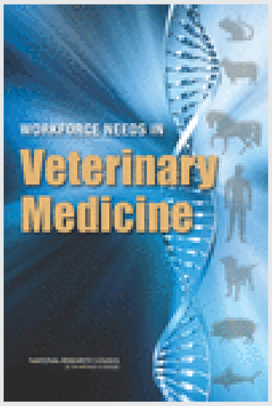

Workforce Needs in Veterinary Medicine

DETAILS

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Veterinary Medicine

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Preface

In 2007, the American Veterinary Medical Association, the Association of American Veterinary Medical Colleges, the American Animal Hospital Association, Bayer Animal Health, and the Burroughs Welcome Fund asked the National Research Council (NRC) to conduct a comprehensive study of the current and future workforce needs in veterinary medicine. The request was motivated by concerns about how well the veterinary profession was presently meeting its public responsibilities and, in terms of human resources and facilities, how well it could adjust to the complex challenges facing society in the 21st century.

Many of the concerns about the profession came into focus following the outbreak of West Nile fever in 1999: despite the spread of a zoonotic disease, human and veterinary public health agencies acted independently and did not communicate with one another. Subsequent outbreaks of SARS, monkeypox, bovine spongiform encephalopathy, highly pathogenic avian influenza, H1N1 influenza, and a variety of food safety and environmental issues heightened public concerns. They also raised further questions about the directions of veterinary medicine and the capacity of public health services the profession provides both in the United States and abroad. After September 11, 2001, concern about the vulnerability of the food supply, including the American livestock and poultry industries, drew attention to the declining presence of veterinarians serving the animal industries across the nation.

These and other demographic, economic, political, and environmental developments of the 21st century will profoundly change society and the services the veterinary profession must provide in order to remain relevant to the public. Responsibilities will increasingly involve global issues with greater emphasis focused on the interface of human, animal, and ecosystem health. To meet these needs, there are doubts that the present supply of veterinarians are adequate in biomedical research, industry, academia, companion animal practice, food animal medicine, public health, and wildlife health. This report attempts to anticipate some of the needs and measures that are essential for the profession to fulfill given its changing roles in the 21st century.

The study was undertaken at a time when the nation experienced a major economic downturn, which made deciphering the long-term trends in demand for veterinary services very challenging. Some estimates (the number of livestock being raised, for example) will always be in flux due to economic or industry cycles, but in the long term, the number of animals is less important for the profession than the evolution in the care and services needed for those animals.

Under the direction of the NRC Board on Agriculture and Natural Resources and Board on Higher Education and Workforce, a committee was impaneled to address the issues provided in the Statement of Task. The committee was representative of the breadth of interest of the veterinary profession, and first met in April 2007 to consider the large undertaking the study commissioned. Over the next three years, the committee met on six occasions and participated in numerous conference calls to discuss ways of obtaining the needed information, review manuscripts, and revise the report. As would be expected from a committee with such diverse backgrounds, there were distinct and at times conflicting points of view. Nevertheless, committee members were always willing to learn from each other and in the end came to a consensus on the issues posed by the charge.

Throughout the study the committee was very ably supported by the staff of the National Academies and is indebted to Jim Voytuk, Janet Mulligan, and Kara Murphy for their expert assistance. The committee is especially grateful to Robin Schoen, Director of the Board of Agriculture and Natural Resources, for her encouragement, advice, and for keeping the committee focused on their charge.

Alan M. Kelly, *Chair*
Committee to Assess the Current
and Future Workforce Needs in
Veterinary Medicine

Acknowledgments

This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council Report Review Committee. The purpose of the independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of the report:

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Margaret A. Wild, U.S. Department of Interior, National Park Service

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of the report was overseen by Frederick A. Murphy, University of Texas Medical Branch at Galveston, and George E. Seidel, Jr., Colorado State University. Appointed by the National Research Council, they were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests with the authoring committee and the institution.

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Acronyms

AABP	American Association of Bovine Practitioners
AAEP	American Association of Equine Practitioners
AASV	American Association of Swine Veterinarians
AAVC	American Association of Veterinary Clinicians
AAVMC	Association of American Veterinary Medical Colleges
AAWV	American Association of Wildlife Veterinarians
AAZV	American Association of Zoo Veterinarians
ACLAM	American College of Laboratory Animal Medicine
ACPV	American College of Poultry Veterinarians
ACVP	American College of Veterinary Pathologists
AHC	American Horse Council
AHI	Animal Health Institute
ASLAP	American Society of Laboratory Animal Practitioners
APHIS	Animal and Plant Health Inspection Service (U.S. Department of Agriculture)
AVMA	American Veterinary Medical Association
BSE	bovine spongiform encephalopathy
CDC	U.S. Centers for Disease Control and Prevention
CPDF	Central Personnel Data File (Office of Personnel Management)
CRO	Contract Research Organization
DHS	U.S. Department of Homeland Security
DOI	U.S. Department of the Interior
DVM	Doctor of Veterinary Medicine
ECFVG	Educational Commission for Foreign Veterinary Graduates
EPA	U.S. Environmental Protection Agency
FAD	foreign-animal disease
FAO	Food and Agriculture Organization of the United Nations
FDA	U.S. Food and Drug Administration
FMD	foot-and-mouth disease
FSIS	Food Safety and Inspection Service (U.S. Department of Agriculture)
FSVMC	Food Supply Veterinary Medicine Coalition

FTE	full-time equivalent
FWS	U.S. Fish and Wildlife Service (U.S. Department of the Interior)
GAO	Government Accountability Office
GCP	good clinical practice
GLP	good laboratory practice
HHS	U.S. Department of Health and Human Services
HPAI	highly pathogenic avian influenza
H1N1	influenza A (H1N1) 2009 (“swine flu”)
IAAAM	International Association for Aquatic Animal Medicine
LA	large-animal
LAE	large-animal exclusive
LAP	large-animal predominant
MPH	Master of Public Health
NCRR	National Center for Research Resources (National Institutes of Health)
NGO	non-governmental organization
NIFA	National Institute of Food and Agriculture (U.S. Department of Agriculture)
NIH	National Institutes of Health
NPS	National Park Service
NRC	National Research Council
NWHC	National Wildlife Health Center (U.S. Geological Survey)
NWRA	National Wildlife Rehabilitators Association
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
SARS	severe acute respiratory syndrome
SETAC	Society of Environmental Toxicology and Chemistry
STP	Society of Toxicologic Pathology
T-MAC	Talent Management Advisory Council
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VMCAS	Veterinary Medical College Application Service
VMD	Veterinariae Medicinae Doctoris
VMO	Veterinarian Medical Officer
WCS FVP	Wildlife Conservation Society’s Field Veterinary Program
WDA	Wildlife Disease Association
WHO	World Health Organization

WORKFORCE NEEDS IN Veterinary Medicine

Executive Summary

The U.S. veterinary medical profession contributes to society in diverse ways, from developing drugs and protecting the food supply to treating companion animals and investigating animal diseases in the wild. In a study of the issues related to the veterinary medical workforce, including demographics, workforce supply, trends affecting job availability, and capacity of the educational system to fill future demands, a National Research Council committee found that the profession faces important challenges in maintaining the economic sustainability of veterinary practice and education, building its scholarly foundations, and evolving veterinary service to meet changing societal needs.

The committee found little evidence of workforce shortages in most fields of veterinary medicine. True personnel shortages are indicated when salaries rise sharply in an attempt to attract qualified candidates to fill persistent vacancies. That is not occurring in any sector of veterinary medicine, except industry, where high salaries are offered to candidates with both a doctoral degree in veterinary medicine (DVM[1]) and a PhD, or with advanced training in pathology or laboratory-animal medicine.

Nevertheless, some veterinary colleges have increased enrollment and the American Veterinary Medical Association (AVMA) has accredited additional veterinary schools to accommodate more students, most of whom will likely practice companion-animal medicine. Those actions will increase the supply of companion-animal practitioners, the largest group of veterinary practitioners, at a time of uncertain demand for companion-animal services. The profession's leaders should pay attention to improving the economic value of the DVM, especially given the cost of a veterinary education, which is typically shared by the student and the public. The financial reward for the investment of time and money in obtaining a DVM is lower than that in other medical professions, such as dentists and pharmacists, which have the same or fewer years of training.

A larger consequence of increasing enrollments may be for the veterinary colleges themselves, which have inadequate resources for clinical faculty, specialists, and others needed to train future practitioners. Companion-animal veterinary medicine has come to dominate the curriculum and resources of veterinary schools, sometimes to the detriment of other fields of veterinary medicine, at a time when many veterinary schools are facing a precipitous decline in state support for faculty positions and tuition.

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[1]The University of Pennsylvania awards the Veterinariae Medicinae Doctoris (VMD), an equivalent to the DVM.

Future actions should be informed by reliable national data on consumer demand for companion-animal care and the economics of private practice (including the work patterns of practitioners and the role of veterinary technicians), by the need to maintain the quality and affordability of a veterinary education, and by the need to educate veterinarians for other sectors of the profession. Developing new business models for providing specialty training is part of this challenge. The committee recommends that the Association of American Veterinary Medical Colleges, the American Animal Hospital Association, and the AVMA work together to collect the necessary data and conduct planning.

The committee found that increasing student debt associated with a veterinary education is one factor that undermines the inclination of graduates to pursue PhD research training that would prepare them for academic careers, key jobs in public practice, and some positions in industry. Partnerships between industry and academe to expose DVM students to research and the establishment of joint DVM-PhD programs may increase the pool of potential candidates needed by academe, government, and industry .

Because research is important for the future of the profession, leaders in academe should make a greater commitment to strengthening its scholarly base. It is essential to attract more public and private support for veterinary colleges, but that requires academe to demonstrate the value of investment in veterinary medical research. Hiring DVM-PhDs and PhDs to attract grants, serve as mentors, and provide graduate training of veterinarians at the doctoral level for both biomedical and clinical animal research would keep veterinary schools in the mainstream of research.

An important challenge to the profession is its ability to evolve veterinary services in synchrony with societal needs. For example, to increase the value of veterinary services to large, intensive livestock and poultry producers, the education of food-animal practitioners should be reoriented toward herd health and improving the productivity of farm operations. In rural areas, where primary veterinary care is needed but there are too few farms to support full-time veterinarians, a system of animal health care involving rigorously trained technicians under the supervision of veterinarians could be developed. Such arrangements, which would also strengthen disease surveillance, could be initiated through negotiations by veterinary professional associations with state regulatory officials.

The veterinary profession should expand its capacity to address complex global problems, such as those associated with food security, by encouraging interactions between U.S. veterinary graduates and other disciplines and cultures, particularly in the developing world, where the profession has an opportunity to leverage its expertise in One Health[2] and lead advances in food-animal husbandry and welfare, water safety and security, and the health of wildlife and ecosystems.

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[2]One Health is a holistic concept of health that recognizes and addresses the complex linkages between humans, wild and domestic animals, and their ecosystems.

Summary

As the only health discipline with expertise across multiple species and ecosystems, veterinary medicine in the United States plays a vital role in protecting and enhancing human and animal life. The profession is currently facing many challenges. Because of competing priorities and limited resources, veterinary academe is struggling to prepare entry-level veterinarians, provide specialty training, and pursue research to advance veterinary knowledge. Some employers are seeking veterinarians with advanced degrees, but cannot find them, while others cannot support veterinarians they need. Meanwhile, new veterinary school graduates are carrying educational debt that cannot be serviced practically with the salaries they command at present. Those mismatches and others are impeding the ability of veterinary medicine to fulfill its potential.

To address some of the problems facing the veterinary profession, greater public and private support for education and research in veterinary medicine is needed. However, for that support to be forthcoming, society must be convinced that an investment in veterinary medicine is an imperative. The public, policymakers, and even medical professionals are frequently unaware of how veterinary medicine fundamentally supports both animal and human health and well-being. Broadening the public's understanding will require a commitment by veterinary leadership, the academe, and practitioners to develop and promote the profession as a complex, divergent, open-ended set of careers, with many different niches for veterinarians, ranging from traditional farm and companion-animal practice to public- and private-sector positions in biomedicine, animal research, wildlife, the environment, global food production, and public health. Because some of those positions require additional education beyond the Doctor of Veterinary Medicine (DVM)[1] degree, the colleges and schools of veterinary medicine have to engage employers and public and private funders in their efforts to target and strengthen some fields of veterinary expertise and research, while also pursuing less costly approaches to delivering veterinary education and veterinary services.

For some time, the leadership of the veterinary medical profession has been concerned about the health of the profession, the future of its graduates, and the strength of its schools and colleges. To gain a clearer picture of the factors shaping the profession and the implications of those factors for the preparation of the future workforce, the Association of American Veterinary Medical Colleges

[1]The University of Pennsylvania awards the Veterinariae Medicinae Doctoris (VMD), an equivalent to the DVM.

(AAVMC)—with the support of the American Veterinary Medical Association (AVMA), Bayer Animal Health, Inc., the American Animal Hospital Association, and the Burroughs Wellcome Fund—asked the National Research Council to conduct a study on the supply of and demand for veterinarians in the United States. This report of the study's findings characterizes the historical and current state of the veterinary workforce, describes the factors shaping future demand for veterinary expertise, and evaluates the collective potential of the 28 U.S. colleges and schools of veterinary medicine to meet that demand.

STATE OF THE VETERINARY WORKFORCE

The total number of veterinarians in the United States is about 92,000, based on statistics collected by the largest veterinary professional association, AVMA, and other veterinary associations. In 2010, AVMA surveys of members and non-members counted 90,201 veterinarians employed in private practice, publicly-funded positions, and private industry. Table S-1 shows the numbers of veterinarians by categories of employment in 2010, along with the median annual income for each employment category in 2009[2].

Table S-1 understates the diversity of employment in veterinary medicine, considering the large number of animal species with which veterinarians work (from dogs, mice, dairy cows and elk to marine mammals and elephants) and more importantly, the context for veterinary medicine beyond animals themselves. Veterinarians are involved in work that affects human welfare as much as animals, for example, conducting research on chronic (human and animal) illness and hereditary pathologies, monitoring food safety, surveying wildlife for infectious and zoonotic diseases, investigating environmental toxins, boosting food production, reducing agricultural pollution, improving recreational opportunities, and supporting the military.

Major Trends in Veterinary Medicine

More than half of AVMA members in 2010 practiced companion-animal medicine. They now dominate a profession once defined by its service to agriculture and food animals—the original reason for establishing and supporting veterinary schools at Land Grant colleges and state universities. Veterinary support of the food-animal supply is still important to the $120 billion U.S. livestock, poultry, and aquaculture industries, which remain major proponents of state-based support for U.S. veterinary schools.

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[2]The AVMA biennial compensation surveys have a response rate of approximately 25%. If DVMs who are more successful are more likely to respond, the reported earnings may exceed actual medians.

TABLE S-1 Employed U.S. Veterinarians in 2010

Employment Category	Number	2009 Median Earnings
Food-animal-exclusive practice	1,109	103,000
Food-animal-predominant practice	3,890	91,000
Mixed-animal practice	4,326	85,000
Companion-animal-predominant practice	5,966	91,000
Companion-animal-exclusive practice	41,381	97,000
Equine practice	3,743	85,000
Other private practice	1,087	79,000
College or university	6,425	103,000
Federal government	1,780	103,000
State or local government	1,099	106,000
Uniformed services	713	85,000
Industry	3,218	148,000
Other public and corporate	2,066	103,000
Other, unknown	16,766	N/A

NOTE: Total is greater than 90,201 because veterinarians may hold more than one position.
SOURCE: AVMA, 2010a and 2011a.

The increase in companion-animal practitioners has coincided with an increase in the number of women in veterinary practice. In 2009, female membership in the AVMA outnumbered males, and in 2010, 78% of students entering veterinary school were women. It is unclear why fewer men are seeking a career in veterinary medicine. Women are represented in all sectors of veterinary employment, but mainly in companion-animal-exclusive practice, where they constitute 56% of the workforce, and least of all in food-animal-exclusive practice, where they are 18%. As a group, women in veterinary practice earn less than men in every sector of veterinary medicine. Various factors explain some of the income disparity: female companion-animal practitioners work fewer hours than do men, are more likely to work part-time, and more often leave the workplace temporarily to raise families, all circumstances associated with lower pay. More women are associates than practice owners, which may offer greater work schedule flexibility, but lower income. Whether women are reshaping the norms of veterinary practice over the long term is an open question.

A third major trend affecting all of veterinary medicine is that of the indebtedness of graduates. Because of cuts in public support for veterinary schools, student tuition is increasing. Figure S-1 shows the average starting salary of new DVMs accepting positions in private veterinary practice at the time of graduation, and increases in student debt over time.

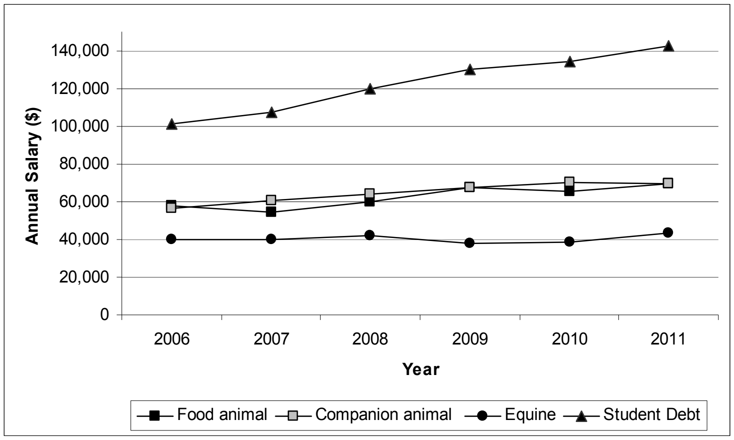

FIGURE S-1 Student debt and mean starting salary for new DVM graduates. DATA SOURCE: AVMA Market Statistics, 2006-2011.

In 2011, new DVM recipients graduated with an average student debt of $142,613 and an average starting salary of $66,469. At the current rate of interest on student loans (6.8%), the annual debt service will be in excess of $18,000 per year for a 10-year payoff. Although the trend toward increased student debt is common in higher education, incomes remain low in veterinary medicine relative to the cost of the education. Most other health-related jobs require fewer years of education and offer higher salaries.

Trends in Companion-Animal Practice

The largest sector of the veterinary medical profession is comprised of private practitioners who treat companion animals exclusively. The companion-animal sector has experienced an increasing degree of specialization, including the development of emergency clinics in urban and suburban settings that have reduced practitioners' after-hours obligations, and opened up opportunities in emergency medicine. In addition, more veterinarians are seeking board certification in one of 21 specialties, such as surgery, oncology, and orthopedic medicine. In 2010, about half of veterinary graduates pursued advanced study in some specialty (including those unrelated to companion-animal medicine). Explanations for the trend include demand (pets are living longer, requiring specialized services), higher earnings of specialists and the need to pay-off debt, and intellectual interest in the specialty fields.

Another trend in companion-animal medicine is the emergence of corporate-owned clinics, like Banfield, a division of Mars, Inc., which owns about 800 hospitals. Corporations have been able to take advantage of the economies of scale in providing services, and use greater numbers of veterinary technicians, so veterinarians can treat more patients per day than in smaller practices.

Projections about the future growth of companion-animal medicine practice are uncertain. Recent average salaries of companion-animal-exclusive practitioners, especially practice owners, continue to rise, while salaries in companion-animal-predominant practice have fallen. The current economic recession makes it difficult to judge trends. Some studies show that expenditures on pets are closely tied to household income, which is likely to rebound. However, the recent accreditation of additional veterinary schools outside the United States (attended by U.S. students) will increase the supply of companion-animal veterinarians in the workforce, placing downward pressure on salaries.

The success of companion-animal medicine has become a double-edged sword in veterinary academe. In orienting veterinary school curricula toward the goals of the majority of students, important subjects (for example, infectious diseases, public health, and environmental toxicology) receive less emphasis. Although fewer numbers of veterinary graduates seek employment in public practice and industry settings (only about 3.5% in fourth year student surveys suggest that they will seek jobs in those sectors) the expertise needed in those positions is no less critical; it requires knowledge of a broader spectrum of veterinary subject matter than that focused on companion animals. Moreover, the pursuit of specialties is competing for resources, thus skewing educational priorities in veterinary schools. The 2-3 year specialty programs, whose requirements are determined by independent boards and colleges, typically involve internships and residencies and require two or more faculty mentors. This draws resources away from the central obligation of veterinary schools to educate entry-level DVMs.

Trends in Equine Practice

The economic downturn has affected almost all major sectors of the profession, and in private practice, equine medicine has been most negatively affected. Investment in the racing industry, horse ownership, and demand for veterinary services have all declined. Associates in equine medicine have the lowest starting salaries of the private-sector practitioners. The average starting salary in equine practice declined by 3.5% between 2010 and 2011, and median salaries for equine practitioners fell from $91,000 to 85,000 between 2007 and 2009. However, the most experienced equine practitioners make salaries higher than those in any other private practice (an average of $160,240 for practitioners over 60 years of age). Still, the current situation suggests that opportunities in equine practice will not substantively increase in the near term.

Unlike companion-animal practice, emergency clinics have not developed in equine practice. Consequently, equine practitioners spend a great deal of time on call. Although equine practitioners are now predominantly male, the proportion of women in the field is growing.

Trends in Food-Animal Practice

Reflecting a decrease in the number of livestock farms nationwide and the consolidation of food-animal production, the demand for veterinarians in the livestock, poultry, and swine industries is changing. Although the median salary for food-animal-exclusive veterinarians has been higher than that of any in private practice ($109,000 in 2009), it is not growing, and neither are the numbers of veterinarians in this sector. The number of food-animal-predominant veterinarians has actually declined, diversifying to treat companion animals and horses.

Consolidation of food-animal production has been accompanied by a decrease in the economic value of animal products relative to feed prices by about half since 1980 (see Figure 4-1 in the full report). The small profit margins received by producers mean that managerial decisions are increasingly based on cost containment, and consequently, much of primary veterinary care is being transferred to non-veterinary farm staff. Those developments have challenged the food-animal veterinary profession to change its role in animal production. For large-scale, intensive farms, that requires maintaining the health of animal herds, rather than individual animals, overseeing environmental stewardship, and increasing overall farm productivity and income. The profession has been slow to adapt to changes in the food-animal sector.

Although the demand for veterinary care in food-animal practice is generally declining, primary veterinary services are still needed in rural areas where widely-dispersed, smaller-scale food-animal producers must share the cost of supporting a large-animal veterinary practice—unsuccessfully, in many cases. The reduced number of rural food-animal veterinarians has left a gap in animal care and raises concerns about the level of animal disease surveillance in the field, which is critical to the prompt detection of outbreaks with potentially massive economic consequences, not to mention public health threats such as H5N1 avian influenza. Although the states and the federal government have launched programs to subsidize educational loan repayment for veterinarians needed in rural areas, it is uncertain whether those incentives will keep veterinarians in food-animal practice long term.

Trends in Public Sector Practice

Public sector veterinarians are employed by states and the federal government to fulfill a wide array of public responsibilities, including regulatory oversight and enforcement (food safety, animal welfare, and animal health), research (laboratory animal science, toxicology, risk assessment, disease control, antimicrobial resistance, drug-reactions, and disease-outbreak investigations), natural-resource stewardship (wildlife and ecosystem management and disease monitoring), national security (medical intelligence, biosecurity, and agro-terrorism prevention), and human health (human- and animal drug review, health commissioners and sanitarians).

The number of veterinarians employed in state governments is small, perhaps fewer than 1,500, working in departments of public health, agriculture, and natural resources. About 3,000 veterinarians work in the federal government, the majority in the U.S. Department of Agriculture (USDA), the Department of Defense (DOD), and the Department of Health and Human Services (DHHS) (Table S-2). According to a 2009 Government Accountability Office (GAO) report, the number of veterinarians in the federal government has declined by 40% since 1990; numbers in state public-health services have been static or have declined. In addition to vacancies, one-third of veterinarians employed by USDA, the Food and Drug Administration, and the Army were eligible to retire in 2011.

Since the GAO report was issued, the Office of Personnel Management established an advisory council to evaluate the federal government's need for veterinary expertise, and several agencies within USDA, DHHS and DOD increased hiring. Salaries for veterinarian positions in the federal government also have increased. However, some positions require a PhD or additional expertise. There are not many individuals available to fill those jobs, considering the demand for similarly qualified veterinarians in the biomedical industry, where salaries are significantly higher.

Trends in One Health: Wildlife, Ecosystems, and Global Food Security

A category of veterinary medicine that cuts across the public and private sectors is the broad discipline of wildlife and ecosystem health, which can be best understood in the context of its major areas of responsibility, which include: 1) health management of free-ranging wildlife populations; 2) zoo-animal medicine; 3) aquatic wildlife and marine mammal health; 4) wildlife rehabilitation; and 5) environmental, wildlife, or ecological toxicology. Determining how many veterinarians are employed in these fields is challenging because quantitative data are not captured by any one professional association. Employers include federal and state agencies, public and private universities, non-governmental organizations (NGOs), and zoos, aquaria, and marine and wildlife parks that may be publicly or privately operated.

Given the numbers of wildlife species and their multiple direct and indirect interactions with humans, the needs are quite broad. Numerous veterinary schools have established centers and educational programs that address wildlife, but there is no single career track pursued by DVMs with these interests, and students are advised to be entrepreneurial in defining veterinary roles in these fields.

Many aspects of veterinary medicine in wildlife and ecosystem health epitomize the multi-disciplinary field of One Health—a holistic concept of health that recognizes and addresses the complex linkages between humans, wild and domestic animals, and their ecosystems. Although not new for veterinarians, the concept is not yet in the mainstream of public consciousness. Greater

TABLE S-2 Veterinarians in the Federal Government

Federal Agency	Number of Veterinarians
U.S. Department of Agriculture	1,771
Department of Defense	841
Department of Health and Human Services	316

SOURCE: GAO, 2009.

interactions among veterinary students and medical students, and between veterinary and human-health faculties, could advance the understanding of One Health as a way to reconcile wildlife and ecological stewardship with food-animal production and improved public health.

The connection of disease to food production argues for an expansion of the One Health agenda from one that is U.S.-centric to a more global view of the role of veterinarians in meeting the challenges of feeding the world's growing population. Veterinary expertise will be needed to address the intertwined problems of urban food security, intensification of livestock production, and environmental health in the developing world. The eradication in 2010 of rinderpest—a dreaded livestock disease and the only viral pathogen since smallpox to be eliminated globally, highlights what is possible, given financial support and leadership. The facilitation of broader interactions with those involved in global food security outside of veterinary colleges could bring additional resources to the wide range of activities related to this important field.

Trends in Veterinary Medicine in Private Industry

The highest paying jobs for veterinarians are those in pharmaceutical, biotechnology, diagnostics, contract research, animal health, animal feeds, and agrochemical companies, which in 2009 paid an average annual salary of $167,415. Positions for veterinarians include those in basic (discovery) research, product development, pre-clinical research and product safety research, regulatory affairs, marketing and sales, and customer support.

Trends affecting private industry suggest that hiring of veterinarians is poised to grow. Food-animal producers want scientific and financial evidence to prove the value of animal-health products in their increasingly complex operations, so veterinarians are needed to educate customers and to demonstrate the value of products. Similarly, companion-animal owners want products that prevent and treat diseases or improve an animal's quality of life. As the technologic complexity of veterinary products has increased, so have regulatory requirements related to product safety, driving the need for veterinarians with specialized training in laboratory animal studies, pharmacokinetics, and toxicology.

The high salaries offered in industry are suggestive of a strong demand for veterinary expertise for which there is a true shortage. Simply expanding the number of new DVMs by itself, however, will have little effect in filling industry positions, which require advanced training in pathology, toxicology, laboratory animal medicine or other sciences. The major associations and societies of board certified veterinarians in industry-relevant specialties are taking steps to attract and train diplomate candidates. Their efforts to establish student clubs, mentorships, training positions, and fellowship programs with support from industry have begun to show encouraging results.

Trends in Veterinary Medicine in Academe

AVMA statistics indicate that there are 6,425 veterinarians employed by U.S. colleges and universities. Of that number, about 4,000 comprise the academic faculty for colleges and schools of veterinary medicine. In addition to preparing students to be "practice ready" in 4 years, academic veterinary faculty also conduct research and participate in the post-graduate programs offered by most colleges of veterinary medicine, including MS and PhD programs, as well as internships and residency programs. The post-graduate programs, which are housed within veterinary science departments in U.S. colleges of agriculture and comparative medicine departments in U.S. medical schools, are designed to develop additional expertise for positions in academe, industry, regulatory agencies, biomedical research, or specialty private practice.

A major trend affecting veterinary academe is the precipitous decline in state support for faculty positions and tuition support, resulting in reduced hiring, layoffs, and the elimination of whole programs from veterinary schools. As noted earlier, veterinary schools cannot easily support the needs for advanced specialty training. The academic environment is a logical place for specialty training, with a diverse caseload and expertise in many core disciplines, but the proliferation of specialties has been pursued without adequate infrastructure support, core funding for faculty, and other training resources and equipment.

Increasingly, veterinary faculty are required to cover a portion of their salaries from grants, and purchase laboratory equipment and support graduate students with funds from extramural sources. Competitive research grants from the National Institutes of Health (NIH) offer one source of such extramural funding, but only a few veterinary schools are competitive in attracting research dollars. More than half of NIH funding to veterinary colleges in 2011 went to 5 institutions. The total funding awarded to all veterinary colleges was approximately $171 million.

Colleges and schools of veterinary medicine face a precarious situation. They are in desperate need of trained graduates for faculty positions in structural biology, physiology, pharmacology, pathology, clinical pathology, infectious diseases of animals and zoonotic diseases, virology, microbiology, food safety, epidemiology, and nutrition. Also needed are clinical faculty members with expertise in both companion-animal and food-animal specialties, who would typically be expected to have specialty-board certification or a PhD in addition to the DVM. In the near future, the profession will experience major setbacks if veterinary schools lack a sufficient number of experts to serve as faculty. Unfortunately, the trends suggest that the academic veterinary community will not meet its own needs, let alone those of state diagnostic laboratories, federal research and regulatory agencies, or the pharmaceutical and biologics industry.

CONCLUSIONS AND RECOMMENDATIONS

Matching the supply of veterinarians to demand for veterinary expertise depends on the commitment of the profession to promote and develop diverse careers paths in veterinary medicine and on the efficient delivery of veterinary services. In the conclusions and recommendations presented below, the committee calls for partnerships, resource sharing, and collective action to consider how to strengthen the profession's foundations.

CONCLUSION 1: In its review of the profession, the committee found little evidence of widespread workforce shortages in veterinary medicine, although industry and some areas of academic veterinary medicine are experiencing shortages of veterinarians who have advanced training. The committee noted a difference between workforce shortages and unmet needs for veterinarian positions. Societal needs for veterinary expertise are substantial and growing, but the potential contributions of veterinary medicine are not realized because appropriate positions in relevant sectors are lacking.

True personnel shortages occur when positions go unfilled, even as employers increase salaries in an attempt to attract qualified candidates. In contrast, a situation of unmet needs occur in settings where positions with competitive salaries are lacking, for varying reasons. The committee found that each sector of the profession faces somewhat different issues, and each will require different solutions.

> **Recommendation 1A: Industry veterinary workforce shortages can be addressed by deeper partnerships between academe and industrial employers of veterinarians. Academe should more actively seek industry biomedical research partnerships, student mentoring, and opportunities in the curriculum to expose students to corporate practice.**

In the committee's view, the new and vacant positions found in industry represent a clear shortage because there are few qualified individuals to fill those jobs. This shortage can only be addressed by partnering with industry to educate future veterinarians with the skills for these positions.

The establishment of student clubs for pathology and laboratory-animal science at veterinary colleges, as recently initiated by the American College of Laboratory Medicine, the American Society of Laboratory Animal Practitioners, and the American College of Veterinary Pathologists (ACVP) is a favorable development, as is industry support for internships and training positions through the ACVP/STP [Society of Toxicologic Pathology] Coalition for Veterinary Pathology Fellows. Such programs, in addition to tracking options in veterinary colleges, offer the best opportunity for channeling students into careers in laboratory-animal medicine, pathology, and comparative biomedical research.

Recommendation 1B: To meet the need for positions for veterinarians in public practice, the committee urges state and federal governments to re-examine their policies on remuneration, recruitment, and retention of veterinarians.

In the federal government, the work of the Veterinary Medical Officers Talent Management Advisory Council should continue to refine veterinary positions. Changing a number of personnel policies—from recruitment strategies and hiring practices to retention initiatives, including child care and parental leave—could improve the government's opportunity to employ veterinarians.

Recommendation 1C: The Association of American Veterinary Medical Colleges, American Animal Hospital Association, and American Veterinary Medical Association should develop realistic strategies for meeting companion-animal veterinary medical workforce needs. Building such a strategy requires reliable national data on consumer demand for companion-animal care, the economics of private practice, the role of veterinary technicians in extending companion-animal care, and the implications for the profession of growth in accredited and non-accredited veterinary schools both inside and outside the United States.

Companion-animal veterinary medicine has come to dominate the curriculum and resources of veterinary schools, sometimes to the detriment of other fields of veterinary medicine. To accommodate more students, some veterinary colleges have increased enrollment, and the AVMA has accredited additional veterinary schools. However, better data on the demand for companion-animal services and the capacity of the economy to support companion-animal practitioners would help to inform decisions about increasing the number of DVM graduates. Strategic planning is needed to identify how to support the clinical faculty, specialists, and others required to train new companion-animal practitioners and the companion-animal paraprofessionals who assist them. Those decisions also should consider how to maintain the quality of a veterinary education, provide access to students at a reasonable cost, and meet the need for veterinary services in all sectors of the profession.

CONCLUSION 2: The decade-long decline in funding of education and research has jeopardized the profession's future capacity to serve societal needs.

Strengthening the scholarly base for veterinary medicine is fundamental to its future. Agricultural industries have effectively promoted state government support for veterinary education, but there is little support from the federal government. Although an American veterinary education is widely regarded as the world's gold standard for veterinary education, low salaries, heavy workloads, and inconsistent policies for federal funding of research on animals have made it extremely difficult to attract research leaders to academic veterinary medicine. If the schools and colleges will not be able to fill faculty positions, some segments of teaching in veterinary education will be reduced.

> **Recommendation 2: Veterinary academe should increase its commitment to research, developing future faculty, and encouraging current faculty to work across disciplinary and professional boundaries. The Association of American Veterinary Medical Colleges is well positioned to take on the challenge.**

Effective research programs require long-term commitments by teams of investigators. Efforts to restructure veterinary medical education using distance learning and consortia should develop in ways that build on the research base. Research-based educational environments draw students to research careers, an essential process for sustaining the profession's intellectual core.

To remain in the mainstream of biomedical research, veterinary schools can improve their ability to attract funding by hiring more DVM-PhD and PhD mentors to attract grants and provide graduate training of veterinarians at the doctoral level, both in biomedical research and in research projects of primary importance to animals. There are unique opportunities for building such programs in the biomedical sciences. For example, comparative veterinary medicine addresses a broad spectrum of spontaneously occurring diseases that are homologues of diseases in humans and could be funded by the NIH.

CONCLUSION 3: The current return on investment for veterinary education is unsustainable and the cost of veterinary education is at a crisis point. The profession may be at risk for lowering the quality of applicants to the profession and the quality of veterinary education. The veterinary profession has been slow to respond to these challenges.

The financial reward for the investment of seven to eight years or more for a student to obtain a professional veterinary degree is out of synchrony with the debt carried by graduates. For about the same number of years of training, veterinarians make much less than dentists and about the same as pharmacists, who can graduate with the required PharmD in as little as six years.

The large debt load has another adverse effect on the future of academic veterinary medicine; it undermines the willingness of young veterinarians to pursue PhD research training that would prepare them to take positions in academe. The current level of state support has kept academic salaries low (relative to those in industry and clinical specialty practices) so the additional years of training do not ultimately provide an adequate economic reward for the education investment made.

Recommendation 3a: Professional veterinary organizations, academe, industry, and government should work together with a sense of urgency to stimulate the collective actions needed to ensure the economic sustainability of veterinary colleges, practices, and students. A national consortium or committee should be jointly supported to bring together initiatives that focus on the economic sustainability of the profession in all sectors of service, education, and research.

Veterinary education is the most expensive of all health-science education, in part because of the intense clinical training that produces "practice-ready" graduates. The full cost of a 4-year veterinary education is substantial—about $66,000 per year. Previous groups have called for a change and coordination in the nation's approach to veterinary education and its costs. In 2011, the North American Veterinary Medical Education Consortium report *Roadmap for Veterinary Medical Education in the 21st Century: Responsive, Collaborative, Flexible* provided a wide array of options. An ongoing consortium of key veterinary organizations, deans, industry, government, and economists is needed to put into place those solutions that improve the sustainability of the profession.

Recommendation 3b: As part of a comprehensive strategy to address the economic sustainability of the veterinary profession, the working groups appointed by the consortium should create nationally shared curricula.

To reduce costs, veterinary schools and colleges urgently need to share facilities and expertise. The growth of distance education and webinars offers an opportunity to achieve this goal. The emerging power of distance education provides the greatest opportunity for advancing food-animal veterinary education at a comparatively modest cost. Webinars and similar technologies can lead to continuing-education credits for veterinarians. Teaching veterinary students from other developed and developing countries should be encouraged to extend the reach of U.S. academic programs and to capture the potential revenue that these sources can generate.

Recommendation 3c: U.S. veterinary colleges should evaluate and implement alternative options for the delivery of veterinary education and research.

Veterinary teaching is evolving and some non-traditional models are now used by AVMA-accredited veterinary colleges. Alternative models for veterinary education, and those that spread the cost of specialty training, in particular, need to be evaluated by inter-professional committees to identify those that hold promise for improving the efficiency of veterinary medical education and research in the United States. Alternatives for further evaluation include:

- Creating university-private sector collaborations to establish comprehensive medical centers that can meet the needs of animal owners and provide a state-of-the-art infrastructure for specialist training in companion-animal and equine medicine. Such centers would also serve as a focus for clinical trials and other research.
- Sharing responsibility for specialty training though interschool collaborations; relying on talent in private veterinary practices, specialty practices, industry, and public agencies; and by enlisting the support of government, nongovernmental organizations, and other stakeholders.
- Reducing the length of pre-veterinary education to permit students with strong academic records to apply to veterinary school after 1 or 2 years of undergraduate study.
- Establishing more joint degree programs, such as the DVM-MPH and DVM-MBA. Finding financial support for DVM-PhD programs is essential to make the pursuit of a PhD more attractive, increase the pool of potential veterinary faculty, and broaden the base of veterinary medicine.

CONCLUSION 4: The veterinary profession is losing its presence in food-animal production and care.

With the changing nature of food-animal production in America, the demand for traditional veterinary services has declined, creating two related problems: how to develop production medicine to serve the dynamically changing and increasingly intensive livestock and poultry industries; and, how to provide veterinary services in the rural United States where fewer and more widely dispersed farms make it difficult for food-animal clinicians to remain in practice.

Recommendation 4a: To increase the economic value of veterinary services to producers, the education of food-animal practitioners should be reoriented towards herd health and interventions aimed at improving the financial health of the farm operation. Veterinary schools and colleges should work together to achieve this goal by creating centers of emphasis on food-animal medicine.

Veterinary academia has been slow to respond to educational needs in food-animal production medicine. Large producers who dominate the livestock industries expect veterinarians to make decisions aimed at increasing herd health, productivity, and the overall profitability of the farming operation. Those are the services that producers seek and for which they are willing to pay. At the same time, the profession is also expected to increase its role in monitoring food safety, drug residues, animal welfare, nutrient management, and stewardship of the environment.

The most compelling case for creating centers of emphasis is in those disciplines where small numbers of students are involved and it is difficult for each school or college to justify faculty costs. Such is the case for food-animal medicine. There are models of successful centers in which advanced practical training and research is available, such as the Agricultural Research Service Meat Animal Research Center at Clay Center, Nebraska; the Swine Center of Excellence at Iowa State University in conjunction with the Audubon-Manning Veterinary Clinic; the University of California at Davis Dairy Center at the Veterinary Medical Teaching and Research Center at Tulare, California; and the recently formed National Center of Excellence in Dairy Production Medicine Education for Veterinarians funded by USDA that is a collaboration among the veterinary schools of the Universities of Georgia, Minnesota, Illinois, and Kansas State University.

Forming centers of emphasis is not a new idea, but it needs to be revisited and nurtured by veterinary leaders and affected stakeholders. In addition to advancing the quality of food-animal education, the committee sees the advantages of a strategically-planned network of cooperating centers for reducing a duplication of effort, faculty salaries, and facilities.

The centers will develop only as entrepreneurial deans and faculty initiate inter-institutional discussion, formulate creative ideas, use distance education, and attract funding from industry, public-health agencies, foundations, international organizations, and federal and international governments. Maintaining flexibility in center programs will be an ongoing challenge. A system of regular review or accreditation should be put in place at the time the centers are created.

Recommendation 4b: The veterinary profession should formulate new ways of delivering cost-effective services to rural America, using veterinary technicians to extend animal-health services to underserved areas.

In rural areas where there are too few farms to support a full-time veterinarian, a system of animal health care that integrates the licensed clinicians with rigorously trained paraprofessionals is needed. For this to be accomplished, AVMA and the professional associations of food-animal practitioners will need to enter a dialogue with officials to modify state practice acts to permit credentialed veterinary technicians to administer livestock health services provided that they are subject to oversight by (and in constant communication with) licensed practitioners who may be in distant locations. Veterinary technicians working with veterinarians have the potential to strengthen the nation's capacity to implement and administer health surveillance and early warning systems in rural America. Supporting this capacity could be an opportunity for private-public partnerships.

CONCLUSION 5: Global food security is one of the most pressing challenges of the 21st century. The food and water security and safety concerns confronting the world today are far more daunting than anything veterinary medicine has previously had to confront. Because these challenges are enormously complex, they will require the veterinary profession to engage in interdisciplinary and interprofessional One Health solutions.

One Health issues cut across the interests of both industrialized and developing countries. The rapid urbanization in many newly-industrializing societies will create significant challenges to public health related to the spread of disease, the availability of clean water resources, the safety and abundance of food production, and the quality of the natural environment. These are local-scale issues with global implications. In view of the importance of increasing world food supplies, and the growing global trade in foods of animal origin, the establishment of global health programs would strengthen veterinary manpower in developing countries while protecting U.S. and global interests.

> **Recommendation 5: Veterinary medical organizations and the deans of veterinary colleges should work to increase the visibility, standing, and potential of the profession to address global food security. Establishing a One Health think tank with the goal of advancing food-animal husbandry and welfare policies, ecosystem health standards, and the capacity of the veterinary profession in the developing world would help future generations of veterinarians to collaborate across professions, disciplines and cultures. A part of this body should also consider the necessary competencies required of U.S. veterinary graduates to address the global challenges of food and water safety and security, and the health of wildlife and ecosystems.**

The scientific and medical issues at the nexus of animal, human, and ecosystem health are of growing importance, and knowledge can be gained from understanding how changes in one system can affect others. To meet the demand for animal protein by a growing world population, animal production in the developing world has expanded, and with it has come increased environmental pollution, food-safety concerns, and the potential for infectious diseases to spread. Antibiotic resistance, greenhouse-gas emissions, and feed- and food-based toxins are the issues the veterinary medical profession is poised to address, but ultimately, defining and implementing the priorities for a One Health initiative is a responsibility to be shared with public health professionals, social scientists, and others.

Every sector of veterinary medicine is experiencing changes that have important implications for the profession and the future tasks that it inevitably needs to assume. The greatest challenge facing the profession is how its educational system and the research enterprise at its foundation will survive economic constraints, at a time when the private and public sector are looking for increasingly sophisticated veterinary expertise. With a serious examination of their collective purpose and a national perspective on the future of the veterinary workforce, the schools and colleges of veterinary medicine can meet those expectations.

