of Fish and Game and the University of California into the cause of Western duck disease are initiated; similar investigations by the Bureau of Biological Survey (BBS) follow. California investigations lead to development of the Department of Fish and Game Wildlife Investigations Laboratory; the BBS investigations lead to the establishment of the Bear River Wildlife Disease Laboratory at the Bear River National Wildlife Refuge (NWR) in Utah.	1913
Type C avian botulism is found to be the cause of Western duck disease.	1930
The Michigan Department of Conservation Wildlife Disease Laboratory is established.	1933
The New York Conservation Department hires a wildlife research pathologist to provide diagnostic services for the agency and serve the needs of its new experimental game farm.	1933
The Wisconsin Conservation Department hires its first Game Division pathologist to provide support for the Department's fur and game-breeding activities; position terminated at the start of the 1960s.	1934
President Franklin D. Roosevelt includes a wildlife disease laboratory as a component of the Patuxent Research Refuge in Maryland; the primary mission of the laboratory is to provide a scientific basis for evaluating disease transfer between wildlife and livestock on grazing lands and between wildlife and humans.	1939
Avian cholera epizootics in wild waterfowl are first documented in California and Texas, despite the presence of this disease in chickens in America since the 1700s.	1944
The Wildlife Disease Association (WDA) is organized as the first professional society for advancing and sharing knowledge about disease in free-ranging wildlife.	1951
The Wyoming Fish and Game Department establishes the Sybille Wildlife Research Station as a research facility for the development of wildlife management techniques and wildlife disease investigations.	1952
Outbreaks of hemorrhagic disease in deer during the 1950s stimulate the development of the Southeastern Cooperative Wildlife Disease Study (SCWDS) as the United States' first regional wildlife disease program.	1957
Congressional legislation to create a Federal national wildlife disease center at a Land Grant university fails to be acted upon due to lack of support as a needed program.	1960

Table 3. Pre-21st century wildlife disease milestones.—Continued.

[See also Friend (2012)]

Event	Date
Rachel Carson publishes "Silent Spring." Growing environmental concerns involving pesticide use push wildlife agencies away from diseases caused by microbes to the study of synthetic chemicals being deposited in the environment.	1962
The WDA transforms the "Bulletin of Wildlife Diseases" into "The Journal of Wildlife Disease"—the first scientific journal devoted exclusively to sharing research findings and other information about wildlife diseases.	1965
The Smithsonian Institution initiates The Center for Short-Lived Phenomena to alert subscribers of unusual ecological events (including plagues) via a postcard system; the Center existed until 1975.	1968
Duck plague kills an estimated 40,000 waterfowl wintering at the Lake Andes NWR in South Dakota, prompting FWS development of the National Wildlife Health Center (NWHC) in 1975 to enhance its internal capabilities for addressing disease in wildlife under agency stewardship.	1973
Lyme disease begins to emerge as a significant and increasing disease of concern.	1975
Raccoon rabies emerges in the Mid-Atlantic states as a major and rapidly spreading disease.	1977
Chronic wasting disease (CWD) emerges in captive cervids and is followed by the first diagnosis in wild cervids in 1981.	1978
The American Association of Wildlife Veterinarians is founded.	1979
Emerging infectious diseases (EIDs) become a global issue for humans and wildlife alike (see Friend, 2006).	1980s
The American Veterinary Medical Association initiates Board Certification in Zoo and Wildlife Animal Health.	1983
The remaining California condors in the wild are taken into captivity to protect them from lead poisoning; the birds are placed in a captive breeding program to prevent the species from becoming extinct.	1987
Persistent lead poisoning of waterfowl and bald eagles results in a national ban on the use of lead shot for waterfowl hunting in the United States; Canada completes implementation of a similar ban in 1995.	1991
The Canadian Cooperative Wildlife Health Center is founded at the School of Veterinary Medicine at the University of Saskatchewan with components of the program located at each of the other Canadian veterinary schools.	1992
Highly pathogenic H5N1 influenza virus emerges in China and triggers multiyear international mass sampling of waterfowl and other birds in North America and elsewhere.	1995
West Nile virus emerges in crows in the New York City area and begins a nationwide spread of the disease across the entire United States and into Canada.	1999

The 1951 formation of the Wildlife Disease Association (WDA) is an especially important milestone relative to the convergence of wildlife management and wildlife disease. As noted by one of those involved in that origin:

> "In 1951, 36 scientists who shared a common interest in disease of wildlife gathered at the North American Wildlife and Natural Resources Conference in Washington, D.C., and established the [WDA]. For the first time, professionals who had a common interest in diseases of wildlife were formally brought together. The growth and development of the [WDA] in subsequent years illustrates an increasing interest in the subject, but it was a slow and laborious process that did not significantly change the status of disease as an ecological factor in wildlife management" (Trainer, 1987).

