

# Essential veterinary education in conservation medicine and ecosystem health: a global perspective

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## Summary

Conservation medicine is an emerging discipline that links human and animal health with ecosystem health and global environmental change. The biosphere is threatened by several pervasive and synergistic phenomena that are the result of increasing human pressures on the planet: climate change, biological impoverishment (loss of biodiversity and ecological processes), emerging infectious diseases ('pathogen pollution') and global 'toxification' (pollutants such as endocrine-disrupting chemicals). These factors are working in concert to diminish human, domestic animal, wildlife and environmental health on this planet. By including conservation medicine and ecosystem health into veterinary curricula worldwide we can train young veterinarians that will help change paradigms and be able to form transdisciplinary teams. These veterinary professionals will develop new tools for assessing and monitoring ecological health and will be prepared to fulfil critical roles in sustaining global ecological health.

## Keywords

Conservation medicine – Ecosystem health – Sentinel species.

## Introduction

In recent years, the term 'conservation medicine' has been used in various contexts by different scientific communities, research groups and national and international organisations. This novel approach to the protection of biological diversity challenges scientists and practitioners in the health, natural and social sciences to think about new, collaborative and transdisciplinary ways of addressing ecological health concerns in the current biodiversity crisis. Conservation medicine strives to understand health in an ecological context (identifying the environmental determinants of health) and use that understanding to develop preventive or corrective approaches and to maintain the health of all species in a sustainable fashion. Here, the authors briefly review the concepts of ecosystem health and conservation medicine

and suggest ways to incorporate them into current and future veterinary curricula at the undergraduate and postgraduate levels.

## Health and global environmental change

Large-scale anthropogenic habitat alteration and biodiversity loss have led to ecosystem disruptions that include, among other impacts, the modification of disease transmission patterns, the accumulation of toxic pollutants, and the introduction of alien species and pathogens. As the natural resilience of ecosystems is reduced and ecological barriers to disease transmission are weakened or eliminated, we will see the emergence and

redistribution of infectious diseases and other symptoms of deteriorating global health. Disease emergence is one of the major challenges of society today, and is associated with socio-economic, environmental and ecological factors (7). Of special interest to veterinarians is the fact that a significant proportion of all human emerging infectious diseases are zoonotic (7). Other global environmental alterations, such as urbanisation and climate change, have profound influences over the distribution and transmission intensity of many infectious diseases (3, 12). Biodiversity has an important role to play in protecting health and can, in some cases, act as a buffer to the transmission of infectious diseases (4, 5, 11). It is clear, therefore, that the long-term maintenance of global health requires the preservation of biodiversity and ecosystem functioning.

Because changes to the ecosystem have had an obvious effect on disease emergence and transmission, there is a growing awareness of the relationship between health and the environment. The complexity of this interconnectedness means that there is a need to develop novel strategies for disease prevention, environmental management and biodiversity conservation. For the most part, current veterinary programmes do not include specific training components to prepare graduates to be aware of these multifactorial linkages or deal with the health impacts of environmental change. Often veterinary professionals lack the skills to link ecosystem, animal, and human health issues (1, 15). As human influence over the global environment increases, the training of veterinarians in ecosystem health and conservation medicine becomes a critical priority (9, 10).

## Defining ecosystem health and conservation medicine

The concept of ecosystem health, initially termed 'ecosystem medicine', was established in the late 1970s when researchers began looking at ecosystems as patients with 'vital signs' (14). Common signs of ecosystem degradation were characterised as the 'ecosystem distress syndrome'. Although defining the concepts of ecosystem health and ecosystem medicine can be challenging, one definition is: 'a systematic approach to the preventative, diagnostic, and prognostic aspects of ecosystem management, and to the understanding of relationships between ecosystem health and human health. It seeks to understand and optimise the intrinsic capacity of an ecosystem for self-renewal while meeting reasonable human goals. It encompasses the role of societal values, attitudes and goals in shaping our conception of health at human and ecosystem scales' (2). Other definitions include a greater emphasis on biodiversity and conservation, but

all of them take a broad, ecosystem-wide view of health and disease.