1

Introduction

The veterinary medical profession leads the world in developing a medical and scientific understanding of animals that supports society's desire to care for and derive benefits from them. Veterinary medicine provides a foundation for the medical care of pets (companion animals); for the efficient and safe use of animals for food and other products; for the care and use of animals as research models and agents for improving human health; for understanding animals as sentinels of disease and toxic threats and as signals of ecological change; for wildlife conservation; and for supporting the lives and welfare of animals in captive environments.

In the United States, the veterinary medical profession comprises a small workforce (around 92,000 professionals, about one-tenth the size of the human medical profession) educated at a relatively small number of academic institutions. More than half of the members of the workforce are companion-animal practitioners, who are by far the most visible veterinarians to the public. The public is generally unaware that a smaller, but no less important cadre of individuals are working to fulfill other societal priorities involving animals, for example, in producing meat and milk that is safe, monitoring the spread of animal infectious diseases that are transmissible to humans (zoonotic diseases) such as H5N1 avian influenza, West Nile virus, rabies, and Severe Acute Respiratory Syndrome, and for discovering new treatments for cancer and other diseases. Most would be surprised, upon reflection, to comprehend the frequency at which human and animal lives intersect daily, and the breadth of the little publicized domain of the veterinary profession.

The modest size and disciplinary composition of the U.S. veterinary workforce is relatively fixed as a function of the annual number of graduates awarded the degree of Doctor of Veterinary Medicine (DVM)[1] by 28 U.S. veterinary schools and colleges—approximately 2,500. Growing at a rate that has increased

[1]At the University of Pennsylvania, the degree is called the Veterinerae Medicini Doctoris (VMD). This report uses DVM throughout to refer to both degrees.

slowly but steadily in the last decade, the workforce in the past has been in balance with the needs of society and has made major contributions and achieved great progress in supporting critical human (and animal) needs. However, a changing environment for veterinary medicine has disturbed that balance, raising concerns inside and outside of the profession that the workforce might be insufficient to address all of what is being asked of it, placing at risk not only society's priorities for caring and using animals, but also animal and human health, lives, and livelihoods.

Some of those changes have altered the demand for traditional veterinary services, particularly in relation to the production and care of food animals both in the United States, where consolidation has resulted in fewer but larger, intensive animal-production units, and globally, where food-animal production in developing countries has sharply expanded to accommodate growing urban populations who want more meat and milk in their diets. In addition to altering the kind of veterinary services needed and the way in which they are delivered, the changing footprint of food-animal production has also created concerns related to pollution, impacts on wildlife and ecosystems, food safety, and infectious diseases that have collectively expanded the purview of veterinary medicine into a newly forming discipline described as "One Health." A key question is whether the veterinary profession is preparing adequately to address the food security and health needs of the closely-interconnected world of the 21st century through participation in the One Health discipline.

The demand for veterinary services has also been modified by new advances in medical treatments for companion animals that are increasingly requested by pet owners. To deliver those treatments, a growing number of veterinarians are seeking board certification in specialty veterinary medical fields. Although it represents an advancement of the companion-animal workforce, that trend has strained the resources of veterinary colleges and schools that have attempted to provide specialty training in addition to a broadly-based education to entry-level veterinarians, without sufficient resources to do both.

The biggest change affecting veterinary schools and colleges is, in fact, the decline in public support for basic veterinary education and research at the state and federal levels. A consequence of tightened budgets, the loss of funds has raised concerns that the ability of the profession to continue contributing to biomedical science and public welfare is being quickly eroded, because the pipeline of future veterinary research scientists depends on strong research and teaching programs in academe. It is not surprising that there is a strong demand for DVM-PhDs in the biomedical and pharmaceutical industries—since comparative medicine is a basis of biomedicine; however, without support for the specialty training needed by industry or the academic research training needed by both industry and academe, the pipeline of those candidates will soon be empty. How to reverse this trend is a major question and a challenge for the colleges and schools of veterinary medicine. The decline in public support for veterinary education has also placed a growing tuition burden on students, and student debt has significantly outpaced income growth, a situation exacerbated by the current economic downturn.

Since 2009, women have comprised the majority of U.S. veterinarians (AVMA, 2010a). Most are companion-animal veterinarians who are more likely to work fewer hours than veterinarians in other sectors of practice, and their incomes are lower than their male counterparts (Felsted and Volk, 2000). In addition to the fact that fewer men in general are entering veterinary medicine, minorities remain at about 10% of the workforce, although efforts by the Association of American Veterinary Medical Colleges (AAVMC) have increased minority student enrollment to about 12% of the student population (Cima, 2008).

The number of women in the veterinary profession has increased at the same time that corporate ownership of companion-animal veterinary clinics, such as Banfield, a division of Mars, Inc., have expanded. Those clinics employ many veterinarians as associates, but veterinary associates make less money than private practice owners. In addition, as additional veterinary schools outside the United States have come on-line, the pool of companion-animal veterinarians in the United States is growing. Therefore, there is another set of critical questions for the profession: how to adjust to the global economic slowdown, how to reduce the cost of a veterinary education, and how to maintain a strong profession, not only in companion-animal practice, but in other sectors of veterinary medicine that are important to society.

This report examines such questions and how they relate to the size and composition of the workforce and the occupational roles of veterinarians in the public and private sector (Table 1-1). Societal needs can only be met if there are jobs filled by individuals who are qualified to address the demands of the job. Thus there is concern that for some occupations—biomedical laboratory-animal researchers, for example—jobs are remaining unfilled for long periods, while in other cases where their expertise could be applied, such as in ecosystem health, jobs for veterinarians appear to be scarce. In other instances, such as food-animal practice in rural areas and public food-safety inspection, openings exist, but the financial incentives are too low to attract qualified candidates. If salaries aren't likely to increase, other solutions to delivering veterinary expertise would be needed.

Although every profession is affected by changes that occur in society, there is a limited ability to redirect veterinary expertise to respond quickly to the changes affecting it. To begin, there is often a debate about what changes are needed or even what can be achieved. And because the size of the workforce cannot be expanded easily, a small gap in response (for example, in redirecting part of the workforce) could have large effects in the sectors affected by them (such as increasing vulnerability to disease in the $120 billion livestock sector). In addition to uncertainty, there are multiple barriers to changing the size and composition of the veterinary workforce that can only be overcome with substantial, long-term, economic and human investments.

TABLE 1-1 Number (2010) and Earnings (2009) of Veterinarians Employed in the United States

Employment Category	2010 Number	2009 Median Earnings
Food-animal-exclusive practice	1,109	$103,000
Food-animal-predominant practice	3,890	$91,000
Mixed-animal practice	4,326	$85,000
Companion-animal-predominant practice	5,966	$91,000
Companion-animal-exclusive practice	41,381	$97,000
Equine practice	3,743	$85,000
Other private practice	1,087	$79,000
College or university	6,425	$103,000
Federal government	1,780	$103,000
State or local government	1,099	$106,000
Uniformed services	713	$85,000
Industry	3,218	$148,000
Other public and corporate	2,066	$103,000
Other, unknown	16,766	NA

NOTE: Total is greater than 90,201 because veterinarians may hold more than one position.
DATA SOURCES: AVMA 2010a and AVMA, 2011a[a].
[a]Most of the data on the salaries of veterinarians in the report are drawn from the biennial AVMA Compensation Surveys, which are based on a randomized, stratified-disproportionate sample of employed U.S. veterinarians (including AVMA members and nonmembers). The response rate of the surveys is about 25%. If DVMs who are more successful are more likely to respond, the reported rate of earnings may exceed actual averages.

For some time, the veterinary profession and the colleges of veterinary medicine have been asking if the veterinary educational system should expand, and if so, in what ways, to meet these changing workplace demands. Hence, in 2007, the American Veterinary Medical Association, the Association of American Veterinary Medical Colleges, the Burroughs-Welcome Foundation, the American Animal Hospital Association, and Bayer Animal Health, Inc. approached the National Research Council (NRC) to ask it to undertake a study of the broad scope of issues related to the veterinary workforce in the United States. The study committee established by the NRC (see Appendix A for bios of committee members) was charged with preparing a report that describes the adequacy of the current supply of veterinarians in different occupational categories and employment sectors, evaluates trends that would affect the kinds of jobs available to veterinarians in the future, and identifies the options for meeting the requirements of a veterinary workforce. Box 1-1 contains the formal statement of task for the study.

BOX 1-1
Statement of Task

An expert committee will be charged to study the broad scope of issues related to the veterinary workforce in the United States. The study will explore historical changes in the size and characteristics of the veterinary workforce; assess the demographics and adequacy of the current supply of veterinarians in different occupational categories and sectors of the economy; and identify incentives, disincentives, and other factors that are likely to affect the numbers of veterinarians seeking jobs in different sectors in the future. The study will also examine trends affecting the kinds of jobs available to veterinarians and assess future demand for veterinary expertise in existing and new employment sectors. The study will examine the current and future capacity of universities and colleges to provide sufficient numbers of adequately trained veterinarians and identify training needs relative to the demand for specific expertise. A report will present the findings of the study, and identify options for meeting requirements for a veterinary workforce.

Over the course of 2007 to 2009, the committee held six meetings and interviewed more than a dozen experts on veterinary workforce issues in academe, as well as in public, private, and industrial practice. The committee developed and distributed exploratory questionnaires to veterinarians and employers in different sectors to obtain preliminary insights that could be integrated with other information, such as membership surveys and data from veterinary associations to discern trends. Appendixes B, D, and G contain the questionnaires used by the committee. The report has been long in the making, in part because of the inconsistent ways in which organized veterinary medicine compiles data, rendering it difficult to analyze long-term trends in the profession. Accurate predictions for the future are rooted in understanding these trends.

Chapters 2, 3, and 4 of the report examine data, information, and trends in the private practice of companion-animal, equine, and food-animal medicine, respectively. Appendix C contains supplementary material related to food-animal practice. Chapter 5 explores information from companies in the biomedical and pharmaceutical industries and the specialty colleges that seek to produce specialists who are in demand in those industries. Chapter 6 examines public practice—the employment of veterinarians by states and the federal government, who oversee areas of significant national interests. Appendix E provides a list of recruitment tools available to agencies of the federal government for attracting veterinary talent. Chapter 7 examines the role of veterinarians in wildlife and ecosystem health, where many important scientific and veterinary challenges are now emerging, and Appendix F contains a list of short courses available to prepare students for careers in these fields. Chapter 8 makes a case for extending the concept of One Health to the issue of global food security. Chapter 9 explores the challenges facing the veterinary medical schools, which sit at the center of the supply pipeline for veterinary expertise. Chapter 10 contains an economic lens through which to view the workforce supply and demand issues. Finally, Chapter 11 provides the committee's overarching analysis, findings, conclusions, and major recommendations.

The changes facing the profession are serious and consequential, and it is critical that the attention of all sectors concerned with the need for veterinary expertise (and as this report shows, there are many) be engaged in supporting the evolution of the profession. This report is the first comprehensive review of the profession since the 1988 Pew National Veterinary Education Program report, *Future Directions for Veterinary Medicine*. In the intervening 24 years, veterinarians have made impressive contributions to human and animal health through clinical service, innovation, and research. Increasingly, however, concerns are mounting about the slow pace with which the recommendations of the Pew Report are being implemented. Because the pace of change is unlikely to abate, the committee urges the veterinary profession to review its place in society and analyze its future directions more regularly and with a greater sense of urgency. This report provides additional evidence of the need for essential and more rapid adjustments in support of a profession that is presently critical to the social well-being of the American people and will almost certainly become more important as the 21st century unfolds.

2

Companion-Animal Medicine

This chapter describes the workforce changes in the companion-animal sector over the last 30 years, assesses the current need for companion-animal services, projects the demand for companion-animal veterinary services in the next five years, and estimates the supply of companion-animal veterinarians in that time period. Finally, alternative models for meeting the needs for companion-animal veterinary services in the future are proposed.

COMPANION-ANIMAL VETERINARIANS

Of the 90,201 members of the American Veterinary Medical Association (AVMA) employed in the United States in 2010, the employment status is known for 76,803 (85%) (AVMA, 2011a). Of that number, over 70% spend all or part of their time devoted to companion-animal practice, a proportion that has remained relatively steady for the last 14 years, having increased markedly since the 1960s (AVMA, 2010a). Most companion-animal veterinarians spend 100% of their time on companion animals (companion-animal-exclusive). The remaining are categorized by AVMA according to the estimated amount of time they spend on companion animals: 90% (companion-animal-predominant), 49% (mixed animal), and 6% (food-animal-predominant) (AVMA, 2009a).

LIFESTYLE BENEFITS OF COMPANION-ANIMAL MEDICINE

Veterinarians in private practice are typically practice owners or work as associates in practices established by others, including animal health care companies, such as Banfield, which, with a network of 2,000 veterinarians and over 750 pet hospitals, is the largest such firm in the United States. One factor that attracts veterinarians to companion-animal private practice is lifestyle. Although most companion-animal practitioners work full-time, they work the least number of hours per week of all private practitioners (AVMA, 2009a; AVMA, 2011a).

Companion-animal-exclusive owners work a mean of 45.9 hours per week (median 45), compared to food-animal-exclusive (mean 52.7 hours, median 51.5 hours) and equine (mean 53.8 hours, median 53.0 hours) practice owners. The comparison for associates is similar, with companion-animal-exclusive associates working a mean and median of 44.2 and 44.0 hours per week, or approximately 8 hours less than food-animal-exclusive associates, and approximately 14 hours less than equine associates (AVMA, 2011a).

In addition to working fewer hours in general, the development of emergency clinics in urban and suburban settings has diminished the after-hours obligations for companion-animal practitioners. In many instances companion-animal practice owners in a region cooperate to establish emergency clinics that see clients from all practices after-hours. These factors and others serve as incentives to attract a majority of new veterinarians entering the profession to pursue companion-animal private practice.

Earnings[1]

The median and average incomes of companion-animal practice owners reflect different aspects of the earnings of that workforce. A number of very high earners in the industry pull the average income upwards. The median might be a better indication of the income of most of the mid-level earners. However, the trends in both measures can be useful. In 2007, the median income of a companion-animal-exclusive practice owner was $133,000, which was about the same as practice owners in food-animal or equine private practice. In 2009, the median income of exclusive practice owners increased to $139,000, while that of food-animal-exclusive and equine practice owners was $133,000 and $109,000, respectively. Between 2005 and 2009, the average income for companion-animal-exclusive practice owners increased from $142,501 (2005) to $155,518 (2007) to $171,119 (2009) (AVMA, 2011a).

The median income of a companion-animal-exclusive associate in 2007 was $85,000, demonstrating the substantial financial benefit of practice ownership over an associate position. However, salaries are rising for associates as well as owners. Between the years 2005 and 2009, the average income for companion-animal-exclusive associates rose from $79,827 (2005) to $91,592 (2007) to $97,074 (2009) (AVMA, 2009a; AVMA, 2011a). The companion-animal- exclusive associates in the 90th percentile of earnings saw their mean income increase 22% ($109,000 to $133,000) from 2005 to 2007 (AVMA, 2009a), and to $145,000 in 2009 (AVMA, 2011a).

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[1]Veterinarian salary data are drawn from AVMA Compensation Surveys, which are based on a randomized, stratified sample of employed U.S. veterinarians (including AVMA members and nonmembers). The response rate of the Surveys is about 25%. If DVMs who are more successful are more likely to respond, the reported rate of earnings may exceed actual averages.

Among associates in all areas of private practice, the mean earnings of companion-animal-exclusive associates was the highest in 2007 (AVMA, 2009a; see Figure 2-1). This was also true in 2009 with mean associate incomes reported as follows: companion-animal-exclusive \$97,074, companion-animal-predominant \$86,982, food-animal-exclusive \$87,765, food-animal-predominant \$79,790, equine \$85,055, and mixed animal \$73,000 (AVMA, 2011b). Real income, expressed in 1997 dollars and corrected for retail price inflation for private practice associates in all sectors, increased from a mean of \$64,218 in 2005 to \$69,431 in 2007 (an 8% increase over 2 years).

The income gap between companion-animal-exclusive associates and associates for other species also widens with experience. Companion-animal-exclusive associates with 25 years or more experience earn substantially more (median income \$115,000) than equally experienced associates in food-animal-predominant (median income \$64,000) or equine medicine (median income \$91,000) (AVMA, 2009a).

Specialization Increases Earnings

An increasing number of veterinarians are becoming specialists by pursuing advanced study and board certification in one of 21 areas of expertise. In 1989, 15% of veterinary graduates pursued advanced study in some specialty (not just companion-animal-related). In 2008, the figure increased to 40.0% and jumped to 49.2% in 2010 (AVMA, 2011c). One explanation for this trend is an increase in the demand for specialized services. Pets are living longer and receive more specialized veterinary care, for example, oncology and orthopedic surgery.

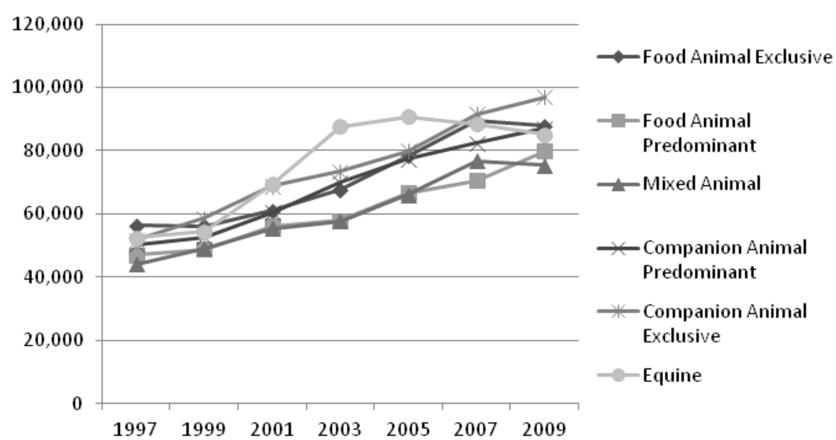

FIGURE 2-1 1997-2009 Associate mean income by practice sector. SOURCE: AVMA Biennial Compensation Surveys.

Companion-animal practitioners' earnings are substantially increased with board certification. The mean and median incomes of companion-animal practice owners who were board certified in 2009 were $208,446 and $175,000, respectively, versus $168,586 and $139,000 for practice owners who are not board certified (AVMA, 2011a). Another possible reason that a growing number of veterinary graduates who seek the higher incomes that specialists can potentially earn is also related to the need to service their educational debt (Chieffo et al., 2008). Even with taking lost income during specialty training into consideration, the return on investment from specialty board certification, as measured by lifetime earnings, compares favorably to that of practice owners and associates (Gordon 2010). Those who pursue advanced study and specialize no doubt do so for professional fulfillment, as well as financial gain. As is discussed in greater detail in the Chapter 10 and elsewhere, graduates from veterinary colleges are facing educational debt burdens due to rising tuition costs that are increasing more rapidly than starting salaries.

Women and Companion-Animal Medicine

Since the late 1970s, the number of women entering veterinary schools has been growing (while the number of male applicants has been declining). Women now represent about 80% of the students in U.S. veterinary schools (Slater and Slater, 2000). As noted earlier, since 2009, there were more female than male AVMA members, most identifying themselves as companion-animal practitioners; in 2010, women comprised 56% of the companion-animal-exclusive veterinary workforce (AVMA, 2011B).

Women in veterinary medicine work fewer hours than men (Brown and Silverman, 1999a), but anecdotal evidence suggests that younger veterinarians, men and women, place a higher priority on having time for their personal lives than previous generations (Kennedy, 2004). This plays a significant role in career decisions, and may continue to do so in the future.

However, women are more likely to work part-time, exit the labor market more often, and, although interested in owning their own practices, are less likely to pursue that route following graduation (Smith, 2006; Felsted and Volk, 2000). Whether as a practice owner or an associate, women earn less than men (AAHA, 2004). Although the flexibility of a profession in companion-animal veterinary medicine may be considered a worthwhile tradeoff, the earnings discrepancy between men and women (discussed in greater detail in Chapter 10) suggests that future earnings increases of companion-animal practitioners may follow a lower pay trajectory as women come to dominate the field.

DEMAND FOR COMPANION-ANIMAL VETERINARY SERVICES

The primary sources of demand for veterinary services are the growth in the number of pets owned in the United States and the growth in expenditures for veterinary medical services per pet-owning household. While the percentage of American households owning companion animals has stayed relatively constant in recent years (57.9% in 1991 vs. 59.5% in 2006), the growth of the U.S. population has been paralleled by increases in the pet population, especially dogs and cats, whose numbers have increased sharply since 1996 (Figure 2-2).

Average veterinary expenditures per pet-owning household grew even more quickly than the populations of companion animals, particularly those by dog and horse owners, which are nearly twice the average expenditures per cat-owning household (Figure 2-3). Increased expenditures per household, stated in dollars of 2006 purchasing power, reflect in part an increased number of pets per household, some increase in the number of annual visits to veterinarians, and increased expenditures per pet.

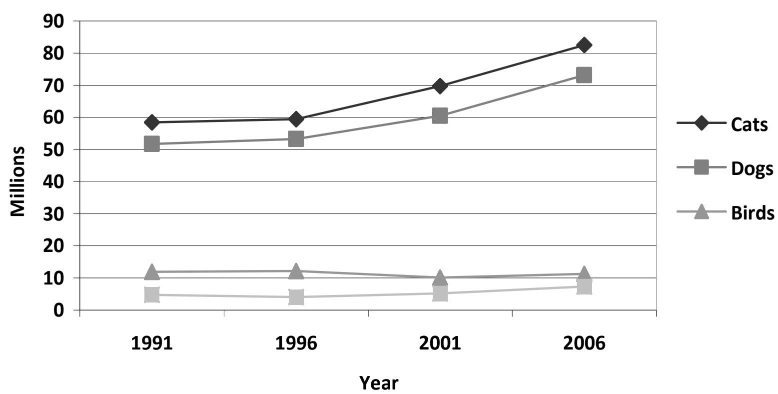

FIGURE 2-2 Numbers of pets in American households. DATA SOURCE: Calculated from AVMA, 2007a.

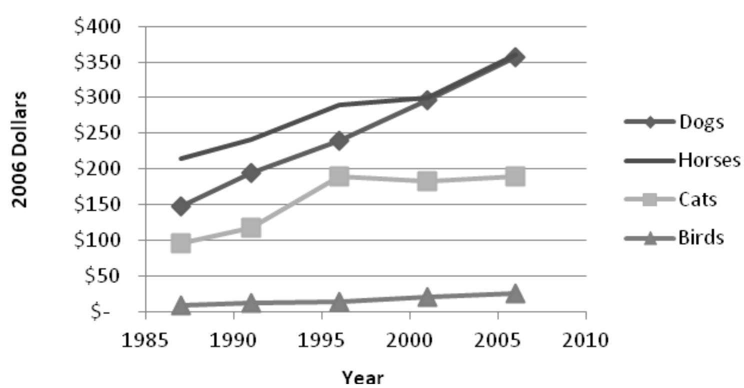

FIGURE 2-3 Average annual expenditure per pet-owning household. DATA SOURCE: Calculated from AVMA, 2007a.

The economic recession that began in December 2007 (with national unemployment at 4.9%) has been long and deep, and unemployment rose to 10.2% in October 2009. It will be some time before surveys of animal owners and veterinary practices reveal the effect of the recession on veterinary medicine. Anecdotal evidence points to declines in spending by pet owners. The effect may be largest in areas that have the highest unemployment rates, such as California, Nevada, Michigan, Rhode Island, and South Carolina, where unemployment exceeded 12% in October 2009 (BLS, 2009). A recent examination of veterinary practices shows a 3% decrease from 2006 to 2009 in the average amount that clients spend before they stop treatment (Verdon, 2009). There is also a substantial decrease in the number of announcements of job openings posted in the AVMA placement service.[2] Because a larger share of the veterinary profession focuses on services to companion animals, professional incomes become more sensitive to changes in the aggregate performance of the economy and vulnerable to declines during recessions.

However, despite the economic downturn that began in 2007, the starting salaries for graduates of the class of 2009 increased by 6.8% and 7.2% in the companion-animal-exclusive and companion-animal-predominant sectors, respectively, when compared to the class of 2008 (Shepherd, 2008, 2009). Graduates in 2010 saw a modest increase in starting salaries, with $71,462 (3.3% increase) for graduates entering careers in the companion-animal-exclusive sector, and $68,826 (4.0% increase) for the companion-animal-predominant sector (AVMA, 2011c). In 2011, however, starting salaries for students entering the companion-animal-exclusive sector declined to $69,789, while those for the companion-animal-predominant sector edged upwards to $69,654 (Shepherd, 2011). The most compelling evidence of the demand for veterinary manpower is the increase in income.

In the long-term, the demand for companion-animal services may be more durable than other veterinary sectors. The extent to which owners of companion animals use pet insurance may influence spending in the future (see Box 2-1). In addition, the largest growth rate in pet ownership is in retired couples, and the aging of the baby boomers will have its effect on the need for companion-animal veterinary services in the coming years (AVMA, 2007a).

Predicting Future Needs for Companion-Animal Veterinarians

Since the proportion of households in the United States with companion animals has been historically constant, then the number of pets (and pet visits to veterinarians) might be reasonably correlated to size of the U.S. population. Thus, it might be possible to calculate the demand for veterinary services in the future using data on the current number of pet visits annually (and an estimate of

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[2]Count of advertisements of openings for DVMs in the *Journal of the American Veterinary Medical Association*.

BOX 2-1
Pet Insurance

In Europe, up to 50% of pet owners buy pet health insurance. Pet insurance has probably played a central role in supporting the development of specialty practices in the United Kingdom (Petplan, 2008). In the United States, less than 1% of pet owners' expenditures on pets are for pet insurance (Pulliam Weston, 2009). It is uncertain, but expanded sales of pet insurance might increase total spending for veterinary services for pets. Pet insurance has been available in the United States for several decades, but the market penetration remains slight. Because basic veterinary services are available at modest cost in many cities, sales of veterinary services are sensitive to price, particularly for low-income households (Brown and Silverman, 1999a). A 10% increase in price would lead to a 4% decrease in services on the average. Although insurance spreads the price of costlier services among insurance clients through premium payments, the cost of operating an insurance company adds to the total cost. People who want to spend more per pet are more likely to buy insurance than people who intend to spend less, but it is not necessarily the case that a person who is induced to buy insurance would see more dollars flow to veterinarians than they would have spent directly on veterinary service without insurance.

the number of veterinarians who cared for those animals during the visits) and information on the current size and projected growth of the U.S. population. In the following section of the report, the committee used information from various sources to develop predictions about future needs for companion-animal veterinarians. Given the uncertainty at various points in the analysis, including the influence of the economic downturn on demand, the predictions should only be considered as broad estimates. Indeed, the committee would like to see better and more continuous data collection on companion-animal practices and the demand for services.

Current Pet Visits and Veterinarians

In 2006 there were 188.7 million pet visits (dogs, cats, birds, and exotic pets) to veterinarians who either spent full time treating companion animals (companion-animal-exclusive) or some lower fraction of time (companion-animal-predominant, mixed animal, and food-animal-predominant). Using AVMA membership information on the numbers of veterinarians in each category and the percentage of time spent treating companion animals, the committee calculated that services for the 188.7 million pet visits were met by the full time equivalent (FTE) of 48,158 veterinarians. Box 2-2 describes the assumptions the committee made in calculating its estimate of total companion-animal FTEs working in 2006. Table 2-1 illustrates the results of the committee's calculations.

BOX 2-2
Calculation of Companion-Animal, Full Time Equivalent Veterinarians

Veterinarians who work with pets devote 100% (companion-animal-exclusive), 90% (companion-animal-predominant), 49% (mixed animal), and 6% (food-animal-predominant) of their time to companion animals (AVMA, 2009a). The majority of companion-animal specialists in private practice list themselves as companion-animal-exclusive. The percentage of veterinarians working part-time is 6.7% for food- animal-predominant, 7.4% for mixed animal, 14.5% for companion-animal-predominant, and 19.4% for companion-animal-exclusive. Those working part-time work an average of 21-23 hours per week (AVMA, 2009a). Part-time veterinarians were counted as 0.5 full-time equivalent (FTE) for the purposes of this analysis. It was presumed that the 13,083 veterinarians whose employment was listed in the AVMA membership database as unknown would be similar to the 68,385 veterinarians whose career choices are listed, and that the number working part-time also would be similar (AVMA, 2006). The FTE devoted to companion-animal private practice in 2006 is outlined in Table 2-1.

TABLE 2-1 Companion-Animal Full-Time Equivalents in 2006

Veterinarians	Number of DVM	Half-time FTE	FTE	Total FTE	CA Total FTEs
Food-animal-predominant	4,924	165	4,594	4,759	286
Mixed animal	5,192	192	4,808	5,000	2,450
Companion-animal-predominant	6,745	489	5,767	6,256	5,630
Companion-animal-exclusive	44,065	4,274	35,516	39,790	39,790
Total					48,158

NOTE: CA=Companion-animal, DVM=Doctor of Veterinary Medicine, FTE=Full-time equivalent

The estimate that 188.7 million pet visits in 2006 were accommodated by 48,158 DVM FTEs can be equivalently stated as 3,918 visits per DVM FTE per year. In the context of a typical work year, 3,918 visits per DVM FTE equates to approximately 83-87 visits per DVM FTE per week (assuming the work year includes 2-3 weeks of vacation, 6-9 holidays, 4-5 days of continuing education, and 5-6 sick days).

To investigate if the relationship between the number of veterinarians and the number of pet visits might be confirmed by other data, the committee sought input from current companion-animal practice owners listed in the AVMA membership database.[3] Companion-animal practices in rural, urban, and suburban communities were included in an exploratory survey that asked practice owners, among other things, to provide the average number of office calls per week for the practice, along with the number of veterinarian FTEs employed. That information was used to calculate the average number of office calls per veterinarian (DVM) per week.

Based on the responses of practice owners, the committee found that the average number of office calls per DVM per week was 70. For those practices in which the gross revenue per DVM was above the mean ($462,782) the average number of visits per week per DVM was 87, while those practices with gross revenue per DVM below the mean saw an average of 56 visits per DVM per week.

For another point of reference and to determine the expectation of visits per week in a corporate veterinary practice, the committee obtained data from Banfield. Each DVM FTE at Banfield is expected to service 110 visits per week (J. Payne, Banfield, the Pet Hospital, personal communication, June, 2008). The Banfield practice is comprised primarily of wellness visits, with a lower number of time-consuming procedures (such as surgery) being performed than in non-corporate veterinary practices, so higher numbers of visits per week could be expected.

Notwithstanding the limitations of the AVMA membership data and the survey limitations, the committee's calculation of between 83 and 87 visits per DVM FTE per week falls in the middle of the range of reported figures from the surveyed practice owners and Banfield.

Estimating Future Visits and Veterinarians

Assuming that pet ownership per household remains relatively constant, as it has in recent years, and the frequency of veterinary visits per pet is consistent, the number of pet visits in 2016 can be projected from growth in the U.S. population. In 2006, there were 188.7 million pet visits and the U.S. population was 298,362,000, making the number of pet visits per person 0.632. Multiplying that factor by the projected U.S. population in 2016, (328,678,000 people; [U.S. Census Bureau, 2010]), the predicted number of pet visits in 2016 will be 207,742,496.

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[3]The committee's Survey of Companion Animal Practice Owners included a sample of 596 owners drawn from the total number of 17, 886 such owners in the AVMA membership database. The survey responses should be treated as suggestive only, as they may be biased in unknown ways because the sampling frame is incomplete—it does not include owners who do not belong to the AVMA or AVMA members who do not indicate their employment category (15%). Moreover, the response rate of 48.2% (287 responses) provides the potential for non-response bias. See Appendix B for details.

The number of veterinarians needed to attend to the approximately 207.7 million pet visits in 2016 will depend on the number of pet visits handled per DVM FTE per week and the number of weeks each DVM FTE works per year. The committee calculated a range of estimates, using a low end figure of 70 pet visits handled per DVM FTE per week (the average of survey responses) and a high of 87 (the average of responses from practices with gross revenue per DVM FTE above the mean). The total number of pets treated will vary depending on the number of weeks worked per year, which the committee estimated would vary from 45 to 47 per FTE. Table 2-2 shows that the predicted range of DVM FTEs needed in 2016 is between 50,805 and 65,950, based on the variables described above. Recent data suggests that the demand for pet services has weakened due to the economy but it is too early to tell if this trend will reverse itself. In the absence of better data on both the demand for pet services and the number of pets attended to by veterinarians in a given year, the predictions in Table 2-2 should only be considered as broad estimates.

The weak economy notwithstanding, responses to the committee's survey of current veterinary practice owners lend support to the committee's predictions of increased future demand for more veterinarians in the companion-animal sector. When asked how many DVM FTEs they would like to add in 2008, 2010, 2012, 2014, and 2016, the survey response was an average of 1.42, 1.24, 1.14, 1.14, and 1.17 respectively. Banfield, which employed 1,533 DVM FTEs in 730 hospitals in 2008, described plans to expand in 2012 to a total of 3,479 DVM FTEs in 1,100 hospitals, and by 2016, to 5,516 DVM FTEs in 1,450 hospitals. The additional Banfield hospitals will be new hospitals, not purchased from existing practices.

FUTURE SUPPLY OF COMPANION ANIMAL VETERINARIANS

A key question is whether the estimated number of FTE companion-animal veterinarians needed in 2016—a figure somewhere between 50,805 and 65,950 (based on predicted numbers of pets and pet visits)—will be available. To answer that question, it is necessary to estimate 1) how many currently working companion-animal veterinarians will still be working in 2016 and 2) the projected number of graduates from U.S. veterinary colleges who will join the companion-animal sector between now and 2016. Using data from a number of sources about retirements, graduation rates, and trends in career preferences, the committee predicts that under projected circumstances, the number of companion-animal veterinarians available will be approximately 51,445, exceeding the lower demand estimate and falling short of the higher demand estimate. As predicting the future is inherently difficult, the committee acknowledges the uncertainty of presenting a single estimated figure. The assumptions and calculations that went into developing this estimate are described in the following section.

TABLE 2-2 Predicted DVM Full-Time Equivalents Needed in 2016 Based on Committee Estimates

Visits per Week	Work Weeks per Year	Visits per DVM FTE per Year	2016 CA DVM FTE
70	45	3,150	65,950
70	46	3,220	64,516
70	47	3,290	63,144
87	45	3,915	53,063
87	46	4,002	51,910
87	47	4,089	50,805

NOTE: CA=companion-animal, DVM=Doctor of Veterinary Medicine, FTE=full-time equivalent.

Estimating the Number of Companion-Animal Veterinarians Working in 2016

To calculate how many veterinarians currently working in companion-animal medicine would still be working in 2016, the committee used 2007 demographic and membership information from AVMA, and assumed that the percentage of time spent on companion animals among companion-animal-exclusive, companion-animal-predominant, mixed animal, and food- animal-predominant practitioners to be consistent with current reports, as described earlier in this chapter. The committee assumed an average career span of 35 years and also assumed that veterinarians who will be less than 65 years of age in 2016 would be working full-time and part-time in 2016 in the same proportions as reported currently. The committee counted veterinarians who will be 65-70 years of age in 2016 as 0.25 FTE each (under the general assumption that much less of their time, collectively, would be spent in the clinic). Based on these assumptions, the total FTE of veterinarians employed currently who will contribute to companion-animal veterinary services in 2016 is 38,329. The results of the committee's calculations are displayed in Table 2-3.

Estimating the Number of New Companion-Animal Veterinarians

Predicting the number of veterinary school graduates who will join the companion-animal private practice workforce by 2016 is a little less straightforward. To develop its projection, the committee used various estimates of the total numbers of new DVMs graduating during the years leading up to 2016, and made assumptions about the percentage of those who would choose to enter companion-animal practice, including the proportion of those who would seek advanced degrees in an area of specialization related to companion-animal medicine. The committee's analysis focused on information about AAVMC-accredited veterinary schools in the United States, Canada, and outside of North America.

TABLE 2-3 An Estimate of Veterinarians Employed in 2008 Expected to be Working in 2016

	Age and Work Category							
Veterinarians	<65 DVM	<65 full time	<65 part time FTE	<65 total FTE	65-70 DVM	65-70 FTE	Total FTE	CA Total FTE
FA-predominant	2,819	2,630	94	2,724	717	179	2,903	174
Mixed	3,628	3,360	134	3,494	566	142	3,636	1,782
CA-predominant	4,608	3,940	334	4,274	929	232	4,506	4,055
CA-exclusive	34,448	27,765	3,342	31,107	4,842	1,211	32,318	32,318
Total								38,329

NOTE: CA=companion-animal, DVM=Doctor of Veterinary Medicine, FA=food-animal, FTE=full-time equivalent.

The committee used information from AVMA and AAVMC on the numbers of graduates in recent years and on current and projected enrollments to estimate the overall number of DVMs graduating between the years of 2008-2013 (AAVMC, 2009, 2010; Shepherd, 2009). The committee assumed increases of 3.5% per year for the classes of 2014-2016, based on increases from previous years, and assumed that enrollment of Americans in accredited Canadian schools would remain constant throughout the 2008-2016 period. For accredited veterinary colleges outside of North America, the committee predicted annual increases of 10% in the classes of 2013-2016.

Table 2-4 summarizes the committee's projections for new DVM graduates between 2008-2016. In this time period, a total of 25,566 new graduates are expected: 24,283 from U.S. veterinary colleges, 217 from Canadian veterinary colleges, and 1066 from non-North American veterinary colleges.

Proportion of New Graduates Pursuing Companion-Animal Medicine

The committee assumed that the percentage of future graduates of U.S. veterinary colleges who choose to pursue companion-animal medicine would mirror that of the class of 2008, but it made slightly different assumptions about Canadian and non-North American accredited schools. Because of the cost of education incurred by students attending those schools is much greater than for those attending U.S. schools, the committee predicted graduates would choose to enter careers that would generate sufficient income to serve that debt. The proportion of students entering different careers was assumed to be as follows: companion-animal-exclusive (40%), companion-animal-predominant (10%), advanced study of all fields (40%), and other non-companion-animal fields (10%). Table 2-5 presents the committee's assumptions about the distribution of new DVMs among career paths from the different colleges.

TABLE 2-4 Projected Number of Graduates of Accredited Colleges of Veterinary Medicine 2008-2016

Class	United States CVMs	Americans in accredited Canadian CVMs	Americans in accredited non-North American CVMs
2008	2,477	24	45
2009	2,514	24	56
2010	2,583	24	69
2011	2,672	24	89
2012	2,765	25	132
2013	2,674	24	145
2014	2,768	24	160
2015	2,865	24	176
2016	2,965	24	194
Total	24,283	217	1,066

NOTE: CVM=College of Veterinary Medicine.

TABLE 2-5 Projected Career Paths for Graduates 2008-2016

Career Path	United States CVM	Americans in accredited Canadian CVMs	Americans in accredited non-North American CVMs	Total
CA-exclusive	7,649	87	426	8,162
CA-predominant	1,846	22	107	1,974
Mixed-animal	2,258	0	0	2,258
FA-predominant	656	0	0	656
Advanced Training	9,689	87	426	10,202

NOTE: CA=companion-animal, CVM=College of Veterinary Medicine, FA=food-animal.

Three additional calculations are needed to estimate the number of new DVMs joining the companion-animal private practice workforce. One involves approximating the percentage graduates seeking advanced training who pursue specialties related to companion-animal medicine. For this, the committee relied on AVMA market research statistics and data made available from the American Colleges of Veterinary Surgeons and Veterinary Internal Medicine on residency- or graduate-study trained board certified specialists in 2007. That information indicated that 36% of board certified specialists in all fields were employed in companion-animal private practice specialties (AVMA, 2007b; ACVS, 2008; T. Anglim, American College of Veterinary Internal Medicine, personal communication, October 9, 2008). If a similar proportion for the projected 10,202 students seeking advanced training can be assumed, there will be 3,714 more companion-animal veterinarians who have pursued advanced training in 2016. It was projected that 400 of those companion-animal veterinarians would enter careers other than private practice (such as academe) based on the demographics of veterinarians currently employed in these sectors. As a result, 3,314 of new graduates who pursued advanced training should be employed in companion-animal private practice in 2016.

The second calculation involves applying the rates at which companion-animal practitioners in different types of practice (companion-animal-exclusive, mixed, etc.) work full- and half-time, which is assumed to follow the current trends discussed earlier. Companion-animal specialists in private practice were presumed to follow the same percentage of full-time vs. part-time as companion-animal-exclusive veterinarians; that is, 19.4% working half-time.

Finally, the computation of FTE must consider the percentage of time spent on companion animals by graduates in each practice type, which was applied according to current trends. Companion-animal specialists are assumed to devote 100% of their efforts towards companion animals.

The total additional companion-animal DVM FTEs resulting from new graduates in the classes of 2008-2016, as estimated by the committee, is outlined in Table 2-6. The committee predicts that 13,116 new DVM FTEs will be added to companion-animal workforce by 2016.

Estimated Total 2016 Supply versus Demand

Based on the committee's calculations, the projected total supply of companion-animal DVM FTEs in 2016 is 51,445, comprised of 38,329 currently working veterinarian FTEs, and 13,116 FTE graduates of accredited schools between 2008 and 2016. As noted earlier, based on differing levels of efficiency of private practices (see Table 2-2), the committee predicted that the number of veterinarians needed to service an estimated 207.8 million pet visits in 2016 might range between 50,805 and 65, 950 DVM FTEs. Comparing the committee's estimates of supply versus need, it appears that the expected outcome would be either a surplus of 640 or a shortage of 14,505 FTEs. If one assumes that practices will become more efficient in seeing pets (using an average efficiency of approximately 80 visits per companion-animal DVM FTE per week with a 46 week work-year), the result is a need for fewer (56,452 FTEs) veterinarians, but still a shortage of 5,007 FTEs. If the percentage of veterinarians providing companion-animal services working part-time continues at current levels, for all the companion-animal FTEs needed in 2016, approximately 10% more veterinarians will be needed in the workforce, or 5,508 more veterinarians than the anticipated supply.

MEETING FUTURE WORKFORCE DEMANDS

If the demand for companion-animal veterinary services follows the trajectory observed in the past, the committee predicts that the number of veterinarians available in 2016 will be insufficient to provide those services, at least

TABLE 2-6 Estimated Number of 2016 Companion-Animal Full-Time Equivalents from New Graduates

Career Path	Total new graduates	Full time FTEs	Half time FTEs	Total FTEs	CA FTEs Private Practice
CA-exclusive	8,162	6,579	792	7,371	7,371
CA-predominant	1,974	1,688	143	1,831	1,648
Mixed-animal	2,258	2,091	84	2,175	1,066
FA-predominant	656	612	22	634	38
Advanced Training CA	3,314	2,671	321	2,993	2,993
Total	16,364	13,641	1,362	15,004	13,116

NOTE: CA=companion-animal, FA=food-animal, FTE= full-time equivalent.

at current levels of efficiency (the number of pet visits per veterinarian). To avoid such a mismatch, the demand for services could be met by 1) more efficient use of paraprofessional staff, such as veterinary technicians, so that client needs can be met with fewer DVM FTEs; 2) additional graduates of currently non-accredited schools entering the companion-animal workforce, and 3) more DVMs switching from other veterinary sectors to companion-animal medicine. A fourth way to fill the gap would be for companion-animal veterinarians to work more hours per week; however, current workplace trends do not support that likelihood.