It was not just the wildlife management profession that was struggling at that time with what role, if any, they had in addressing wildlife disease. In 1955, the American Veterinary Medical Association published "A Bibliography of References to Diseases of Wild Mammals and Birds," compiled by Patricia O'Connor Halloran, the staff veterinarian at the Staten Island Zoo in New York. The citations within that 465-page special edition of the "American Journal of Veterinary Research" overwhelmingly consisted of those involving research, zoo, and other animals in captivity (few other wildlife disease publications existed at that time). In the introduction for her bibliography, Halloran boldly stated:

> "For many years, popular opinion entertained the mistaken conception that wilderness areas produced a healthy lot of animals. As a matter of fact, there is no other group of animals in which disease appears so consistently and as disastrously as it does among wildlife. Every animal in nature, from the smallest and least important minnow to the largest mammal, may be affected. While it is now realized that widespread disease occurs among all species, the occurrences of individual deaths usually passes unnoticed" (Halloran, 1955).

The author's statements strongly suggested that wildlife disease was a grave issue at that time and thus an issue needing greater response. However, the journal editors' foreword for the bibliography was more moderate and suggestive of wildlife disease being an issue for future attention:

> "The value of works of this sort cannot be measured in terms of immediate or wide interest to "Research Journal" readers, but there is no question of the real and long-term value of the present work to the considerable and increasing number of veterinary and other scientists in the field of interest covered by Dr. Halloran's bibliography of references" (Halloran, 1955).

My personal entry into the conservation field as a field biologist (with minimal academic training) the year after publication of Halloran's bibliography was not accompanied by my having any major concerns about wildlife disease. Avian botulism, lead poisoning, and leucocytozoonosis in waterfowl, distemper in raccoons, and mange in foxes were the major "wildlife diseases" I was aware of, along with wildlife contributions to several "public health diseases" such as rabies, tularemia, and trichinosis. Over time, greater awareness increased the number of diseases I became familiar with. Nevertheless, it was not until about a decade after my entry into the wildlife conservation field that declining population numbers for some familiar wildlife species and obvious habitat losses associated with human population pressures caused personal concern about wildlife resiliency. Specifically, that concern began to focus on the sustainability of already decreased wildlife population levels in the face of habitat loss and other challenges, including disease. Clearly, human population pressures and conversion of wildlife habitat to serve human interests would continue. Therefore, my attention turned to what appeared to be increasing wildlife losses from disease. This seemed to be an important focus for conserving desired wildlife population levels.

The implied future by the editor for Halloran's 1955 bibliographic publication arrived (in part) in the form of a series of books on diseases of free-ranging wildlife published during 1970 and 1971 by Davis and others that "…provided the first real references for scientists working with wildlife diseases." Those books also "served as the first 'text-book' for academia and as a catalyst for the development of wildlife disease courses in universities and colleges" (Trainer, 1987). Enrollment in those courses was primarily by the new generation of wildlife biologists and natural resource managers being trained within land grant colleges and other institutions of higher learning.

From the 1970s on, an increasing number of individuals entering the wildlife conservation field within the United States has received some academic exposure to diseases of wildlife. In addition, increases in the numbers of wildlife disease events stimulated wildlife agencies to seek workshop training events for those in the front lines who deal with eruptions of wildlife disease. During my personal role in conducting numerous workshops for National Wildlife Refuge (NWR) managers, along with other interactions involving wildlife conservation personnel, it became evident that a highly illustrated, plain language, pragmatic field manual would be a useful product. Thus, publication of a "Field Guide to Wildlife Diseases: General Field Procedures and Diseases of Migratory Birds" (Friend, 1987) was undertaken. As noted in the introduction for that publication, it was intended to provide practical information on selected diseases of free-living [ranging] migratory birds and was developed specifically to assist NWR managers and other users of the NWHC.

The content and format was in response to feedback from inquiries made by NWHC of field personnel relative to what would be of most assistance to them. At that time, the focus on migratory birds was consistent with the NWHC role as a component of the U.S. Fish and Wildlife Service (FWS) dealing primarily with disease issues involving migratory birds. Fish disease was addressed by other FWS programs when the NWHC came into existence in 1975. An administrative decision was made to continue that separation of program activities as the time had not yet come for wildlife to be holistically addressed within the FWS rather than segregated into broad components such as fish and birds. Nevertheless, publication of the "Field Guide to Wildlife Diseases" (Friend, 1987) served as a catalyst for the FWS to publish the "Field Manual for the Investigation of Fish Kills" (Meyer and Barclay, 1990).