Conservation medicine can be briefly defined as the practice of achieving ecological health, and should be understood as a solution-oriented approach to predicting, preventing and controlling the health implications of anthropogenic environmental change. By bringing the health sciences, ecology and conservation biology together, conservation medicine is an attempt to examine the world in an inclusive way, since health impacts affect populations and ecosystems. The central principle of this discipline is that health connects all species, because it is inextricably linked to the ecological processes that govern life on the planet (1). In response to the growing health implications of environmental degradation, researchers in conservation medicine have begun to examine linkages among:

- changes in habitat structure and land use
- emergence and re-emergence of pathogens and the effects of environmental contaminants
- maintenance of biodiversity and ecosystem function
- the effects of disease on rare or endangered species (1).

A critical aspect of conservation medicine is that it provides bridges between disciplines separated by tradition or by the lack of a common language. By creating these bridges, conservation medicine becomes transdisciplinary, that is, it transcends classical disciplinary paradigms and integrates research approaches for the creation of solutions to real-world problems (17). The authors believe that transdisciplinarity, as it applies to understanding and solving complex health problems, is a valuable intellectual approach and should be explicitly incorporated into veterinary education. By reaching out to multiple disciplines, conservation medicine provides new skills, tools and vision to the field of both conservation biology and medicine. This includes bringing biomedical research and diagnostic resources to address conservation problems, e.g. development of new non-invasive health monitoring techniques; training veterinarians, physicians, and conservation biologists in the promotion and practice of ecological health; and by establishing transdisciplinary teams of health and ecological professionals to assess and address ecological health problems (1, 15).

## Conservation medicine and ecosystem health in the veterinary curriculum

The introduction of an ecosystem-health viewpoint, which represents a fundamental shift in thinking (switching the emphasis from treatment to prevention), has been successful in some medical and veterinary colleges

(Table I) (13). Although integrating new material into the already crowded veterinary medicine curricula is a difficult task, the authors believe that all veterinarians should be made aware of basic concepts in ecosystem health, environmental change and conservation biology. They strongly believe that the veterinarians of the future will be better prepared to help solve the world's most pressing problems if they are invited to challenge paradigms for understanding health and are keenly aware of current environmental concerns. The authors suggest that health is a powerful unifying principle and that veterinarians with an ecological mindset will ask themselves: What are the broad biological, spatial and temporal scales at which costs and benefits to health accrue? They will, therefore, be better able to find sustainable solutions to health problems at local, regional and global scales.

Fortunately, veterinary education already includes training in the basic skills that can facilitate this ecosystemic approach to health. For example, veterinarians are taught to be critical thinkers that obtain information from multiple interconnected systems in order to provide a therapeutic solution to a larger whole. Veterinarians are charged with caring for the health of many species, and, in addition, they often find themselves caring for the well-being of humans (e.g. pet owners, ranch workers and

animal product consumers) at the same time as they are providing health care for individual animals. Finally, many veterinarians, including epidemiologists, those working in rural areas and those specialised in large animal medicine, frequently engage in designing environmental management strategies as part of their normal routines.

At a minimum, the authors suggest, basic issues about biodiversity loss, global climate change and drivers of disease emergence should be presented to all students during the basic science courses in the first year of veterinary training. Additional concepts dealing with the environment and biodiversity conservation can be included as part of required courses, such as those dealing with animal production and husbandry, epidemiology, physiology and pharmacology. The basic principle of considering health in an ecological framework can be included in most classes in a veterinary curriculum without the need for additional content, simply by adding a different perspective to the traditional viewpoints. For example, during a dairy cattle husbandry course, the professor can emphasise the environmental determinants of changes in health or productive output, and the environmental consequences of specific production strategies. By applying the concepts of conservation medicine and ecosystem health the student can develop a

**Table I**  
**Undergraduate, graduate and continuing education opportunities for veterinary students in conservation medicine and ecosystem health**