Companion-animal practices are striving to become more efficient; that is, to see more patients in the same amount of time, with more responsibility for patient care and client communication being delegated to veterinary paraprofessionals. The private practices that responded to the committee's inquiry confirmed this. Practices in which the gross revenue generated per DVM was above the mean saw more patients per week per DVM than those below (87 vs. 56). The time for each office visit was 21 minutes for the practices that reported gross revenue per DVM above the mean, versus 26 minutes for those grossing below the mean. Practices with gross revenue per DVM above the mean employed an average of 3.06 veterinary technicians and assistants per DVM versus 1.94 for lower grossing practices. Several studies have demonstrated the relationship between paraprofessionals and the revenue level of private practices: when the number of veterinary technicians and assistants approaches 3 per DVM, gross and net revenue per DVM rise and more veterinary service can be provided (Brown and Silverman, 1999b; J. Payne, Banfield, the Pet Hospital, personal communication, June 2008; Stanley Creighton, National Veterinary Association, personal communication, June, 2008). The committee's analysis of private practice responses shows that there is a point of diminishing returns. Once the number of veterinary technicians and assistants per DVM exceeds 3, there is little additional gain in gross revenue per DVM (Figure 2-4).

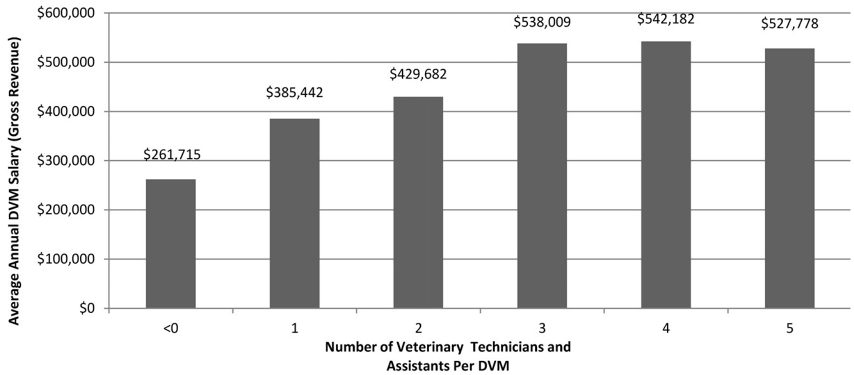

FIGURE 2-4 Impact of veterinary technicians and assistants on DVM practice revenue.

The effective and efficient use of veterinary technicians is of paramount importance if the future needs for companion-animal veterinary medical services are to be met. Ideally, veterinary medical care is a service-oriented business, run by a well-trained health care team that is led by a veterinarian. The veterinarian is trained to diagnose, prescribe treatment, perform surgery, and assign prognoses for cases presented. Proper and appropriate use of veterinary technicians, which utilize their technical expertise, will allow veterinarians to concentrate on the responsibilities that require their knowledge and skill.

An alternative for meeting the demand for companion-animal veterinary services is to increase the number of veterinarians devoted to companion-animal private practice. If there is no substantial increase in the number of graduates from accredited veterinary colleges, the demand could be met by employing veterinarians from colleges not accredited by the Council on Education of the AVMA, or by redirecting existing DVMs from other sectors of the profession. Both are occurring already. The number of graduates from non-accredited veterinary colleges obtaining licensure is increasing annually. During 2006, 371 certificates from AVMA Educational Commission for Foreign Veterinary Graduates (ECFVG) were awarded, 160 of which were to U.S. citizens. As of March 2007, 1,826 candidates were enrolled in the ECFVG program, 336 of whom were U.S. citizens (AVMA, 2007c). The projections in this analysis suggest that this trend will continue as the need for companion-animal veterinary services continues to grow. The U.S. citizens who enroll in these non-accredited institutions will pay the full cost of their education, which is not subsidized by public funds as are most U.S. veterinary schools, and their ability to obtain licensure in the United States is frequently delayed by a year or more while they progress through the ECFVG program.

Americans ultimately can obtain licensure and contribute to the veterinary workforce after having attended a non-accredited institution, but the time required can be longer and the cost to the students higher than if they had attended accredited colleges of veterinary medicine in the United States. The high cost of education assumed by U.S. students attending veterinary school outside the United States, whether accredited or not, necessitates that they will enter higher-paying practices such as companion-animal-exclusive so their educational debt can be served more readily.

The redirection of veterinary manpower from other sectors of the profession where service is sorely needed to the companion-animal sector is also apparently occurring as large animal practitioners are increasingly becoming mixed animal and companion-animal practitioners. Increases in the salaries of companion-animal practitioners would foster that redirection. However, these conditions may be diverting the veterinary workforce away from underserved, yet important sectors such as public health, food safety, rural practice, and biomedical research, among others.

Other Factors Affecting Demand in the Future

The assumptions that underlie the committee's predicted need for a larger companion-animal workforce in the future must be considered in light of recent information showing the impact of the economic recession on companion-animal private practice. According to a recently published survey, the number of pet visits per DVM per week declined from 75 in 1997 to 66 in 2009 (Bayer Health Care, 2011). That information suggests that in spite of an increasing number of companion animals, owners are not seeking services at the same level as in the past. It remains to be seen whether this trend will persist when the economy improves.

There also is some indication that companion-animal practices are doing better at leveraging paraprofessional personnel. The number of veterinary technicians and assistants per DVM FTE increased from 1.5 in 2003 to 2.4 in 2009 among the survey participants in this study (Bayer Health Care, 2011).

In addition, despite the high educational debt load incurred when attending U.S. veterinary schools, and even higher debt incurred when attending non-U.S. schools,, the demand for enrollment is robust (AVMA, 2007c). While the annual applicant pool through the Veterinary Medical College Application Service remains steady, it is estimated that annually, at least 340 U.S. citizens are attending veterinary schools at Ross University, St. George's University, and St. Matthews University alone (AAVMC, 2011). Precise data on the number of American students attending accredited and non-accredited veterinary schools outside the United States are not available; but 500-600 per year is a reasonable, yet conservative estimate. The number of Americans leaving the United States to obtain a veterinary education must be considered when analyzing enrollment demand and future workforce supply.

While some U.S. colleges of veterinary medicine have increased their capacity in recent years, they are still not meeting the demand. If capacity in U.S. veterinary colleges does not increase substantially, more and more of the companion-animal veterinary workforce will be comprised of veterinarians who graduated from colleges outside the United States, and those redirected from other sectors of the profession. To maintain the quality of and the access to veterinary education at a reasonable cost to the student, and to meet the need for veterinary services in all sectors of the profession, the veterinary profession and the U.S. higher education system must consider this reality carefully.

The trends discussed in this chapter are further explored in Chapter 10, which examine the dilemma of the companion-animal sector relative to the cost of education. Chapter 11 provides an analysis of these issues in the overall context of veterinary profession and offers recommendations for addressing them.

3

Equine Veterinary Medicine

THE EQUINE INDUSTRY

In 2005, the United States had an equine population of over 9.2 million horses (AHC, 2005), the largest horse population in the world. With the recession that began in 2007, the number of horses has probably declined but no recent estimates of total horse numbers are available. The equine industry underwent a similar decline in the recession of the mid-1980s only to rebound and grow in the 1990s. There is an ongoing effort by the industry to expand horse ownership among former horse owners and also to attract new owners. If that initiative is successful it will have a positive impact on equine veterinary medicine.

Horses are used for racing, showing, competition, sport, breeding, recreation, and work (AHC, 2005; see Table 3-1). With the exception of the racing industry, the number of horses in all of these activities has increased in the past two decades as a result of the availability of greater disposable income in the general public and the desire for new recreational pursuits. The increase has been driven more by riders acquiring additional horses than by an increase in numbers of individual owners.

TABLE 3-1 Horse Population by Activity

Activity	Population
Racing (Thoroughbred and Standard bred)	844,531
Showing (show jumping, dressage, reining, performance horses)	2,718,954
Recreation (trail riding)	3,906,923
Other (includes draft, ranch, rodeo, police, and carriage horses)	1,752,439
Total	9,222,847

DATA SOURCE: AHC, 2005.

Nearly 4.6 million Americans are involved in the equine industry as horse owners, service providers, employees, and volunteers. There are 2 million horse owners and 70 percent of them live in communities with 50,000 or fewer people (AHC, 2005). The industry is estimated to directly provide 460,000 full-time equivalent (FTE) jobs. In addition to creating jobs, horse farms and training centers maintain open space in peri-urban communities.

The American Quarter Horse is the most popular and most numerous breed in the United States and is used for racing, western riding events, and pleasure riding. Figure 3-1 records the number of American Quarter Horse Association registrations from 1995 to 2008. The 10.5% increase in registrations in those 13 years reflects the general increased interest in equine activities and increased available disposable income. The 17.6% decline in registration from 2007 to April 2009 (Duff, 2009)—compared to 2006 peak numbers—parallels the economic decline in home prices during that same period (S&P Indices, 2011), with accompanying cutbacks in discretionary spending reflecting the sensitivity of the equine industry to prevailing economic conditions.

Maintaining horses is expensive. In 2005, the average annual cost of maintaining a horse was estimated at $2,882, a figure that has increased at least 20% since then (Tomseth, 2008). Approximately 46% of horse owners are in households with incomes between $25,000 and $75,000, and 34% are in households with incomes of less than $50,000 (Tomseth, 2008).

A major concern for horse lovers and the general public is the issue of unwanted horses. A 2007 survey of horse owners reported that sales of unwanted horses had doubled compared to the previous year, indicating the economic downturn as one of the primary reasons (UHC/AHC, 2009). The number of abandoned horses also has increased while many owners have surrendered

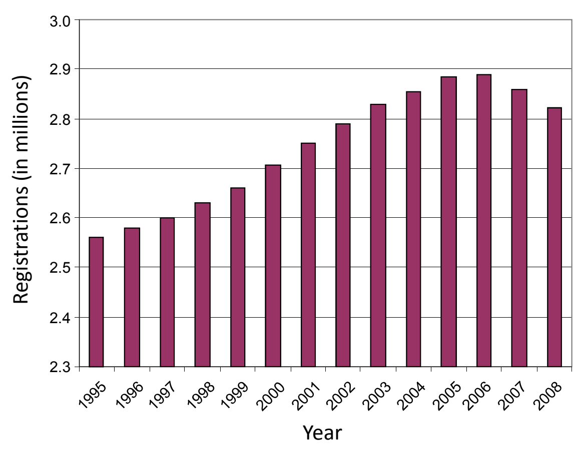

FIGURE 3-1 American Quarter Horse Association registrations, 1995-2008. DATA SOURCE: American Quarter Horse Association annual reports.

their animals to overcrowded rescue organizations (Tomseth, 2008). The problem of unwanted horses has been exacerbated by the closure of horse slaughter facilities in the United States in 2006, when funding for federal inspection was eliminated by Congress. An unintended consequence of the legislation is that roughly the same number of horses previously slaughtered in the United States annually (about 138,000) are now shipped long distances to slaughter facilities in Mexico or Canada, raising animal welfare concerns about the effects of handling and transportation on the animals (GAO, 2011). In late 2011, Congress reversed its funding decision, although no facilities have yet reopened. An alternative to sending unwanted horses to slaughter is euthanasia. However, in 2007, the average cost of euthanasia and carcass disposal was $385 (UHC/AHC, 2009).

Thoroughbred racing has traditionally been the premier equine sport in the nation. The industry has declined over the past decade (see Figure 3-2) as a result of waning family interest in horse racing, public aversion to the rare occasion of seeing an injured horse destroyed on the track, and competition from other forms of entertainment and gambling. Slot machines have been licensed at racetracks in several states, such as Delaware, Florida, New York, and Pennsylvania, and a proportion of the revenues are returned to horsemen where it has increased purses and renewed interest in both Thoroughbred and Standardbred racing. Without revenues from slots, racetracks in these states face a difficult future. This is most acute in states where slot machines have not been licensed at racetracks, including California, Maryland, and New Jersey where several prominent racetracks have either closed or face an uncertain future.

The racing industry's decline has resulted in a 35% decrease in Thoroughbred stallions at stud and a 14% decrease in Thoroughbred mares bred (see Figures 3-3 and 3-4). This decline has impacted breeding centers, including those in Kentucky, and the current recession has only exaggerated the ongoing slump. For example, gross receipts were reportedly down 41.5% at the September 2009 yearling sales at Keeneland, the largest reported decline (Felsted, 2009).

EQUINE VETERINARIANS

Equine veterinarians provide vital services to the large equine industry by caring for the health and welfare of horses. Equine veterinary medicine is more sensitive to fluctuations in the nation's economy than most areas of the veterinary medical profession because the demand for services are strongly linked to the racing industry, an industry that was already in decline prior to the current recession; the recession merely reduced the demand for veterinary services further (Felsted, 2009). In states where racing purses are generous, owners and trainers can afford to seek the best veterinary care available; conversely, in states where purses are restricted, owners are generally unable to afford the most sophisticated care and quality is less exacting.

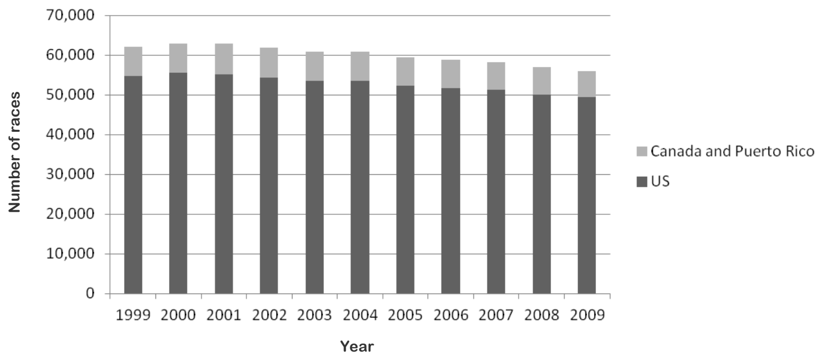

FIGURE 3-2 Number of Thoroughbred races in the United States and Canada/Puerto Rico, 1999-2009. SOURCE: The Jockey Club, 2010.

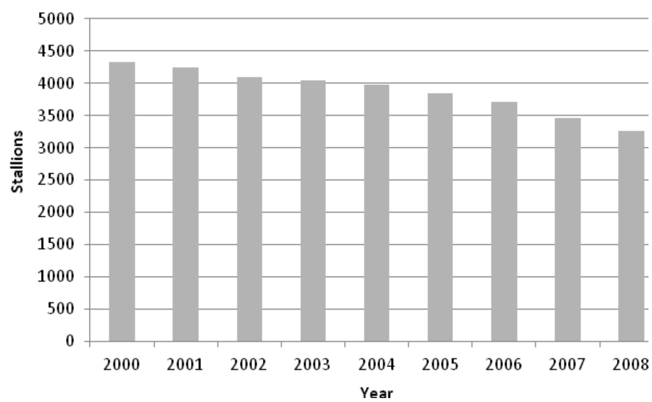

FIGURE 3-3 Registered Thoroughbred stallions, 2000-008. SOURCE: The Jockey Club, 2010.

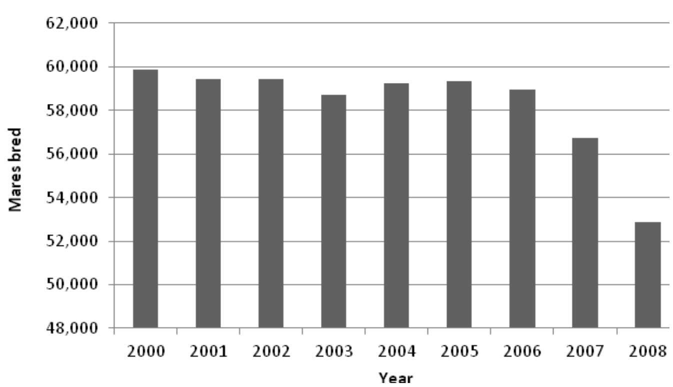

FIGURE 3-4 Thoroughbred mares bred, 2000-2008. SOURCE: The Jockey Club, 2010.

In contrast to the thoroughbred industry, values of performance horses, dressage, show jumping, barrel racing, and endurance event animals have risen significantly in the past twenty years, and owners now expect standards of care comparable to that historically provided to the best Thoroughbreds. In response, regional equine centers have developed to provide advanced care to sick and injured sports horses, and veterinary paraprofessionals are increasingly needed to provide all-hours care in these centers. Because of the unique demands placed on horses in different sports, each activity is associated with distinctive health problems and many equine veterinarians are specialized to serve one or more of these specific constituencies. The weak economy in the racing industry has also encouraged many racetrack veterinarians to provide care for sports horses between race meets.

Recreational horses generally receive care from veterinarians in mixed-animal practice. In rural areas, that care is likely to come from veterinarians in mixed food-animal/equine practice; in peri-urban areas, from mixed companion-animal/equine practitioners. Data from the American Association of Equine Practitioners (AAEP) shows that 874 practitioners (11% of the total AAEP membership in 2008) were in companion-animal/equine practice (AAEP, 2008). The number of such practices has grown in peri-urban areas with the increasing popularity of pleasure riding, availability of riding trails, and urban sprawl into rural areas.

Equine veterinary medicine has experienced a period of prosperity and expansion for the past two decades, but the prevailing economic conditions in the last few years has forced the profession to adjust to new and more challenging economic circumstances. Conditions differ from state to state, and there is limited data on the severity of cutbacks in different parts of the industry. Anecdotal evidence, however, suggests that practices involved with performance horses, equine reproduction, and racetracks are among the hardest hit (Osburn, 2009; Clark, 2009). Practices that are heavily dependent upon pleasure horse work are also experiencing difficulty as a result of declining personal incomes that force cuts in discretionary, horse-related spending (Osborn, 2009).

The Size of the Workforce in Equine Veterinary Medicine

For 2009, the American Veterinary Medical Association (AVMA) membership included 3,204 equine exclusive practitioners (100% commitment to equine practice), and 794 equine predominant practitioners (80% commitment to equine practice) (AVMA, 2010b). Many more mixed-animal practitioners serve the equine industry with a smaller percentage of their time but their numbers are not recorded by the AVMA.

The AAEP is the largest veterinary equine organization in the world. As of March 2011, its membership consisted of 7,766 veterinarians and 1,697 veterinary students from the United States, Canada, and 64 other countries (AAEP, 2011), a small decline from 2010 (AAEP, 2010). Approximately 83% of the veterinarian members of the AAEP work in the United States. California, Texas, and Florida are the top three states represented in the AAEP membership (AAEP, 2011).

AAEP membership had been growing for several recent years due to an active recruitment program both for new graduates and for mixed animal practitioners (Opportunities in Equine Practice Seminar, co-sponsored by AAEP) initiated by a group of equine practitioners concerned by the diminishing number of graduates entering equine practice. The objective of the recruitment program was "to promote equine practice as [a] viable and rewarding career option" (OEPS, 2006). The number of new members joining AAEP, which had been constant from 1983 to 1997, increased from 1998 to 2008 (see Figure 3-5).

About two-thirds of AAEP members spend over 75% of their time involved with the equine industry, and the remaining one-third devote varying amounts of time to non-equine, mixed animal practice (see Table 3-2). A majority of practitioners (29%) work on performance horses, 28% focus on pleasure and farm horses, 13.2% devote their practice to racing, and 12.8% work in reproduction (AAEP, 2011).

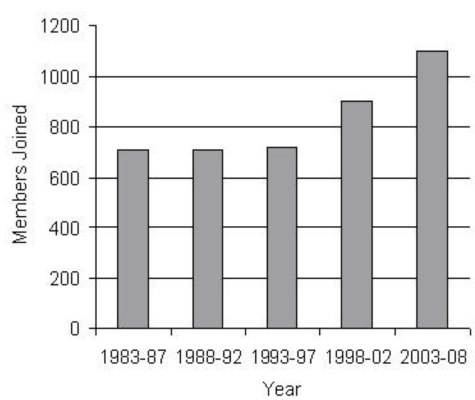

FIGURE 3-5 Years in which current American Association of Equine Practitioners members joined the Association. SOURCE: Data provided by AAEP.

TABLE 3-2 Equine Practices Devoted to Horses

Percentage of Practice Devoted to Horses	Percentage of AAEP membership
100	44.9
75-99	21.0
50-74	8.4
25-49	9.1
1-24	12.2
Not reported	4.4

SOURCE: AAEP, 2011.

Membership Attrition

Anecdotal evidence from practitioners suggests that a high percentage of new graduates leave equine practice within 5 to 10 years, and the AAEP has reported that more than half of all equine practices have a hard time retaining employees (AAEP, 2008). In 2007, 37.5% of those who graduated within the previous 4 years did not renew AAEP membership, and 19% of those who had graduated within 5 to 9 years failed to renew AAEP membership (see Table 3-3). The latter group noted the least job satisfaction, with only 28% reporting a high level of job satisfaction (AAEP, 2008). After 9 years, attrition rates declined significantly, and most equine practitioners renewed their AAEP membership. The highest attrition rates occur among those with the lowest commitment to equine practice. In 2007, 22% of practitioners with less than 25% commitment to equine work did not renew their AAEP membership. These are presumably mixed-animal practitioners who shifted their focus of interest. Reasons for the high attrition rates include long hours, too much emergency work, and limited time for personal life (AAEP, 2008).

Nearly 85% of equine veterinarians were either very satisfied or somewhat satisfied with their job (AAEP, 2008). However, there were age-related differences in relation to job satisfaction: only 29% of practitioners under 30 years old reported they were "very satisfied," whereas 64% of practitioners over 60 years old were "very satisfied" (AAEP, 2008). Job satisfaction was strongly correlated with income levels, as is the likelihood of encouraging others to enter equine practice.

Young equine practitioners are aware that their classmates in small animal practice have higher starting salaries, better work hours, and experience less stress, risk of injury, and emergency work. Practices with multiple practitioners, which are more commonly found in companion-animal practices, provide practitioners with shorter hours and greater flexibility for personal leave: Companion-animal practitioners averaged 42 hours per week with 4 hours of emergency

TABLE 3-3 American Association of Equine Practitioners Membership Attrition Rates by Years in Practice

Number of years post graduation	Percentage of all members in 2007	2007 percentage not renewing membership	2006 percentage not renewing membership	2005 percentage not renewing membership
4 years or less	18.5	37.5	36	32.1
5- 9 years	15	19.9	19.7	20.7
10-14	12.3	11.2	12.1	11.4
15-19	12.1	10.1	8.4	11.1
20-24	12.1	7.1	7.6	8.6
25 or more	0	14.2	16.3	16

SOURCE: AAEP, 2008.

duties, whereas equine practitioners averaged 51 hours per week with 8 hours of emergency work (AAEP, 2008). Companion-animal practices limit off hour calls at their emergency clinics, increasing the attractiveness of the lifestyle that the small animal practice affords. On the other hand, with few exceptions, emergency clinics have not developed in equine practice and it is questionable whether they will develop because of client expectations: clients develop personal relationships with their equine practitioner and are generally reluctant to accept substitutes. Consequently, equine practitioners spend a great deal of time on call, which presents a special challenge for practitioners with family responsibilities.

AAEP membership has been predominately male since its inception in 1954, but that is changing. Now AAEP membership is composed of 56% men and 44% women (AAEP, 2011). The number of women involved in equine practice is likely to outnumber men in the next several years, as indicated by a 5:1 female-to-male ratio among current AAEP student members and in the under-30 years-old category.

EQUINE PRACTICE AND EARNINGS

The mean starting salary for all types of veterinary practice was $46,971, down 3.5% from 2010 (Shepherd and Pikel, 2011). By comparison, the mean starting salary in equine practice was $43,405. The mean educational debt carried by graduates in 2011 was approximately $142,613, a 6.5% increase over the previous year (Shepherd and Pikel, 2011). This suggests annual debt payment in excess of $10,000. With the starting pay offered in equine practice, a new graduate with a family would have few earnings on which to live. One third of graduates entering equine practice in 2009 had debt equivalent to four times their starting salary. Thus it is difficult to see how new graduates can make ends meet let alone considering practice ownership, without a supplementary source of income.

It takes time for young equine clinicians to gain the trust and respect of perceptive horse owners, especially in the racing and performance horse industries. As a consequence, senior equine practitioners who have gained the trust of owners are well remunerated and earn among the best salaries in veterinary medicine. A 2007 survey of total personal income among AAEP members revealed that respondents 50 to 59 years of age commanded average salaries of $155,740 while those over 60 averaged $160,240 (AAEP, 2008). At $190,000, practitioners who focused on the racing industry have traditionally earned the highest salaries, and most practitioners in this category were men. Those working with increasingly valuable performance horses now vie with racetrack veterinarians for the best salaries.

However, practitioners under the age of 30 are mainly women, and earn an average of $48,280 per year because of their junior status (AAEP, 2008). For those graduating in 2009 with the misfortune of entering the workforce during a recession, the initial earning losses can be expected to eventually fade away after 8 to 10 years, according to an optimistic study on short- and long-term career effects of graduating in a recession (Oreopoulos et al., 2006). In the mean time, educational debts have to be serviced.

FUTURE WORKFORCE NEEDS

Though no definitive data is available on whether there is a shortage of equine veterinarians, there was, prior to the recession, a perception of such a shortage among equine practitioners (Green, 2008). In the 2007 AAEP Lifestyles and Salary Survey, 68% of respondents reported that their practice had difficulty recruiting new staff, and 39% reported a shortage of practitioners in their area (AAEP, 2008).

One estimate of future workforce needs in equine medicine would be to consider the rate at which the current pool of AAEP-member veterinarians in the United States who spend more than 75% of time in equine practice (approximately 4,254) would need to be replaced over time, assuming that an average working career is projected to last 35 years. To determine the number of new graduates needed annually to replace those who retire, the total current workforce (4,254) is divided by the projected career span (35 years). The result is that an estimated 122 new equine veterinarians are needed each year to maintain the size of the current workforce. According to AVMA annual surveys of new graduates, a much smaller number of new veterinarians are taking jobs in equine practice, ranging from a high of 66 in 2006 to 37 in 2011 (AVMA, 2011b).

The recession that began in 2007 has reduced demand for equine veterinary services and has changed workforce needs in equine veterinary medicine, but to what extent it has done so is still largely unknown. One way to measure the recession's impact is by monitoring the decline in the number of new positions advertised through the AAEP. As of June 2009, AAEP online job postings had fallen by 25% compared to previous years, and had stabilized at this reduced level over the next months. During the same period, overall traffic at the AAEP Career Center had also decreased by 25%.

An Aging Workforce

Equine veterinarians are aging as a group, with the average age of equine practitioners increasing from 44 to 46 years between 2001 and 2007 (AAEP, 2008). In 2001, 70% of AVMA members who identified themselves as equine practitioners were younger than 50 years old, and by 2009, the proportion had fallen to 60%. Based on a continuation of those trends, AVMA has projected that by 2013 only about 50% of its members who are equine practitioners will be under the age of 50.

Inter-related forces appear to influence the advancing age of equine practitioners. First, there is an inadequate number of new graduates willing to make long-term commitments to equine practice (see Table 3-3), a situation likely to exacerbated by increasing levels of student debt that put practice ownership out of reach. Second, senior equine veterinarians are unable to sell their practices and are therefore continuing beyond their originally planned retirement age. Thus, the aging of equine practitioners as a group appears to be a direct result of the inadequate number of young veterinary practitioners entering the equine workforce to replace those leaving and retiring.

Equine medicine is aging and in need of new talent. Presently the racing industry is experiencing difficulties whereas show jumping, dressage, barrel racing events, pleasure riding and other equine sports remain energetic. Horses in all these categories need veterinary care. However, given the present conditions of practice and financial circumstances, it is difficult to attract and retain adequate numbers of young graduates in the profession. In order to address future workforce needs, the equine veterinary medical profession will need to consider the challenges related to low starting salaries, a shift in gender, and an aging workforce. Of particular concern is the difficulty of delivering equine care in rural areas, where the population of mixed equine/food-animal practitioners who have traditionally provided services to most of these animals is now declining. As is discussed in Chapter 4, Food-Animal Practice, this is likely to require new ways of delivering equine veterinary services and may provide the needed impetus for the creation of emergency equine services.

It is unknown how long the equine industry and equine veterinary medicine will take to recover from the recession. Economic forecasts predict that consumer spending will remain thrifty for the next several years (CBO, 2010). Under these circumstances, planning for future workforce needs in equine medicine will need to be conservative. In the foreseeable future, a majority of new graduates entering equine practice will be women, who may be likely to seek accommodations to fulfill family responsibilities while being no less committed to succeeding in practice. Large group practices, regional equine centers, involvement of paraprofessionals, and part-time work can accommodate the sharing of clinical duties and provide coverage for family emergencies, maternity leave, and elder care.

In emergency situations, many clients insist on seeing the veterinarian with whom they have established a trusted relationship; therefore, practitioners generally have to be available to their clients on a 24-hour basis. Unless they are part of a multi-person practice where clinical responsibilities can be shared, veterinarians have few alternatives but to work around this obligation. Well-trained paraprofessionals who are capable of follow-up visits after surgeries and other procedures may provide partial relief. It might be advisable that before entering equine medicine, veterinary students undertake externships in equine practice to be fully aware of its stresses and rewards. Academic centers need to find the resources to maintain state-of-the-art facilities and sufficient faculty to educate the next generation of equine clinicians and for research to energize outstanding teaching and create the future of equine medicine. High-quality specialty practices developed through university-private sector collaborations may offer exceptional resources of both infrastructure and highly trained specialists. The instruction of veterinary students and residents in equine medicine and surgery would be best accomplished in clinics situated in areas that have adequate populations of horses to ensure the large caseload needed for strong teaching and clinical-research programs.

Support from the USDA and from state legislatures is evaporating as the horse is generally not viewed as an agricultural animal, yet the equine industry is large, generates significant revenues, helps to maintain open space, and provides nearly half a million jobs annually. Support for research on equine health is equally problematic but critically needed for improved animal well-being and improved cures from diseases such as equine laminitis. Voluntary contributions from the public and from the equine industry may be the only way this unmet need can be addressed.

4

Food-Animal Veterinary Medicine

INTRODUCTION

Food-animal veterinarians are entrusted with the safety and the security of the nation's foods of animal origin. That responsibility is the first step in the continuum of supply-chain surveillance that safeguards the nation's milk, meat, and eggs "from farm to fork". Mastitis, *E. coli* O157:H7, salmonellosis, bovine tuberculosis, and brucellosis are some of the many diseases that threaten the safety of the food supply and are controlled on the farm by food-animal veterinarians working with food-animal producers. As the "eyes and ears" of the national animal health network, food-animal veterinarians also work to prevent and control foreign-animal disease outbreaks on the nation's farm lands. The essential public health nature of those responsibilities has come into focus in recent years because of the expansion of global trade and the spread of infectious diseases, including newly emerging diseases, many of which are zoonotic, such as bovine spongiform encephalopathy (BSE), severe acute respiratory syndrome (SARS), highly pathogenic avian influenza (HPAI), and pandemic swine influenza (H1N1). In addition, the events of September 11, 2001 called attention to the potential vulnerabilities of agriculture to bioterrorism and the expanded roles that veterinarians must play in surveillance, early detection, and rapid response (DeHaven et al., 2006).

Foot-and-mouth disease (FMD) is arguably the greatest threat to the American food-animal economy. FMD has not come to the nation's shores for over 80 years; the last outbreak of FMD in the United States was in 1929 (USDA-APHIS, 2007). Nevertheless, it is unrealistic to believe that FMD could never return or that other foreign animal diseases (FADs) are not a constant concern. One estimate of the economic impact of an FMD outbreak in California projected national agriculture losses of \$2.3 to \$69.0 billion as detection delay increased from 7 to 22 days, respectively (Carpenter et al., 2011). Assuming a detection delay of 21 days, it was estimated that every additional hour of delay would result in the slaughter of 2,000 animals and an hourly loss of \$565 million.

The threats are not limited to FMD. A large-scale outbreak of HPAI could be catastrophic not only for human health but also for the poultry industries. With annual revenues of $40 billion, the U.S. poultry industries are the world's largest producer and second largest exporter of poultry meat (USDA-NASS, 2009a). A single outbreak of HPAI would halt U.S. exports of poultry products and, based on experiences in Europe, could result in probable declines in domestic consumption (Knowles et al., 2007). Three previous cases of BSE in the United States led to a dramatic and continuing reduction in beef exports to Japanese and South Korean markets that cost the U.S. beef industry between $3 and $4 billion. Similar consequences could follow the diagnosis of a single case, of classic swine fever, exotic Newcastle disease, and other FADs. In today's global marketplace where there is increased trade in agricultural commodities, the risks of any one of those diseases reaching the nation's shores are also increasing. At best, lost global markets would recover very slowly. Moreover, the integrated nature of the U.S. financial system would send shock waves to linked industries and damage a broad sector of the U.S. economy.

Of equal importance is food safety, which is affected by farm hygiene. The U.S. Centers for Disease Control and Prevention (CDC) estimate the number of foodborne illnesses in the United States each year at 48 million, with 128,000 of those cases requiring hospitalization and resulting in over 3,000 deaths (Scallan et al., 2011). Many of these disease outbreaks are of animal origin (such as *E. coli* O157:H7 in ground beef and Salmonella in eggs) and many have resulted in massive food recalls (especially of eggs, spinach, and ground beef). The need for stronger producer-veterinarian relationships to address these issues is reinforced by the recent passage of the 2010 Food Safety Modernization Act, which expands the inspection power of the Food and Drug Administration (FDA) over farms and increases the need for improved hygiene on the farm.

Despite their vital importance, there is concern that the services of food-animal veterinarians are now in jeopardy as numerous reports conclude that there is a critical shortage of food-animal veterinarians in the United States (AVMA, 2006; Fiala, 2006; Gwinner et al., 2006; Prince et al., 2006a,b; Sterner, 2006).

Shortly after World War II, more than half of the American Veterinary Medical Association (AVMA) members were engaged in food-animal practice. In 2010, that proportion has declined to 13% translating into fewer than 11,000 practitioners caring for food-animal populations of 93 million cattle, 5.5 million sheep, 66 million hogs, 338 million laying hens, 248 million turkeys, and 8.5 billion broilers (USDA-NASS 2011 a, b, c; USDA-NASS 2012 a, b, c). AVMA demographic studies confirm that there are unmet needs across the country: there are 750 counties that each have more than 5,000 head of livestock, yet have no resident veterinarian (AVMA, 2006). In Appendix C, Figure C-1 shows a map of animal density in counties that lack a resident veterinarian. In total they are home to over 10 million food animals.

This chapter explores and describes the multiple forces that underpin the reasons for the change in the numbers of food-animal veterinarians, and changes in the kind of veterinary medicine needed by food-animal producers. Among the concerns is the diminishing number of new graduates who are making a long-term commitment to food-animal practice. Inadequate mentoring and frequency of night and weekend emergency work are commonly given as the reasons for graduates' not entering food-animal practice or leaving it after short periods. Other reasons are the inability of earnings to keep pace with the rapidly increasing costs of veterinary education and the need to repay educational loans. An additional reason for the lack of veterinary services in some areas is linked to rapid and fundamental changes in the social and economic structure of rural America, driven in large measure by changes in the U.S. livestock and poultry industries.

Since World War II, U.S. livestock and poultry production has evolved from a "small-town America" way of life to a competitive business enterprise that emphasizes entrepreneurship, management, efficiency, and earnings. Profit margins are thin, and small producers have difficulty in competing as they are being replaced by large, intensive systems of production in which higher returns can be realized when fixed costs (such as labor and capital investments) are spread over greater numbers of animals. Most poultry, feedlot beef, and pork production in the United States now takes place in concentrated animal feeding operations (CAFOs) in which management is driven by competition and the demands of supermarket chains for ever-lower food prices. But declining food prices come from declining animal values, and increasingly, the cost of primary animal care administered by a veterinarian is commonly viewed as too expensive relative to the value of the individual animal. In large operations, primary care is now usually administered by adroit lay staff (Jensen et al., 2009).

Figures in the 2009 U.S. Department of Agriculture (USDA) Census of Agriculture for the years 2002-2007 show a continuation in the trend toward an increase in very large (and small) farms and fewer middle-sized operations. However, although the overwhelming preponderance of foods of animal origin come from large operations, most U.S. farms are still small, and there is also a growing trend toward more small livestock operations, usually with more diversified and specialty products, fewer acres, and younger operators, many of whom also work off the farm (USDA-NASS, 2009a). They include organic farms and farms that rear small ruminants for meat and milk production. Development of these small operations is driven by a consumer movement to eat locally-produced foods coupled with concerns about the environment, animal welfare, and the quality and safety of foods produced in concentrated animal-feeding operations. Some believe those small operations present the greatest risk for introducing a food-animal disease into the United States.

Hence, food-animal practice needs for the future appear to be increasingly bisected. Animals in CAFOs and other large operations are likely to be under the supervision of highly specialized, production-medicine veterinarians who manage the health of animals as a group, focusing on "herd health." Those veterinarians are most likely to be food-animal-exclusive practitioners, recognized by AVMA as those devoting 100% of their professional activity to the care of food-animal populations, and who, because of the complexity of the work, usually limit their practice to a single species. Appendix C, Figure C-3 is a map of the distribution of food-animal-exclusive practitioners in the United States.

In contrast, animals on small farms may be under the care of mixed-food-animal practitioners, defined by AVMA as devoting over 50% of their professional activities to care and the balance to the care of other species. Services are usually focused on care of individual animals, pregnancy diagnosis, and emergency work. Most mixed-food-animal practitioners live close to populated areas because a substantial amount of their time is devoted to companion animals. Appendix C, Figure C-4 is a map of the distribution of mixed-food-animal practitioners in the United States. The consequence is that livestock farmers who live far from populated areas have difficulty obtaining veterinary care. One solution may be through the use of well-trained veterinary paraprofessionals working in a team with licensed veterinarians who may be at a distant site but are in constant communication with the paraprofessionals via smart phones.

Veterinarians in food-animal-predominant practice comprise the third category of AVMA-recognized food-animal practitioners. They devote 80% of their professional activities to food-animal care and the balance to the care of other species, including horses and companion animals, and are currently the largest group of veterinarians serving the food-animal industries. Over 40% of them practice in the grain states of the Midwest and in Texas, where with mixed-food-animal practitioners, they have been a critical part of the once prosperous infrastructure of small-town America. Since new graduates are not entering this type of practice anymore, food-animal-predominant veterinarians, as a group, are now composed of rapidly-aging members. As will be discussed, it is the imminence of this demographic shift that constitutes the most immediate challenge confronting food-animal veterinary medicine. Appendix C, Figure C-5 is a map of the distribution of food-animal-predominant practitioners in the United States.

INDUSTRY CONSOLIDATION: CHANGING DEMAND FOR VETERINARY SERVICES

Figure 4-1 presents the ratio of food-animal commodity prices to the price of corn (in 2006 dollars) from 2000 to 2012. Since 2006, increases in the price corn—a major component of animal feed and a significant portion of the cost of food-animal production—significantly outpaced the value of livestock products.

Figure 4-1 illustrates why consolidation, management, efficiency, and increased productivity per animal have become so essential for the survival of the livestock and poultry industries. However, because of decreasing animal values relative to the cost of inputs, farmers are unwilling or, more likely, unable to pay veterinarians to deliver primary veterinary care. As a result, revenues for supporting salaries and operating costs in food-animal practices have generally declined.

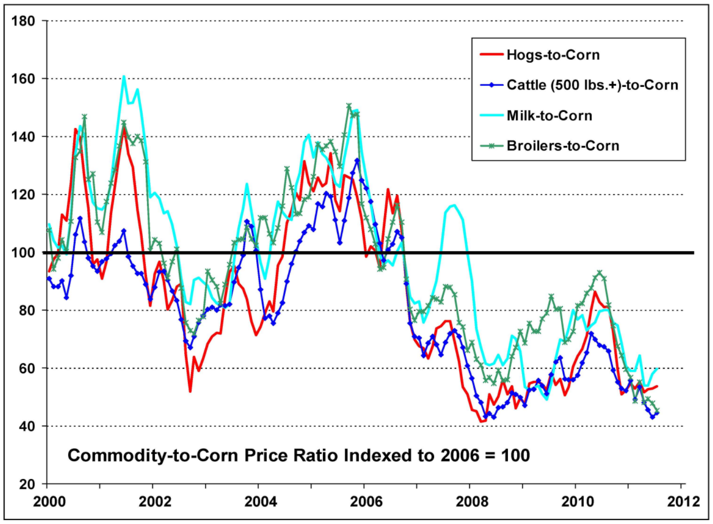

FIGURE 4-1 The value of livestock products relative to corn from 2000-2012. SOURCE: Schnepf, 2011. Calculations by CRS using data from USDA-NASS, July 31, 2011.

The Food Supply Veterinary Coalition (FSVC) (Andrus et al., 2006) was formed by leaders in the veterinary medical profession to analyze workforce needs and used an expert-judgment forecasting method (the Delphi method) to predict trends. FSVC panelists were not in agreement about workforce needs in any major food-animal sector except poultry; they did not agree on predicted manpower needs for dairy, beef, or swine practice. They did not see the need to increase the number of graduates in poultry medicine. They recognized that consolidation reduced demand for traditional veterinary services, but there was wide disagreement on the long-term effect on the profession. Some panelists saw opportunities for veterinarians to provide new, value-added services to large producers that would far outweigh losses due to consolidation; others expressed a concern that jobs for veterinarians would decrease.

The next section of the report examines more closely some of the trends in segments of industry and their implications for the veterinary workforce.

The Poultry Industries

The U.S. poultry industries were the first of the livestock sectors to consolidate and integrate. That occurred after World War II when the poultry industries originated the vertically integrated production model that is now the norm. The broiler industry introduced the model in the 1960s, and the turkey industry adopted the model in the 1970s. As will be discussed, the hog industry followed the trend beginning in the 1980s.

Poultry veterinarians play a vital role in flock health and management for the turkey, broiler, and egg-producing industries. The American College of Poultry Veterinarians (ACPV), the professional organization of certified poultry-health professionals in North America, has 315 members in the United States and Canada. ACPV was formed in 1991, and over 200 diplomates joined in the following 5 years. However, from 1995 to 2005, the college grew by approximately 9 new members annually. Members are dispersed in the poultry industries, their allied industries, federal and state diagnostic laboratories, and academe. The numbers are small in view of the U.S. industries' productivity—8.9 billion broilers produced per year and more than 90 billion eggs obtained from 336 million laying hens. Layers are housed principally in the Northeast, Appalachia, and the Corn Belt regions, whereas broiler production is principally in the Southeast (see Appendix C Figures 6a and 6b [USDA-NASS, 2009a]).

Production of both broilers and eggs increased for many years but has recently leveled off because of the maturation of domestic markets. As a result, there is currently no serious shortage of poultry veterinarians in the United States (Glisson and Hofacre, 2006). The FSVC (Andrus et al., 2006) projected a 4.11% increase in the demand for poultry veterinarians between 2004 and 2016. The estimates of Glisson and Hofacre (2006) project three to five new job opportunities per year for veterinarians in live-poultry production, technical services, or diagnostic laboratories. Those estimates do not appear to include poultry veterinarians employed in research and the pharmaceutical industry, where they are involved in product development, including vaccine development, licensing, and provision of technical services to producers; poultry expertise is in demand in this sector of the pharmaceutical industry.

Poultry veterinarians in poultry-producing states commonly hold faculty positions in universities where they provide instruction, maintain poultry-research programs, and provide services in state diagnostic laboratories. Those in live-poultry production are employed primarily by integrator companies that contract with producers; there are few independent veterinary consultants in poultry medicine. To be eligible for positions with integrators, the overwhelming majority of poultry veterinarians undergo specialized post-DVM training in poultry husbandry, disease diagnosis, health management, environmental management, animal welfare, and food safety. There are few specialized training programs: five are active in U.S. veterinary schools, but only three currently report enrolled students.

Veterinarians employed in production facilities are responsible for implementing and managing programs to prevent disease in company flocks. Poultry veterinarians typically work in multiple locations, and each facility functions as a closed system. Health and biosecurity programs are developed in conjunction with production managers and flock supervisors, many of whom have undergraduate degrees in poultry husbandry (Glisson and Hofacre, 2006). To be effective in those positions, it is important for poultry veterinarians to have both first-hand knowledge of primary bird care and the skills in handling managerial issues.