By the time a new edition of the field guide was published as the "Field Manual of Wildlife Diseases: General Field Procedures and Diseases of Birds" (Friend and Franson, 1999), reorganization within the U.S. Department of the Interior had resulted in the transfer of most of its agency science programs to the U.S. Geological Survey. The NWHC was among those transferred. The continued focus on migratory birds in the 1999 field manual reflected needed updates and expansion of coverage for that subject area. Those needs are seen in the increase of chapters to 51, compared with 19 in the 1987 field guide, and a resulting increase in pages from 225 to 426. The 1999 field manual is also more responsive to information needs associated with chemical and other toxins in keeping with the increasing focus at that time on environmental contaminants.

Intentions to address diseases of wild mammals and coldblooded vertebrates in additional field manuals were curtailed to address the more pressing need for considering the importance of wildlife in the ecology of emerging infectious diseases (EIDs) as well as the challenges of such diseases for the global conservation of wildlife resources. Those issues were highlighted by publication of "Disease Emergence and Resurgence: The Wildlife-Human Connection" (Friend, 2006). That similar (in part) type of publication is also responsive to a basic question posed by Professor Yuill in his foreword for the "Field Manual of Wildlife Diseases"—"DO WILDLIFE DISEASES REALLY MATTER" (Friend and Franson, 1999).

Since the latter part of the 20th century, the transition and convergence of wildlife conservation and wildlife disease is increasingly interfacing with the challenges EIDs are posing for human and domestic animal health. It does not currently seem plausible that an objective evaluation of wildlife disease would conclude other than that, in general, wildlife diseases really do matter. Yet a major disconnect remains for many within the wildlife conservation community relative to why they need to be involved in addressing such issues. For others within that community, a primary question is why are they not more involved in managing disease in the species for which they have stewardship responsibility? A recent USGS publication Circular 1401 "Why Bother About Wildlife Disease?" (Friend, 2014) is specifically devoted to that question and also offers commentary relative to the question "How Can We Do Better?"

An important focus within Circular 1401 "Why Bother About Wildlife Disease?" (Friend, 2014) that has relevance for both questions just posed is that of the double jeopardy faced by wildlife in being victims and (or) villains, depending upon the specific diseases involved. That document also highlights how changing times continue to alter the relations between humanity and nature and in doing so impact human-wildlife relations. The current era of EIDs has brought wildlife disease out of the shadows to the full illumination of center stage. That added exposure has further illuminated the connectivity between infectious diseases across host-species boundaries and has led to enhanced pursuit of a "One World—One Health" approach for addressing infectious diseases.

Emerging Infectious Diseases—What Are They?

Perhaps the earliest formal definition associated with emerging infectious diseases (EIDs) that has current relevancy is that of Dr. Stephen Morse (1995) of Rockefeller University:

> "Infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range."

The focus for that definition is disease in humans. The context involved is that during the previous three decades, humanity had been informed by leading scientists and by administrators of leading human health programs that the battle against infectious disease had essentially been won in the developed countries of the world. However, in 1981 human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) appeared in the United States, followed by several other devastating infectious diseases. Those events catalyzed a renewed focus on infectious disease as evidenced by a host of special scientific symposia and other meetings focused on infectious disease emergence, a presidential directive to address this issue, a great deal of media attention devoted to this subject, initiation of various academic training programs, and the development of specific scientific programs to combat these diseases.

Key points in the definition provided by Morse (1995) are:

1. The pathogens/diseases involved are not necessarily new in themselves (as is true for HIV/AIDS), but instead only new in recognition within areas of recent occurrence;

2. The term population does not equate to species. *Homo sapiens* is the only human species; however, within our species are discrete subpopulations that are of different ethnicity and other cohorts. Thus, an established disease that somewhat regularly appears in specific population cohorts is seen as an endemic disease (or enzootic if

animals are the affected hosts), yet when it first appears in population cohorts where it has not previously existed, it becomes an emerging disease within those cohorts.

3. Furthermore, should the frequency of disease events within the established population cohorts increase significantly, or the existing geographic range for disease occurrence begin to expand rapidly, the diseases involved become emerging or resurging.

4. While Morse's definition is limited to infectious disease, the concepts involved can also be applied to noninfectious diseases.

5. Also, it is common to include the dimension of time within the scope of EID detections to separate persistent historic diseases from those not known to have been present within more current time.