Institution	Programme	Website
Wildlife Trust: an international organisation of scientists dedicated to the conservation of biodiversity	International externships	<a href="http://www.wildlifetrust.org">www.wildlifetrust.org</a>
Consortium for Conservation Medicine: a collaboration between the Wildlife Trust, five American universities and the National Wildlife Health Center in the USA	International externships	<a href="http://www.conservationmedicine.org">www.conservationmedicine.org</a>
Centro Universitario Vila Velha School of Veterinary Medicine in Spirito Santo, Brazil	Conservation medicine course as part of core curriculum	<a href="http://www.uvv.br/cursos/info_curso.asp?id=9&amp;tpcurso=1">www.uvv.br/cursos/info_curso.asp?id=9&amp;tpcurso=1</a>
Faculty of Veterinary Science at the University of Liverpool, UK	Veterinary conservation medicine course	<a href="http://www.liv.ac.uk/vets/study/vcm1.htm">www.liv.ac.uk/vets/study/vcm1.htm</a>
Inger and Walter Rice Environmental Center at the Virginia Commonwealth University, Richmond, Virginia	Conservation medicine programme	<a href="http://www.vcu.edu/rice/research/research-conservation.html">www.vcu.edu/rice/research/research-conservation.html</a>
University of Georgia, Athens	Courses in conservation medicine and conservation biology	<a href="http://www.studyabroaddirectory.com/listingsp3.cfm/listing/58512">www.studyabroaddirectory.com/listingsp3.cfm/listing/58512</a>
The Wilds: a wildlife conservation centre in Cumberland, Ohio	Three-year residency programme in wildlife and conservation medicine	<a href="http://www.thewilds.org/what/conservation.asp">www.thewilds.org/what/conservation.asp</a>
The Wildlife Center of Virginia, Waynesboro, Virginia	Three-year residency in wildlife and conservation medicine	<a href="http://www.wildlifecenter.org/veterinary/index.php">www.wildlifecenter.org/veterinary/index.php</a>
Environmental Medicine Consortium at North Carolina State University College of Veterinary Medicine, Raleigh, North Carolina	Postgraduate training: internships or a zoological medicine residence with emphasis in conservation medicine, depending on the interest of the graduate veterinarian	<a href="http://www.emc.ncsu.edu/programs/conservmed/index.html">www.emc.ncsu.edu/programs/conservmed/index.html</a>
Conservation Medicine Center of Chicago	Research projects for veterinary students	<a href="http://www.luhs.org/depts/cmcc/index.htm">www.luhs.org/depts/cmcc/index.htm</a>
New England Aquarium	Veterinary internship	<a href="http://www.neaq.org/conservation_and_research/projects/conservation_medicine/index.php">www.neaq.org/conservation_and_research/projects/conservation_medicine/index.php</a>

UK: United Kingdom

USA: United States of America

more holistic approach to herd and environmental management, which can ultimately be used in ecosystem management.

In track-based programmes (programmes in which students can choose to take certain specialised courses along a particular 'track'), the authors suggest that students take at least one semester-long course in conservation biology and conservation medicine and are exposed to real-world conservation medicine research and practice, perhaps by means of internships or research theses. Elective courses such as eco-epidemiology and infectious disease ecology can be included in the last two years of the programme. Externships and extra-curricular activities are also important for the success of this kind of training. Students in these programmes should become conversant with the main issues, research approaches and scientific literature in the field of conservation medicine. The authors envision that these graduates will expand their professional practice to include work in transdisciplinary teams and in roles not traditionally occupied by veterinarians (e.g. designing environmental policy, designing and managing protected areas, predicting changes in the ecology of infectious diseases and developing mitigation plans against the health consequences of environmental change).

One of the first programmes implementing conservation medicine in the veterinary curriculum, through core teaching, elective and research opportunities, and extracurricular seminars and workshops, was established at Tufts University Veterinary School (<http://www.tufts.edu/vet/ccm/>) (8). This veterinary college has been able to create special programmes and increase collaboration with other institutions, providing their students with many national and international conservation medicine opportunities. Additionally, there are extra-curricular educational opportunities that have provided intensive training in wildlife and ecosystem health for veterinary students and other health professionals; for example, the Envirovet Summer Institute (<http://vetmed.illinois.edu/envirovet/>) provides courses that combine lectures with field and laboratory experiences and include training in several specific areas such as terrestrial and aquatic wildlife and ecosystem health (6).