Although the poultry industry employs comparatively few veterinarians, they are supported by an infrastructure of flock supervisors or their equivalent who assume major responsibilities for the everyday care of flocks and can augment surge capacity if emergencies arise. In recognition of the importance of their duties, flock supervisors are provided with opportunities for continuing education in health-care management and biosecurity policies by their corporate employers, by the poultry federation, or through industry-supported courses given by colleges of animal science and veterinary medicine. Broiler companies maintain a cadre of field technicians who are skilled in recognizing problems, conducting field necropsies, and collecting appropriate diagnostic specimens for laboratory submission. Turkey and layer companies provide similar support to their contract producers, and several states certify poultry technicians who are involved in regulatory affairs for the industry. The poultry industries have experienced repeated outbreaks of avian influenza, laryngotracheitis, and other infections and have a strong commitment to the continuing education of producers, flock supervisors, and poultry staff, in addition to their veterinarians. The programs provide a model for the livestock industries in general.

Public concerns about multiple-drug resistant organisms, waste disposal from large poultry operations, animal welfare, and food-safety regulations are increasingly important and occupy more and more of the poultry veterinarians' time, taking them away from their immediate responsibilities for flock health. Those administrative tasks are likely to increase in the future and will add to the opportunities for poultry veterinarians to contribute to the industry.

Growth of the movement to use locally-produced food, including free-range and backyard flocks, is a concern for the poultry industry because it implies potential sites for foreign-animal diseases, including exotic Newcastle disease and avian influenza, to gain access to the United States. Mixed-food-animal veterinarians usually provide health care and disease surveillance for these birds, which require having knowledge about the symptoms of those and other infections.

The Swine Industry

The nation's swine industry has undergone massive reorganization, consolidation, and changes in scale of operation in the last 25 years, with the number of hog farms declining by more than 70% since 1992—from more than 240,000 to fewer than 70,000 in 2008 (Figure 4-2). Despite this, the hog inventory has remained stable at around 62 million animals. In Iowa, the nation's leading producer, the number of farms with pigs declined by 83%, from 59,134 in 1978 to 10,205 in 2002 (Honeyman and Duffy, 2006). Throughout the period of consolidation, the total breeding-herd inventory declined from some 10 million to 6 million sows, but, because of better management and housing, litter sizes have progressively increased with survival, and the annual pig crop has risen by over 30% since 1980 (USDA-NASS, 2009b).

Fewer and larger farms assumed an increasing share of the total output by improving yields and reducing costs of production. Table 4-1 presents the increase in number of farms selling over 5,000 pigs per year from 1994 to 2006. By 2008, farms with over 2,000 sows represented over 85% of inventory (USDA-NASS, 2009b). Consolidation advanced at unprecedented rates in the 1990s**,** continues more slowly today, and is expected to persist for at least the next decade (Key and McBride 2007). Those changes have resulted in what Carr and Kefalas (2009a) term "the hollowing out" of small towns in the United States, especially in the Midwest Corn Belt, with declining populations and prosperity and reduced demand for food-animal veterinary services.

Large swine operations succeeded in increasing efficiency of production by making use of new technologies, including improved genetics, artificial insemination, more efficient feeding programs with better feed-to-weight-gain ratios, environmentally-controlled buildings, highly-efficient production systems, and strict sanitary (biosecurity) measures for workers to prevent disease from entering or leaving the buildings (Honeyman and Duffy, 2006). Those measures not only improved herd health but permitted one person to efficiently manage the production of much larger numbers of pigs than in the past and in the process altered the requirements for veterinary services.

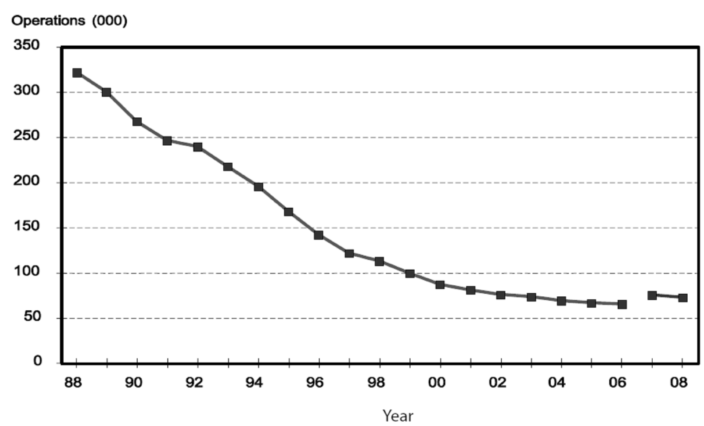

FIGURE 4-2 Number of hog operations, 1984-2008, in thousands. SOURCE: USDA-NASS, 2009b.

TABLE 4-1 Number of Farms Producing Pigs, 1994-2006

	Number of farms (in thousands)				
Farm size (Number of pigs)	1994	1998	2000	2003	2006
0 - 4,999	208	120.3	84.2	71.3	63.5
>5,000	0	1.83	2.0	2.27	2.47

SOURCE: National Pork Board, 2011.

As consolidation has proceeded, the industry has concentrated its operations in specific geographic regions of the country, creating high pig densities in some counties and low densities in others. That is illustrated in Appendix C, Figure C-7, which shows the striking changes in distribution of pigs in the United States from 1992 to 1997 during the period of rapid consolidation of the industry. The change is also illustrated in Appendix C, Figure C-8, which shows the number of hogs per square mile by county in Iowa in 1987 and 2002. The pig inventory was relatively evenly distributed through all counties of Iowa in 1987; by 2002 this was substantially changed, inventories in counties in the south of Iowa were substantially reduced while those in counties in the north and west of the state along the Minnesota border were greatly increased. Those locations were selected based on economic factors, including access to packing plants, local prices of corn, transportation facilities, and other established service infrastructures.

In contrast to the poultry industry, veterinarians in private practice serve a significant portion of the swine industry. Consolidation and regionalization of the industry, particularly in Iowa and Minnesota, has permitted some veterinary practices to grow and provide a variety of swine health, managerial, and marketing services to their clients. Veterinarians in these practices are infrequently involved in primary animal care, because it is more cost-effective for the producer to assign such duties to herdsmen who have been trained by veterinarians to fulfill specific, specialized tasks. Instead, one veterinary practice may be given responsibility for the overall health of large herds of sows and pigs. Animals are usually in multiple locations where producers are tied by contract to large swine integrators. Such integrated networks of producers are in marked contrast with the traditional system of independent family farms involved in farrow-to-finish production, where food-animal veterinarians would typically provide primary care for some 10,000 sows. The new responsibilities create much greater expectations of detailed knowledge of swine physiology, nutrition, pathology, herd health economics, management, and marketing than in the past. To meet those needs, a demanding, specialized system of education in swine health management is needed that involves both high-quality academic and practice-based training. Mounting calls for more veterinary oversight in animal welfare, zoonotic diseases, food safety, and antimicrobial resistance are also likely to have a substantial effect on the need to further expand the range of services that veterinary practices should offer and the educational programs needed to prepare students for successful careers in the industry. In view of these needs, it is gratifying that a new Center of Excellence in Swine Medicine Education has been created at Iowa State College of Veterinary Medicine in collaboration with the Audubon-Manning Veterinary Clinic.

The swine industry consolidation may be the cause of the overall decline in food-animal veterinary services in several rural states where swine operations had predominated. Large declines in the number of food-animal-exclusive and food-animal-predominant veterinarians in Iowa, Illinois, Indiana, Kansas, Minnesota, Missouri, North Carolina, Nebraska, and Texas between 2001 and 2007 (see Appendix C, Table 1) closely parallel the progress of consolidation and the change in the geographic distribution of the swine industry. Although it may not have been the only factor involved, lost opportunity because of swine industry consolidation has almost certainly been a contributor to the rural population's flight from America's heartland. Iowa, in common with other Midwestern states, felt the brunt of this population flight that left small rural towns in a weakened state. Loss of resident food-animal veterinarians is just one manifestation of the decline.

The number of Iowa veterinarians who were members of the American Association of Swine Veterinarians (AASV) dropped from 401 in 1993 to 217 in 2004—a decline of 46% in 11 years (Honeyman and Duffy, 2006). Parallel changes are seen throughout the nation. Most swine veterinarians belong to AASV; in 1995, AASV had about 1,400 members; by 2008, the number had decreased to 769—a decline of 45% in 13 years. This was due in part to resignations of mixed-food-animal practitioners, but also to a shift to specialization in a single species by food-animal practitioners. Figure 4-3 shows membership of AASV by year of graduation from veterinary school. AASV averaged 22 new members per year in the 15 years from 1976 to 1990 but just 12 new members per year in the 15 years from 1991 to 2006. This number is consistent with anecdotal estimates that suggest the need for 10 to 15 new graduates per year, depending on the swine industry economy.

If a working career is considered to be 30 years, the addition of only 12 new graduates per year can be projected to yield an AASV membership of 360 veterinarians, and not all will be in clinical practice.

Estimates of future workforce needs in swine medicine will depend on the structure, organization, and success of clinical practices to invest in the local community. Workforce needs will also depend on the competence of farm staff, their knowledge, expertise, and stability in their jobs. The better they are trained, the more of them a single veterinarian can supervise. Presently, there are few training programs for food-animal veterinary technicians in the swine industry. AASV is beginning to address that issue, recognizing that a skilled infrastructure of animal care is in the best interest of animal health and the industry. In addition, veterinarians are required in the conduct of basic and applied research on swine diseases, nutrition, welfare, food safety, environmental impacts, and in regulatory services—all fields that are inadequately supported today.

The Dairy Industry

The dairy industry is more diverse than the poultry or swine industries. Although consolidation is progressing more slowly, the number of dairy farms in the United States fell by 88%, from 648,000 operations in 1970 to 75,000 in 2006 (MacDonald et al., 2007); conversely, the size of herds has increased (Figure 4-4).

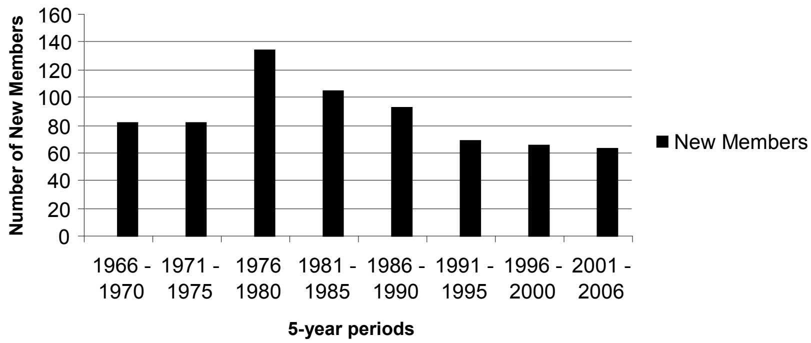

FIGURE 4-3 New members of American Association of Swine Veterinarians, 1966-2006. SOURCE: American Association of Swine Veterinarians.

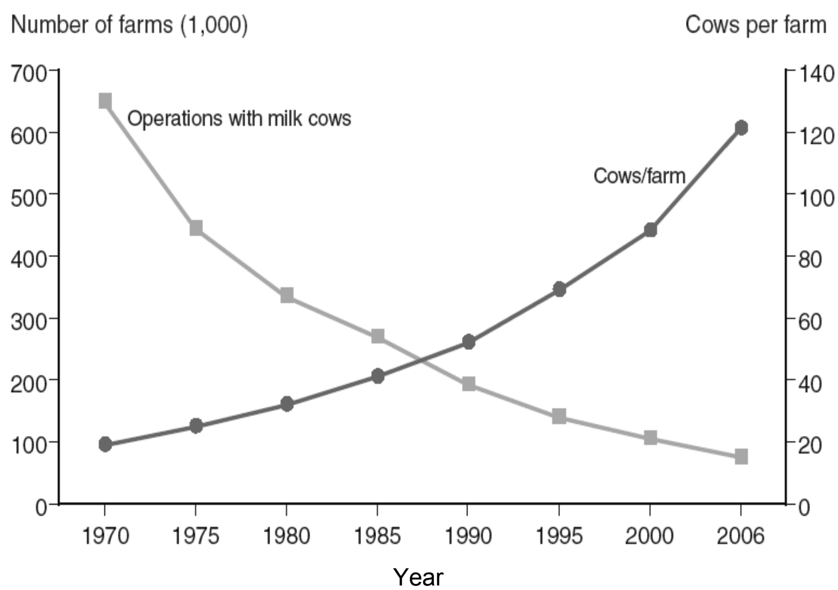

FIGURE 4-4 Number and average size of dairy farms in the United States, in thousands, 1970-2006. SOURCE: MacDonald et al., 2007.

As in every other aspect of livestock production, the movement toward greater specialization and herd size is driven by the economies of scale and lower costs of production. Large dairy enterprises use fewer resources per cow and generate returns that, on the average, substantially exceed the cost of operation. Small enterprises, in contrast, are reported to incur economic losses (MacDonald et al., 2007). Costs per hundredweight of milk produced decline by nearly one-half as herd size increases from fewer than 50 head to 500 head. Costs continue to fall, although less sharply, in even larger herds (MacDonald et al., 2007). For those reasons, the structure of the industry is changing; from 2000 to 2006, farms with fewer than 30 to 199 cows declined by over 30%, while farms with 2,000 or more cows increased by more than 100% (Table 4-2).

The present trend toward larger dairy farms is expected to continue; reports project that the number of dairy farms could decrease to 15,000 with an average of 600 cows each by 2020 (LaDue et al., 2003; Fetrow et al., 2004,). In addition, consolidation has been accompanied by advances in technology and increased milk yields per cow, from an average of 9,500 lb./cow in 1970 to 19,500 lb/cow in 2008 (MacDonald et al., 2007). Because the demand for milk has remained steady, the improved yields have allowed for the reduction in the number of cows on dairy farms: the national herd decreased by 25%, from 12 million in 1970 to around 9 million in 2008 (MacDonald et al. 2007). It is expected that increases in milk yield per cow will continue and result in a further slow decrease in the number of cows in the national herd.

Those changes in the structure of the dairy industry directly affect the veterinary medical profession. Dairy veterinarians are the largest group of veterinarians engaged in the food-animal industries, in part because the dairy cow is the most valuable food-animal species. As the dairy industry undergoes consolidation, dairy veterinarians are obliged to change from primary animal health-care providers to consultants on herd health, nutrition, animal welfare, sustainability of complex farming operations, establishment of herd health protocols, and the training of herders in the implementation of the protocols. As is the case in the swine industry, dairy veterinarians have to adjust their practices, albeit in a more slowly-evolving marketplace, to ensure that as consolidation proceeds, large and small producers have access to veterinary services appropriate to their needs. These are driven by scale and economics; large operations generally seek consulting services on a wide array of issues, whereas smaller producers typically seek more traditional primary care. For many veterinary practitioners, that presents a dilemma as it requires them to shift from the traditional fee-for-service relationship with clients to a consultative, business relationship that is focused on the financial performance of the entire dairy enterprise. It is not an easy transition and many food-animal veterinarians have difficulty charging for advice that in the past they have given freely. Moreover, without additional training in animal-health economics, practitioners do not necessarily have the background and confidence to make the change. As a consequence, operators of large dairies have looked elsewhere for advice, and the central role that food-animal veterinarians should play in the success of dairy operations is marginalized (DSI, 2006).

The scale of dairy operations varies across the United States, and the effect of consolidation on the veterinary medical profession is regional. Table 4-3 incorporates data on the 16 largest dairy states, which account for 83% of the nation's milk production, to illustrate the changes in production and herd sizes by region.

TABLE 4-2 Changes in the Size Structure of U.S. Dairy Farms, 2000-2006

Herd Size - Number of Head	Number of Operations 2000	2006	Percent Change 2000	Percent of Inventory 2000	2006	Percent of Production 2000	2006
1-29	30,810	21,280	-31	2.9	1.9	1.8	1.2
30-49	22,110	14,145	-36	9.1	6	7.7	4.9
50-99	31,360	22,215	-29.2	22	16.3	19.4	14.3
100-199	12,865	9,780	-24	18	14.1	17.3	13
200-499	5,350	4,577	-14.4	16.7	15	18	15
500-999	1,700	1,700	0	12	12.6	13.7	14.3
1,000-1,999	695	870	25.2	10.1	12.5	11.6	13.9
2,000+	280	573	104.6	9.2	21.6	10.5	23.4
Total	105,170	75,140	-25.6	100	100	100	100

SOURCE: Adapted from MacDonald et al., 2007.

The traditional dairy states are in the Northeast, the eastern Corn Belt, and the upper Midwest. Collectively, those states produced 72.4 billion pounds of milk in 2006 compared with 77.7 billion pounds produced by dairies in the Southwest and the West (MacDonald et al., 2007). As Table 4-3 shows, all regions increased milk production from 2000 to 2006, but the rate of increase in the Southwest and West was twice that in the other regions. The change reflects the progressive westward movement and growth of the nation's dairy industry (see Appendix C, Figure C-9). However, it is uncertain how long the westward trend will continue in view of climate change and water supply problems in the South and West.

Table 4-3 illustrates that a large percentage of the dairy farms in the traditional dairy states are small. Nearly half the farms in Wisconsin have fewer than 100 cows, whereas this type of operation is uncommon in the Southwest and West, where the overwhelming majority of dairy farms have more than 500 cows and the number of dairies with over 12,000 cows is increasing. However, the traditional dairy states are moving slowly toward larger units; the number of herds with over 500 head in the Northeast and Corn Belt states more than doubled from 2000 to 2006 and as this occurs, the type of veterinary services required change.

There are large numbers of food-animal-exclusive practitioners in Wisconsin and the traditional dairy states of the Northeast and many fewer in California and the West (Appendix C, Figure C-3). That is consistent with the premise that continued consolidation and reduced demand for veterinary services will proceed at different rates in different parts of the country. As the size of dairy herds increases, the ratio of cows to veterinarians also increases.

TABLE 4-3 Changes in the Size and Location of U.S. Dairy Farms, 1994-2006

	Production in billions lbs.			Percentage of herd size <100 head		Percentage of herd size< 499 head	
Region	1994	2000	2006	2000	2006	2000	2006
Northeast NY, PA, VT	24.0	25.5	25.3	46.5	38.9	10.4	21.3
E. Corn Belt IN, MI, OH	12.3	12.8	15.3	39.9	28.4	13.1	31.2
Upper Mid West MN, WI	31.7	31.0	31.8	56.7	48.2	8.9	15.6
S. West NM, AZ, TX	11.6	13.6	17.8	2.8	1.6	78.2	87.3
West CA, CO, ID, OR, WA	37.3	50.1	59.9	1.8	1.3	73.4	84.2

SOURCE: Adapted from MacDonald et al., 2007.

Table 4-4 shows the numbers of members of the American Association of Bovine Practitioners (AABP) in 2007 who were designated as dairy veterinarians and the number of cows per veterinarian in California and Wisconsin. These are the two leading milk-producing states in the United States; their dairy industries differ in structure.

Most large dairy facilities in California and other parts of the Southwest and West are dry lot operations; all feed is purchased, and capital investments are focused exclusively on milk production (MacDonald et al., 2007). As those specialized operations enlarge, economies of scale enable them to reduce veterinary bills by employing technicians to provide routine herd health care. Alternatively, foreign-trained veterinarians, some of whom speak little English, are hired as herders and herd health-care providers. Large operations achieve further economies of scale by purchasing dairy supplies and drugs in bulk from sources other than local veterinary practices that have depended on traditional markups. As a result, large farms spend just over half as much as small farms on veterinary services per animal (Remsburg et al., 2007).

In contrast, dairies in Wisconsin and other traditional dairy states are predominantly farm-based family operations that have much larger capital investments per cow for crop machinery and dairy facilities (Bailey, 2000; MacDonald et al., 2007). The 1999 *Pennsylvania Dairy Farm Business Analysis* on 1,126 farms in Pennsylvania revealed an average of 87 cows per operation and assets of $7,452 per cow (versus $3,500 in large Western farms) (Bailey, 2000).

The current recession and a decline in the price of milk will negatively affect small dairies; many are likely to go out of business, and dairy practitioners will lose clients and, income. In addition, inexpensive serologic tests for pregnancy diagnosis are now competing with a traditional lynchpin of dairy practice—pregnancy diagnosis by rectal palpation, such as those produced by BioTracking LLC and IDEXX Laboratories, Inc. Increases in the use of that and similar technologies have the potential to profoundly alter practitioner-farmer relationships, veterinary oversight of the nation's dairy herds, and the structure of dairy veterinary medicine in the United States.

Estimating the Demand for Dairy Veterinarians

The number of veterinarians needed by the dairy industry depends on how the dairy industry evolves, in particular with respect to the rates of consolidation in different regions of the country. For example, an assessment of need could be based on the number of cows for which one veterinarian can effectively provide health care, or based on the number of farm personnel that one veterinarian can effectively supervise. Assumptions or estimates can be made about several model parameters, such as in the following scenario:

- National milk consumption remains at 182 billion pounds.
- Average annual milk yield per cow is 18,000 pounds.
- Average herd size is 500 head.
- Number of farms served per veterinarian is 10.
- Number of cows per veterinarian is 5,000.
- Dairy veterinarians practice for an average of 30 years.

These estimates of parameters in the dairy industry project a need for 20,222 dairy farms, a workforce of 2,022 dairy veterinarians, and 67 new graduates each year with long-term commitments to the dairy industry to sustain that workforce. However, different assumptions, including those that approximate many of the current trends, might include the following:

- National milk consumption remains at 182 billion pounds.
- Average milk yield per cow is increased to 22,000 pounds.
- Average herd size is 2,000 head.
- Number of farms served per veterinarian is 5.
- Number of cows per veterinarian is 10,000.
- Dairy veterinarians practice for an average of 30 years.

TABLE 4-4 California and Wisconsin: Comparison of Operations, Operations' Size, and Members in the American Association of Bovine Practitioners

State	Number of AABP Members	Number of Dairy Cows	Number of Operations	Number of Cows per Operation	Number of Cows per Veterinarian
Wisconsin	234	1,247,000	14,440	87	5,329
California	112	1,796,000	2,115	849	16,036

NOTE: AABP = American Association of Bovine Practitioners.
DATA SOURCE: American Association of Bovine Practitioners membership and USDA National Agricultural Statistics Service.

This scenario projects a need for 4,136 dairy farms, a workforce that is reduced to 827 dairy veterinarians, and only 28 new graduates per year to sustain that workforce. These projections are based on the work of LaDue et al. (2003) and Getz (1997). They illustrate that, unless changes are made in the services that the veterinary medical profession offers the dairy industry, consolidation will lead to substantially reduced demand for dairy practitioners. Figure 4-5 is a snapshot of a "dashboard" analysis tool that can be used to visualize how different estimates of industry parameters affect the number of veterinarians needed by the industry.

Trends in the recruitment of new members to the American Association of Bovine Practitioners (AABP), a professional association for dairy and beef cattle practitioners, are illustrative of the two scenarios described above.

From 1975-1984, 706 veterinarians joined AABP, an average of 70.6 per year (Figure 4-6). Assuming a 30-year commitment to the industry, that level of new practitioners in bovine practice annually would maintain a population of 2,118 veterinarians, a figure that approximates the conclusions of the first scenario. However, during 1995-2004, only 317 joined AABP, an average of 32 per year. Over 30 years, the annual addition of 32 new practitioners would support at most a population of 960 veterinarians in bovine practice, a figure that is within the range estimated by the second scenario.

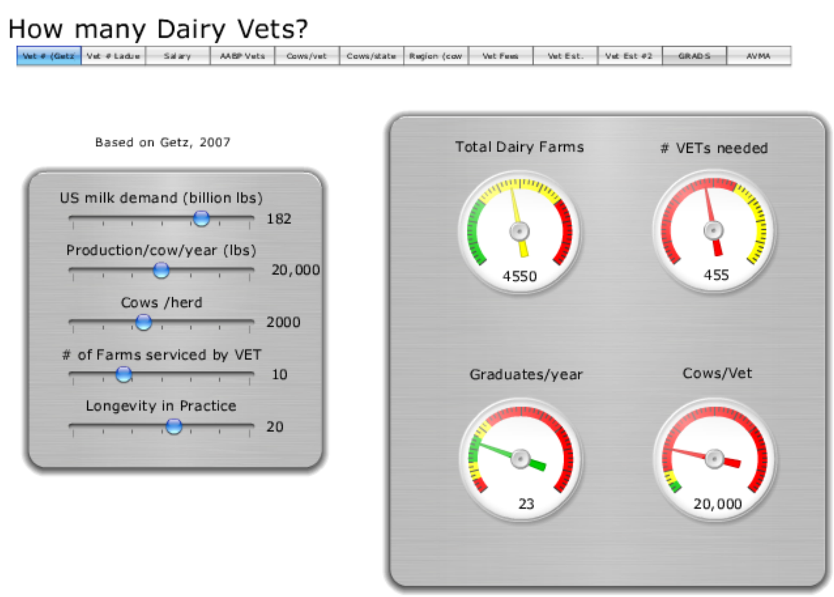

FIGURE 4-5 Dashboard analysis tool: How many dairy vets? NOTE: http://dgalligan.com/galliganx/howmanyvets/howmanyvets.html. (User and password: howmanyvets). SOURCE: Galligan and Kelly, 2007.

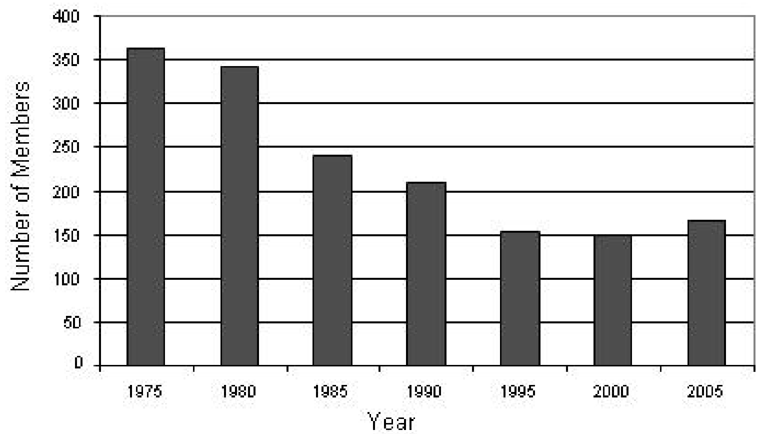

FIGURE 4-6 Recruitment to the American Association of Bovine Practitioners 1975-2005. SOURCE: American Association of Bovine Practitioners, 2007.

The second scenario assumes that the veterinary medical profession makes changes in the services that it offers the dairy industry and takes into account the increased specialization, complexity, and intensity of production in large dairies. As dairy operations increase in size, farm personnel are given specialized responsibilities. The veterinarian would be responsible for establishing the overall infrastructure of herd health, for setting protocols in each specialized production sector, for training farm staff in the implementation of the protocols, for ensuring that excellent records are maintained, and for seeing that the staff is aware of the clinical signs of illness in animals under their care. To succeed, the veterinarian needs an in-depth education on the entire dairy operation and should acquire skills in team-building. Dairy veterinarians also need the business skills to analyze records for an entire dairy farming operation and provide owner-managers with objective advice that will result in improved animal health, productivity, and overall farm profitability.

Consolidation of the dairy industry is expected to persist for at least the next decade with two predictable results: more farms will go out of business, and more rural areas will be without veterinary services. One approach to solving the problem is to develop veterinary public-private partnerships that provide livestock, wildlife, and ecosystem health-surveillance services in underserved areas. Another practical approach is to train a cadre of veterinary paraprofessionals to serve rural areas while working under contract with licensed veterinarians who may be at remote sites but in continuous contact via digital technologies. This approach may permit food-animal veterinarians to offer high-quality consultative services to dairy farms in remote areas.

The Beef Production Industry

The U.S. commercial beef-cow population of about 33 million animals with an additional 4.7 million replacement heifers is distributed on approximately 750,000 ranches in all states of America (USDA-NASS, 2009a). Texas has the largest beef-cow inventory, followed by Nebraska, Kansas, Oklahoma, and California (USDA-NASS, 2009a; see Appendix C, Figure C-10). Cow numbers have been declining for many years, but the number of ranches is decreasing more rapidly, having fallen by 17% between 1988 and 2008 (Figure 4-7).

In contrast with the swine and poultry industries, cow and calf farms (in which a herd of cows is maintained for producing calves that are sold to feedlots) are largely family-owned operations in the United States (Outlaw et al., 1996). However, the trend toward consolidation of the cow-calf industries is proceeding as competition forces producers to seek ways to reduce costs and survive (Table 4-5). Consolidation is driven by the declining value of feeders and by razor-thin profit margins (Andrus et al., 2006; Gay, 2011). As in the other food-animal industries, consolidation affects demand for veterinary services: large herds require consulting services in production medicine delivered efficiently and inexpensively, and small herds typically require basic animal-husbandry services, health testing, vaccination, dehorning, castration, and obstetrics.

Commercial cow and calf producers typically raise cows and calves on grass in warm weather and feed hay and grain supplements in winter. Many are small operations, with 53% maintaining 20-199 cows. Another 16% of cows are on ranches that have 500 to more than 2,500 cows (Table 4-5). Of the cow-calf operators in the United States, 8% own 51%, or 17.5 million, of the beef cows (Gay, 2011).

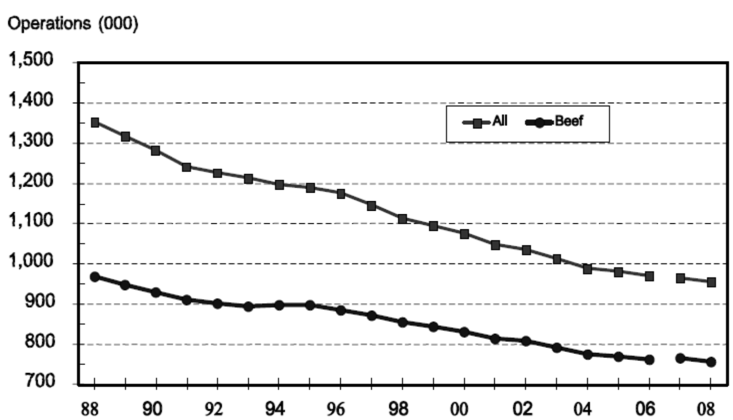

FIGURE 4-7 Number of all U.S. cattle and beef-cow operations, 1998-2008. SOURCE: USDA-NASS, 2009b.

TABLE 4-5 Size Distribution of U.S. Beef Farms

Beef herd size	Number of beef herds	Percent of all herds	Number of beef cows	Percent of all cows
1-9	246,863	32	1,160,439	4
10-19	160,005	21	2,162,448	7
20-49	200,840	26	6,090,407	19
50-99	84,253	11	5,656,207	17
100-199	45,575	6	5,753,342	17
200-499	23,635	3	6,722,106	20
500-999	4,413	1	2,861,202	9
1,000-2,499	1,215	0	1,648,412	5
2,500+	185	0	780,238	2
Average Herd Size: 43	Total: 764,984		Total: 32,834,801	

SOURCE: Adapted from USDA-NASS, 2009a, and Gay, 2011.

Primary-income producers make up only 14% of all producers but account for 79% of herds of over 300 beef cows. For those ranchers, the cow-calf enterprise is the main means of family support. Because of declining animal values, producers have been forced to consolidate, and herds of over 1,000 cows are now considered necessary to support a family of four (Gay, 2011). With larger numbers of animals, routine health problems are more frequent and ranch personnel become accustomed to diagnosing and treating them, while providing other basic husbandry services, such as castration, dehorning, and immunization. Under those circumstances, the veterinarian is responsible for defining treatment protocols, training ranch personnel on routine health care, and consulting producers on managerial issues, including disease prevention and risk management. One survey of producers has found that the larger the cow-calf operation, the greater the use of veterinary consultative services (see Table 4-6).

In contrast with primary-income producers, supplemental-income producers make up 69% of beef producers. Most have herds of fewer than 300 cows and seek veterinarians for routine services. Noneconomic producers make up 17% of producers. Most are small producers who have cattle for noneconomic reasons, such as maintaining a family property. They call on veterinarians for basic husbandry services, such as vaccination, breeding, castration, and dehorning and for traditional care of individual sick animals. Cow-calf operations are usually in areas of low human population density. Services of veterinarians are required mainly for spring calving and in the fall. Because the demand for services is seasonal and the industry is dispersed, many veterinarians serving the industry are in mixed-food-animal practice. The decline in numbers of veterinarians practicing in rural and remote areas of the United States constitutes a serious problem for the security and safety of the nation's beef industry, as well as for the

TABLE 4-6 Use of Veterinary Services by Herd Size in Different Sectors of the Beef Industry

	Producer Source of Income			
Herd size (cows)	Percent of primary income	Percent of supplemental income	Percent noneconomic	Percent reported veterinarian use in 1996
<50	5	72	22	48
50-99	26	69	4	72
100-300	50	47	3	79
>300	79	17	4	83

SOURCE: Adapted from Gay, 2011, and USDA-APHIS, 1997.

stability of the rural economy. Developing a cadre of veterinary paraprofessionals to serve remote areas may provide one solution. In contrast with the cow-calf industry, feedlot operations are highly concentrated. The 25 largest feeding organizations produce 40% of fed cattle (USDA-ERS, 2010). Almost all feedlot operators use veterinary services. There are three common models:

- 3.3% of operations (8.4% of herds that have over 8,000 head) have full-time food-animal-exclusive veterinarians on staff.
- 34.6% of operations (76.2% of herds that have over 8,000 head) contract for routine veterinary visits, usually by consultant food-animal-exclusive veterinarians who regularly serve a feedlot circuit. Most large feedlot producers use this model. Anecdotal evidence suggests that consultant veterinarians in this part of the industry are appropriately compensated and that there are adequate numbers to serve the industry.
- 70.9% of operations (39.3% of herds that have over 8,000 head) call a veterinarian as needed.

Thus, in contrast to the dairy industry, veterinarians in feedlot operations commonly work under contract with producers and are paid for services as consultants. Their responsibilities include defining health-care protocols for a feedlot, training personnel in the implementation of the protocols, and advising feedlot operators on the overall health-care management of the herd. To perform these tasks, consultant veterinarians draw upon their knowledge of routine animal care with focus on the health of individual animals and their proficiency in production medicine with focus on the performance, profitability, and nutrient management of the entire herd.

Sheep and Goat Industries

The size of the U.S. sheep industry has been falling for over 50 years and suffers from the perception of an “industry in decline.” Since 1991, the U.S. population of sheep and lambs has dropped by nearly 50% (Figure 4-8) to around 10 million head in 2008 as a result of weakness in demand for wool and lamb. However, the decline has recently leveled off because of several factors, including the emergence of ethnic niche markets for lamb, and for sheep's milk, and the growing popularity of sheep cheeses. Nearly half of the world's exports of sheep's milk cheese are destined for the United States, making it the largest importer of sheep's milk cheese (NRC, 2008).

The 2009 U.S. goat inventory totaled 3.1 million head and was made up of a variety of breeds used in the production of meat, milk, and fiber. Demand for goat fiber is declining, whereas demand for goat meat and milk is increasing. Growing ethnic niche markets led to a 64% increase in the number of U.S. farms that produce goats for meat from 2002 to 2007, and today there are more than 120,000 meat-goat producers (see Figure 4-9). During the same period, the meat-goat population increased by 24%, from 2.5 to 3.1 million animals. Texas is the largest producer of meat goats in the United States with production concentrated in west Texas, an area that has a large Hispanic population that prefers goat meat to beef (Appendix C, Figure C-11a).

Dairy goats are raised throughout the United States with specific concentrations in Wisconsin and New York (Appendix C, Figure C-11b). Across the nation, dairy-goat inventories increased by 15% from 2002 to 2007 (USDA-NASS, 2009a). The increase was driven by the growing sophistication of U.S. cuisine and niche markets for goat milk and cheeses (Haenlein, 2001).

There are inadequate studies of sheep and goat health and of the economic effects of disease on the sheep and goat industries (NRC, 2008). Parasitic diseases are of particular concern in connection with the development of resistance to the anthelmintic drugs that are used to treat for them. Food-animal veterinary services for the sheep and goat industries are inadequate in many parts of the country (NRC, 2008). Continued expansion of small-ruminant production is expected and seems likely to provide new opportunities for food-animal practice.

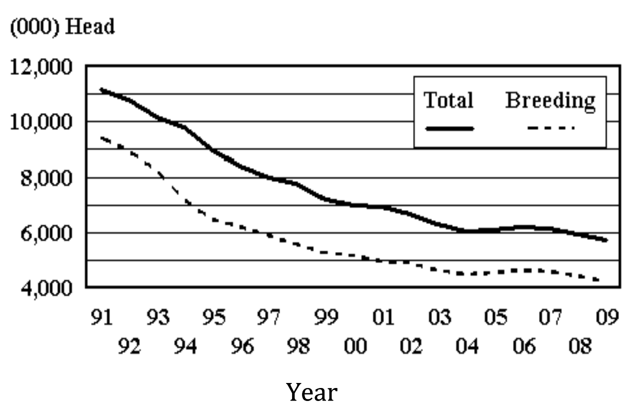

FIGURE 4-8 U.S. sheep and lamb population, 1991-2009. SOURCE: USDA-NASS, 2010.

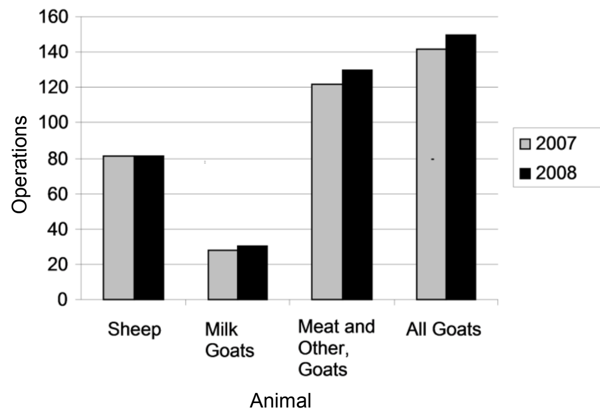

FIGURE 4-9 U.S. sheep and goat operations in 2007 and 2008. SOURCE: USDA-NASS, 2009a.

THE SUPPLY OF FOOD-ANIMAL VETERINARIANS

The Changing Profile of Food-Animal Veterinarians

As the largest professional organization for veterinarians, the American Veterinary Medical Association (AVMA) maintains data on its members that is useful for examining workforce trends. AVMA membership data can be challenging to interpret, however, because of changes in the way that it members' practices are reported over time (see Box 4-1).

Nevertheless, the data can be used to see some changes in the composition of the food- animal workforce. Table 4-7 shows the numbers of AVMA members in private practice by practice species from 1966 to 2007. Between 1966 and 2007, total AVMA private and public membership (column 5) increased from 26,632 to 87,946 veterinarians—an increase of 330%. During this time period, the number of large-animal practitioners (LA-exclusive + LA-predominant, column 2)[1] grew from 1,861 to 5,090—an increase of 270%.

Care for food animals is provided both by large-animal and mixed-food-animal veterinarians, the latter group defined by AVMA as practicing food-animal medicine 50% of the time. Thus, from 1966 to 2007, the total number of full-time equivalents (FTEs) engaged in food-animal practice (adjusting for 50% of the time of mixed-food-animal practitioners) increased by 11%, from 5,820 FTEs in food-animal practice in 1966 to 6,454 FTEs in 2007 (column 6).

[1]The terms large-animal exclusive (LAE) and large-animal predominant (LAP) were used by AVMA until 2009, and are used when discussing historical AVMA data that is labeled as such. However, the more recently adopted terms FA-exclusive and FA-predominant are essentially synonymous with LAE and LAP, respectively.

BOX 4-1
Changes in the American Veterinary Medical Association Membership Data

Over the years, the American Veterinary Medical Association (AVMA) has changed the definitions of categories of membership, which provide a more refined picture of the membership, but make it challenging to understand long-term trends. For example, data from 1966 on membership includes veterinarians from all countries, but in more recent years, the figures include only U.S. members. Comparisons, therefore, can be confusing.

In 1994 there were 13,998 members designated as mixed-animal practitioners, who cared for companion animals and probably some portion of the livestock and poultry raised in small-town America. In 1995, the definition of mixed-animal practice was narrowed to include only those who devoted at least 50% of their time to food- animal practice. Under this definition, the number of AVMA members in mixed-animal practice immediately dropped in 1995 to 3,148. Some portion of veterinarians previously categorized as mixed-animal practitioners were likely added to the large-animal practice category, which increased by 1,594 members between 1994 and 1995, and others to the companion-animal category, which added 1,720 members. Others may have been excluded as they were not U.S. members.

In 1995, AVMA split the large-animal practice and small-animal practice categories into four categories: large-animal exclusive (LAE), large-animal predominant, (LAP), small-animal exclusive, and small-animal predominant. From 1995 to 2005, the designation of LAE or LAP was in the hands of members. In 2006, AVMA began assigning the designation depending on specific practice activity, resulting in a sudden change in the large-animal membership profile. In addition, since 2009, AVMA has begun to use the terms food-animal exclusive, food-animal predominant, and mixed-food-animal in place of LAE, LAP, and mixed-animal. All of these changes complicate interpretations of the workforce over time.

To obtain a clearer picture of the composition of veterinarians practicing food-animal medicine over time, Figure 4-10 uses data from Table 4-8 to plot the percentage change in the number of FTEs working in food-animal medicine (LAE + LAP and food-animal mixed-animal) by year from 1995 to 2007. The figure shows that the makeup of the food-animal veterinary workforce is changing toward greater participation by mixed-food-animal practitioners. In 1995, the year that AVMA established the definition of mixed-food-animal practitioners as veterinarians who devoted 50% of their effort to food-animal care, there were 3,148 mixed-food-animal practitioners. They represented 23% of the total FTEs (adjusting for the 50% time of these practitioners) in the food-animal workforce at that time. By 2007, the number had increased to 4,345, representing 33% of the total FTEs in the food-animal workforce, and an increase of 38% over the 1995 number.

TABLE 4-7 Number of U.S. Veterinarians in AVMA Membership by Category[1]

	1		2	3		4	5	6	7
Year	Large Animal (LA)		Total LA	Small Animal		Mixed[4]	All	Total Food FTEs	Percent of Members
1966	1,861		1,861	4,700		7,917	26,632	5,820	21.85
1971	1,700		1,700	7,050		8,583	25,665	5,992	23.35
1976	1,958		1,958	9,524		9,437	27,889	6,677	23.94
1981[2]	1,113		1,113	12,210		11,153	33,545	6,690	19.94
1986	4,024		4,024	17,682		13,344	46,625	10,696	22.94
1987	4,023		4,023	18,984		13,479	48,646	10,763	22.12
1988	4,020		4,020	19,885		13,502	50,612	10,771	21.28
1989	4,054		4,054	20,721		13,420	52,027	10,764	20.69
1990	4,086		4,086	22,056		13,769	53,299	10,971	20.58
1991	4,122		4,122	22,920		13,757	55,157	11,001	19.94
1992	4,243		4,243	23,967		13,944	56,421	11,215	19.88
1993	4,280		4,280	24,682		14,047	58,099	11,304	19.46
1994	4,289		4,289	24,493		13,988	59,360	11,283	19.01
	LAE	LAP		SAE	SAP				
1995	1,805	4,078	5,883	22,839	5,376	3,148	54,852	6,641	12.11
1996	1,857	4,078	5,935	23,635	5,514	3,215	55,252	6,727	12.17
1997	1,860	4,024	5,884	24,567	5,661	3,207	56,694	6,683	11.79
1998	1,771	3,802	5,573	24,727	5,528	3,097	57,052	6,361	11.15
1999	1,894	3,876	5,770	26,235	5,717	3,418	60,829	6,704	11.02
2001	2,195	3,583	5,778	30,460	6,399	3,909	72,423	7,016	9.69
2002^	2,142	3,013	5,154	30,999	5,953	3,666	72,598	6,385	8.80
2003	2,253	3,273	5,526	32,391	6,285	3,882	76,026	6,812	8.96
2004	2,285	3,145	5,430	33,417	6,324	3,890	77,889	6,746	8.66
2005	2,268	3,047	5,315	34,022	6,244	3,900	79,569	6,656	8.36
2006[3]	993	4,150	5,143	37,137	5,688	4,376	84,946	6,501	7.65
2007[2]	1,048	4,042	5,090	38,974	5,811	4,345	87,946	6,454	7.34

NOTE: FTE=full-time equivalent, LAE=large-animal exclusive, LAP=large-animal predominant, SAE=small-animal exclusive, SAP=small-animal predominant.