   For context here the following definition applies:

   "Diseases of living resources whose occurrence has increased within the past three decades or threatens to increase in the near future relative to populations affected, geographic distribution or magnitude of impacts."

The time frame of three decades is both arbitrary in length and consistent with providing sufficient time for social, physical, and biological environmental changes to result in ecological impacts that facilitate disease emergence.

From a wildlife conservation perspective, noninfectious diseases are of as great concern as infectious diseases. For example, avian botulism is a long-standing disease that continues to kill large numbers of free-ranging wild birds. In addition, avian botulism also continues to emerge on the basis of geographic and host range extensions (see chapter on avian botulism).

A final point is that disease emergence is an important statement of the occurrence of biological change, and timely identification of its occurrence provides the best opportunity for cost-effective, meaningful mitigation to protect the well-being of potential hosts and biological systems that could be jeopardized by the pathogen involved.

"One Health"—A Team Approach for Combatting Disease Emergence

Conceptually, the "One Health" paradigm exalts the benefits to be derived by "…a team approach with complementary expertise from animal and human health professionals, ecologists and other specialists to reduce risks from emerging infectious diseases for all species" (Landford and Nunn, 2012). The authors just cited go on to state that:

> "The concept of public governance, in which the State acquires and exercises the authority to provide and manage public goods and services, is an essential element of One Health approaches…. Cooperative approaches are important between veterinary services, human health services and other relevant government services at the interface between domestic and wild animals, ecosystems, and human populations."

In most countries, including the United States, many of the other relevant government services referred to involve the stewardship of wildlife resources by natural resource agencies whose responsibilities include the maintenance of "healthy" ecosystems and their biota. Thus, because wildlife are subjected to substantial challenges from disease, the wildlife conservation community has developed considerable expertise and program capacity for addressing disease diagnosis, ecology, and control (Thorne and others, 2005). Also, because wildlife are often the recipients of human diseases (such as great apes in Africa) and those from domestic cultured animals (such as livestock and aquaculture), it is equally important for the "One Health" team approach to enhance disease prevention and control efforts on behalf of free-ranging wildlife populations.

The "One Health" approach requires true integration of disparate perspectives and expertise that may involve nontraditional team members for addressing the challenges EIDs pose for society and wildlife conservation. Cook and others (2004) have noted that:

> "It is clear that no one discipline or sector of society has enough knowledge and resources to prevent the emergence or resurgence of diseases in today's globalized world. No one nation can reverse the patterns of habitat loss and extinction that can and do undermine the health of people and animals. Only by breaking down the barriers among agencies, individuals, specialties and sectors can we unleash the innovation and expertise needed to meet the many serious challenges to the health of people, domestic animals, and wildlife and to the integrity of ecosystems. Solving today's threats and tomorrow's problems cannot be accomplished with yesterday's approaches. We are in an era of "One World, One Health" and we must devise adaptive, forward-looking and multidisciplinary solutions to challenges that undoubtedly lie ahead."

The basic foundation for "One Health" dates back to the late 19th century and is attributed to Rudolf Virchow, a German pathologist who is credited as the architect of social medicine (Zinsstag and Weiss, 2001). An important concept advanced by Dr. Virchow is that "…disease is never purely biological, but often, socially derived" (http://en.wikipedia.org/wiki/Rudolf_Virchow, Wikipedia Foundation, Inc.). The

importance of this fact is seen by various supporting statements within the more current scientific literature on disease emergence such as that of Roizman and Hughes (1995):

> "The two key factors which affect the spread of infectious diseases in the human community other than the nature of the infectious agent are human ecology and behavior."

Within the United States, the "One Health" concept is linked to veterinary epidemiologist Calvin Schwabe, who coined the phrase "the one medicine" in his 1984 book "Veterinary Medicine and Human Health." Despite the plethora of current programs and scientific papers focused on the clinical outcomes from EIDs, it is important to consider that environment is a key factor in disease emergence, and its role is often advanced by human actions. For example, it has been recently stated as an undeniable fact that human health is intimately linked to the environment in which people live (Landford and Nunn, 2012). The situation is no different for animals.

Aldo Leopold advanced the concept of wildlife health-environment relations in his classic book "Game Management" (1933). He later commented on the failures of land doctoring taking place on behalf of conservation being due to inadequate scientific knowledge and concluded that: "The art of land-doctoring is being practiced with vigor, but the science of land health is a job for the future" (Leopold, 1941). Now that we have entered the 21st century, it has become increasingly evident that the "science of land health" is no longer a job for the future; it has become a necessity for sustaining global biodiversity and requires a team effort embracing the "One Health" concept.

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