## Postgraduate opportunities in conservation medicine for veterinarians

Postgraduate programmes in conservation medicine are currently designed to immerse students in a transdisciplinary view of health and to explore more deeply the interconnectedness of the biotic and abiotic

environment with the health of all species. The authors suggest that graduate students in conservation medicine should be offered in-depth instruction in ecology, environmental policy and conservation biology and advanced training in more familiar areas such as epidemiology and biostatistics. Skills in areas such as geographic information systems, mathematical modelling and biochemistry and molecular biology should be offered as needed in accordance with individual or institutional research interests. Identification of the main country-level threats to ecosystem health and, in non-English speaking countries, the development of appropriate technical language to be used in conservation medicine and transdisciplinary research teams, are two particularly interesting issues that should be strongly considered for inclusion in these graduate programmes.

There are currently several postgraduate opportunities for veterinarians in conservation medicine (8). For example, Murdoch University in Western Australia has developed a Postgraduate Certificate in Veterinary Conservation Medicine and a Master of Veterinary Sciences (Conservation Medicine) with a flexible programme structure and distance education. The establishment of such a programme required the removal of disciplinary, institutional, cultural, experiential and professional development boundaries, which have impeded veterinary involvement in conservation projects in the past (16). In Chile, a master's programme in wildlife management was created by the Faculty of Agronomy and Forestry of the Pontificia Universidad Católica de Chile. This programme emphasises conservation medicine projects in collaboration with a local wildlife conservation research group (<http://www.fauna-australis.puc.cl>). More recently, another Chilean veterinary school created a doctoral degree in conservation medicine ([www.postgradounab.cl/doctorado\\_medicina\\_conservacion\\_5.html](http://www.postgradounab.cl/doctorado_medicina_conservacion_5.html)). In addition to courses offered by universities, there are currently several postgraduate opportunities for veterinarians in private and non-governmental institutions, rehabilitation centres and wild animal parks around the world (Table 1) (9).

## Role of veterinarians in conservation medicine and ecosystem health: H5N1 highly pathogenic avian influenza surveillance in North America

Birds infected with avian influenza (AI) viruses provide an extensive reservoir from which highly pathogenic strains of

the disease can evolve. To date, all outbreaks of highly pathogenic avian influenza (HPAI) have been caused by influenza A viruses of subtypes H5 and H7. In some instances, direct or indirect contact of domestic flocks with wild migratory waterfowl has been implicated as a cause of epidemics. Several cases of non-pathogenic AI H5N1 virus have been detected in wild waterfowl in North America recently and the potential of HPAI spread is of high concern. Some questions to answer include: Which wild birds are involved in carrying AI in North America? What are the potential movements along the North American flyways? Are there seasonal patterns to the spread of influenza in birds? Can we predict the spread of HPAI in both the breeding and wintering grounds if it emerges? In addition to the increase in morbidity and mortality in wild bird populations, these species may serve as a source of virus for humans and domestic animal populations. Close collaboration among Canada, Mexico and the United States of America, through continental agreements, is supporting HPAI response and surveillance protocols, improving live bird surveillance in all shared flyways, and helping these countries to develop waterbird/waterfowl and wetland risk assessment maps and to conduct complementary population delineation studies. The development of an early detection system for surveillance has involved many trained veterinarians with a strong background in epidemiology, modelling, conservation medicine and ecosystem health. Approaches to preventing epidemics have included protection of export trade in poultry and poultry products, early detection of HPAI strains, maintenance and improvement of international laboratory and surveillance capacity for AI viruses and information in support of risk analysis and risk communication (including information for human health). The health implications of a global pandemic of HPAI mean that we must develop novel strategies for disease prevention, surveillance, and monitoring, as well