[1]Includes actively employed AVMA members and verified nonmembers in the Membership Database. Between 1996 and 1995, veterinarians from all countries were included. After 1995, numbers reflect U.S. members only.

[2]Includes only actively employed AVMA members.

[3]Veterinarians may hold multiple positions (counted in multiple categories).

^2002 is based on estimated percentages and the end of year total number of veterinarians from the 2002 Membership Report.

[4]2001-2005 Equine/Small Animal species code was pulled from Mixed Animal. These numbers will be different than what is published.

SOURCE: AVMA.

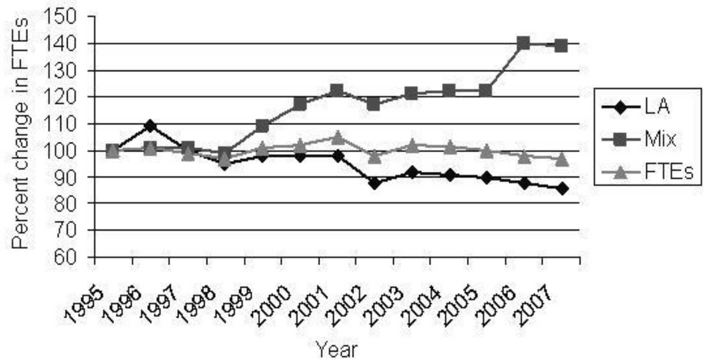

FIGURE 4-10 Changes in the composition of the food-animal workforce. NOTE: LA=large-animal, Mix=mixed-animal, FTEs=full-time equivalents. There are no data on 2000; figures for 2000 are averages of the 1999 and 2001 values. SOURCE: Based on membership data of the AVMA.

From 1995 to 2007, the total number of LAE and LAP veterinarians declined by 13%, from 5,883 to 5,090. Because the numbers of mixed-food-animal practitioners had increased as described above, the total food-animal FTEs did not change much from 1995 to 2007 (Table 4-7, column 6). Thus, although the total FTEs in food-animal practice have changed very little during this time period, the composition of the workforce has been changing toward mixed-food-animal practice. More food animals are in consolidated livestock facilities that generally require veterinarians with full-time, specialized commitment to food-animal practice, but an overall decline in the demand in food-animal practice and an increase in reliance on companion-animal care to supplement incomes is pushing professional services towards mixed-food-animal practice and delivery of traditional food-animal veterinary services.

There are other changes in the demographics of rural America that may impact the directions of food-animal veterinary practice and explain the rise in numbers of mixed-food-animal veterinarians. Urban areas continue to spread into the countryside and usurp large tracts of farmland. In addition, more isolated, low-density, large lot developments are occurring with increasing frequency further out in the rural countryside, especially in some of America's richest farmland (Heimlich and Anderson 2001). Across the country these areas are described as under intense pressure from development (AFT, 2011). For example, the population of Tulare County, a center of California's dairy industry increased by 20% between 2000 and 2010, in the same period the population of Calumet County, Wisconsin increased by 20.5%, and Lancaster County, the heart of Pennsylvania's dairy industry, by 10%. The increasing populations coexist with farming operations and expand opportunities for companion-animal and equine care in regions that were once purely agricultural and the realm of food-animal-exclusive and food-animal-predominant veterinarians.

The growing movement toward small farming operations and locally-grown and specialty-food markets with increased demand for primary veterinary care may have had an additional effect in supporting mixed-food-animal practices. Appendix C, Table C-1 details the change in distribution of mixed-food-animal veterinarians by state and shows that increases in mixed-animal practice have occurred in all but six states. In view of these trends, the veterinary profession needs to consider how it will be able to meet the needs of all food-animal producers.

Aging and Attrition

The food-animal-exclusive, food-animal-predominant, and mixed-food-animal practice categories have different age compositions, and they are changing at different rates. Figures 4-11, 4-12, and 4-13 provide a snapshot of changes in the age structure of each category of food-animal practice between 2001 and 2007. AVMA membership data (Appendix C, Tables C-2a,b; 3a,b; and 4a,b) show that food-animal practitioners, as a group, are aging in general, with the food-animal-predominant category approaching retirement age the fastest. That is important because food-animal-predominant veterinarians currently make up 50% of the FTEs in food-animal practice (Table 4-8). It is also the segment of food-animal practice that is attracting the fewest new graduates, and as will be discussed later, has the lowest salary.

In 2007, there were 4,042 AVMA members in food-animal-predominant practice in the United States (Table 4-7), with 57% of that group being over 50 years old (Figure 4-12). This is in contrast to 50% and 43% of AVMA members being 50 years and older in food-animal-exclusive and mixed-food-animal practice, respectively (Figures 4-11 and 4-13). Fewer and fewer graduates have entered food-animal-predominant practice for over two decades. Consequently, this sector of the profession is facing an uncertain future.

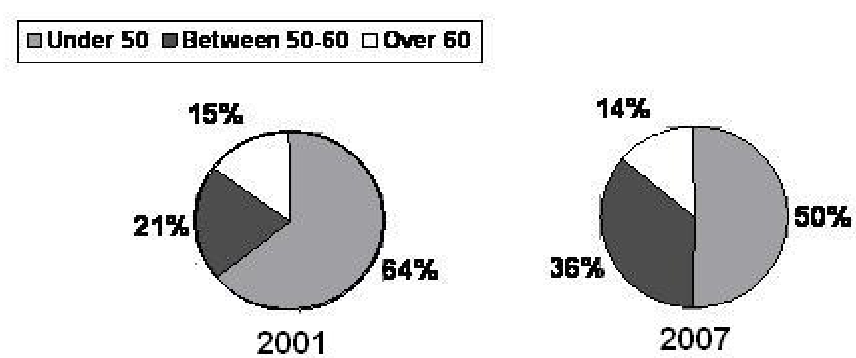

FIGURE 4-11 Age groups within food-animal-exclusive practice, 2001 and 2007.

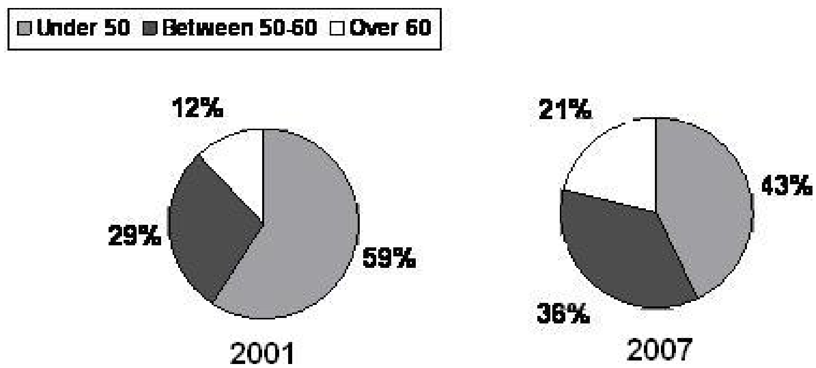

FIGURE 4-12 Age groups within food-animal-predominant practice, 2001 and 2007.

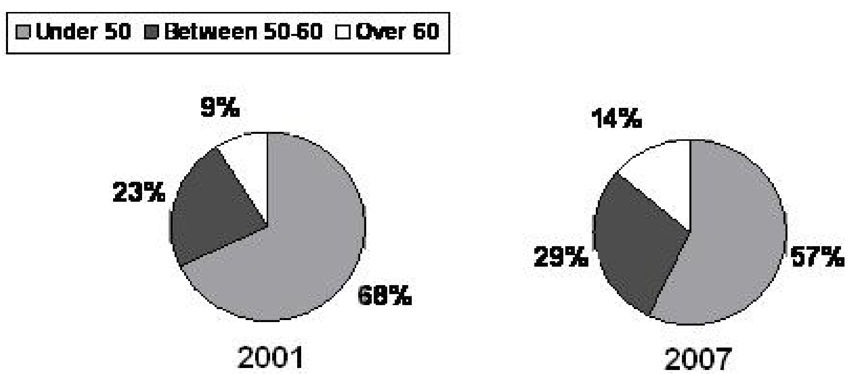

FIGURE 4-13 Age groups within mixed-food-animal practice, 2001 and 2007.

Mixed-food-animal practitioners have an average age of 47 years, and the group is aging more slowly than the other two categories of food-animal practice. However, the percentage of mixed-food-animal practitioners under 50 years old declined by more than 10 percent between 2001 and 2007 (Figure 4-13).

Appendix C contains several maps (Figures C-12a, b; C-13a, b; and C-14a, b) that show the geographic distribution of food-animal practitioners by age groups, which vary by category of practice. Most of the states that have large numbers of food-animal-predominant practitioners are in the Midwest (Appendix C, Figure C-5) so this region is likely to be the most severely affected by the change in demographics. The shortfall is not strictly sex-driven: comparatively few women have entered this branch of veterinary medicine, and fewer men are going into the field (Chieffo et al., 2008).

Recruitment of Graduates into Food-Animal Practice

According to information from AVMA, 531 graduates of the class of 1989 entered food-animal practice (Figure 4-14). In 2009, the number was 203—a drop of 62% in 20 years. The decline occurred in all three categories of food-animal practice and is attributed to the economy and the decrease in availability of jobs in food-animal practice. There is great pressure to increase the number of graduates going into food-animal practice, but the profession may first need to consider the nature of the opportunities that are available and the education needed by food-animal veterinarians.

The greatest decline involved the numbers of graduates entering food-animal-predominant practice, which fell from 229 in 1989 to 34 in 2009—a decrease of 85%. Entry of graduates into mixed-food-animal practice also declined, falling from 253 to 147—a decrease of 42%. The number of graduates entering food-animal-exclusive practice, presumably with the goal of serving intensive systems of production focused on a single species, increased from 1989 to 2007 and then decreased by nearly 70% from 2007 to 2009. Inasmuch as starting salaries were nearly $10,000/year more in food-animal-exclusive than in food-animal-predominant and mixed-animal practices (discussed later in this chapter), the decrease was most likely due to a decline in the number of food-animal-exclusive positions available.

What will be the size of the future food-animal workforce in comparison to today? In 2007 there were 5,100 food-animal-exclusive and food-animal-predominant practitioners who were members of AVMA (Table 4-8), and approximately 994 of them were over the age of 60 (Figures 4-10 and 4-11). Because of the physical and strenuous nature of food-animal practice, the length of an average career is generally assumed to be 30 years, about 5 years shorter than that of practitioners in either companion-animal or equine medicine. If half of the practitioners over 60 were to retire in the next 5 years, the addition of 99 new graduates each year would be required to maintain the 2007 level of 5,100 practitioners in the future, not accounting for those who retire early or work part-time.

From 2006-2007, an average of 74 graduates each year indicated their intention to pursue food-animal-exclusive and food-animal-predominant practices (Shepherd, 2008). If this level of new additions to the food-animal workforce continues, the number of food-animal-exclusive and predominant practitioners will shrink the present workforce. As half of new food-animal practitioners can be expected to leave food-animal practice within 5 years (Remsburg et al., 2007; Jelinski et al., 2008), the workforce may potentially decline dramatically. On the other hand, if food-animal-exclusive practice becomes less physically intensive and more supervisory, those that stay may work for more years than in traditional food-animal practice.

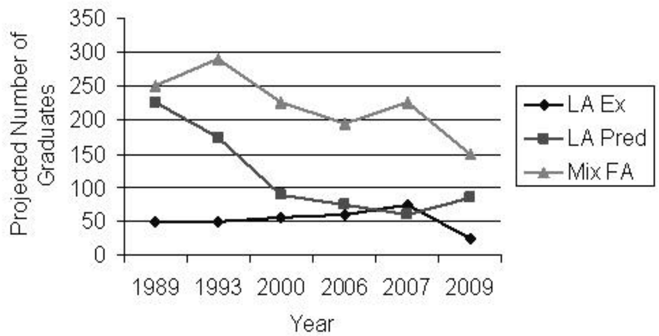

FIGURE 4-14 Career selection of veterinary graduates entering food-animal practice. NOTE: LA Ex=large-animal exclusive, LA Pred=large-animal-predominant, Mix FA= mixed-food-animals. SOURCE: Data courtesy of AVMA.

TABLE 4-8 Starting Salaries and Mean Debt for New Graduates, 1989-2011

	Mean starting salaries ($)			Salary growth/year (percent)	
Practice Type	1989	2007	2010-11	1989-2007	2010-11
Food-animal exclusive	25,210	62,424	71,096	4.65	3.1
Food-animal predominant	26,663	57,744	67,338	4.10	8.5
Mixed-food-animal	23,961	58,522	62,655	4.15	.5
	Mean Debt ($)			Debt growth/year (percent)	
	27,726	119,802	142,613	7.6	6.5

NOTE: Response rates of annual surveys of graduating DVMs are typically greater than 90%.
SOURCE: Chieffo et al., 2008; Shepherd and Pikel, 2011.

Starting Salaries and Student Debt

From 1989 to the present, starting salaries for new graduates entering food-animal-exclusive practice are higher ($71,096) and have grown faster than those entering either food-animal-predominant or mixed-food-animal practice, according to exit surveys of new graduates (Table 4-8). Student debt, however, has grown even faster, increasing at a rate of 7.6% each year between 1989 and 2007, and by 6.5% between 2010 and 2011. Students now owe an average of $142,613 upon graduation. In 1989, educational debt was approximately 110% of starting salaries. In 2011, those entering food-animal-predominant practice face debts of around 205% of their initial salary. Although interest rates on government-backed educational loans in 2010 were capped at 6.8%, the debt burden mortgages the future for those wishing to enter food-animal practice. State and federal grants to help graduates with their debt burden are useful but will not overcome the depressed market for associates in food-animal veterinary practice.

Compensation

In a survey of members' compensation in 2007, AVMA found that food-animal-exclusive practice owners earned the highest median income ($139,000) of all branches of private practice. In AVMA's 2009 survey (AVMA, 2010a), the figure dropped to $133,000 (Figure 4-15), possibly due in part to the effect of the recession that began in 2006. The reported income of this group had increased previously by 16% from 2005 to 2007 (Burns, 2009). In 2009, mixed-food-animal and food-animal-predominant practice owners had median incomes of $103,000, somewhat less than practice owners in the other branches of private practice; this circumstance may be an impediment in attracting and retaining graduates in food-animal medicine with substantial educational debts. In 2009, the annual median salary of food-animal-exclusive associates was $79,000, while food-animal-predominant and mixed-food-animal associates earned median incomes of $73,000, the same as associates in companion-animal-predominant practice. In contrast, companion-animal-exclusive associates had an annual median income of $85,000. The salary difference is consistent with a view that the problem in food-animal practice in rural America is one primarily of unmet needs and not one of shortages. In other words, demand is there but compensation is too low for veterinarians to survive in rural practice.

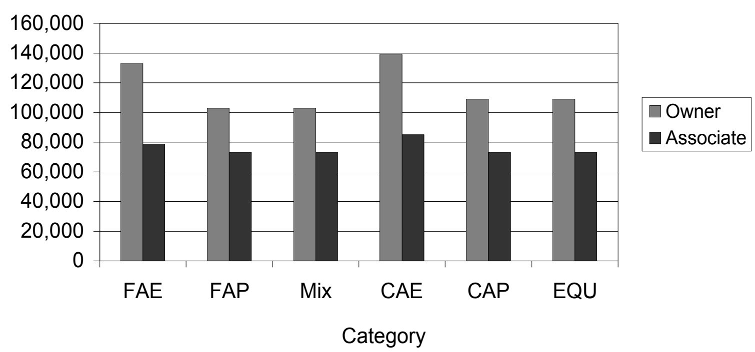

FIGURE 4-15 2009 median incomes of practice owners and associates by category. NOTE: FAE=Food-animal-exclusive; FAP=Food-animal-predominant; Mix=Mixed-animal; CAE=companion-animal-exclusive; CAP=companion-animal-predominant; EQU=equine veterinary practice. SOURCE: Adapted from AVMA, 2011a[2], Burns 2009.

[2]Veterinarian salary data are drawn from the biennial AVMA Compensation Surveys, which are based on a randomized, stratified sample of employed U.S. veterinarians (including AVMA members and nonmembers). The response rate of the Surveys is about 25%. If DVMs who are more successful are more likely to respond, the reported rate of earnings may exceed actual averages.

FUTURE DIRECTIONS IN FOOD-ANIMAL VETERINARY MEDICINE

With the changing nature of food-animal production in America, the overall demand for traditional veterinary services has declined. Nevertheless, if future food-animal veterinarians can master a broad understanding of the complex challenges of production medicine, there is a great potential to redefine the role of food-animal medicine in the intensive livestock and poultry industries, while at the same time fulfilling the profession's responsibilities to an American public concerned with food safety, drug residues, animal welfare, and stewardship of the environment. If not, the veterinary medical profession is in danger of relinquishing its role in animal production to others who are able to consider the economic needs of producers but who have less understanding of the complexity of animal health and public health (King, 2000). Large dairies already routinely use consultants to advise on such issues as housing, communication, employee training, nutrition, and environmental regulations—matters that are frequently seen by producers as "outside the realms of veterinary medicine" (DSI, 2006). Because of the profession's declining presence in food-animal care, the nation is losing the all important food-animal veterinarian-producer relationship upon which the health and welfare of livestock populations depend. For the veterinary profession, this is untenable.

A Vision for Food-Animal Veterinary Medical Education

To ensure their future in food-animal medicine, veterinary graduates should be well-grounded in the specialized aspects of the livestock or poultry industries they wish to serve and have the skills needed by these increasingly intensive, specialized, and concentrated industries. This direction was advocated by the late Otto Radostits (2002) who wrote that "meeting the needs of progressive livestock producers is a full time career for a progressive food-animal practitioner and is not a part time job."

J. B. Herrick was among the first to redefine how veterinary services should be offered to livestock operations and popularized the term *production medicine*. Herrick emphasized a food-systems approach to food-animal services and defined production medicine in 1990 as "the utilization of many facets of production, e.g. nutrition, environment, genetics, and health, into a well-managed program monitored by records" (Herrick, 1990). With a few notable exceptions, progress in moving food-animal practice in that direction in the intervening two decades has been inadequate. The Food Supply Veterinary Medicine Commission (Andrus et al., 2006) drew attention to the thin supply of new graduates entering food-animal veterinary medicine and to the lack of focus on this field by many veterinary schools. Veterinary schools are accused of being slow in their willingness to change and develop curricula that meet the needs of the dynamically changing livestock industries and of an increasingly apprehensive public. Nielsen (2001) is harshly critical, stating that there has been a failure to provide graduates with sufficient entry-level competence to practice modern health and production management in herds of food-producing animals.

Large producers who dominate the livestock industries seek veterinarians who are either exclusively or predominantly committed to food-animal practice. Implicit in this is the need for food-animal veterinarians who understand production systems, can read farm records, and can use them to make decisions aimed at increasing herd health, productivity, and the overall profitability of the farming operation. It is these objective services that farmers seek and for which they are willing to pay. Veterinary practitioners also need to know how to charge for their consultative services. Many either don't know how to charge or don't like to charge for consulting and would rather bill for primary care or pregnancy exams instead.

In veterinary academe, some faculty members recognize that food-animal curricula must fundamentally change, but the present state-based infrastructure of veterinary education and declining budgets make change difficult. To succeed will require veterinary schools and colleges to share resources and work together to create on-line courses in production medicine and centers of educational excellence that can efficiently provide comprehensive, high-quality veterinary education for the nation. As a start, an accepted definition of a herd health management program should be developed so the goals of the profession are delineated.

Food-animal veterinary medicine is now specialized by food-animal species and focused expertise in the nutrition, reproduction, genetics, housing, economics, risk management, etc. of the relevant species. Authorities in each of these areas are present in veterinary schools and industry across the country and no one school can afford to provide positions in all of the areas. Creation of virtual "centers of emphasis" in the theoretical aspects of poultry, dairy, beef, and swine medicine could be created making use of recognized experts in academe, food-animal practice, the livestock industry, and the pharmaceutical industry and others to provide a portfolio of essential on-line courses in food systems. The courses should be easily available to veterinary students in the United States and internationally.

The benefits of consortia in food-animal veterinary medicine have been reviewed by Miller and Prasse (2006). Troutt and Osburn (2008) proposed the creation of regional centers in veterinary education for the dairy industry. In their model, senior students from cooperating veterinary schools would spend part of, or their entire fourth year at an established regional center. Two-year residency programs would be included in the center program. The University of California at Davis Veterinary Medicine Teaching and Research Center at Tulare, California, the Iowa State Swine Medicine Education Center partnered with the Audubon Manning Veterinary Clinic, and the recent USDA grant to create a National Center of Excellence in Dairy Production Medical Education for Veterinary Students provide encouraging examples. These initiatives could prepare veterinary graduates to fully and successfully participate in the dynamically changing food-animal industries of this country and beyond.

Providing Veterinary Services to Rural America

In the last 25 years, many farms that produced food animals have gone out of business which resulted in food-animal practitioners being unable to survive. This difficulty is not new; in 1982, a National Research Council committee report *Specialized Veterinary Manpower Needs Through 1990* (NRC, 1982) noted that "the problem is in large part a matter of the economics of food-animal veterinary practice, [and] areas with perceived shortages commonly do not provide satisfactory remuneration." The report raises a question that is as salient today as it was in 1982: Are there unmet needs for food-animal veterinarians in rural America because of economic circumstances, or are there real shortages with adequate compensation but inadequate numbers of food-animal veterinarians? (NRC, 1982).

The changing circumstances of food-animal veterinarians in rural America should not be viewed in isolation but in the broad context of the changing demographics of small-town America and the impact of concentrated-feeding operations on these societies. These once flourishing rural communities are described as suffering from "a slow acting wasting disease" being transformed by the flight of so many young people (Carr and Kefalas, 2009a, b; see also Artz, 2003; Romer and Wolverton, 2010). Appendix C, Figure C-2 illustrates changes in population in the United States between 1990 and 2000. Carr and Kefalas (2009a) describe local ownership as suffocated by the rise of CAFOs and large box-stores with the result that the rural middle-class of merchants, bankers, and professionals has left. Moreover, as farming operations increase in size, the American-born workforce is progressively replaced by migrant labor (WisconsinWatch.org, 11/21/11). Carr and Kefalas (2009b) further report that 42% of Mid-western farmers now earn less than $20,000 per year making it difficult for them to afford professional veterinary services and highlighting the need for a different system of food-animal care.

To attract more students into rural practice, several state legislatures have passed or are considering legislation to provide educational-loan forgiveness to graduates who move into rural and underserved areas. The federal Veterinary Medicine Loan Repayment Program has also made awards to veterinarians willing to practice for at least three years in areas designated by the Secretary of Agriculture as having shortages in food-animal or public practice veterinarians. The average award size (to cover federal and commercial loans taken to attend an AVMA-accredited college of veterinary medicine) was $96,582 (USDA-NIFA, 2010). In the present economic climate, those initiatives are important as they will immediately help debt-burdened graduates to accept positions in underserved areas of America. In the longer-term however, additional solutions are needed as half of the graduates entering food-animal practice are reported to leave within 5 years (Remsberg et al., 2007; Jelinski et al., 2009).

To change these demographics, the veterinary profession has to make a concerted effort to recruit and retain more students in food-animal veterinary medicine. In the past, most students who went into food-animal practice have come from rural backgrounds or have had other previous experiences with livestock or poultry farming (Schmitz et al., 2007; Jelinski et al., 2008). This is a diminishing population. Furthermore, as livestock and poultry operations are increasingly housed within biosecure facilities, the opportunity for students even from rural background to gain farm experience is diminishing. In view of this, the profession has to look to urban and peri-urban communities and recognize that students from these backgrounds, including students from minority groups that are underrepresented in veterinary medicine, who may know little about their food supply may be unaware of the significant opportunities that food-animal veterinary medicine has to offer. The digital media provides numerous ways of addressing that issue—social media, on-line programs, webinars, and other forms of communication should be prepared to educate high school and college students and the general public about the importance of food-animal medicine to society with regard to food-animal health and welfare, food safety, and environmental health. Such programs could also be aimed at correcting misconceptions about livestock and poultry farming that currently abound and bias students away from considering careers in agriculture.

Expanding the Role of Veterinary Paraprofessionals

As a goal, the veterinary profession should endeavor to provide health care to the largest possible population of livestock and poultry. For economic and other reasons the profession is presently not meeting this goal. In view of this, the committee supports a proposal to integrate rigorously-trained and credentialed food-animal veterinary paraprofessionals (veterinary technicians or individuals with veterinary training) working in health-care teams with licensed veterinarians who may be at a distant site (Remsberg et al., 2007). This is similar to the expanding system of health care in the medical profession in which nurse practitioners in rural locations are linked digitally to physicians who are located distantly. For food-animal paraprofessionals to become part of a veterinary health-care system, state practice acts will need to be modified to permit paraprofessionals to administer primary care services provided that they are subject to collaborative oversight (and constant communication) with licensed practitioners who may be in a different location. This approach offers the potential for clinicians to provide affordable patient care as well as for providing care for patients in underserved rural areas without reducing quality. The system can also improve animal-disease surveillance and provide surge capacity in rural America should emergencies arise.

The food supply is a matter of national security and public health, but generally taken for granted by the American public. As is discussed in Chapter 6, the job of safeguarding food and overseeing the welfare of food animals is a shared responsibility of the private and public sector. Neglecting that responsibility poses significant risks. Additional considerations for strengthening the veterinary oversight of the food-animal sector and the need for research in food-animal health are explored in the final chapter of the report, Chapter 11.

5

Veterinarians in Industry

INTRODUCTION

Outside of private practice and corporate animal health care, the majority of private sector jobs for veterinarians are in the pharmaceutical, biotechnology, diagnostics, contract research services, animal feeds, and agrochemical industries. Those industries offer a diversity of job opportunities to veterinarians and provide the highest salaries of any category of veterinarian employment, with an average salary of around $167,415 (AVMA, 2011a)[1]. Along with the public sector, industry offers the most generous plans for life insurance, pension plan, and medical coverage (AVMA, 2009a).

In 2010, the American Veterinary Medical Association (AVMA) counted 3,218 veterinarians (AVMA members and non-members) in the United States who identified themselves as working in private industry jobs. That number is probably an undercount of veterinarians working in industry. However, the total number of veterinarians in industry is not likely a large number. Despite the attractiveness of industry employment, and the primary significance of salary and benefits to graduates of veterinary schools, only 0.1% of recent DVM graduates who responded to a 2010 survey had selected a job in industry, reflecting a similar fraction of surveyed graduates in prior years (Shepherd, 2010).

As discussed in this chapter, a defining feature of veterinarians in industry is the number with advanced training in pathology, toxicology, laboratory animal medicine or other basic sciences, so it might be expected that fewer students take industry jobs immediately after graduation. However, in recent years, the number of diplomates certified in specialties that are most associated with positions in private industry has been less than 50 per year.

[1]Salary data are drawn from the biennial AVMA Compensation Survey, which is based on a randomized, stratified sample of employed U.S. veterinarians (including AVMA members and nonmembers). The response rate of the survey is about 25%. If DVMs who are more successful are more likely to respond, the reported rate of earnings may exceed actual averages.

Because there are few sources of information on the jobs of veterinarians in industry, the committee endeavored to take a closer look by using the committee members' knowledge about the kinds of companies in private industry that hire veterinarians. The committee developed a set of questions and contacted companies across the spectrum of the private industrial sector. Because the companies chosen for the questionnaire were selected on the basis of their familiarity to the committee members, and not through a statistical sampling procedure, the information from responses to the questionnaires cannot be taken as broadly representative of all companies that employ veterinarians. However, it does provide a "first look" into the kinds of positions that veterinarians fill in companies in private industry and the expertise that those companies find useful. In addition to information from the exploratory questionnaires, the chapter discusses data from other sources on job postings, salaries in industry, and the numbers of new board-certified diplomates in specialties of importance to private industry. Together they are presented as partial indicators of both demand and supply.

TYPES OF INDUSTRY EMPLOYERS

Human Health Pharmaceutical and Biotechnology Companies

There are over 200 companies worldwide that discover and develop new drugs to improve human health. In the past, many novel drugs came to light serendipitously, but today drug discovery is a methodical process that begins by exploring the metabolic pathways of a disease or disease agent to identify potential targets upon which a novel compound, or drug, can be designed. The metabolic targets are detected at the molecular level using methods such as x-ray crystallography, and computer simulations are used to predict the chemical interactions between a particular drug and its targets. Once a promising drug compound has been designed, it must go through a development phase to evaluate its formulation, dose and safety. Both animal (pre-clinical) and several formal phases of human (clinical) studies are involved in these evaluations, which in the United States is a highly-regulated process. The Food and Drug Administration (FDA) oversees drug discovery as well as the manufacturing and marketing of approved drugs.

In the past, biotechnology companies were defined by their emphasis on drug discovery, while pharmaceutical companies were better equipped to take candidate drugs through clinical trials, manufacturing, sales and marketing. However, this trend is changing, as biotechnology firms are evolving into integrated companies, retaining ownership of their developmental compounds and continuing to build in-house sales and marketing functions (Business Insights, 2005). Regardless of their origins, of the large number of new compounds investigated for human use, only a small number of novel drugs—about 25 each year—receive approval. The time from discovery to marketing a drug is 10-15 years and the costs are significant. The Tufts Center for the Study of Drug Development estimated that the total costs of bringing one drug to market was $1.2

billion in 2006 (TCSDD, 2008). However, novel drugs can be very profitable. In 2005, sixteen (16) new blockbuster drugs generated sales of $18.1 billion. The value of the global pharmaceutical market in 2009 was $837 billion, and is forecasted to grow to $1.0 trillion by 2014 (Urch Publishing, 2010).

Animal Health Companies

Animal health companies represent three main business areas: veterinary pharmaceuticals and biologicals, veterinary biotechnology, and veterinary diagnostics. Like their counterparts in human drug discovery and development, their activities are highly regulated and must meet the same rigid specifications for safety and efficacy as those for human consumption. According to the Animal Health Institute (AHI)—which represents 20 animal health companies with a presence in the United States in 2008—the industry spent $670 million for research and development and had U.S. sales of $6.7 billion. On average a new animal drug takes between 7 and 10 years to reach the marketplace and may cost $80-100 million to develop (AHI, 2008). The AHI asserts that the largest factor influencing the recruitment of veterinarians in this industry is the continuing demand for new drugs for companion animals, being driven in part by consumers. Animal health companies have followed the trend in direct advertising to patients, established by human pharmaceutical companies, which resulted in many more patients requesting brand named drugs from their physicians. Animal health companies have begun similar advertising on a smaller scale and pet owners are more aware of brand named drugs than they were in the past (AHI, 2008).

Animal Feed Companies

Animal feed companies manufacture feed for animals, from fish to livestock. Dominated by the pet food industry, these companies engage in clinical testing in the target species to better define the nutritional requirements for animals of different species, different ages, and different disease conditions. Feed companies have also begun to diversify into veterinary diagnostics, biotechnology, crop protection and even the manufacture and sales of human food. As a result the roles available for veterinarians are as diverse as those for animal health companies. The top 8 U.S.-based companies supplying pet food had domestic sales in 2000 of $11.6 billion (Petfood Industry, 2001).

Animal Supply Companies

Animal supply companies provide specialized, genetically- and microbiologically- defined laboratory animals, and other services to meet the needs of the pharmaceutical, biotechnology, food, and contract research industries, as well as universities, medical centers and government agencies engaged in biomedical research. Some companies have also diversified their operations to include research and development of human and veterinary pharmaceuticals, human diagnostics, contract management of research animal facilities, and contract research involving toxicology and pathology.

Diagnostic Laboratories

Commercial laboratories that provide veterinary diagnostic services for companion-animal medicine and laboratory animal medicine comprise a relatively immature and small industry that is likely to grow in the future. More than 70 such companies were operating worldwide in 2006 (Animal Pharm, 2006). Reports by the National Research Council identified veterinary diagnostics as a necessary, but underdeveloped, part of the U.S. national animal health infrastructure that would be important in overcoming a major epidemic, the introduction of an exotic disease in food animals, or an act of agricultural bioterrorism (NRC, 2003, 2005). Since 2002, the USDA, in collaboration with state and university diagnostic laboratories, has developed the National Animal Health Laboratory Network to directly address this critical need (USDA-APHIS, 2010a).

Contract Research/Testing Laboratories

Contract research organizations (CROs) provide services to pharmaceutical and biotechnology companies by performing pre-clinical and clinical trials on new drug candidates. They must abide with the regulations of the FDA and are supplied with animals for testing by animal suppliers. The top 20 CROs worldwide had revenues in 2000 of $7.5 billion with many showing increases from 5-40% over their 1999 revenues. Some CROs have developed businesses in laboratory animal breeding and sales and employ veterinarians in pre-clinical research, safety testing in toxicology and pathology, research animal support and senior management.

Agrochemical Companies

Agrochemical companies manufacture herbicides, insecticides, fungicides, and other pesticides to protect both crops and animals. Worldwide sales of the top 10 agrochemical companies in 2008 was $42 billion with four of the ten companies reporting increases of more than 20% over 2007 (Henderson Communications, LLC, 2009).

INQUIRY OF SELECTED COMPANIES

The committee members identified companies familiar to them from across industry sectors that are known to employ veterinarians and developed a questionnaire (Appendix D) that would help determine the current veterinary positions in those companies and the companies' future needs for veterinarians. Of the 118 companies contacted, 59 responded to the committee's questionnaire. Those that responded to the inquiry included both industry giants (which employed the largest number of veterinarians) and smaller companies. The companies were divided into the following groups: animal feed, animal health, animal supply, biotechnology, chemicals, CROs, diagnostics, and pharmaceuticals and biologicals (Table 5-1). These groups closely mimic the categories for employment types used by the AVMA under its sub-group industry/commercial.

The companies that responded to the committee's questionnaire (from here on referred to as respondents) collectively employed a total of 1,527 veterinarians in 2007, about 49% of the 3,125 industry veterinarians that AVMA counted that year (members and nonmembers which, as noted earlier, is likely to be an undercount). Figure 5-1 shows the average number of veterinarians employed by the respondents according to industrial sector. Because the respondents are not a statistically-representative sample of the industry, the results should only be viewed as exploratory. However, the numbers suggest that animal health, CROs, and pharmaceutical companies may be the primary employers of veterinarians in private industry.

TABLE 5-1 Number of Companies that Responded to the Committee Questionnaire, by Industry Sector

Industry Sector	Number of Respondents/Number Contacted
Animal feed	6/20
Animal health	9/16
Animal supply	7/16
Biotechnology	10/16
Chemicals	1/2
Contract research	6/8
Diagnostics	3/15
Pharmaceuticals and biologicals	17 /25

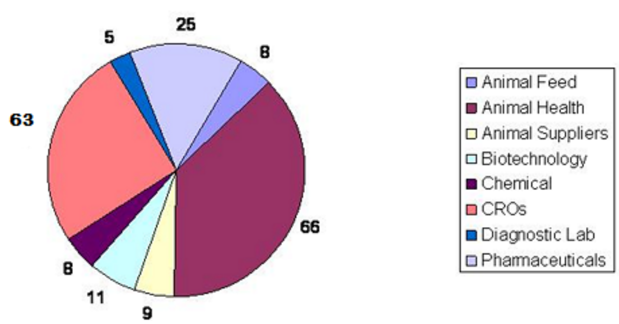

FIGURE 5-1 Average number of veterinarians employed per company responding to committee questionnaire, by sector.

Of the 1,527 veterinarians employed by all of the respondents, 65% had an additional graduate degree and/or a board certification beyond the Doctor of Veterinary Medicine (DVM). Some of the respondents carry out research on animals to demonstrate the safety and efficacy of new products. Those products may be human drugs, veterinary drugs and biologicals, animal feeds, diagnostic tools, or pesticides. In the case of animal supply companies, the products are themselves animals. Animal research is carried out by clinical veterinarians and diagnosticians, often with board certification in laboratory animal medicine. Veterinarians with board certification in pathology or toxicology conduct safety testing and toxicology studies, the kinds of activities carried out in CROs. Table 5-2 illustrates the preponderance of veterinarians with advanced degrees in positions related to safety research and laboratory animal medicine, based on CRO responses to the committee's questionnaire. In contrast, Table 5-3 displays the responses of animal health companies, in which positions held by veterinarians are more concentrated in clinical and pre-clinical research, as well as in technical and customer service. Not surprisingly, DVMs hold positions in the senior management of both CROs and animal health companies.

TABLE 5-2 Qualifications of Veterinarians in Six Contract Research Organizations that Responded to the Committee Questionnaire

	Degrees/Credentials					
Category	DVM only	DVM, Boards	DVM, PhD	DVM, Boards, PhD	DVM, MBA	Total
Technical/Customer Services	0	0	0	0	0	0
Safety Research/Development-Pathology	22	36	16	21	2	97
Safety Research/Development-Toxicology	63	45	25	27	1	161
Research Support-Lab Animal Medicine	58	23	5	4	2	92
Clinical Research/Development	0	0	0	0	0	0
Preclinical Research/Development	0	0	0	0	0	0
Regulatory Affairs	1	1	0	0	1	3
Senior management	9	9	4	4	2	28
Marketing	1	0	0	0	0	1
Sales	1	0	0	0	0	1
Other[1]	0	0	0	0	0	0
Total	155	114	50	56	8	383

[1]Other includes production, project management, business development/alliances, research and post-docs, research in cell therapy, diagnostic and anatomic pathology services.

TABLE 5-3 Qualifications of Veterinarians in Nine Animal Health Companies that Responded to the Committee Questionnaire

	Degrees/Credentials					
Category	DVM only	DVM, Boards	DVM, PhD	DVM, Boards, PhD	DVM, MBA	Total
Technical/Customer Services	143	28	16	1	18	206
Safety Research/Development-Pathology	2	0	0	31	0	33
Safety Research/Development-Toxicology	0	0	7	4	0	11
Research Support-Lab Animal Medicine	8	10	7	0	0	25
Clinical Research/Development	80	3	87	13	4	187
Preclinical Research/Development	14	0	9	2	0	25
Regulatory Affairs	29	0	26	1	1	57
Senior management	14	2	11	1	0	28
Marketing	10	0	0	0	6	16
Sales	8	0	0	0	0	8
Other[1]	9	0	0	0	0	9
Total	317	43	163	53	29	605

[1]Other includes production, project management, business development/alliances, research and post-docs, research in cell therapy, diagnostic and anatomic pathology services.

Research leading to improvements in animal health usually involves the study of the species of animal expected to be the beneficiary of the intervention. This requires a broad understanding of animal physiology and pathology across many different species, ranging from fish and poultry to livestock and companion animals. As research moves from basic to clinical studies, veterinarians continue to be involved in product development, refinement, and ultimately in meeting regulatory requirements for market approval, in most instances, by FDA or USDA. After a product is available on the market, veterinary expertise is needed to explain the benefits of the product to customers, who might be veterinarians, food-animal producers, or others.

One respondent, a large pharmaceutical company (Company A) with an animal health products division, provided the committee with a detailed breakdown of the distribution of the veterinarians employed across the areas of discovery research, product development, regulatory affairs, support services, field/customer support, and marketing and sales (Table 5-4). These areas encompass a great diversity of positions within the company. Interestingly, the majority of the firm's veterinary workforce (71%) is employed in the business operations side of the company (field/customer support and marketing). Those veterinarians were the least likely at the company to hold PhDs or board certification, but more likely than those involved in research and development to hold a Masters in Business Administration (MBA) degree.

Company A indicated that the majority of veterinarians it employs had at least 5 years of clinical experience and/or post doctorate training in specialized areas. That was consistent with the committee's questionnaire results: private animal health companies are seeking candidates with training and expertise beyond the DVM/VMD.

Company A also has a human health division in the United States. It employs more than 60 veterinarians who serve in multiple roles, but in contrast to the animal health division, very few hold positions in business support-related roles. Table 5-5 illustrates the distribution of veterinarians in its human health division. Most of the positions are for pathologists and require board certification. Research that targets new drugs and biological treatments for human health use fewer animal species but require individuals who can think in terms of biological systems and understand integrative medicine.

Companies that develop drugs for human diseases often model those diseases in genetically-engineered mutant mice, the available varieties of which have increased exponentially over the past two decades. This has increased the demand for veterinarians with specialized knowledge of murine physiology, behavior, and pathology, and also for veterinarians with special knowledge of the care, nutrition, and diseases of mice and how to protect them from the introduction of infectious agents.

Job Vacancies

In 2007, Company A indicated that it had 10 open positions for pathologists. The company also sought veterinarians for its pre-clinical, discovery research area and the majority of these positions require post-DVM training in comparative medicine fields (e.g. board certification in laboratory animal medicine).

Many of the other respondents indicated that they were also trying to hire more veterinarians in at least one job category. Table 5-6 reflects the number and types of open positions at the 59 companies that responded to the questionnaire in 2007. Of the 170 open positions, 57% required a degree in addition to the DVM and/or board certification. The 170 open positions represented 10% of the current veterinary workforce employed by these companies, and while not necessarily representative of the broader trends in industry, suggests a strong future demand for veterinarians.

TABLE 5-4 Distribution and Expertise of Veterinarians in an Animal Health Products Division of a Pharmaceutical Company (Company A)

Area	Number of DVMs	Percent of all Veterinarians in Company	Positions	Percentage of Veterinarians with Advanced Degrees: Ph.D.	Board Certification	Ph.D. and Board Certification	MBA	Total
Research and Development								
Discovery Research	9	4	• Basic Research Scientists • Project Leaders	67	--	--	--	67
Development	34	16	• Clinical Researchers • Project Leaders	32	9	9	9	59
Regulatory Affairs	9	4	• Regulatory Agency Liaison • Pharmacovigilance • Global Registration Support	22	11	--	11	44
Support Services	11	5	• Pathology • Toxicology • Laboratory Animal Medicine • Clinical Medicine • Metabolism and Pharmacokinetics • Management	18	18	27	--	63
Business Operations								
Field/Customer Support	136	63	• Technical Services/Veterinary Operations • Pharmacovigilance	4	18	--	9	31
Marketing and Sales	17	8	• Marketing • Sales • Business Development • Strategic Alliances • Management	6	--	--	24	30

TABLE 5-5 Veterinarians in the Human Health Division of Company A

				Percentage of Veterinarians with Advanced Degrees			
Area	Number of DVMs	Percent of all Veterinarians in Company	Positions	Ph.D.	Board Certification	Ph.D. and Board Certification	MBA
Pre-Clinical Research Support	20	30	• Comparative Medicine • Laboratory Animal Medicine	--	15	85	--
Safety Research	43	66	• Pathology • Toxicology	10	50	5	5
Regulatory Affairs	2	3	• Regulatory Affairs	--	--	--	--

TABLE 5-6 Open, Full-Time Positions for Veterinarians Advertised in 2007 by Companies that Responded to the Questionnaire

	Degrees/Credentials					
Category	DVM only	DVM, Boards	DVM, PhD	DVM, Boards, PhD	DVM, MBA	Total
Technical/Customer Services	25	8	0	0	0	33
Safety Research/Development-Pathology	2	8	2	21	0	33
Safety Research/Development-Toxicology	3	2	1	1	0	7
Research Support-Lab Animal Medicine	19	5	0	3	0	27
Clinical Research/Development	7	4	8	9	0	28
Preclinical Research/Development	4	7	11	4	0	26
Regulatory Affairs	0	0	0	0	0	0
Senior management	3	0	2	0	0	5
Marketing	3	0	0	0	0	3
Sales	7	0	0	0	0	7
Other	0	0	0	1	0	1
Total	73	34	24	39	0	170

Respondents also saw a need to hire more veterinarians in the future, collectively anticipating a total of 463 new position openings between 2008 and 2016 (exclusive of retirements), which represents a 30% increase over the 1,527 currently employed industrial veterinarians reportedly working in those companies. The majority (70%) of these positions require post-DVM training or degrees, an even higher percentage than previously identified for current employees or currently open positions.