as for health management and conservation. Attempts to identify migratory flyways, determine habitat requirements and characteristics along those flyways and protect reproduction, nesting and overwintering wetlands for several migratory bird species are essential. As those habitats are protected, the rates of contact with domestic animals should decrease. These protected areas would also favour the arrival of endemic species that may serve as alternative hosts and act as a buffer to infection with avian influenza. Therefore, protecting biodiversity and its habitats will help 'dilute' the effects of H5N1 virus. The role of veterinarians is key in applying these strategies, as they can bring a proactive/predictive approach to future outbreaks and develop an agenda for environmental management of zoonotic diseases.

## Conclusion

There are no simple solutions to addressing global environmental problems. A multi-pronged strategy is required. By including conservation medicine and ecosystem health into veterinary curricula worldwide, we can train young veterinarians who will be able to help find solutions to critical environmental problems by changing paradigms and forming transdisciplinary teams. These veterinary professionals can develop new tools for assessing and monitoring ecological health concerns. The concepts of ecological health and conservation medicine should form a natural part of veterinary education. By integrating these ideas into veterinary curricula, veterinarians will be prepared to fulfil critical roles in sustaining global health. ■

## Les fondamentaux de l'enseignement vétérinaire dans les domaines de la médecine environnementale et de la santé des écosystèmes : une perspective mondiale

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### Résumé

La médecine environnementale est une discipline émergente qui relie la santé humaine et animale à celle des écosystèmes, ainsi qu'au changement environnemental mondial. La biosphère est menacée par plusieurs phénomènes envahissants et synergiques qui résultent directement de la pression grandissante exercée par l'homme sur la planète : changement climatique,

appauvrissement biologique (déclin de la biodiversité et des processus écologiques), émergence de maladies infectieuses (« pollution par des pathogènes ») et pollution toxique globale (agents chimiques perturbateurs endocriniens). Ces facteurs cumulent leurs effets et menacent la santé humaine ainsi que celle des animaux domestiques, de la faune sauvage et de l'environnement à l'échelle planétaire. En intégrant la médecine environnementale et la santé des écosystèmes dans les programmes d'enseignement vétérinaire du monde, nous pourrions former de jeunes vétérinaires capables de faire évoluer les paradigmes et de travailler au sein d'équipes interdisciplinaires. Ces futurs vétérinaires seront à même de mettre au point de nouveaux outils pour évaluer et contrôler la santé écologique ; ainsi, ils seront préparés à assumer des fonctions essentielles visant à protéger la santé écologique mondiale.

**Mots-clés**

Espèce animale sentinelle – Médecine environnementale – Santé des écosystèmes.



## Perspectiva mundial de la enseñanza veterinaria básica en materia de medicina de la conservación y salud de ecosistemas

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**Resumen**

La medicina de la conservación es una disciplina incipiente que liga la sanidad humana y animal a la salud de los ecosistemas y el cambio ambiental planetario. La biosfera está amenazada por una serie de fenómenos omnipresentes y sinérgicos que son consecuencia de las crecientes presiones que el ser humano ejerce sobre el planeta: cambio climático, empobrecimiento biológico (pérdida de biodiversidad y de procesos ecológicos), enfermedades infecciosas emergentes ('contaminación patogénica') e 'intoxicación' mundial (por contaminantes como los disruptores endocrinos). Todos estos factores actúan de forma combinada para minar la salud de personas, animales domésticos, fauna salvaje y medio natural en todo el planeta. Integrando materias como la medicina de la conservación y la salud de ecosistemas en los planes de estudios veterinarios de todo el mundo podemos formar a los titulados que el día de mañana ayudarán a transformar paradigmas y constituirán equipos interdisciplinarios. Esos profesionales elaborarán nuevas herramientas para evaluar y controlar el estado de los ecosistemas y contarán con la preparación necesaria para cumplir una función capital a la hora de proteger y preservar la salud ecológica del planeta.

**Palabras clave**

Especie centinela – Medicina de la conservación – Salud de ecosistemas.



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