Effect of Retirements

The respondents reported that an average of 15.7% of the currently employed veterinarians would reach or exceed the age of 65 by the year 2016 (percentages ranged from 0-100%, with the extremes due to companies with very few veterinarians, all or none of whom may reach the age of 65 by 2016). Based on the 1,527 veterinarians employed by respondents, that represents an additional 240 positions over and above the companies' current vacancies and anticipated future hiring needs. These figures are in general agreement with other projections of current and future needs for industrial veterinarians. The so-called KPMG study predicted that by 2015, industry could experience a shortfall in veterinarians equal to 24% of its workforce (Brown and Silverman, 1999b). However, just as other sectors of veterinary medicine and the economy at-large have been affected by the recession that began in 2006, it is likely that some of those veterinarians will delay retirement, thus weakening the demand for replacements. Nevertheless, in a 2008 survey of employers prepared for the College of Veterinary Pathologists, 62.7% of respondents identified the major difficulty in hiring was the limited number of qualified pathologists available (Owens et al., 2008).

Use of Veterinary Technicians

Thirty-six of the respondents indicated that they employ veterinary technicians. The companies, predominantly pharmaceutical firms and CROs, collectively employ 279 technicians, of which 50% are licensed. A majority of the respondents (71%) indicated that they would use veterinary technicians in the future. While veterinary technicians are already used robustly in industry, expanding the use of such technical support might provide more time for veterinarians to perform their professional responsibilities and may overcome shortages in veterinary manpower in the short term.

Views on Factors Affecting Future Demand

When asked about the factors likely to increase the employment opportunities for U.S.-trained veterinarians in their industry, the respondents provided a list of multiple factors, reflecting various industry trends (see Box 5-1). In general, the growth in the overall market and for some respondents, individual company growth, was the key source of demand.

One CRO noted that many pharmaceutical and biotechnology companies have begun to outsource preclinical studies to reserve valuable in-house resources for activities closer to their core strengths (such as discovery). As a result, CROs are taking on this work, and hiring more U.S.-trained veterinarians as a consequence.

BOX 5-1
Perceived Factors that Drive the Demand for Veterinarians in Industry According to Company Respondents to Committee Questionnaire

- growing food safety and regulatory issues
- overall company growth
- globalization
- increase in the demand for technical services
- development of new products
- increase in the growth in the companion-animal market
- increase in the use of nonhuman primates in research protocols
- growth in the number of biomedical research programs
- increased use of outsourcing for preclinical trials

For respondents in the animal health sector, the increasing sophistication of customers has resulted in higher expectations for, and demands of, the products they purchase. Food-animal customers want increased scientific and financial evidence to prove the value of animal health products in their increasingly complex operations. Therefore, veterinarians with a keen knowledge of food-animal production (at the level of a herd versus individual animals) are needed to educate customers in how to utilize new products and to demonstrate the financial value of products in large scale production systems.

Similarly, as companion-animal owners are willing to expend resources for animal health products, there is greater demand for innovative products that prevent, control and treat diseases or improve a companion animal's quality of life. Thus, in this sector there will continue to be an increased need for veterinarians in key areas of discovery and product development but also those with board certification in targeted areas to provide practicing veterinarians with field-based support as more technologically complex companion-animal products are introduced into the marketplace (for example, obesity and oncology drugs).

Moreover, as the technologic complexity of products being introduced into both food- and companion-animal marketplace is increasing, so are the regulatory requirements related to product safety. The increasing use of pharmacokinetics in drug development and registration processes is driving the need for veterinarians with specialized training in this area. Increasing regulatory standards throughout the product development and registration process continues to drive increased standards such as Good Laboratory Practices (GLP) and Good Clinical Practice (GCP) in the conduct of animal studies. All of these factors drive the need to hire more veterinarians, especially those with advanced training in biomedical sciences that qualify them to effectively oversee the type of studies needed by industry for regulatory purposes. It is also anticipated that there will be an increasing need for veterinarians with training in food safety, including microbial safety and toxicology.

Companies were specifically asked whether and how globalization would affect their hiring decisions. The majority of respondents (68.8%) indicated that globalization would not affect the number of veterinarians in their company, 14% said they would hire more foreign-trained veterinarians and 8.3% said that globalization would result in them hiring more U.S.-trained veterinarians. One company observed that a shift was underway in the pharmaceutical industry to move R&D activities from Europe and Japan to North America and the Pacific Rim. While economic factors are involved in these decisions, the critical shortage of appropriately-trained veterinarians in the Pacific Rim, including China, has placed more emphasis on recruiting veterinary expertise in North America, especially those with toxicological and pathology expertise.

When asked about factors that will likely *decrease* their demand for U.S.-trained veterinarians, the respondents indicated that a change in the size of the market (such as changes in the size and scope of dairy operations) and outsourcing of some work to companies overseas could negatively affect the hiring of U.S.-trained veterinarians. Some respondents suggested that an inadequate supply of veterinarians, especially diplomates of the American College of Laboratory Animal Medicine (ACLAP) and the American College of Veterinary Pathologists (ACVP), would lead companies to seek individuals from outside the United States or from other scientific fields to fill key positions.

Views on the Future Workforce: Veterinary Student Training

When asked whether the current system of training adequately prepared veterinarians for careers in industry for positions that require no more than a DVM degree, slightly more than half of the 59 respondents answered in the negative, providing a long list of characteristics they found lacking in new veterinarians. Regarding the preparation of veterinarians for positions requiring advanced training or degrees (post DVM), 24 of the respondents believed that the education system fell short. Many of the factors identified as lacking in post-DVM education were the same as those identified in DVM programs.

Industry-Specific Research and Technical Skills

Among the competencies that respondents found lacking in graduates and post-graduates were training in: clinical pathology, laboratory-animal medicine, and basic safety assessment (as well as training in more specific fields, such as nutrition and poultry medicine). But it is not clear if this is an issue of training or simply the lack of available candidates with the desired expertise. Not surprisingly, companies wanted job candidates to be prepared to fit their needs immediately upon taking a position. For example, according to one respondent, the single greatest deficiency among veterinarians seeking employment with industry is a lack of knowledge about how to fulfill GLP and GCP regulatory requirements.

However, many companies also commented that new graduates lacked the fundamental knowledge of the scientific process, which is a necessary skill for the organization of scientific studies, the ability to think critically and to properly interpret the scientific literature. Some respondents mentioned a lack of training in statistics as part of their criticism of the research skills of new graduates.

Business and Other Skills

In some sectors, veterinarians are more likely to be asked to fill positions in regulatory affairs, technical and customer services, marketing, sales, and management. Thus, many respondents also felt that graduates and post-graduates should have better training in business skills, as well as communications, interpersonal and human resource management. It is worth noting that employers view soft skills as important in the training of anatomical and clinical pathologists (Owens et al., 2008). The 1999 KPMG study also identified non-technical skill sets that lead to success in veterinary careers: leadership, communication and business skills (Brown and Silverman, 1999b). The perception by industry is that these skills are still lacking in new graduates and post-graduates.

The great diversity of educational experiences of the applicants to veterinary schools, combined with the ability of astute admissions committee members to select those with the best communication and interpersonal skills aids in the final development of veterinarians capable of meeting the needs of industry. Likewise, the breadth of knowledge in physiology and medicine, coupled with the diversity of species covered in conventional veterinary education, prepares veterinarians to think in terms of whole-animal systems biology. This comparative approach also aids in the development of individuals who are capable of modeling human physiology and diseases in animals. Because proficiency in clinical skills extends across the same diversity of species, graduate veterinarians can more easily adjust to the animals commonly used in human pharmaceutical research. Finally, many veterinarians hired by industry spend at least part of their efforts on regulatory matters where good organizational skills are essential.

BOARD-CERTIFIED VETERINARIANS: SUPPLY AND DEMAND

Job Advertisements

Based on their responses to the questionnaire, the committee surmised that the companies contacted by the committee want to hire veterinarians with advanced training, in particular those with board certification in laboratory-animal medicine and pathology. To see how prevalent the requirements for board certification are in job listings, the committee examined job advertisements on the American Association for Laboratory Animal Science listserv, COMPMED, posted between 2006 and 2008. The analysis revealed that 12% of all positions advertised required board certification in order to apply, 19.5% required that the candidate be board-eligible, and 31% stated that board certification was desirable or preferred. Overall, more than two-thirds of the advertisements commented on board certification, and some advertisements indicated that the employer would support an individual's effort to achieve certification. The most common certifications mentioned in the ads, in rank order, were those of the American College of Veterinary Pathology (ACVP), the American College of Laboratory Animal Medicine (ACLAM), and the American Board of Toxicology.

Filling some of those advertised positions was also challenging. Of the 78 job postings placed in the COMPMED listserv in 2006, 8.9% were re-posted in 2007 and 1.2% were re-posted in 2008. Of the 67 advertisements posted in 2007, 8.9% were re-posted in 2008.

Salary Levels

Increasing salary levels are an indicator of a tight supply of qualified applicants. Results of the 2005 and 2008 surveys of the members of the American Society of Laboratory Animal Practitioners (ASLAP) and ACLAM show that salaries of its diplomates have risen from $133,803 in 2005 to $153,038 in 2008, an increase of approximately 14% in the 3-year period. The surveys also showed that the average salary of ACLAM diplomates employed by industry increased at about the same rate, but from a higher level; that is, from $171,704 in 2005 to $199,437 in 2008 (Huneke et al., 2009). In contrast, the average salary of ACLAM diplomates employed in academe in 2008 was $153,509.

In 2007, an ACVP survey of its members found that the average and median income of diplomates with 6-10 years experience beyond certification was $157,000 and $166,000. Similar to that of their ACLAM peers, some of the highest salaries were paid by industry employers.

Supply of Diplomates for Industry

The ACLAM and the ACVP provided the committee with information on the employment of their diplomates (Tables 5-7 and 5-8, respectively). The tables demonstrate the competition between academe and industry for ACLAM and ACVP diplomates. The number of ACLAM diplomates hired by industry over the past three decades increased from 45 in 1981 to 178 in 2007 (personal communication, Melvin Balk, ACLAM, 2008). These two colleges are major pipelines for industry candidates.

Supply of New Diplomates

Since 2007, ACLAM has seen increased growth in its membership and the number of new diplomates certified (Table 5-9). In addition, the pass rate of candidates taking the ACLAM examination has improved, from 31% between the years 2004-2007 to more than 50% between 2008-2010 (ACLAM, 2010). This outcome is in part the result of a concerted effort by the College to respond to demands for veterinarians in biomedical science. However, since ACLAM began certifying diplomates, the average number of years from veterinary college graduation to board certification is 9.3 years. In fact, the average time between graduation to certification has increased from 7.71 years in 1985, to 9.97 years in 1995, and 11.12 years in 2005 (ACLAM, 2007). There are many possible explanations for the increase in the passage of time to certification: candidates leaving private practice and beginning a residency training program (which average 3 years), candidates seeking advanced degrees (average for PhD is 4 years), more candidates having to repeat the examination before passing, and some candidates taking time off after graduation before returning to a training program. More investigation is warranted to elucidate the precise cause of this current trend.

TABLE 5-7 American College of Laboratory Animal Medicine Diplomates by Employment Sector, 2007

Employment Sector	Number of ACLAM members	Percent of Membership
Academia	370	54
Industry	178	26
Government	116	17
Private Practice	14	2
Other	7	1

DATA SOURCE: ACLAM.

TABLE 5-8 American College of Veterinary Pathology Diplomates by Employment Sector, 2007

Employment Sector	Number of ACVP members	Percent of Membership
Academia	488	29.5
Industry	500	30.2
Private Diagnostic	142	8.6
Federal	58	3.5
State	33	2.0
Private Practice	61	3.7
Other	119	7.2
Military	34	2.0
Did not designate	233	14.1

DATA SOURCE: ACVP.

TABLE 5-9 Number of Active American College of Laboratory Animal Medicine Members, Retirees, and New Diplomates

	Year		
Membership Category	2004	2007	2010
Active	677	686	746
Retired	95	134	153
New Diplomates	17	19	48

DATA SOURCE: ACLAM.

Table 5-10 presents data on the numbers of active ACVP members, retirees, and new diplomates. The number of active members in ACVP has not increased markedly. The annual numbers of new board-certified veterinary clinical pathologists remains especially small (17 new diplomates in 2010), despite an annual pass rate that has hovered around 50% for the past five years.

TABLE 5-10 Number of Active American College of Veterinary Pathology Members, Retirees, and New Diplomates

	Year				
Status	2004	2005	2006	2007	2010
Active	1461	1543	1573	1609	1705
Retired	198	210	223	229	259
New Diplomates	101	39	69	81	86

DATA SOURCE: ACVP Newsletters (www.avcp.org); Additional data provided by the Executive Director, ACVP.

In 2002 and again in 2008, the ACVP completed demographic surveys of veterinary pathology training programs and employers to determine if the supply of veterinary pathologists moving through the programs would be sufficient to cover market needs (Owens et al., 2008a, b; Kelly-Wilson, 2002). Among other things, the results indicated a continued deficit in the supply of veterinary pathologists. Insufficient funding remained the biggest factor limiting the number of residency positions, and retirements continued to account for approximately 50% of job openings.

Strengthening the Specialty Colleges

ACLAM accredits 45 training programs throughout the United States and Canada. However, only 12 of these programs are based in veterinary colleges with many of the remaining programs based in medical colleges and hospitals. There are also three programs based in federal government institutions, one associated with a pharmaceutical company, and several others which derive trainee support from pharmaceutical companies. Although ACVP does not accredit training programs, of the 45 U.S. training sites listed on its website, 18 are not based in veterinary colleges. Clearly, training for these two disciplines has benefitted from expanding the training venue to include research centers in medicine, government, and industry. ACLAM and ACVP are aware of the demand for highly-trained specialists and are taking steps to attract candidates for diplomates and to improve the efficiency of their residency and examination processes.

To assist mentors involved in residency training programs for laboratory animal medicine, ACLAM began developing a Role Delineation Document (RDD) in 1997, defining the knowledge, skills, and abilities required to be considered an ACLAM-certified laboratory-animal specialist. After two updates to the RDD, it was ultimately incorporated into the ACLAM certification examination as a template against which exam questions were aligned.

In 2002, ACLAM created a Career Pathways Committee (CPC) that developed programs at veterinary colleges to attract students into the profession through seminars, workshops, and summer externships. The CPC also encourages private practitioners to explore the profession by providing educational sessions at AVMA meetings and by funding scholarships to clinicians to attend these sessions.

Together with the Charles River Laboratory, ACLAM developed Camp ACLAM, a week-long summer session for veterinary residents and veterinarians intending to take the ACLAM certification examination within the next 3 years. In addition to intense course work there is a practice session for the examination. During the same period ASLAP actively encouraged veterinary students to enter the profession by creating a student liaison in every North American veterinary college who answered student questions and provided access to additional reading material on laboratory animal medicine. ASLAP also provides summer fellowships to veterinary students to work in the field.

Together, these changes appear to be making an impact. Between 2002-2008, the number of ACLAM-approved training programs increased from 35 to 41, and the number of residents enrolled in these programs has increased from 85 to 115. In 2008, a record 92 candidates took the exam and the pass rate was 51% (compared to 31% in the past).

Like ACLAM, ACVP has recognized the need to increase membership and has established pathology clubs in each of the U.S. veterinary colleges. It also has just completed a RDD which it plans to use as a template for their certification examination, and it regularly employs an educational consultant to provide quality control and to validate the examination. In addition, it has created a joint program with the Society of Toxicologic Pathology (STP) called the ACVP/STP Coalition for Veterinary Pathology Fellows which seeks funds from industry to support additional pathology fellows at academic institutions throughout North America. With the support of biotechnology and pharmaceutical companies, as of 2009, the Coalition had competitively established 22 new training positions, including 15 anatomic pathology residencies, 3 clinical pathology residencies, and 4 post-residency PhD pathology research positions (Cockerell et al., 2009). Trainees have no payback obligation following completion of their fellowships other than to complete the ACVP certification examination and/or the PhD, and to become employed as a veterinary pathologist. Results to date indicate that fellows are distributing themselves among positions in academia and the private sector. Furthermore, the percentage of fellows who have successfully completed the ACVP certification exam is approximately 2-times the average pass rate of all first time candidates over the past 3 years, reflecting the quality of Coalition trainees and the excellence of their training programs. The majority of sponsors have renewed their funding for additional Coalition training positions, demonstrating their satisfaction with, and commitment to, this unique educational initiative.

The NRC report *National Needs and Priorities for Veterinarians in Biomedical Research* (NRC, 2004) highlighted the need to expand the number of veterinarians qualified for research and other positions in biomedical science in public and private sectors. Many of the report's conclusions and recommendations related to the costs of a veterinary education and student debt, the lack of public support for residency training, and the need to boost awareness among veterinary students of opportunities in biomedical science remain true today.

In the committee's view, opportunities for highly-trained veterinarians in industry are growing, and the new and vacant positions represent a clear unmet need. Although more graduating veterinarians are pursuing post-DVM training, the numbers entering the specialties of laboratory-animal medicine and pathology are still inadequate to fill current vacancies and future needs in industry. The establishment of student clubs for pathology and laboratory-animal science at veterinary colleges as recently initiated by ACLAM, ASLAP and ACVP is a positive development, as is industry support for internships and training positions through the ACVP/STP Coalition for Veterinary Pathology Fellows. Deeper partnerships between academia and industrial employers of veterinarians are possible during the professional veterinary medical curriculum. Although externships currently sponsored by industry provide greater exposure to career opportunities in pathology, laboratory-animal medicine, and toxicology, the development of additional partnerships would help increase awareness of these opportunities. Moreover, this type of academic/industry collaboration should be pursued to help defray the costs of PhD education.

Given the limited resources of veterinary colleges, consideration should be given to tracking options in veterinary colleges, which may offer the best opportunity to channel students into career opportunities in laboratory-animal medicine, pathology, and comparative biomedical research. The merits of such an approach are discussed further in the final two chapters of the report (Chapters 10 and 11).

6

Veterinarians in Public Practice

INTRODUCTION

Public practice veterinarians employed in local, state, and federal government agencies are involved in activities to ensure food safety, safeguard animal and human health from diseases and toxins, conduct biomedical research, and facilitate trade. They play pivotal roles in addressing issues spanning agriculture to human medicine, and have a long and distinguished history of contributions to human and animal health largely unrecognized by the general public (Hoblet et al., 2003; Pappaioanou, 2004). The safe, wholesome, and inexpensive animal-based food and product supply enjoyed by United States citizens has been achieved, in part, by disease control and eradication programs managed by veterinarians and by meat and poultry inspections conducted by public practice veterinarians (King, 2000). As animals are used as models of human diseases, ranging from diabetes to cancer, veterinarians involved in biomedical research have made fundamental contributions to advances in human health (Roberts, et al., 2009; Gordon and Khanna, 2010). Veterinarians also actively participate in reducing the impact of zoonotic diseases on humans (Riddle and Mainzer, 2004).

This chapter summarizes the types of positions that veterinarians most commonly occupy in the public sector, reviews information on the numbers of veterinarians employed, and discusses key concerns and recent developments related to the public practice workforce. The committee was troubled by the state of the veterinary workforce in the public sector. Longstanding job vacancies, a looming wave of retirements, declining programmatic support for animal research, and reports of too few positions in key agencies raise questions about the ability of the government to achieve its missions to ensure food safety and prevent and respond to infectious diseases of animal and humans. The federal government has recently begun to address its veterinary workforce issues, albeit at a time of fiscal constraint. Some federal agency managers indicate that vacancies can be attributed in part to applicants not having the requisite knowledge and training for positions needing to be filled, with some agencies starting educational programs to address this issue. On the other hand, salaries of public practice positions are low relative to some job opportunities in the private sector and are sometimes below those offered in the public sector for positions with comparable higher education (8 years or more). Even veterinarians with advanced degrees (MPH, board certification) in the Civil Service are often not offered significant pay bonuses similar to the Physicians Comparability Allowance/Medical Pay for MDs. This is because veterinarians who conduct similar "mission critical" activities have not been considered for equal pay as physicians (5 USC § 5948). Because a failure in the public sector's mission-critical responsibility to prevent, respond and recover from catastrophic disease outbreak events would have severe consequences in terms of human illness, lost lives and livelihoods, and animal suffering, the inadequate pay for the veterinary workforce in public practice could pose a substantial risk to the nation.

PUBLIC PRACTICE VETERINARIANS

Veterinary Medical Officer

There are two federal-government employment systems in which veterinarians can be hired. One is the Civil Service and the other is the Uniformed Services, such as in the Department of Defense or the Health and Human Services Public Health Service Commissioned Corps. Most, although not all, positions for veterinarians in the federal government fall under the classification Veterinary Medical Officer (VMO), also known by the Civil Service designation VMO 0701 (OPM, 2009). Many of the jobs held by VMOs typically involve regulatory oversight and the enforcement of rules related to domestic food safety, animal care and welfare, and animal health, or regulatory activities associated with imported food and animals, such as inspecting foreign systems for equivalency to U.S. standards. The official areas of specialized focus within the VMO category are listed below, with a brief description of the central duty of each position.

- **Epidemiology** - control and eradicate human and animal diseases, conduct surveillance and investigate current diseases and emerging infectious diseases including zoonoses; conduct activities in the areas of food safety, food security, and biostatistics, and perform scientific review functions.
- **Import/Export** - certify the health of animals and animal by-products for import and export and oversee quarantine.
- **Laboratory Animal Medicine** - provide clinical support and medical treatment for laboratory animals used in research activities.
- **Pathology** - interpret complex pathological conditions and evaluate findings that indicate the presence of foreign or emerging animal diseases of economic or public health significance; work with public health groups on issues pertaining to disease management.

- **Product Development** - review and ensure the safety and effectiveness of drugs, biologics, devices, and feed for domestic and companion animals.
- **Public Health** - develop and participate in the prevention, surveillance, detection, control, and regulation of human and animal health vulnerabilities from agro- or bio-terrorism threats; zoonoses and foreign animal diseases, and conditions that render meat and poultry products unfit for human consumption.
- **Toxicology** - investigate concerns related to animal feed and evaluate pesticide, industrial, chemical, and mycotoxin contaminants in animal feed.
- **Wildlife** - provide medical and surgical expertise and program administration for captive and free roaming wildlife, including epidemiological, pathological, and toxicological investigations.
- **Zoological Animal Medicine** - provide a comprehensive animal health program in a zoo's collection.
- **Clinical Care** - provide medical and surgical management of domestic animals not included in biomedical research, wildlife, or zoo populations, such as work animals.

VMO positions are also likely to carry organizational or functional titles related to their work, such as Chief Scientist, Research Director, Program Manager, Grant Manager, Policy Fellow or Policy Analyst, Occupational Health and Safety Officer, Bio-security Specialist, and Environmental Health Officer. Some hold titles related to one of the many disciplinary fields of veterinary research, including Risk Assessor, Microbiologist, Pathologist, Chemist, and Toxicologist. Some of these positions require advanced degrees and participation in government training programs.

It is difficult to obtain a firm number for veterinarians employed in the federal government because some hold jobs that are not specifically classified by the Office of Personnel Management or Human Resources as being in the VMO 701 Series. Some non-VMO jobs are simply classified with the term "veterinary," however additional veterinarians are in positions with more generic titles, and many government jobs for which veterinarians qualify are neither specifically classified nor advertised to require a veterinary degree, such as research scientists working at the National Institutes of Health. Individuals with a veterinary degree can be found at all levels of government, including as elected officials in the U.S. Congress.

FEDERAL AGENCY EMPLOYERS OF VETERINARIANS

In 2009, the Government Accountability Office (GAO) released a report on the numbers of veterinarians employed by the federal government (GAO, 2009). The report is the best available source of information to date and is cited heavily here, augmented with more recent data collected by the National Association of Federal Veterinarians (NAFV), the VMO Federal Talent Management Advisory Council (TMAC) and the U.S. Office of Personnel Management (OPM).

The GAO found 13 major units of the federal government that reported employment of veterinarians (see Table 6-1). In 2008, agencies reported 3,058 federally-employed veterinarians, 2,900 who work in the U.S. Departments of Agriculture (USDA), Defense (DOD), and Health and Human Services (HHS). The total number includes veterinarians hired as VMOs in the Civil and Uniformed Services and those holding other non-veterinary position titles. In 2011, the TMAC released an update of the numbers of federally employed veterinarians for 2010, based on its survey of the agencies (Table 6-1). Comparison of the data sets suggests that the number of veterinarians employed increased in some agencies and declined in others, with virtually no change in the total.

U.S. Department of Agriculture

Food Safety and Inspection Service

The USDA is the largest single employer of veterinarians in the federal government. Of the 1,809 veterinarians at USDA in 2010, the Food Safety and Inspection Service (FSIS) employed an estimated 1,068, up from 1,043 in 2008 (GAO, 2009; VMO TMAC, 2011). A majority held positions as Public Health Veterinarians (classified as VMOs) in the Office of Field Operations, identifying diseased animals and enforcing humane slaughter and food safety regulations at slaughter and processing operations. Other veterinarians in FSIS develop policy and public health risk assessments; provide expertise in chemistry, toxicology, pathology, and microbiology laboratories; conduct international programs; and serve as managers and executives.

TABLE 6-1 Veterinarians in the U.S. Government in 2008 and 2010

	Number of Veterinarians	
Major Federal Agency	2008	2010
U.S. Department of Agriculture	1,771	1,809
U.S. Department of Defense	841	853
U.S. Department of Health and Human Services	316	322
U.S. Department of Veterans Affairs	37	17
U.S. Department of the Interior	24	34
U.S. Department of Homeland Security	16	7
Smithsonian Institution	16	10
U.S. Environmental Protection Agency	13	3
U.S. Agency for International Development	8	0
U.S. Department of Commerce	9	2
National Aeronautics and Space Administration	5	0
U.S. Department of Energy	1	No data
U.S. Department of Justice	1	No data
Total	3058	3057

DATA SOURCE: GAO, 2009 and VMO TMAC, 2011.

In 2008, FSIS reported vacancies of 166 veterinarian (15% of the FSIS veterinary workforce) positions assigned primarily in slaughter plants. Officials and veterinarians attribute those vacancies to several factors, including the physical and emotionally grueling nature of the work in slaughter plants, the remote location of many of the plants, the negative effects of staff shortages, the lack of opportunity for training and promotions especially for new graduate hires, and low pay compared to private practice. However, by 2011, the FSIS vacancy rate was reduced, possibly due to the effect of the economic recession, and to direct-hire authority granted by OPM. In February 2009, shortages of FSIS veterinarians were identified in 39 of the 50 states. In September 2011, the FSIS website listed only 25 locations in 18 states with vacant positions (FSIS, 2010).

Animal and Plant Health Inspection Service

In 2010, the Animal and Plant Health Inspection Service (APHIS) has an estimated 695 veterinarians, up from 667 in 2008, who are engaged in protecting the health of animals in U.S. agricultural production (GAO, 2009; VMO TMAC, 2011). Their jobs include performing duties such as the diagnosis, control and eradication of animal diseases; developing policy and risk assessments; planning and implementing emergency responses to foreign animal disease incursions; leading and working on international teams and overseas programs; enforcing the Animal Welfare Act; and serving as managers and executives. APHIS managers have expressed concern that the supply of veterinarians generally, and veterinary pathologists in particular, will not be adequate to fill vacancies in the future.

Agricultural Research Service

The Agricultural Research Service (ARS) employed 57 veterinarians 2008. In 2010, that number declined to 40 (GAO, 2009; VMO TMAC, 2011). These veterinarians, most of whom are required to have a Ph.D. degree in addition to the DVM, conduct critical research to develop solutions for high priorities in food safety, zoonotic diseases and agricultural problems. ARS reported that the agency is 12% short of its goal of employing 65 veterinarians. The agency asserts that there are too few qualified candidates willing to work in government given the disparity in salary levels between federal positions for DVM/PhDs and those in the pharmaceutical and other sectors.

National Institute of Food and Agriculture (formerly Cooperative State Research, Education and Extension Service)

The National Institute of Food and Agriculture (NIFA) added 2 veterinarians in 2010 to increase its total to 6 (GAO, 2009; VMO TMAC, 2011). The assignments of those veterinarians are to plan, develop, organize, and manage animal health and food safety related research and educational programs in coordination with land grant universities, other federal agencies and national and international partners. They help support the work of state extension veterinarians. Some oversee grant programs that allocate millions of dollars for research and education.

U.S. Department of Defense

Army and Air Force

The 853 veterinarians employed by the DOD in 2010 serve mainly in the Army as authorized active service members (506) or Army reservists (266). Many of those veterinarians are responsible for the food safety of thousands of troops around the world. Others conduct research on medical defenses against chemical and biological warfare threat agents, conduct intelligence work, care for service animals, and provide for veterinary services on military installations. The Air Force has 88 veterinarians who track infectious diseases, ensure the food safety and health of personnel, and are responsible for enforcing Occupational Safety and Health programs. There are veterinarians in critical management and military leadership positions. In 2008, the Army reserves reported a shortage of 34 veterinarians (12%) but that gap was filled by the addition of 93 reservists in 2010 (GAO, 2009; VMO TMAC, 2011).

U.S. Department of Health and Human Services

Food and Drug Administration

Of the 322 veterinarians employed by the Department of Health and Human Services in 2010, 154 held positions with the Food and Drug Administration (FDA). Within FDA, the Center for Veterinary Medicine (CVM) employs 116 DVMs, an increase of 10% from the number reported to GAO in 2008. The Center attributed the expansion to the approval of FDA-wide direct hiring authority for VMO positions in 2009 (CVM, 2010). Veterinarians in CVM ensure that food and drugs for animals are safe, and ensure that food from medically-treated animals is safe for human consumption. Veterinarians in other FDA units contribute to work on the safety of drugs, cosmetics, and medical devices. The GAO report indicated that FDA expected 10-20% growth in jobs requiring veterinarians over the next five years.

National Institutes of Health

The National Institutes of Health (NIH), which focuses on biomedical research primarily for human health, reported employing 85 veterinarians in 2008 and 92 in 2010 (GAO, 2009; VMO TMAC, 2011). These individuals hold various positions from management to laboratory animal care and research. They conduct basic scientific and translational research in the intramural research program, are administrators of the external research programs, and provide disease surveillance and diagnostic expertise. According to the 2009 GAO report, NIH faces challenges recruiting veterinarians who have specialization in laboratory animal medicine and veterinary pathology; NIH forecasts significant shortages for at least the next 10 years in these veterinary specialties.

Centers for Disease Control and Prevention

Between 2008 and 2010, the Centers for Disease Control and Prevention (CDC) increased the number of veterinarians it employed from 77 to 90 (GAO, 2009; VMO TMAC, 2011). The agency reported to the GAO that veterinarians contribute to human health programs through their veterinary science and public health expertise. Veterinarians work to identify, prevent and control public health threats through applied epidemiology, laboratory animal medicine, toxicology, technical assistance, consultation, surveillance, field and clinical investigations, and human-animal interface research. They support public health training and activities among state, local, tribal, and global health programs. Veterinarians provide expertise in public health emergency preparedness and provide surge capacity following public health disasters, global disease outbreaks, and terrorist attacks. They serve CDC in jobs that prevent the entry of imported animals and animal products that pose human health risks. CDC reported to the GAO that they could enhance veterinary contributions to public health; however no specific shortages were noted.

Office of the Assistant Secretary for Preparedness and Response

This agency employed 2 veterinarians in 2008 with critical public health responsibilities. Some of those responsibilities include developing effective response programs to public health emergencies. They identify, coordinate, and provide qualified veterinary medical personnel for events requiring emergency and disaster-related veterinary services to affected animal populations, including household pets and service animals, in or outside of shelter locations until local infrastructures are reestablished. This Office reported to the GAO that they need more veterinarians but no specific number was offered.

Other Federal Agencies

Fewer numbers of veterinarians are employed by other federal agencies. Veterinarians at two of those agencies, the Department of Veterans Affairs (17 veterinarians in 2010), and the Environmental Protection Agency (3 veterinarians in 2010) address research and other activities associated with protecting human health; neither reported shortages related to meeting their missions (VMO TMAC, 2011). Three other agencies use veterinarians to address animal health issues (often with human health ramifications). They include the Department of Homeland Security (DHS), which has oversight responsibility for the security of the national food supply. DHS reported a veterinary workforce of 7 in 2010, a decline from 16 in 2008. The Department of the Interior markedly increased its veterinary workforce from 24 to 34 between 2008 and 2010. The agency has responsibility for monitoring wildlife on federal lands. The Smithsonian Institution lost veterinarians that provide care for zoo animals and conduct research, down from 16 to 10 in the same period). All three agencies had reported concerns to GAO that too few veterinarians were involved in carrying out their mission. The Fish and Wildlife Service increased the number of veterinarians it employs from 4 to 10 between 2008 and 2010 (GAO, 2009; VMO TMAC, 2011). The role of veterinarians in wildlife and ecosystem health is discussed in greater detail in Chapter 7.

VETERINARIANS IN STATE GOVERNMENT

Veterinarians who are employed by state governments are typically involved in one or more of the activities across the "One Health" spectrum: public health, agriculture and food; animal welfare; and wildlife and the environment (AVMA, 2008). The committee could not find aggregate information on the number of state-employed veterinarians. However, in 2010, research surveys by the American Veterinary Medical Association (AVMA) found 1,099 veterinarians employed in state and local governments (AVMA, 2011b). Veterinarians at land-grant colleges and universities are also state employees, but those are identified by AVMA as being employed by a "college or university". There were 6,425 individuals in that category. Some of them are employed at private colleges and universities (AVMA, 2011b).

Chapter 9 discusses veterinarians in academia. However, in addition to their roles as veterinary school faculty members, many are involved in operating veterinary diagnostic laboratories on behalf of their respective state and as part of the National Animal Health Laboratory Network (NAHLN). In this regard they perform tests for endemic animal diseases and conduct surveillance of foreign animal diseases (USDA-APHIS, 2010a).

That work is complemented by state veterinarians (SVs), which usually are housed in a state's agriculture or environment department, and occasionally in a state-supported school of veterinary medicine. The office of the SV is usually involved in the certification of veterinarians who wish to practice in a state. There are SVs in all 50 states, and they have broad responsibility for monitoring diseases and other threats (such as animal abuse) to companion and food animals within the state. As noted in Chapter 7, a handful of states employ veterinarians in fish and wildlife departments. Some veterinarians are involved in carrying out disease control programs or testing meat for antibiotic residues.

In addition to an SV, all 50 states have a designated public health veterinarian (PHV), most of whom hold positions in their state's Department of Health. The work of a state's PHV is primarily focused on zoonotic disease control and prevention. They interact with other elements of the public health system, from doctors to emergency rooms, to address the exposure of the public to risks from animals and animal products (NASPHV, 2011).

SALARIES OF PUBLIC PRACTICE VETERINARIANS

Salaries Reported by the American Veterinary Medical Association

Every two years, the American Veterinary Medical Association (AVMA) conducts a survey of U.S. veterinarians for salary information.[1] For 2009, the mean salary reported by members with veterinary positions in state government was $108,806. Uniformed (military) service employees reported a mean salary of $92,172, while employees in federal government reported a mean salary of $111,964 (AVMA, 2011a).

Salary and Compensation of Federal Employees

In contrast to the AVMA, the OPM Central Personnel Data File reported the average salary of federally-employed 701 Series veterinarians in 2009 to be $93,062. Federal VMOs make more on average than their counterparts in the 0600 Series (positions in medical, hospital, dental and public health), but that may be attributable to the group's longer average length of service (see Table 6-2), so there is a concern that they are paid less than physicians performing similar duties (OPM, 2010).

Salaries for VMOs vary across federal agencies, with the lowest reported by FSIS and the highest by NIH. Table 6-3 provides information from the 2009 GAO report and estimates developed by the National Association of Federal Veterinarians (NAFV), based on its membership data (Michael Gilsdorf, NAFV, personal communication, December 1, 2010). The differences in pay reflect numerous factors, such as length of service and the average grade level of the veterinary workforce at each agency.

[1]AVMA salary data are drawn from the biennial AVMA Compensation Survey, which is based on a randomized, stratified sample of employed U.S. veterinarians (including AVMA members and nonmembers). The response rate of the Survey is about 25%. If DVMs who are more successful are more likely to respond, the reported rate of earnings may exceed actual averages.

TABLE 6-2 2009 Average Annual Salaries of Federal Employees

	701 Permanent Appointment	All 600 Series	All Federal Employees
Number Employed	1,878	234,266	2,038,183
Average Salary	$93,062	$78,013	$71,887
Average Age	52.4	47.5	46.2
Average Length of Service	13.5	10.5	13.9

SOURCE: OPM, 2010.

TABLE 6-3 Reported Mean Salary Levels for Federal Veterinarians

	Mean Salary Estimates	
Agency	Government Accountability Office	National Association of Federal Veterinarians
Food Safety and Inspection Service (USDA)	$77,678	$81,998
Animal and Plant Health Inspection Service	$90,000	$82,997
Agricultural Research Service (USDA)	$102,081	No data
Centers for Disease Control and Prevention (HHS)	$90,000	$93,964
National Institutes of Health (HHS)	$115,000	$100,000
Food and Drug Administration (HHS)	$85,000	$91,863

NOTE: USDA=U.S. Department of Agriculture; HHS=U.S. Department of Health and Human Services.
SOURCE: Estimates adapted from GAO (2009), and National Association of Federal Veterinarians (2010).

In 2009, at the request of USDA, the OPM raised the entry grade level for newly hired veterinarians from GS-9 to GS-11. Almost 75% of FSIS veterinarians were at grade level GS-12 or below and are now part of a pay-banding pilot program that eliminates the GS Grade categories to determine if this can improve the salaries of veterinarians in FSIS based on performance. In contrast, 90% of APHIS and 62% of ARS veterinarians are at grade level GS-12 or above. The report also noted that APHIS routinely sourced experienced veterinarians from FSIS, offering greater pay, training, and working conditions than its sister agency. The GAO report did not explore the level of education required by different agency positions, except that ARS indicated that its requirement for candidates to have PhDs in addition to the DVM degree put it in direct competition with private industry, where salaries are significantly higher.

Retirements

A 2006 study supported by the Food Supply Veterinary Medical Consortium estimated that for the 12-year forecast period of 2004 to 2016, the average annual shortage of public practice veterinarians would be 6.86% of the total federal veterinary workforce (Andrus, 2006).

Based on projected retirements reported by the federal agencies to GAO, filling the shortage in federal public practice can be only characterized as daunting. The GAO reported that 27% (approximately 697) of the veterinarians employed by APHIS, FSIS, ARS, FDA, and the Army will be eligible to retire between 2009 and 2012. As noted above, these agencies collectively reported 206 vacancies in 2009—166 in FSIS, 6 in ARS, and 34 in the Army (GAO, 2009). If these reports are accurate, there will be a need for approximately 740 veterinarians for positions in the federal government by 2012. Given the current rate of hiring by the agencies, filling that gap is unlikely. Data from the OPM Central Personnel Data File shows that over the last four years, 438 permanent VMO positions were filled across all agencies. Of the 100 positions filled in 2009, 30% of the positions were filled with job candidates age 50 and above (OPM, 2010). Between 2006 and 2008 an average of 71% of new hires by FSIS were veterinarians in private practice; only 14% on average were new graduates (GAO, 2009). As a result of these hiring practices, VMOs are older (average age 52.4) than the balance of the federal workforce (average age 46.2) (OPM, 2010). Although the current economic crisis and improved recruitment benefit programs in some agencies has retarded this exodus, the U.S. federal veterinary workforce is facing an impending mass retirement. As a result, the protection of animal and public health could be weakened, making workforce planning in the federal government critically important.

FUTURE SUPPLY OF PUBLIC PRACTICE VETERINARIANS

Based on the employment decisions of newly-minted DVMs, few are interested in immediately pursuing public service positions. In an AAMVC survey of 2,396 of the 2010 graduates of U.S. veterinary colleges, about three-quarters (1,827) reported accepting a job offer or advanced educational opportunity, such as a residency or graduate program. Of those, 38 (2.5%) had accepted a position in the uniformed services, and 3 (0.2%) had accepted a position in the federal government. None reported taking a state-level position. However, 760 graduates (49.2%) were accepting a position in an advanced education program, so it might be expected that a small number of those will be future candidates for public sector positions (Shepherd, 2010). However, the 2010 OPM VMO Strategic Workforce Plan, "acknowledged that veterinary schools are limited in the number of graduates they can produce and private industry compensation packages are highly competitive." There is clearly a need to find ways to prepare and recruit DVMs for public practice.

Examples of Federal Recruitment and Training

The primary requirement for the majority of federal positions is a DVM, but federal agencies are finding it difficult to hire new graduates who have basic training in public health that is required of these entry level government jobs or who have an interest in work in public practice. The committee's assessment that multiple factors contribute to this situation, including a lack of awareness about public practice and few mentors in the field, the movement of curriculum away from the public practice sciences, and students' need to pursue higher-paying jobs to service education debt. Although the salary levels in the federal government are lower for entry level jobs relative to the private practice sector, there are incentives that can be offered to candidates. Appendix E contains a list of recruitment tools that were identified for that purpose by USDA and the Office of Management and Budget. Given the number of women entering veterinary school, additional incentives to consider are those that could increase the recruitment and retention of women, such as policies that accommodate family formation, parental leave, and childcare (Williams and Ceci, 2012).

With the recent economic crisis and the attention that GAO brought to the status of the federal veterinary workforce, a steady improvement in the recruitment and retention offers has occurred, resulting in fewer vacancies in key federal departments, especially the FSIS. Some agencies have active programs to attract veterinary students. For example, FSIS established a program in 2001 that employs veterinary students for 6 weeks in the summer. The students are paid to work with a VMO in meat and poultry plants as well as in other parts of the agency, learning about food safety and animal welfare regulations (FSIS, 2010).

An FDA Veterinary Clerkship Program provides fourth-year veterinary students with work experience at the FDA's Center for Veterinary Medicine, which approves new animal drugs, evaluates claims of new drugs, sets policies for the use of antibiotics in medicated animal feeds and conducts a number of other regulatory activities. Students participate in the program on a volunteer basis (FDA, 2010).

Several of the agencies told GAO that the positions for which they hire veterinarians require advanced training in laboratory animal medicine and pathology. As this is the same kind of expertise in demand by private industry, some agencies have recognized that if they want candidates with the advanced skills, they will need to provide support for that training. Two such programs are described below.

Centers for Disease Control and Prevention Support for Laboratory Animal Medicine

In 2008, CDC started a two-year residency program (Laboratory Animal Medicine Residency Program) designed to address a shortage of veterinarians working in biomedical research. The program is a partnership with Emory University's Robert W. Woodruff Health Sciences Center, and includes 200 hours of academic coursework at Emory University. This is combined with 2,000 hours of hands-on experience in CDC's high-containment laboratory facilities as well as experience in infectious-disease research with a CDC mentor. Graduates of the program will be proficient in the daily treatment of laboratory animals, working in high-containment laboratories, designing scientific experiments and the use of animal models and administration of lab-animal medicine programs (CDC, 2008).

National Cancer Institute Support for Training in Pathology

To encourage the development of veterinarians in biomedical sciences, the National Cancer Institute's Center for Cancer Research, in collaboration with the National Institute of Allergy and Infectious Diseases, the National Institute of Diabetes and Digestive and Kidney Diseases, and The National Heart, Lung, and Blood Institute, have established graduate education partnerships with several colleges of veterinary medicine. The program includes a residency and PhD training support for those with a DVM in comparative pathology (NCI, 2010).

The Role of a Veterinary Education

Most government agencies assume that veterinarians with a DVM are educated in the basic sciences of epidemiology, food safety, public health, pathology, and food-animal production and population health. However, the committee found a general lack of understanding by members of the veterinary profession (and recent graduates) about the job availability and requirements for which veterinarians could qualify in the federal government. One reason is the predominance of clinical practitioners among veterinary school faculty members that made clinical instruction an increasing focus of most veterinary curricula. As a result, instruction in core disciplines, particularly those central to the expertise of public practice veterinarians, has decreased.

The foundational knowledge required by most of the VMO positions in the federal and state governments include the professional knowledge of veterinary medical concepts, principles, and practices concerned with the full range of animal health and disease, ante mortem and post mortem, and the basic sciences. This includes knowledge of basic production and husbandry practices, the use of animal drugs, biologics, and antibiotics relevant to food safety and public health, and practices for humane handling and slaughter. In addition, candidates need to be familiar with the pathology of various foreign and other diseases with public health and economic significance, and have an understanding of microbiology, parasitology, toxicology, physiology, chemistry, anatomy, epidemiology, and surveillance.

For most veterinary students, the last opportunity to learn the basic sciences is as students in the DVM program. Most continuing education offered to DVMs is for enhancing and developing additional clinical skills and hospital management. Veterinary college curricula have lost ground in preparing the DVM for public practice over the last several decades, and consequently, many government agencies that hire DVMs need to provide additional training to bring them to agency standards. To meet the increased needs in this area, schools should encourage public practice careers for both pre-veterinary and veterinary students.

Many colleges of veterinary medicine are implementing programs to encourage DVM students and graduate students to enter public practice and food supply veterinary medicine through the rationale for One Health (AVMA, 2008). However, resource limitations and financial constraints have reduced the capacity of academic institutions to implement effective and sustainable educational programs. One approach to filling the need for public practice veterinarians has been the development of DVM programs in conjunction with a Masters of Public Health (MPH). The committee found thirteen colleges of veterinary medicine that offer dual DVM/MPH degrees. At the University of Illinois, for example, students can transfer a portion of the credits earned for the DVM degree toward an MPH degree. However, without matching what is required in various MPH programs with government talent needs and strategic planning, this additional educational and financial burden may not reap the benefits intended. It is critical that academic programs work closely with the OPM and the Talent Management Advisory Council to match government needs with educational programs.

Another strategy would be to match admission criteria with workforce needs. Schools could target recruitment and offer scholarship programs for students with public practice interests (Prince et al., 2006). Admission criteria could be modified to select for a broader range of skills required for public practice. Colleges that are aware of public practice competencies developed by government are seeking ways to attract a more diverse pool of students by putting emphasis on written and oral communication and leadership skills.

The Food-Animal Production Medicine Consortium, a partnership formed by several veterinary colleges (California, Illinois, Michigan, and Florida) to provide food-animal and food safety educational and research programs, operated for more than a decade but lost momentum; there may be lessons learned from that experience (Troutt, 1994). More recently, Miller and Prasse (2006) recommended concentrating faculty into Centers of Excellence so that instructional quality and accuracy of information delivered can be maintained. These Centers would seek to hire faculty with public practice, public health and food supply veterinary medicine experience, or establish ways to use the expertise of such individuals. There is a cadre of experienced and talented veterinarians working in government who, by the nature of their employment and regulatory limitations to professional practice, may not hold advanced degrees but have research grants or extensive publications. These veterinarians are often available to take adjunct and full or part-time faculty appointments to help train the next generation of public practice veterinarians. Working with government agencies at the state and federal levels, Centers could match strategic government needs to develop continuing educational programs in food safety, epidemiology, pathology, zoonotic diseases, environmental hazards, and other public health sciences. There is a great potential for agencies to outsource mission-focused training and education and potentially partner with public practice Centers of Excellence or Institutes.

Additional efforts by academia, veterinary professional organizations and the public sector are needed to increase the exposure of pre-veterinary and veterinary students to opportunities and important career paths that are available to veterinarians in public practice. For example, more postgraduate fellowships for public practice veterinarians are needed; paid public practice externships should be increased; and more student and postgraduate internships should be developed with national and international experiences.

ADDRESSING THE RISK OF GAPS IN THE PUBLIC VETERINARY WORKFORCE

An overarching critique contained in the GAO report was that agencies had conducted very little assessment of the kind of veterinary expertise that they need. FSIS was criticized specifically for not responding to a 2004 GAO recommendation that the agency assess "whether it has enough inspection resources, including veterinarians, dedicated to humane handling and slaughter activities." GAO repeated the recommendation in its 2009 report, adding food safety to the list of responsibilities for which the agency should assess the sufficiency of its resources. The GAO's review of veterinary positions in the government concluded that, in addition to current vacancies, an impending wave of retirements, and the absence of a comprehensive assessment of federal veterinary workforce needs, the government is likely to miss recruitment opportunities, use veterinarians inefficiently, and experience an insufficient workforce during critical disease outbreaks (GAO, 2009).

The last element of the GAO critique—an insufficient workforce during critical disease outbreaks—is particularly worrisome in light of the declining numbers of veterinarians engaged in private food-animal practice, described in Chapter 4. With less routine veterinary oversight in the private sector, the chance of an outbreak is increased. When an outbreak of disease in food animals occurs, veterinarians in the public and private sector are called on to coordinate activities in control and recovery operations. If no surge capacity exists in either the private or public sector, the spread of disease will be much more difficult to manage. The "poster child" for that kind of event is the 2002-2003 outbreak of exotic Newcastle disease of poultry, which ultimately required 1,250 veterinarians and a supporting workforce of nearly 5,000 working for almost a year to control the disease.

As Chapter 4 points out, foot-and-mouth disease (FMD) is the foreign animal disease of greatest concern to the United States, having large populations of cattle and swine that would be susceptible to the disease. One of GAO's recommendations, directed at the Secretary of Homeland Security, was for a coordinated, interagency effort to identify the data necessary to model the spread of FMD in wildlife and how best to gather the data (GAO, 2009). An FMD outbreak in the United States could have an economic impact of between $9 and $50 billion (NRC, 2010).

Although USDA recently has begun planning for a potential FMD outbreak (USDA-APHIS, 2010b), it is difficult to understand why staggering cost estimates such as these have not motivated a more substantial investment in the infrastructure and planning to prevent, mitigate, and respond to such a disease threat. Several recent reports have called for greater surveillance, coordination, and workforce planning and coordination to address threats from animal diseases, including zoonoses (NRC 2005; IOM and NRC, 2009).

Additionally, there is a concern that if a pandemic event were to arise requiring 40% of the VMO workforce to divert attention to the event, federal agencies may be unable to perform their critical missions, placing at risk the health of the American public. Essentially, agencies with a veterinary workforce must ensure they can provide the VMO personnel needed during a catastrophic or emergency event, while maintaining the VMO workforce needed to achieve each agency's day-to-day mission (OPM, 2010)

As the committee explored the demand for public practice veterinarians, it found long-standing vacancies that would appear to indicate a shortage of appropriate candidates. As opposed to a shortage, however, the committee concluded that a long-term persistence of openings for veterinarians in some federal agencies may indicate that other factors are influencing the ability to fill positions; for example, a tacit decision not to increase the hiring of veterinarians (by raising salaries or offering incentives); the inability to make the working conditions more attractive; and the existence of internal and external competition for a limited number of candidates, such as those with advanced degrees or specialized knowledge and skills such as pathology.

The committee also saw connections to issues beyond the federal government's policies for recruitment and retention. The inability to resolve the problem of long-standing vacancies may be related to trends in funding for agricultural science, and animal science, in particular. Federal funding for research in many aspects of animal science in general has declined by as much as 44% in the last two decades, accompanied by shrinking faculty and new student numbers, to the point at which some have called the situation a crisis (Roberts et al., 2009). Veterinary groups now routinely call for additional spending on animal diagnostics, food supply security, and veterinary manpower (AVMA, 2009b) or decry unstable funding for programs such as the USDA Food-Animal Residue Avoidance Databank, which had to be temporary rescued by private donations in 2009 until federal funding was restored (AVMA, 2009c). The current level of priority for issues related to the veterinary care of animals and research on animal health seems incongruent with the potential consequences of continuing vulnerabilities in both animal and public health. The committee concludes that the current national investment in veterinary research and training for public health veterinarians is inadequate.

Following the publication of the 2009 GAO report, the OPM created the TMAC to collect information and provide advice on a strategy to address federal veterinary workforce needs. In a plan developed for implementation between 2011 and 2015, the OPM is now exploring three key areas:

- creating innovative and coordinated approaches to recruiting and hiring students, mid-career professionals, and retirees to meet agency needs
- streamlining the hiring process to create a positive experience for applicants and managers, and
- implementing programs and initiatives that will encourage current veterinary employees to remain within federal service.

It is encouraging that a Workforce Task Force now exists and that a strategic plan has been developed for the federal workforce. The committee is hopeful that federal agencies will be able to clearly articulate the full value of the veterinary medical profession to their missions, and take steps to support a coherent plan to strengthen their role in research, food safety, animal welfare, and public health.

7

Veterinarians in Wildlife and Ecosystem Health

INTRODUCTION

Life forms including humans, other animals, plants, and microbes are interdependent; together with the non-living environment they comprise ecological systems. Wildlife species in those systems have intrinsic value and are connected to human health and wellbeing. Thus, the promotion of healthy ecosystems that sustain wildlife is a social responsibility locally and globally. The need for veterinary expertise to address wildlife health and ecosystem dysfunction is exemplified by the accelerating declines and unprecedented extinctions of animal species (Wilcove and Master, 2005), the growing incidence of wildlife and zoonotic diseases (Daszak et al., 2000; Jones et. al., 2008), and the impacts of environmental contaminants such as mercury (Pacyna et al., 2006), toxins from harmful algal blooms (Anderson et al., 2002), endocrine disruptors, including ubiquitous polybrominated diphenyl ether flame retardants (Blazer et al., 2007; Guillette, 2006; Ross, 2005), and carcinogens (Martineau et al., 2002). These hazards directly affect humans and animals, causing food deprivation, epidemics of infectious diseases, altered sexual development, thyroid abnormalities, neurologic impairment, liver and other organ failures, a range of cancer, and psychological stress. Indirect exposure to toxic and infectious stressors can occur by way of the consumption of animals, for example, fish and shellfish, in which harmful chemicals and pathogens accumulate.

Human-Wildlife-Ecosystem Connection

The number of Americans whose lives include a focus on wildlife and the amount of private sector expenditures related to wildlife are remarkable. In 2006, for example, more than 87 million Americans of age 16 years and older enjoyed some form of wildlife-related recreation and, in pursuit of these activities, spent $122 billion, about 1% of the U.S. gross domestic product (GDP) (FWS, 2007). This economic activity depends on an abundance of healthy wildlife, which is beautiful to witness, and for those who hunt and fish, bountiful and safe for human consumption. Recognizing and preventing the impacts of principal stressors that undermine the health and reproduction of animals in the wild is a core responsibility for wildlife and ecological veterinarians, but the challenges are significant, and the number of veterinarians in this sector of the profession is relatively small. In the United States, many species of invertebrates, fish, amphibians, birds, and mammals are threatened with extinction. Unless wildlife stewardship improves, wildlife recreation, and its economic benefits, will be undermined.

As a group of animals that are free to move about, wildlife can carry diseases to and from domestic animals and people. Examples include diseases such as influenza, which often arises in wild birds and infects domestic poultry, swine, and other species, and brucellosis, which originated in cattle and is now found in elk and bison. Wildlife diseases such as West Nile virus, Lyme disease, and Hantavirus infection are also a threat to human health. In some cases, wildlife and the diseases they carry come into contact with humans and domestic animals because of shrinking or degraded wildlife habitat, which in itself results in increased outbreaks of diseases that undermine wildlife populations and sustainability. Exotic species introductions also bring new diseases to wildlife, as in the case of chytrid fungal infections that have decimated frogs. Wildlife and ecological veterinarians therefore have key roles to play in limiting the risks of such diseases through surveillance, diagnosis, and implementation of control measures.

Veterinary expertise in wildlife and ecosystem health is essential for efficient exploration of the interactions that underlie these complex phenomena as well as their broader implications for public (human) health, but the number of veterinarians involved in this sector at present is relatively small. While veterinarians are spear-heading an interdisciplinary approach to understanding the health effects of mismanaged ecosystems, greater effectiveness will depend on the priority that colleges and schools of veterinary medicine place on educating future veterinarians to expand their knowledge and influence in this field and on the resources available to support research, advanced training, and responsible environmental stewardship. A new paradigm for veterinary education will be necessary, requiring courage and effort on the part of the profession's leaders to reverse the divergence of the human and veterinary public health agencies over the last 30 years (Salman, 2009) and to acknowledge the relationships among the environment, the health of wildlife, domestic animals, and humans.

These relationships form the foundation of the "One Health" initiative (http://www.onehealthinitiative.com), a co-equal collaboration of physicians, veterinarians, conservation biologists, ecologists, and other scientific and health-related disciplines (Sherman, 2002; Kahn et al., 2007; Kaplan et al., 2009).

Endorsed by the American Medical Association, the American Society for Tropical Diseases and Hygiene, the Centers for Disease Control and Prevention, and the American Veterinary Medical Association, One Health seeks to support a holistic concept of health that recognizes the complex linkages among diseases of humans, livestock, poultry, and wildlife (See Box 7-1).

The EcoHealth Alliance (which until September, 2010, was called the Wildlife Trust), established in 1971, was among the earliest to address the essential links among human, animal, and ecosystem health (Daszak et al., 2004). In 2004, the Wildlife Conservation Society (WCS) drew attention to the plight of wildlife in an increasingly crowded world as well as to the related growing health risks from trade in wildlife and bush-meat. WCS outlined these concerns in "The Manhattan Principles" (Box 7-2), and recommended that wildlife health science become an essential component of global disease prevention, surveillance, monitoring, control, and mitigation.

BOX 7-1
Excerpts from the Executive Summary of
One Health - A New Professional Imperative

The convergence of people, animals, and our environment has created a new dynamic in which the health of each group is inextricably interconnected. The challenges associated with this dynamic are demanding, profound, and unprecedented. While the demand for animal-based protein is expected to increase by 50% by 2020, animal populations are under heightened pressure to survive, and further loss of biodiversity is highly probable.

On top of that, of the 1,461 diseases now recognized in humans, approximately 60% are due to multi-host pathogens characterized by their movement across species lines. And, over the last three decades, approximately 75% of new emerging human infectious diseases have been zoonotic. Our increasing interdependence with animals and their products may well be the single most critical risk factor to our health and well-being with regard to infectious diseases.

There is a growing concern that the world's latest generation could be the first in history to experience a reduction in life expectancy and health in general. Yet, veterinary and human medicines are considered separate entities and the obvious links between them frequently ignored. According to the KPMG study, "*The Current and Future Market for Veterinarians and Veterinary Medicine in the United States*," published in May of 1999, "our traditional approaches and past requisite skills and levels of knowledge may not be commensurate with the rapid changes and new demands of food-animal industries and the shifting requirements needed for the corporate and public opportunities in the future. These include public health, biomedical research, and the global food system."

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BOX 7-1 *(Continued)*

The Need for a Holistic, Collaborative Approach

One strategy to better understand and address the contemporary health issues created by the convergence of human, animal, and environmental domains is the concept of One Health. Although the concept of One Health is not new, our increasing interdependence with animals and their products has spurred the medical and veterinarian professions to readdress such an approach. This approach would encourage the collaborative efforts of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals, and our environment.

Partnership is Critical to Success

The veterinary medical profession must implement solutions to the critical workforce challenges in collaboration with multiple professions, including public health, human medicine, bio-engineering, animal science, environmental science, and wildlife. By working together, more can be accomplished to improve health worldwide, and the veterinary medical profession has the responsibility to assume a major leadership role in that effort. One Health calls for the collaborative efforts of multiple disciplines working locally, nationally, and globally to attain optimal health for people, animals and our environment.

SOURCE: AVMA, 2008.

ROLES OF VETERINARIANS IN WILDLIFE AND ECOSYSTEM HEALTH

Veterinarians make important contributions to zoos, wildlife conservation, and ecosystems by focusing their efforts on the health of species ranging from coral (Work et al., 2008) and other invertebrates (Lutz-Collins et al., 2009) to fishes (Goldberg et al., 2003), amphibians (e.g. Lips et al., 2006; Rohr et al., 2008), reptiles (Katsu et al., 2010), birds (Franson et al., 2007), and mammals (e.g. rodents to bats, carnivores, ruminants, whales, and primates including humans) (Martineau et al., 2002; Goldberg et al., 2007, 2008). In the wildlife sector, veterinarians are increasingly confronted with the consequences of environmental contaminants and infectious disease outbreaks that potentially threaten wild and domesticated animals as well as humans. Because of the breadth of regions, species, and problems involved in the currently accelerating "sixth extinction" (Pimm et al., 1995; Raven, 2002; IUCN, 2008), veterinarians have abundant challenges, but the pathways to employment are typically nontraditional.

BOX 7-2
The Manhattan Principles on "One World, One Health"

Recent outbreaks of West Nile Virus, Ebola Hemorrhagic Fever, SARS, Monkey pox, bovine spongiform encephalopathy , and Avian Influenza remind us that human and animal health are intimately connected. A broader understanding of health and disease demands a unity of approach achievable only through a consilience of human, domestic animal and wildlife health - One Health. Phenomena such as species loss, habitat degradation, pollution, invasive alien species, and global climate change are fundamentally altering life on our planet from terrestrial wilderness and ocean depths to the most densely populated cities. The rise of emerging and resurging infectious diseases threatens not only humans (and their food supplies and economies), but also the fauna and flora comprising the critically-needed biodiversity that supports the living infrastructure of our world. The earnestness and effectiveness of humankind's environmental stewardship and our future health have never been more clearly linked. To win the disease battles of the 21st Century while ensuring the biological integrity of the Earth for future generations requires interdisciplinary and cross-sectoral approaches to disease prevention, surveillance, monitoring, control and mitigation, as well as to environmental conservation more broadly.

We urge the world's leaders, civil society, the global health community and institutions of science to:

1. Recognize the essential link between human, domestic animal, and wildlife health and the threat disease poses to people, their food supplies and economies, and the biodiversity essential to maintaining the healthy environments and functioning ecosystems we all require.

2. Recognize that decisions regarding land and water use have real implications for health. Alterations in the resilience of ecosystems, and shifts in patterns of disease emergence and spread manifest themselves when we fail to recognize this relationship.

3. Include wildlife health science as an essential component of global disease prevention, surveillance, monitoring, control, and mitigation.

4. Recognize that human health programs can greatly contribute to conservation efforts.

5. Devise adaptive, holistic, and forward-looking approaches to the prevention, surveillance, monitoring, control, and mitigation of emerging and resurging diseases that take the complex interconnections among species into full account.

6. Seek opportunities to fully integrate biodiversity conservation perspectives and human needs (including those related to domestic animal health) when developing solutions to infectious disease threats.

(Continued)

BOX 7-2 *(Continued)*

7. Reduce the demand for and better regulate the international live wildlife and bushmeat trade not only to protect wildlife populations but to lessen the risks of disease movement, cross-species transmission, and the development of novel pathogen-host relationships. The costs of this worldwide trade in terms of impacts on public health, agriculture, and conservation are enormous, and the global community must address this trade as the real threat that it is to global socioeconomic security.

8. Restrict the mass culling of free-ranging wildlife species for disease control to situations where there is a multidisciplinary, international scientific consensus that a wildlife population poses an urgent, significant threat to human health, food security, or wildlife health more broadly.

9. Increase investment in the global human and animal health infrastructure commensurate with the serious nature of emerging and resurging disease threats to people, domestic animals, and wildlife. Enhanced capacity for global human and animal health surveillance and for clear, timely information-sharing (that takes language barriers into account) can only help improve coordination of responses among governmental and nongovernmental agencies, public and animal health institutions, vaccine/pharmaceutical manufacturers, and other stakeholders.

10. Form collaborative relationships among governments, local people, and the private and public (i.e., non-profit) sectors to meet the challenges of global health and biodiversity conservation.

11. Provide adequate resources and support for global wildlife health surveillance networks that exchange disease information with the public health and agricultural animal health communities as part of early warning systems for the emergence and resurgence of disease threats.

12. Invest in educating and raising awareness among the world's people and in influencing the policy process to increase recognition that we must better understand the relationships between health and ecosystem integrity to succeed in improving the prospects for a healthier planet.

SOURCE: Cook et al., 2004.

Determining with precision how many veterinarians are employed in jobs related to wildlife and ecosystem health is challenging because the data are not captured in any one place, such as the membership list of the American Veterinarian Medical Association (AVMA). Although AVMA includes some veterinarians who identify themselves as working on exotic animals and wildlife, others are more likely to be members of specialty groups, such as the American Association of Zoo Veterinarians (AAZV), the American Association of Wildlife Veterinarians (AAWV), and the Wildlife Disease Association (WDA). The latter includes veterinarians and others, wildlife biologists, for example, who do not hold DVM degrees. Other veterinarians who work on wildlife and ecosystem health might be affiliated only with specialty bodies, such as the American College of Veterinary Pathologists (ACVP), which do not distinguish members according to types of animals investigated or the research environment. Some pathologists, for example, work only on domestic animals, others only on rodents or primates, and still others on a host of species including terrestrial and aquatic wildlife. The number of veterinarians in state and federal agencies with missions that are primarily oriented toward wildlife and ecosystem health is easier to determine, and the total number in these agencies is small.

It is also difficult to predict the number of jobs available for veterinarians in this sector in the future, in part because of the diversity and specificity of the situations that generate demand. In contrast to other sectors of the profession, preparation for jobs in this sector can be a greater challenge because animal populations, ecosystems, and their interactions with human activities differ by state and by region. Some jobs may not be classified as requiring a DVM, but could be filled by veterinarians. In spite of very broad legislated responsibilities, the federal and state agencies responsible for wildlife and ecosystem health do not show signs of meaningful expansion of their veterinary staffs; however, these agencies readily admit that their current veterinary expertise is inadequate to fulfill their missions. Until expertise for DVMs in this sector becomes an explicit and a well-identified demand, graduates of veterinary schools will need to define their own niche in wildlife and ecosystem health by identifying and filling a need, and by establishing the added value they bring to an existing position as a DVM.

Employers of veterinarians involved in wildlife and ecosystem health include federal and state agencies and laboratories, public and private universities, non-governmental organizations (NGOs), and zoos, aquaria, and marine and wildlife parks that may be publicly or privately operated. Because many of these institutions have common over-arching goals and conduct similar types of activities in which veterinarians are engaged, the roles of veterinarians in wildlife and ecosystem health can be best understood in the context of their major areas of responsibility, which include: 1) health management of free-ranging wildlife populations; 2) zoo animal medicine; 3) aquatic wildlife and marine mammal health; 4) wildlife rehabilitation; and 5) environmental, wildlife, or ecological toxicology. The careers of veterinarians who assume such responsibilities may focus on diagnostics, basic and applied research, and/or stewardship activities.

The following section describes each of those categories of veterinary activity, identifies the major employers in each category, and estimates the numbers of veterinarians employed. Information is also provided about membership in relevant associations, which gives a partial picture of the numbers of veterinarians in these fields.

Health Management of Free-Ranging Wildlife Populations

Veterinarians whose jobs are concerned with the health of free-ranging wildlife populations include specialists in epidemiology, pathology, infectious diseases, toxicology, reproductive biology, pharmacology, relocation, anesthesiology, endangered species management and reintroductions, public health, and clinical medicine. They often have expertise in more than one of the above specialties and work in team settings with specialists in other fields. Examples of the kinds of activities in which they are involved include conserving wildlife through diagnosing causes of die-offs, management actions to promote healthy wildlife populations, restoring numbers of endangered species, and protecting human and domestic animal populations from threats of infectious agents or toxic chemicals in wildlife.

Wildlife veterinarians at the state and federal levels, as well as those in universities, provide leadership and expertise in addressing infectious disease transfer at the domestic animal-wildlife interface. Preventing the movement of diseases between wildlife and domestic species might, for example, involve the vaccination of wildlife (as with raccoon rabies in the United States) or the use of alternative strategies such as vaccinating domestic food and companion animals, locating food-animal production facilities rationally, and reducing contact between domestic and wild animals.

There are a number of federal, state, university, and cooperative programs focused on wildlife diseases in the United States but not all states are involved. Some programs cooperate with Canadian organizations (Figure 7-1).[1,2]

Veterinarians in the Department of the Interior

Veterinary jobs related to free-ranging wildlife exist in several agencies. On federal lands, the Department of the Interior assumes a measure of responsibility for wildlife health and control. Nevertheless, in 2008, the agency reported having just 24 veterinarians, more than half in the U.S. Geological Survey (USGS), a number that increased to 34 in 2010 (TMAC, 2011). Only 4 veterinarians were identified in the Fish and Wildlife Service (FWS), and only 4 were employed by the National Park Service (NPS) (GAO, 2009).

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[1]The Southeastern Cooperative Wildlife Disease Study, University of Georgia, Athens provides diagnostic and other wildlife disease services for member wildlife conservation agencies in the states of: AL, AR, FL, GA, KS, KY, LA, MD, MS, MO, NC, OH, OK, PA, SC, TN, VA, WV among its program activities.

[2]Canadian wildlife biologists are assisted by the Canadian Cooperative Wildlife Health Centre (CCWHC) program located in Saskatoon, Saskatchewan (Western/ Northern Canada), and have been since its establishment in 1992. Each of the Canadian Provincial Schools of Veterinary Medicine maintains a component of the program.

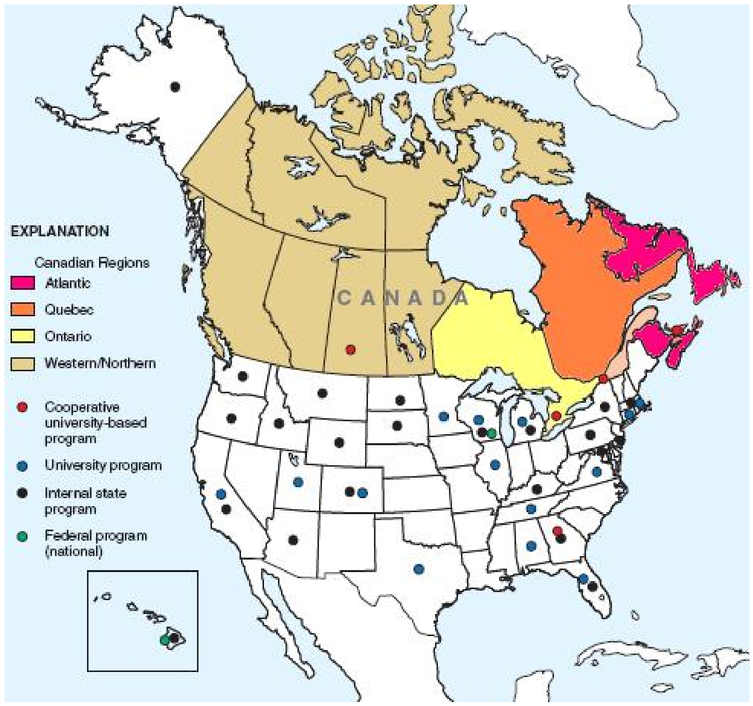

FIGURE 7-1 Locations and sponsorship of North American programs devoted to disease investigations involving free-ranging fauna (state, federal, and university cooperative programs). SOURCE: Friend, 2006. Reprinted with permission from M. Friend, USGS (Emeritus).

USGS veterinarians investigate, diagnose, develop control methods, and develop databases for wildlife diseases; provide training to wildlife biologists and resource managers in wildlife disease identification and control; conduct clinical veterinary research on wildlife diseases; and oversee the health and welfare of experimental and wild animals used in research, including research on wildlife diseases. The USGS' National Wildlife Health Center (NWHC), located in Madison, Wisconsin, coordinates programs across the United States to respond to emerging and resurging diseases in wildlife. Initially, NWHC focused its attention on top priority health issues that influenced the sustainability of waterfowl (Friend and Franson, 1999) and hunted mammals (e.g. cervids), and over time has expanded substantially to include other vertebrates, including such divergent groups as fishes, amphibians, raptors, bats, and marine mammals. The mission of NWHC is to provide "information, technical assistance, research, education, and leadership on national and international wildlife health issues (NWHC, 2012)."

Veterinarians with FWS perform fish health management and diagnostic activities; conduct wildlife disease surveillance; perform diagnostic work and outbreak investigations; provide technical expertise; and draft policy, regulation, and management action plans. Similarly, the NPS veterinarians prepare surveillance and contingency response plans for addressing important wildlife diseases in the national park system and formulate policies for management of wildlife disease. NPS has an active One Health collaboration between its Wildlife Health Program and Office of Public Health. Focus areas of that effort include unified disease surveillance, interdisciplinary response, a combined research agenda, and consensus guidance.

In a GAO study of veterinarians in the federal government, USGS reported that the agency faces difficulty hiring veterinarians to address wildlife diseases, including those that kill many animals in a single outbreak, because the salaries they can offer are not competitive with funding for positions in the private sector. As a consequence, both FWS and NPS, the latter having responsibility for 84 million acres of the park system, reported having too few veterinarians to meet their needs (GAO, 2009).

Veterinarians in State Wildlife Agencies

Most states have agencies that are concerned with wildlife health and management. These range from departments of agriculture or natural resources to fish and game agencies. In 2009, the committee contacted the relevant agencies in each state to determine how many of them employed veterinarians. As indicated in Table 7-1, only 19 states were found to have one or more wildlife veterinarian(s).

Although it might seem obvious that veterinarians can make contributions to the mission of state wildlife agencies, few job openings in this sector explicitly seek individuals with DVM degrees at this time. As described in Box 7-3, state employers' awareness of the potential role for veterinarians in wildlife management may only come about when they have had positive experience with what the profession can offer.

University Programs

Numerous colleges and schools of veterinary medicine have organized centers and educational programs that address wildlife. However, deriving an accounting of the numbers of individuals involved in academic veterinary medicine related to wildlife and ecosystem health is not a feasible goal because of the wide variety of departments, job titles, and duties involved, and because there is no one unifying organization to which these various professionals affiliate. A number of veterinarians have become specialists in epidemiology, pathology, infectious diseases, toxicology or clinical medicine, and devote much or most of their time to research, teaching, and outreach that helps wildlife and ecosystems.

TABLE 7-1 States with Wildlife Agencies that Employ Veterinarians, and Numbers of Veterinarians Employed in 2009

State	Wildlife Agency	Number
Alaska	Department of Fish and Game	1
Arizona	Game and Fish Department	1
California	Department of Fish and Game	5
Colorado	Division of Wildlife	3
Delaware	Department of Natural Resources	1
Florida	Fish and Wildlife Conservation Commission	3
Idaho	Department of Agriculture	2
Maryland	Department of Natural Resources	2
Michigan	Department of Natural Resources	1
Missouri	Department of Conservation	1
Montana	Fish, Wildlife and Parks	1
Nevada	Department of Agriculture	1
New York	State Department of Health	1
Oregon	Department of Fish and Wildlife	2
Pennsylvania	Game Commission	1
Virginia	Department of Game and Inland Fisheries	1
Washington	Department of Fish and Wildlife	1
Wisconsin	Department of Natural Resources	2
Wyoming	Game and Fish Department	2

BOX 7-3
Defining the Role of the Wildlife Veterinarian

The value of hiring veterinarians in wildlife health has been demonstrated by at least one veterinarian who took a non-traditional path to employment in a state agency. Dr. Melody Roelke-Parker accepted a job as a wildlife biologist for the State of Florida, and applied her veterinary knowledge and skills to examine endangered Florida panthers, a subspecies of cougar (*Puma concolor*), revealing through her work their poor fertility and a number of abnormal physical characteristics. Dr. Roelke-Parker reached out to new collaborators, such as Dr. Stephen O'Brien, Chief of the Laboratory of Genomic Diversity at NIH, and they discovered that the animals were highly inbred and genetically impoverished (Roelke-Parker et al., 1993). Ultimately, this discovery prompted introduction of new genes from Texas cougars (historically a part of the same metapopulation), and this successfully offset health problems of the Florida animals. After Dr. Roelke-Parker moved to another position, the State of Florida created a position for a wildlife veterinarian to ensure stewardship of the cougars and other wildlife of the state; and currently, Florida employs three wildlife veterinarians. The recognition of the need for veterinary expertise became apparent after understanding how veterinarians can contribute to the agency's goals.

Table 7-2 lists several active university-based programs that focus on wildlife, each with a different emphasis. Note that there is overlap in the training of veterinarians for work with free-ranging wildlife and wildlife in captive settings.

Additional innovative short courses in wildlife and ecosystem health are discussed later in this chapter in a section on Support for Training for Veterinary Careers in Wildlife and Ecosystem Health.

TABLE 7-2 Examples of University-based Wildlife Programs

University Program	Areas of Emphasis
University of California, Davis - Wildlife Health Center	Wildlife health stewardship, avian influenza management, disease investigations, oiled wildlife, international conservation. All involve outreach, management, research, and training.
University of California, Davis - Masters in Preventative Veterinary Medicine Program	Population health, food safety, public health and zoonoses, wildlife disease and ecology, ecosystem health, international health, and independent topics.
University of California, Davis - The Avian Flu School	Education, research, prevention, and response to avian influenza in wildlife, poultry, and humans.
University of California, Davis - Veterinary Medical Teaching Hospital	Residency in Zoological Medicine in collaboration with the San Diego Zoo, the San Diego Wild Animal Park, the Sacramento Zoo, and SeaWorld.
University of California, Davis - The Emergency Preparedness - ESCAPE (Enhancing Surge Capacity and Partnership Effort) Project	Public health, disaster preparedness.
University of California, Davis - Calvin Schwabe One Health Project	Diversity in future veterinary student bodies, broadening veterinary education.
University of Georgia - The Southeast Cooperative Wildlife Disease Study	Diagnostic and research efforts with emphasis on new disease entities or diseases that threaten the sustainability of wildlife groups or individual species.
Tufts University, Cummings School of Veterinary Medicine - Wildlife Medical Clinic	Care of wild animals and federally endangered species and research.
University of Calgary, College of Veterinary Medicine -Capstone Course	Global health research, and ecosystem, global, and One Health conceptual frameworks.
University of Illinois, College of Veterinary Medicine - Wildlife Medical Clinic	Care of injured wildlife with the goal of release of native species back into the wild.
University of Illinois, Zoological Pathology Program, Residency in Zoo Medicine, Experiential Education for Veterinary Students in Zoo Medicine	Terrestrial and aquatic wildlife problems, with education, outreach, and research in zoos and/or in the wild, locally, regionally, and internationally. Residencies in zoo medicine and zoo and aquatic animal pathology in collaboration with the Brookfield and Lincoln Park Zoos and the Shedd Aquarium.

(Continued)

TABLE 7-2 Continued

University Program	Areas of Emphasis
University of Tennessee, College of Veterinary Medicine - Avian and Zoological Medicine Service	Medical and surgical services, research and education in exotic animal and zoo animal health including residency training in zoo and wildlife medicine.
Texas A&M University, College of Veterinary Medicine - Schubot Exotic Bird Health Center	Captive and wild bird health research, with emphasis on infectious diseases and nutrition of psittacines and sustainability of endangered species.
University of Minnesota - The Raptor Center	Diagnosis, medicine, and research to support the recovery and population health of free-ranging raptors.
University of Minnesota - National Institute for Allergy and Infectious Diseases, Center of Excellence for Influenza Surveillance and Research, and Summer Public Health Institute	Identification of influenza viruses in domestic and international wild bird, poultry, and swine populations. Participant immersion in an individual field of study (food safety, public health, disease control, health surveillance systems, etc.).
University of Wisconsin, Madison, School of Veterinary Medicine - One Health/One Medicine Initiatives with Academic Health Partners	Human medicine, veterinary medicine, nursing, pharmacy.
North Carolina State University, College of Veterinary Medicine	Medicine, aquatic animal health, and epidemiology: education and research.
University of Florida, College of Veterinary Medicine - Wildlife Health Center	Herpetofauna medicine, infectious diseases, wildlife pathology and toxicology, zoo medicine residency in collaboration with White Oak Conservation Center and Disney's Animal Kingdom, and tropical zoonotic disease research.
Cornell University, College of Veterinary Medicine	Epidemiology and conservation medicine, education, and research.

Nongovernmental Organizations

Several nongovernmental organizations have longstanding programs in wildlife* health, including the Wildlife Conservation Society's Field Veterinary Program (WCS FVP), which conducts research focused on threats to wildlife, including endangered species, with emphasis on training of in-country wildlife veterinarians for stewardship and research efforts around the world. The WCS FVP is also routinely involved in providing advice, informed by veterinary and ecological perspectives, on environmental and health policies to reduce transmission of disease organisms among wildlife, domestic animals, and human beings.

The EcoHealth Alliance (formerly the Wildlife Trust) focuses on research and education to protect biodiversity and especially endangered species in places where ecological health is most at risk because of habitat loss, species imbalance, pollution, and other human activities (http://www.ecohealthalliance.org/).

Its mission is to empower local conservation scientists worldwide to protect nature and safeguard ecosystem and human health.

The Consortium for Conservation Medicine focuses mainly on emerging diseases and projects to expand awareness of the basis for disease emergence and rational prioritization of efforts. Key projects of the Consortium include amphibian declines, emerging infectious disease hotspots, West Nile and Nipah virus infections, severe acute respiratory syndrome (SARS), wildlife trade and its role in emerging infectious diseases, and the Yellowstone to Yukon wildlife corridor project.

Membership of Veterinarians in Wildlife Associations

AVMA reported that of its 79,432 members in 2009, 408 indicated that wildlife medicine was their primary employment focus (AVMA, 2009d). As noted earlier, it is likely that not all veterinarians who work in wildlife are members of AVMA. Many companion-animal veterinarians join AVMA to take advantage of competitive insurance packages offered through the Association, but this is less of an incentive to join for wildlife veterinarians who may work for state and federal agencies.

Two organizations that provide insight into the workforce of veterinarians focused on free-ranging terrestrial wildlife population health are the American Association of Wildlife Veterinarians (AAWV) and the Wildlife Disease Association (WDA). Among their members are government veterinarians, and others who work for universities, non-governmental organizations, zoos, and other entities. Membership in AAWV is restricted to veterinarians, and there are about 175 members. AAWV exists to strengthen veterinary contributions to the welfare of wildlife resources through better management, preventive medicine, and research relevant to free-ranging species. It stresses the need to deal with reservoirs of diseases proactively, whether they lie in wildlife, domestic animal, or human populations. It also emphasizes the need for suitable habitats and limits on toxic chemicals. AAWV strongly supports improved teaching programs in colleges of veterinary medicine, and more effective collaborations among wildlife veterinarians, government agencies, and wildlife resource interest groups. AAWV hosts workshops on disease diagnostic methods and an annual meeting featuring presentations of research findings and case reports. The meeting is sometimes joined with that of the American Association of Zoo Veterinarians (AAZV). The 5-year strategic plan of AAWV stresses increasing membership through new student chapters (AAWV, 2007).

WDA, which was founded in 1951, does not compile the degrees of its members, preferring instead to be a unique interface among people of various academic backgrounds with a shared interest in the health of wildlife (www.wildlifedisease.org). The approach taken by WDA revolves around the reality that wildlife veterinarians need other experts and that other experts need wildlife veterinarians. WDA sponsors the *Journal of Wildlife Diseases*. Its stated mission is to acquire, disseminate and apply knowledge of the health and diseases of wild animals in relation to their biology, conservation, and interactions with human and domestic animals. The organization includes veterinarians and others whose careers largely focus on wildlife disease concerns that affect endangered species, game and furbearing animals, conservation efforts, wildlife translocation, wildlife rehabilitation, zoological parks, public health, livestock, and poultry. WDA's membership in 2009, which includes individuals from the United States, Australia, Canada, Europe, and Mexico, was 1,331, of which 587 are American and 63 are Canadian, plus 279 student members, of which 170 are from the United States and 28 are from Canada (Dr. Edward Addison, Wildlife Disease Association, personal communication, 2009).

Zoo Animal Medicine

In zoos and wildlife parks, responsibilities for protecting health and facilitating reproduction, as well as for research to address the many knowledge gaps, are shared among veterinarians, reproductive biologists, nutritionists, technicians, and zoo keepers. Veterinarians employed in this sector include clinicians, epidemiologists, reproductive specialists, and pathologists. Examples of larger zoos or zoo consortia that employ such diverse staffs include Disney's Animal Kingdom, the San Diego Zoo and the San Diego Zoological Park, the Wildlife Conservation Society (formerly the Bronx Zoo), and the Zoological Medicine and Zoo Pathology Program of the University of Illinois at Loyola University, in collaboration with the Brookfield and Lincoln Park Zoos, as well as Shedd Aquarium in the Chicago area. In addition to caring for captive animals, zoos support free-ranging wildlife through public education and outreach to managers of rangelands, generally with a focus on species also found in the zoo's collections. Such outreach work often includes training of in-country wildlife veterinarians. Zoos also use veterinary expertise in support of captive breeding programs that provide animals for collections of the source zoo and other zoos, offer opportunities for comprehensive research on the unique health challenges facing threatened and endangered species, and occasionally serve as sources of animals to restock wild areas.

Veterinarians Employed in Zoos and Aquaria

A recent assessment of the employment of veterinarians and the salaries they received in zoos and aquaria was conducted by McCain and Ramsey (2008). The authors employed a web-based survey of 158 zoos accredited by the Association of Zoos and Aquariums (AZA) and 31 accredited aquaria or marine-life parks in the United States and Canada.

Based on responses from 124 zoos and 15 aquaria, the survey found a total of 274 veterinarians employed full-time, and 96 employed part-time, including clinicians, non-clinical veterinarians, and pathologists. Comparing their findings to those of a 1988 survey, the authors concluded that both the number and percentage of zoos that employed full-time zoo veterinarians had increased. In 1988, only 45% (40 out of 89) of zoos had at least one full-time veterinarian (Gentz, 1990), a figure that increased to 59.7% (74 out of 124) in 2007. They also found an increase in the numbers of zoos that employed more than one full-time veterinarian, from 13% in 1988 to 34.7% in 2007. In addition, during the same time span, the male to female ratio among zoo veterinarians has shifted from a predominantly male group to near 50:50. The authors reported an extremely wide range in annual salaries for full-time veterinarians in 2007—from $20,800 to $150,000 (McCain and Ramsay, 2008).

Membership of Zoo Veterinarians in Associations

Of the AVMA's 77,972 members surveyed in 2008, only 209 indicated zoo medicine as a primary employment focus (AVMA, 2008). However, a better indicator of professional engagement in zoo medicine might be found in the membership of the American Association of Zoo Veterinarians (AAZV), which has the objectives of advancing preventive medicine, husbandry, and research in veterinary medicine related to captive and free-ranging wild animals; providing forums for presentation and discussion of problems related to captive and free-ranging wild animals; publishing and distributing scientific information pertinent to veterinary roles with captive and free-ranging wild animals; enhancing and upholding veterinary professional ethics; and, promoting the general welfare and conservation of captive and free-ranging wildlife. AAZV membership has steadily grown in recent years: there were 524 members in 1988, 754 in 1998, and 915 in 2008 (Dr. Robert Hilsenroth, American Association of Zoo Veterinarians, personal communication, 2009). The latter figure included 197 student members, some of whom had veterinary degrees and were engaged in graduate, residency, or postdoctoral studies.

Aquatic Wildlife and Marine Mammals

Veterinarians in this sector typically provide care for aquatic invertebrates (mollusks, crustaceans, corals), large numbers of fishes, aquatic reptiles (especially turtles), water birds (such as ducks, penguins, puffins), and marine mammals (such as otters, pinnipeds, odontocetes). Other aquatic animal veterinarians are employed in aquaculture for food and restocking, and in marine parks such as Sea World that house and provide public exposure to marine species. A growing role for veterinarians lies in aquatic animal pathology in aquaculture facilities and aquaria, and in determining the environmental causes of morbidity and mortality that influence the sustainability of free-ranging freshwater, estuarine, and marine species.

Larger aquaria, such as the National Aquarium located in Baltimore, the Shedd Aquarium in Chicago, the Aquarium of the Americas in New Orleans, and the Georgia Aquarium in Atlanta are among those with full-time veterinary staffs.

Membership of Veterinarians in the International Association for Aquatic Animal Medicine

In 2008, there were 498 members of the International Association for Aquatic Animal Medicine (IAAAM) which included 12 institutional memberships (Pacifique Rugira, IAAAM, personal communication, 2009). The total number of those with a DVM degree was 301. There were also 102 student members. Among the members of IAAM are veterinarians who work in aquaria and marine parks, other aquatic animal health veterinarians, and other experts. IAAAM, which does not keep data on membership changes over time, describes itself as “an organization of individuals who are professionally interested in and devote a significant amount of time to the practice of aquatic animal medicine, teaching and research in aquatic animal medicine, or the husbandry and management of aquatic animals” (www.iaaam.org). There is a fish health subunit of the organization. Marine mammal health specialists are also well represented within IAAAM.

As noted in its website (www.iaaam.org), DVMs and PhDs comprise most of its leadership. IAAAM hosts an annual meeting, which includes scientific presentations, wet labs, and a proceedings document. Also, IAAAM members have a voice through the AVMA Committee on Environmental Issues as well as the Marine Mammal Unusual Mortality Event Working Group of the National Oceanic and Atmospheric Administration. The organization has a monthly newsletter and offers guidance to students interested in careers in aquatic animal health.

Wildlife Rehabilitation

Veterinarians work with a wide array of wildlife rehabilitation facilities in the United States, in which the diversity of species and funds available for their care necessitate both flexibility and resourcefulness. The work involves both hands-on medicine and surgery for the animals presented for care as well as population health studies based on data collected from those animals. Veterinarians serve in both clinical and administrative roles, and they may guide aspects of public education and outreach programs. The size of the veterinary workforce dedicated to wildlife rehabilitation is unclear. Some states guide the public to approved wildlife rehabilitation facilities where veterinary care is accessible. For example, Massachusetts has established a network of wildlife rehabilitators and veterinarians (http://www.mass.gov/dfwele/dfw/wildlife/rehab/wildlife_rehab_index.htm); and in Wisconsin, wildlife rehabilitators must enter into a written agreement with a consulting veterinarian in order to be licensed (http://www.dnr.state.wi.us/org/land/wildlife/Whealth/rehab/VetAgree-2300298a.pdf).

Veterinarians in Wildlife Rehabilitation Associations

The National Wildlife Rehabilitators Association (NWRA), headquartered in St. Cloud, Minnesota, reported a total membership of 221 in 1984, which increased to 781 in 1988, and almost 1,800 in 2009 (NWRA, 2012). Members of NWRA range from interested beginners who work at their homes to experienced wildlife professionals who administer large wildlife rehabilitation centers. Based on its membership survey, NWRA indicated that 30% of its members were veterinarians, veterinary students, or veterinary technicians; however, it did not distinguish among these groups. Other members included individuals who were affiliated with zoos or humane societies, and those who work as educators and biologists. NWRA did not provide information about compensation for the veterinarians, veterinary technicians or others who lend their expertise to the centers' activities.

In 2002, FWS issued 2,164 Special Purpose Rehabilitation Permits (NWRA, 2010). Thousands of rehabilitators (including many volunteers) operate under states' permitting processes for state-protected non-migratory species. The NWRA website states that approximately 64,000 birds, 39,000 mammals and 2,300 herptiles (reptiles and amphibians) were treated by 343 NWRA survey respondents in 2007; and that release rates were 60% for birds, 72% for mammals, and 69% for herptiles (NWRA, 2012).

Respondents to an NWRA membership survey indicate that they handled more than 250,000 wildlife-related telephone calls. NWRA estimates that more than 75% of the animals cared for by their members have been harmed by human activities. Among the major stressors listed by NWRA as the basis for presentation of wildlife to their centers are: destruction of nest trees, vehicle collisions, unrestrained pets, illegal or legal wild "pet" trading, deliberate or accidental poisonings (including petroleum), window collisions, and non-target trapping or shooting. Although the members of NWRA focus on individual wild animals rather than entire populations and their habitats, they also invest efforts in educating the public about wild animals—both as individuals with inherent value, and as part of the intertwining web of life.

Because many veterinary schools involve their students in clinical work with wildlife presented for care and because many wildlife rehabilitation centers offer externship opportunities, there does not appear to be a shortage of veterinarians with the skills necessary to work in wildlife rehabilitation.

Environmental, Wildlife, and Ecological Toxicology

Environmental toxicology is often conceptualized as the study of the effects of contaminants from the outdoor environment or the food system on human health. However, humans routinely isolate themselves from some toxic exposures, washing their bodies, filtering their air, purifying their water, and eating a diverse diet. Free-ranging animals are not similarly protected. Because of their training and experience in comparative medicine, as well as the routine back-and-forth extrapolation between animal and human toxicologic processes, veterinarians are well suited to careers in environmental, wildlife, and ecological toxicology (Beasley, 1993, 2009).

Toxicology encompasses the study of all adverse, chemically-mediated effects of all elements and compounds on all life forms. Ecology encompasses the study of myriad complex interactions, not only among species, but also with the non-living components of the environment. Thus, ecotoxicology necessarily encompasses the chemically-mediated adverse effects of all chemicals on all the non-human, non-domesticated life forms, and on all of their interactions with one another, as well as with the non-living environment. Because of the number of species and interactions involved, ecotoxicologists have to make recommendations based on incomplete knowledge. Variables include the suite of chemicals involved, their concentrations in different locations, the climate and time of year, and the biotic communities at risk. The major way that preventive medicine in environmental, wildlife, and ecological toxicology is achieved is through regulation coupled with informed and responsible stewardship choices by manufacturers and users of chemicals.

Understanding the complex effects of contaminants on cells, tissues, organs, body systems, organisms, and interactions among organisms, not only in the traditional ecological context, but also in the context of the ecology of infectious disease requires veterinarians to collaborate with other experts. Veterinarians function in wildlife and ecological toxicology through roles in diagnostic medicine; research in mechanistic and applied toxicology, pathology, and epidemiology; and regulatory medicine.

There are many ways in which environmental, wildlife and ecological toxicologists focus their careers. They may specialize in a toxicant group, such as heavy metals, hazardous wastes, pesticides, endocrine disruptors, or polyaromatic hydrocarbons, for example. They may focus on monitoring for exposure and impacts in regard to damage to a given body system or organ (e.g. nervous system, gonads, reproductive tract, kidneys, or respiratory systems). They may address immunotoxicity and the incidence/severity of diseases from viruses, bacteria, fungi, or parasites. Alternatively, they may focus on the indirect effects of contaminants (via impacts on plants, the microbial environment, or "micropredators" that normally consume pathogens or vector species).

Few toxicologists, other than veterinarians, are taught about infectious diseases, body systems pathology, and clinical pathology in a differential diagnosis context. When veterinarians work with others to examine free-ranging animals comprehensively, combining contaminant monitoring in environmental media with assays of residues in tissues, measures of body condition, gross and histologic lesions, parasites and microbial pathogens, they find unique associations among contaminant exposures and other health threats (Rohr et al., 2008).

One problem with such a comprehensive approach to research is the high costs of logistical deployment of teams of collaborators with sophisticated instrumentation. Another challenge is that the multiple permutations that occur in the "real world" cannot all be replicated efficiently in the lab. The concentration at which chemicals are toxic not only to mammals, birds, fishes, reptiles and amphibians, but also to invertebrates and native microbes, is an important consideration in evaluating risks related to chemicals released from human activities into natural areas (corridors, streams, reserves, etc.). Wildlife must not only compete with one another to find food, nesting sites, and mates, but also care for their young, avoid predation, and contend with infectious disease entities. Since this occurs not only in pristine areas, but also in crowded, physically-degraded, habitat remnants, there is a greater need than ever to protect them from additional disabilities related to exposures to chemical contaminants.

Veterinary Membership in Environmental Toxicological Associations

The Society of Environmental Toxicology and Chemistry (SETAC), which focuses on wildlife and ecological toxicology, was founded in 1979 to develop "principles and practices for protection, enhancement, and management of sustainable environmental quality and ecosystem integrity"(SETAC, 2012). Its members address problems related to chemicals through research, analysis, regulation, product substitution, and education. SETAC convenes an annual meeting for scientists, managers, and other professionals to learn from each another through poster and platform presentations, and publishes the journal *Environmental Toxicology and Chemistry*. SETAC membership has increased from 230 charter members in 1980 to nearly 5,000 members at present, representing all 50 states of the United States, 13 Canadian provinces, and more than 70 countries worldwide. Another indication of growth is that participants at SETAC annual meetings increased from 470 in 1980 to more than 2,500 in 2003. SETAC membership includes nearly equal representation from industry, government, and academia. SETAC does not sort its members based on their training, and thus the percentage of members with veterinary degrees is unavailable. Because of the global reach of toxicants and the value of harmonization of environmental standards, SETAC has fostered sister organizations, including SETAC/Europe, SETAC Asia/Pacific, and SETAC/Latin America. SETAC established a Foundation for Environmental Education and a SETAC World Council to promote international communication of environmental issues. SETAC members and other ecotoxicologists focus on reconciling agriculture, forestry, mining, industry, and urban/suburban management with ecological stewardship.

THE FUTURE SUPPLY OF VETERINARIANS FOR JOBS IN WILDLIFE AND ECOSYSTEM HEALTH

In advising students with interests in careers involving zoos, wildlife, conservation, ecosystems, and environments (including human-dominated ones), and in deciding how to allocate limited slots in DVM classes, a number of questions arise. Is the job market to accommodate the interests of such students meager, or instead, is it elastic, and able to capitalize on additional inputs of veterinary knowledge and skills? Does society need and will it hire more veterinarians focused on wildlife health, conservation medicine, ecosystem health, and environmental health? Finally, if there are substantial numbers of jobs that would pay acceptable salaries for veterinary medical expertise, how can veterinary students and veterinarians most readily become aware of and prepare for them?

Many North American veterinary students currently enter into DVM programs intent on careers that address the needs of wildlife and conservation medicine. About a third of students currently accepted into the DVM program at the University of Illinois College of Veterinary Medicine expressed an interest in wildlife or zoo medicine, a reflection of their identity as part of the "Animal Planet generation" (Jonathan Foreman, University of Illinois, personal communication, 2009).

While about 30% of the students in the DVM program initially volunteer to work in the College's Wildlife Medical Clinic, at present only about two or three accept zoo- or wildlife-related positions immediately after graduation. This apparent disjunction may result because the novelty of working with wildlife recedes with time, the students are discouraged by faculty members who suggest that job opportunities involving wildlife are exceedingly few, and there are few advertisements for wildlife and ecosystem health specialists. Graduates might be seeking job positions that do not exist—i.e., ones that explicitly call for veterinary expertise—instead of identifying jobs they can fill regardless of the title.

Defining Positions in Wildlife and Ecosystem Health

Most veterinary students were not aware of the field of wildlife and ecosystem health 30 years ago, but student interest has grown dramatically in recent years and some students have created their own programs of study. Few wildlife and ecosystem health jobs are clearly labeled to target veterinarians, there is no job "guarantee" after training, and few are available in academia (Patricia Conrad, University of California at Davis, personal communication, 2008).

Individuals who get training in this field may need to be mobile and persistent. Veterinary graduates who maintain an interest in wildlife and ecosystem health take a number of pathways into the field. Some, for example, take an internship (often in small animal medicine and surgery) and then a residency in zoo medicine to qualify for employment in a zoo. Others decide to focus on the accelerating structural, biotic, and functional changes in environments for the sake of free-ranging wild animals as well as their fellow human beings.

Of course, there are opportunities to involve veterinarians who usually work on domestic animal patients as specialists in pathology, small animal, equine, and food-animal medicine and surgery through collaborative projects that address needs in wildlife health. Such collaborations address a wide array of disease phenomena, trauma to endangered species, and control of overpopulation of wildlife in crowded habitats. For example, wildlife veterinarians and veterinary surgeons collaborated to develop techniques for minimally-invasive vasectomies of bull elephants in areas of southern Africa where elephant populations have the capacity to devastate plant communities, with secondary effects on a host of other species.

Success in the pursuit of wildlife medicine in academia can come about through involvement in public health and/or ecosystem health. For some individuals, preparation for such careers may include completing a Masters in Preventive Veterinary Medicine degree focused on wildlife. For others, it may include finishing a PhD that involves aspects of public health in an ecological context, such as focusing on vector reservoirs. Some DVM/PhD students who began their graduate work with a specific interest in wildlife health eventually become associated with public health organizations, such as state departments of public health or the federal Centers for Disease Control and Prevention. A new and important area of specialization for which specially trained veterinarians are well-equipped is disease ecology. For those who want to discover new knowledge needed in many aspects of wildlife and ecosystem health or, in the even more integrative discipline of One Health, a PhD and postdoctoral training can be invaluable.

Many wildlife veterinarians work in integrated programs of preventive medicine and research that simultaneously protect the health of wildlife, domestic animal, and human populations, in what might be called a "cross-sectorial" approach (Osofsky et al., 2008). The intensifying wildlife-livestock-human interface is increasingly motivating actions that have the potential to simultaneously protect public health and also biodiversity and agricultural biosecurity. Osofsky and his colleagues suggest that wildlife health and ecological sustainability depend on societal "buy-in" that is most reliably achieved when humans derive multiple health and economic benefits in the process. Ensuring such benefits and effectively communicating them has therefore become a core competency for some wildlife and ecosystem health specialists. An example of this kind of cross-sectorial approach to infectious disease is described in Box 7-4.

Protecting the health of populations of free-ranging wild animals is a different (and arguably greater) challenge than protecting the health of groups of domesticated or laboratory animals. With all species of non-human animals, responsibilities for health are shared—commonly involving veterinarians in leadership roles—with ample dependence on others. With domesticated animals, the others who influence health are generally owners of the animals who provide the economic resources for their care. In contrast, free-ranging wildlife are not owned by individuals or small groups of people; in accordance with state and federal laws, they are a public trust resource held by the government for the benefit of all citizens (Organ et al., 2010; Prukop and Regan, 2005). Laws and regulations that triggered this now long-standing but still evolving legal tradition

BOX 7-4
Cross-Sectorial Approach to Emerging Infectious Diseases

In 2009, the U.S. Agency for International Development (USAID) developed an unprecedented set of initiatives under its Emerging Pandemic Threats (EPT) program to help the world preempt future pandemics at their source. The focus is to prevent the emergence of, prepare for, avoid, and better mitigate infectious diseases that move between wildlife and people, such as H1N1 pandemic influenza, avian influenza, SARS, and Ebola. The EPT program consists of 5 projects: PREDICT, RESPOND, IDENTIFY, PREVENT, and DELIVER. USAID funded two large 5-year grants under its PREDICT and RESPOND initiatives. The first group, PREDICT, received more than $60 million over five years to develop a global emerging infectious disease early warning system. Led by the University of California at Davis School of Veterinary Medicine, its coalition includes the Wildlife Conservation Society, the Wildlife Trust, the Smithsonian Institution, the World Organization for Animal Health, the Food and Agricultural Organization of the United Nations, and the Global Viral Forecasting, Inc. The second group received a 5-year grant exceeding $150 million for the RESPOND project to develop outbreak investigation and response training technologies. Its partners include the Tufts University's Cummings School of Veterinary Medicine, University of Minnesota College of Veterinary Medicine, Development Alternatives, Inc., Training and Resources Group, and Ecology and Environment Inc.

SOURCE: USAID, 2009, 2010.

came about after over-exploitation of wildlife, often for commercial purposes. Today, state wildlife agencies have authority for wildlife and wildlife management on most lands, not just in state parks and reserves. NPS has authority for wildlife in national parks, and FWS has general authority for migratory bird management. International laws dealing with wildlife stewardship responsibilities include the Migratory Bird Treaty, which was signed in 1916, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which was signed by 80 nations in 1973, and which now has 175 signatories (Prukop and Regan, 2005). The application and refinement of those laws are key to the successful restoration and maintenance of healthy wildlife populations.

The economic resources available to influence the health of wildlife on public and private lands depend in large measure on programs of state and federal agencies, but the health of wildlife is also influenced by the choices and related investments of private land-owners. Overall, determining where monies will come from for wildlife health endeavors is dependent on understanding governmental authorities, the related funding streams, and the attitudes, incentives, and disincentives that influence private land holders. Funding, of course, is also dependent upon political constituencies and thus on the knowledge and interests of influential members of the public and their elected officials.

Wildlife are viewed very differently by different stakeholders, such as groups of individuals whose livelihoods or forms of recreation depend on harvest of the animals (fishing, hunting), and people who view the animals themselves in different ways—such as parts of natural beauty and essential to human well-being, or alternatively as pests, competitors, threats, or of such limited importance that their suffering and demise should be dismissed. Moreover, the same individual may regard different species, or even different individuals within a species, in a variety of ways, depending on where, how often, and how many of the animals are encountered. The wildlife and ecological veterinarian, therefore, is often a member of a team or agency that will encounter pressures to help sustain and enhance numbers of some species and to limit the numbers of other species.

As a "transdisciplinary" professional, today's wildlife and ecological health veterinarians must collaborate with others, such as other health professionals (other veterinarians, epidemiologists, physicians, public health specialists, technicians and technologists), as well as wildlife managers, wildlife biologists, conservation biologists, ecologists, engineers, business leaders, private citizens, and policy makers. Depending on the situation, any of these stakeholders may exert crucial influence that determines whether the health management of wildlife and ecosystems will be effective. Accordingly, good interpersonal dynamics and diplomacy are often key components for success in wildlife and ecosystem health.

Educational and Training Needs

In a study of 87 wildlife veterinarians, 16 job seekers, 22 students, and 7 employers exploring the relevance of veterinary training to work experiences, only 39% of respondents reported that the training they received prepared them for their jobs (Mazet et al., 2006). Most felt that their veterinary education would have benefited from courses in wildlife health, zoo medicine, wildlife handling, and ecosystem health. "Mentorship with an experienced wildlife veterinarian, training in leadership and communication, courses and externships in wildlife health, and additional formal training beyond the veterinary degree" was considered important in preparation for success (Mazet et al., 2006).

Despite the involvement of faculty members of several colleges of veterinary medicine in wildlife and ecosystem health, the vast majority of time and effort of the veterinary schools is devoted to preparing small animal practitioners, which increasingly obstructs preparation to meet the new opportunities and challenges of other aspects of veterinary medicine. Veterinarians who will serve in wildlife and ecosystem health roles will not need so much insight into common ailments of companion animals as in methods to prevent an outbreak of avian influenza from spreading between wildlife and domestic poultry or swine populations, or in how to re-establish diverse genetics in endangered native vertebrates, or in how to re-introduce threatened species into previously occupied and rehabilitated habitat. Unless curricula, course offerings, and licensing examinations emphasize some of the key concepts related to wildlife and ecosystem health, the education of wildlife and ecosystem health veterinarians may remain a mystery to most veterinary students and most members of veterinary faculties. In addition to the need for inclusion of some core aspects of wildlife and ecosystem health into veterinary curricula, there is a need to establish more graduate training opportunities in endangered species conservation, One Health epidemiology and preventive medicine, shared infectious diseases, wildlife pathology, and wildlife, ecological, and environmental toxicology in veterinary academia. Box 7-5 outlines examples of essential concepts that would be encompassed in core and elective content in wildlife and ecosystem health education.

Recognizing the importance of the concept of One Health, even veterinary students interested solely in domestic animals could benefit from better training in population health, epidemiology, and ecosystem health, including: 1) how patterns of disease occurrence and transmission are a function of population sizes, contact rates, local biodiversity and vector involvement; 2) how failings at the wildlife-domestic animal interface enable spillover of infectious agents from domestic animals to wildlife, and spillback from wildlife to domestic animals; 3) how accumulation of toxicants in household, farm, and regional environments puts domestic animal, human, and wildlife populations at risk of acute and chronic illnesses; and, 4) how new technologies and coordinated efforts for surveillance, assessment, control, and prevention of diseases can simultaneously protect domestic animal, human, and wildlife populations.

BOX 7-5
Knowledge and Career Competencies in Wildlife and Ecosystem Health

- Conservation of indigenous wildlife populations with attention to genetic diversity and fitness in both disease resistance and reproduction.
- Infectious disease ecology, surveillance, control, and preventive measures at the wildlife-domestic animal and wildlife-human interface.
- The design, implementation, study, and refinement of rehabilitated aquatic and terrestrial ecosystems characterized by reduced threats of toxicologic and infectious diseases and invasive species, as well as improvements in biodiversity.
- Siting and management of food-animal production medicine in ways that enable recovery of biodiversity in nearby agricultural landscapes, natural areas, streams, corridors, and buffer zones.
- The diagnosis and prevention of the adverse impacts of chemical pollutants through knowledge and skills in clinical and diagnostic veterinary toxicology, regulatory toxicology, environmental toxicology, and wildlife/ecological toxicology.

For One Health to be more readily understood and capitalized on as a way to reconcile ecological stewardship responsibilities with economically-viable food-animal production and improved public health, there is a need to have more interaction among veterinary students and medical students and among veterinary and human health faculties. Accordingly, teaching students in overlapping sections in histology, physiology, epidemiology, infectious diseases, basics of pharmacology and toxicology, and preventive medicine seems to be both timely and logical. Also, fusion of meetings of toxicology and wildlife health groups with meetings of mainstream human and veterinary medical specialists, cancer epidemiologists, endocrinologists, and other experts would also be helpful in creating a greater understanding of the shared risks and the underlying sources of health impairment that arise in the global and local environment.

Support for Training for Veterinary Careers in Wildlife and Ecosystem Health

A number of short courses, such as Envirovet, Aquavet, Aquamed, and Marvet (described in detail in Appendix F) have helped veterinary students develop the skills to deal with multiple, often interacting, stressors that undermine the health and sustainability of different types of wildlife populations and communities. Such courses provide knowledge, skills, and mentors needed for specialization in wildlife and ecosystem health.

Convening students and faculty from a host of locations in the United States and abroad, these intensive short courses are sufficiently flexible to adapt their teaching to fill important voids in training not met through openings in degree, internship, and residency programs in universities. Well over a thousand veterinary students and veterinarians have been trained in these programs. Future support for these courses and for new offerings in aquatic ecotoxicology and terrestrial wildlife and ecosystem health could catalyze greater application of veterinary expertise in wildlife and ecosystem health to address emerging needs.

Veterinary schools have the potential to be leaders in the evolving discipline of One Health if faculty positions, graduate programs, and research projects on wildlife and ecosystem health receive greater emphasis. Many of the faculty members of veterinary schools whose research programs are funded by NIH play important roles in core and elective courses needed by veterinarians, and those funds support basic research, laboratory animal medicine, pathology, infectious diseases, toxicology, epidemiology, and other fields that advance One Health. However, given that the risks of infectious and toxicologic diseases are shared by humans and animals, it is consistent with the NIH mission to support the study of diseases that affect humans and other species, as well as the mechanisms of disease prevention at an ecosystem level. There may an appropriate role for the National Science Foundation (NSF) to support some elements of research and education in wildlife and ecosystem health at veterinary colleges and schools to address endangered species and disease emergence at the ecosystem level. In addition to funding for research by graduate and postdoctoral students, support for professional degree DVM participation in summer projects and hourly jobs in wildlife and ecosystem health is also needed.

The interests of numerous state and federal agencies (such as state departments of natural resources or environmental protection, DOI, U.S. Department of Agriculture, Department of Health and Human Services, and the U.S. Environmental Protection Agency) overlap with the educational needs of veterinary students interested in this field. There is an opportunity for these agencies to increase their collaboration with universities to expand and guide capacity building, internship, and research programs in wildlife and ecosystem health.

Foundations and non-governmental organizations that value wildlife as components of the world's natural heritage for ecotourism, or for fishing and hunting, could also play a role in fostering research and education in the United States as well as international partnerships in training and stewardship. Additional user fees on hunting and fishing, for example, could support the training of wildlife and ecological specialists in veterinary medicine and related research programs.

The chaos of interdependent global societies of the early 21st century, with soaring human populations, climate change, exotic species invasions, overharvest of wildlife, infectious disease outbreaks, and chemical contamination, has created opportunities for veterinary medicine to be more relevant than at any other time in history. Protecting wildlife and ecosystem health through organized surveillance and stewardship is essential because of the intrinsic value of wildlife and biodiversity. Such protection is also essential to maintain native species in their traditional roles as food, as species that regulate ecological productivity, as sentinels of environmental health threats, and as objects that enable us to understand the underpinnings of life.

8

Global Food Security

INTRODUCTION

The world population is projected to grow to approximately 9.2 billion by 2050, an increase of over 30% compared to the present (UNFPA, 2010). As a result, food security has become one of the greatest challenges facing this generation (Sheridan, 2010) with the most acute challenges lying in sub-Saharan Africa (SSA) and South Asia. In 2009, nearly one billion people lived with hunger (Nature, 2010) and a further 925 million were malnourished (FAO, 2011). Apart from the compelling moral obligation to address widespread malnutrition and hunger at home and abroad, food insecurity is an international concern because it undermines social and economic development, causes environmental destruction, promotes the spread of disease, and ultimately, threatens global peace. Josette Sheeran, Executive Director of the World Food Programme, has commented that "Without food, people revolt, migrate or die" (NATO PA, 2009).

Food security is a remarkably complex issue that confronts the veterinary profession together with many other scientific, social, economic, and political disciplines. Many of the issues were addressed by the World Health Organization in 2002 under the flag of "health for all," by the American Veterinary Medical Association's (AVMA) One Health Initiative (AVMA, 2008), and recently by the Food and Agriculture Organization (FAO)'s detailed analysis, *World Livestock 2011* (FAO, 2011). The goal of those reports is to find solutions to food security by linking animal and human health together with environmental health, food production, and the preservation of biodiversity. However, because of the complex relationships between animals, humans, and the environment, the dimensions of these initiatives are inevitably much broader and include global population growth, urbanization, poverty, farming efficiency, water conservation, transportation and global trade, and resilience of the food supply. Thus, the veterinary medical profession is confronted with challenges that are far more complicated than anything it has ever had to face and must learn to work with specialists from many other fields to find comprehensive, One Health solutions to one of the most difficult issues of the 21st century. As discussed below, the professional training of veterinarians of the future will need to include an understanding of the ways in which the lives of people and animals are rapidly changing in the broader world, particularly in developing nations, where the changes are driving a need for veterinary expertise.

URBANIZATION IN THE DEVELOPING WORLD

The urban industrial economies of the developing world are growing at a scale and intensity that is unprecedented in human history. In the next 40 years almost all of the world's population growth will occur in urban centers of developing countries that are growing at a rate of nearly 1.3 million people per week (United Nations, 2009). In everyday terms, this growth rate is equivalent to adding the population of a city the size of Dallas, Texas, the eighth largest U.S. city, every week for the next 40 years. For the first time in history, more people now live in cities than in the countryside and the United Nations (U.N.) projects that by 2050, over 70% of the world's population will be urban. Asia is presently the epicenter of the urbanization surge, but the greatest surge is expected to be in SSA, which is projected to add 395 million people to its cities in the next 20 years (Cities Alliance, 2006). As a result, the urban centers of low and middle income countries represent a new global frontier of human activity and are central to the demographic, economic, and environmental challenges of the 21st century (Martine et al., 2008).

Urbanization in the developing world increases and concentrates demand for both water and food, and requires restructuring of food production methods, supply chains, and markets to sustain demand. While people living in rural areas generally depend on their own food production for at least 60% of their needs and barter for the rest, those living in cities depend on the market for 90-100% of their food (Macalla, 2001). As cities can be vulnerable to disruptions in the food supply, finding ways in which these dangers can be mitigated has become increasingly important. They include managing the impact of large, intensive livestock production facilities, maintaining livestock and poultry health and food safety, controlling infectious diseases, and developing a multi-functional veterinary profession. Food supply is linked to water supply because agriculture is a large user of water and changes in the availability of water can have a profound impact on food security. World water resources are finite and are threatened as a result of climate change and drought in most of the world's semi-arid regions. Political conflict over shortages is a potential concern. Pollution is an additional problem as rivers of the developing world are affected by farm run-off, industrial discharges, and poor to non-existent urban waste-management practices. Peri-urban (in close approximation to urban centers) livestock production in Southeast Asia exemplifies the problem. Much of the growth in China's food production in the past two decades has taken place on peri-urban land. Approximately 100% of the milk and 90% of eggs consumed in Shanghai are produced within the limits of lands administered by the city (Yi-Zhong and Zhangen, 2000).

Since there may be little adjacent land to recycle animal waste, it is flushed into waterways where it increases contamination and the spread of waterborne infectious diseases (World Bank, 2005).

Urban sprawl also reduces the amount of farmland available to produce food. The rate of growth in urban land cover will outpace the rate of growth in the world's urban population (Angel et al., 2011). Between 2000 and 2030, the urban population of developing countries is expected to double, while in the same time period, the built-up area of their cities is anticipated grow three-fold. The dimensions of farmland loss are illustrated in one study documenting the growth of four cities situated in China's Pearl River Delta. The cities (Shenzen, Guangzou, Zhongshan, and Dongguan), each with over one million residents, quadrupled their land area in 1989 and 1999, usurping 321 square miles of farmland (Seto, 2011). Thus, as cities expand, agricultural productivity, markets, and the transportation infrastructure must all increase in a sustainable fashion to supply ever more distant markets with food that is wholesome, safe, and affordable for millions of urban rich and poor.

A major question is whether agricultural producers can adapt swiftly enough to meet the demands of rapidly urbanizing populations. With urban sprawl, areas of land devoted to mineral extraction and commercial forests, use of land to produce biofuels, and constrained availability of agricultural land for food production, the world is entering into a period of tightening food supplies. Food prices are likely to continue to rise, and global power struggles over food security have the potential to emerge (Brown, 2011).

URBAN FOOD SECURITY

Most urban people of the developing world will live in slums in the future and are the most food insecure of all. According to Davis (2006), residents of slums constitute "a staggering 78.2% of urbanites in the least developed countries" and equal at least one third of the total urban population globally. Urban population growth in SSA is proceeding at the annual rate of 3.56% whereas the population growth in slums is increasing at the rate of 4.13% (Black and King, 2009). Clean water, transportation, and public health (including veterinary public health) services are generally lacking, and without sewage disposal systems, slums contribute extensively to environmental pollution.

For those who live in slums, food prices and access to food are problems. Supermarkets play an increasing role in marketing foods of animal origin in the developing world, but they are not located in slums. To address food insecurity, slum dwellers may maintain and live in close proximity to domesticated food animals. Feral animals are also ubiquitous, so parasitic diseases are spread in both food animals and people. Outbreaks of zoonotic diseases such as H5N1 avian influenza are difficult problems to control in slums, although legislation preventing the maintenance of urban food animals is increasing. Despite these limitations, urban and peri-urban agriculture presently play important roles in provisioning the urban poor in many parts of the world, but whether these systems have the capacity to provision slums in cities of 30 million or more is less clear (see FAO, 2011). These issues take on particular significance in view of a study by the RAND Corporation on how demographic changes will affect future political conflict, that concludes that urbanization of world poverty has produced the "urbanization of insurgency" (RAND, 1991). The World Bank reached a similar conclusion in the 1990s, and warned that urban poverty would become "the most significant and politically explosive problem" of the 21st century (see Davis, 2006).

People are drawn to cities in Southeast Asia because of booming manufacturing economies, the engine that drives job creation and prosperity. By contrast, growing populations in SSA are generally pushed into cities, unable to survive in rural areas because land is deteriorating from years of poor farming practices, climate change, drought, civil war, and ill-advised government agricultural policies. Eighty percent of arable land in SSA is described as degraded and the poorest on the planet. Rural and urban poverty is pervasive in SSA, the manufacturing engine is yet to develop, city slums are growing rapidly, and childhood malnutrition exceeds 40% (World Bank, 2011).

The Increasing Demand for Meat

Global economic output is expected to increase by 2-3% annually for the next 40 years, meaning that global income will exceed population growth (Goldstone, 2010). Much of the income gain will be in the developing world's urban centers, especially in South Asia and South America. The World Bank predicts that by 2030, the middle-class population in the developing world will be 1.2 billion, an increase of 200% from 2005, and larger than the total populations of Europe, Japan, and the United States combined (Goldstone, 2010). The growth in the middle class is projected to be the world's major driver of economic expansion, with direct implications for the efficiency of food production and veterinary medicine.

As people, generally the young, migrate to cities and earn greater spendable income, they demand diets with more expensive animal products, driving up food prices. Economic expansion in China and Southeast Asia is partially responsible for the present high grain prices that, among other things, aggravate the plight of the poor. Demand for meat and milk poses a problem to food security, as a greater percentage of global corn and soybean harvests are being diverted to animal feed. According to Foley et al. (2011) 35% of global crop production is devoted to animal feed. Climate change, drought, and diversion of corn to biofuel production in the United States further add significantly to world food price increases (Blythe, 2011). The challenge for soil scientists, crop geneticists, agricultural economists, and veterinary scientists worldwide therefore is to develop a common agenda of expanding food supplies rapidly and sustainably to satisfy growing needs while evading price increases. A number of studies suggest that the world can produce sufficient food to meet the global population needs in 2050, but the affordability of food remains an open question.

Land and water are finite resources, and as the demand for foods of animal origin seem likely to increase, the efficiency of food production, the resilience of the food chain, and the role of the veterinary profession appear increasingly important. Increasing demand in China, Southeast Asia, and Latin America is causing a "livestock revolution" (Delgado, 2003) and a shift to large, intensive, livestock operations that make use of fewer people per unit of product than traditional systems of agriculture. Intensive operations are frequently associated with multinational agribusiness conglomerates and supermarket chains selling processed, frozen, packaged, and branded meat, milk, ice cream etc. (see Costales et al., 2005). Rules and standards for food quality and safety have followed, favoring the growth of supermarkets that are expanding at rates of up to 25% per year in Southeast Asia. Because these operations are efficient and generally produce food at lower prices, they are beneficial, but, as noted earlier, generally not accessible to those who live in slums. They also marginalize small producers who are unable to compete in the supply and sales to supermarkets, but farm hillside and other difficult lands that are essential to food security in the world. If the efficiency and productivity of smallholders could be increased, they could be integrated into food supply chains.

Increases in affluence and demand for animal protein have already taken place in cities of Southeast Asia (Delgado et al., 1999; Delgado, 2003) and in the coming decades demand is expected to further increase at least two to three fold over consumption in rural households (Pingali, 1997; Delgado, 2003; Steinfeld, 2005). Milk sales in China demonstrate the effects of urbanization on consumption. Between 1997 and 2002, urban milk consumption in China increased by an average of 25% per year facilitated by increased spendable income and the availability of refrigeration, supermarkets, western-style restaurant chains, and ice cream parlors. By contrast, consumption of dairy products among rural communities changed little (Figure 8-1).

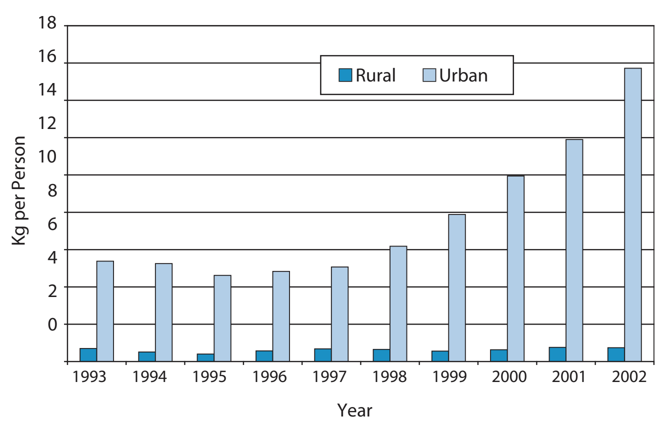

FIGURE 8-1 Urban and rural fresh dairy product consumption. SOURCE: Fuller and Beghin, 2004.

Although the consumption of meat and milk in the industrialized world is significantly greater on a per capita basis than in the developing world, the growing numbers of middle class consumers in the developing world is the force that propels overall demand and prices upward. Table 8-1 outlines the projected changes in meat and milk consumption in developing and industrialized countries between 1980 and 2030. The estimates are for a 560% increase in consumption of meat, mainly pork and poultry, and a 430% increase in milk consumption in the developing world, far beyond the growth of populations. Accompanying this is the increased demand for feed grains, especially corn and soybean, on the world markets. These figures emphasize that global food supplies are directly tied to the health and efficiency of the livestock and poultry industries and point to the growing importance and opportunities for the veterinary profession in sustaining food security in the future.

SUSTAINABLE INTENSIFICATION OF FOOD ANIMAL PRODUCTION

FAO estimates that available arable land will shrink by approximately 33% from 0.23 hectares (approximately 0.5 acre) per person in 2000, to 0.15 hectares (approximately 0.33 acre per person) by 2050 (www.fao.org/hunger/en/). It is not clear that these figures are adjusted for the loss of arable land from urban sprawl, but they nevertheless indicate that global agriculture must greatly increase its efficiency, without damaging the environment, a difficult task as the available land per person decreases.

The importance of production efficiency in relation to environmental sustainability can be illustrated by a comparison of the effects of milk yields per cow. Recognizing the importance of animal protein to childhood physical and cognitive development, several countries in Southeast Asia have promoted expansion of their nation's dairy industry with the goal of providing a glass of milk each day to every child in the nation. The challenge for the dairy industry and the veterinary profession in these countries is to understand how the goal can be fulfilled. Milk yields per cow in China and Thailand, for example, average 27% of yields in the United States (2,423 kg/yr vs. 8,861 kg/yr) (China Livestock Yearbook, 2007; FAO, 2006; FAO, 2009). China is attempting to meet the increasing demand by increasing the number of cows in the nation's dairy herd. But increasing the number of low-producing animals increases the cost per gallon of milk in terms of animal maintenance requirements, numbers of replacement animals, food and water consumption, land use, methane release, and waste production, raising questions about the long-term sustainability of the approach. Progress in the U.S. dairy industry over the past 60 years illustrates the advantages of increased production efficiency. In 1950, there were 22 million milk cows in the United States with an average annual yield of 5,314 lbs (664 gallons) per cow. Using the figure of 1.4 cow units per acre (cow + replacement heifer), this computes to approximately 3,796 lbs of milk (474 gallons) per acre. Expressed another way, using the 2003 USDA/ERS figure of 177 lbs of whole and reduced fat milk consumption per person in the United States, one cow in 1950 could meet the needs of 30 people. By 2010, yields per cow had increased to 21,500 lbs, equaling 15,357 lbs of milk (1,919 gallons) per acre and a four-fold increase compared to 1950. At this level of production, one cow can meet the needs of 121 people with less land, less feed, and less manure per gallon than in 1950.

Similarly, although global meat production has tripled in the past three decades and is projected to double present levels by 2050, increases to date have come primarily from increased numbers of animals rather than improved livestock yields (Pingali, 1997; Delgado, 2003; Steinfeld, 2005; and Steinfeld et al., 2008). For example, Burkina Faso and Cameroon, two of the poorest countries on earth, increased their cattle populations several hundredfold between 1961 and 2007, but with no improvement in carcass yields throughout the period (FAO, 2009). Maintaining such large numbers of animals with low productivity is not only inefficient, it also leads to exploitation of more land, soil stress through overgrazing and erosion, and is not sustainable.

A more efficient and environmentally-sustainable approach to increasing food production is to redirect output towards fewer, higher-yielding animals (Burney et al., 2010; Capper et al., 2010). In countries where available land is in short supply, there are few alternatives but to intensify animal production. Faced with meteoric urban population growth and with 94% of the suitable land already under cultivation, China and countries of South Asia have shifted towards large, intensive systems of swine, poultry, and dairy production, accounting for roughly 80% of the total increase of Asian livestock products since 1990 (Delgado, 2003). The veterinary profession has an opportunity to help improve the efficiency of these operations and also ensure that animal welfare needs are addressed. Large-scale operations have the added advantage that they generally favor the introduction of new technologies and better management practices, factors that result in lower food prices, improved feed conversion and yields per animal, meaning fewer animals are required to meet demand.

TABLE 8-1 Past and Projected Trends of Consumption of Livestock Products

	Developing World			Developed World		
	1980	2030	Percent increase	1980	2030	Percent increase
Total meat consumption (million tonnes)	47	252	437	86	121	41
Total milk consumption (million tonnes)	114	452	297	228	284	25

Adapted from Steinfeld et al., 2006, and FAO, 2006.

In spite of their efficiency, large-scale, intensive methods of livestock and poultry production are often criticized as environmentally damaging. Concerns are growing about the effects of waste and pollution from these plants, as well as management practices, infectious disease control, biosecurity, animal welfare, and food safety. Public and private veterinary services in Southeast Asia are thus under great pressure to adjust their practices to meet the new challenges that have resulted from rapid urban growth, booming economies, and swift consolidation of livestock and poultry industries.

The Role of Science

"Since the way to feed the world is not to bring more land under cultivation, but to increase yields, science is crucial." (Economist, 2008). That food riots were uncommon during the past four decades is largely attributable to the Green Revolution (Borlaug, 2002) which increased world grain production in existing cropping areas by some 250%, saving millions of people from hunger and starvation in Asia. The Green Revolution has been criticized for its heavy reliance on fertilizers, but the increased production spared forests and wildlife habitat, illustrating that responsibly-managed, high-yield farming can be one of the most effective ways of saving human lives while allowing wild species to survive (Green et al., 2005). In India, for example, the Green Revolution's high-yield farming methods are estimated to have prevented 100 million acres of virgin land, an area about the size of California, from being converted into farmland.

The Green Revolution is still important, but its impact has been dampened by rising fuel and fertilizer prices and inefficient irrigation practices; with the Green Revolution's decline, an era of cheap food is coming to an end. A new and more ecologically-informed, energy-constrained "sustainability revolution" is necessary. But that kind of change will require resources and a wholesale realignment of priorities and funding in agricultural research, including in the United States, where investment has steadily withered for over 40 years (Nature, 2010). The FAO estimates that global agricultural investments should increase by 50% by 2050 if there is to be enough food to feed 9.2 billion people. Of this, the FAO suggested that an annual infusion of $13 billion would be needed to increase livestock production (FAO, 2009). Thus, if population growth and the burgeoning cities of the developing world are to be sustained in rapidly warming climates, research and technical development is urgently needed, especially in tropical and sub-tropical agriculture. With the exceptions of China and Brazil where there have been remarkable increases in productivity, the issue of food security has received limited support from world funding agencies. Failure to fund this research will almost certainly precipitate worldwide increases in food insecurity, hunger, instability, and extremism.

Embrapa (the Brazilian Agricultural Research Corporation), is the world's leading tropical agricultural research organization today and the creator of a new "green revolution" in the Cerrado, Brazil's vast savanna lands lying south of the Amazon rain forest. Through a combination of soil improvement, integration of crop and livestock farming, no-till agriculture, and genetic improvement of forage grasses, soybean and livestock, Embrapa has, in the span of 30 years, transformed Brazil from a net food importer to one of the world's bread-baskets, the largest exporter of beef and poultry, and the second largest exporter of soybean in the world (Economist, 2010). This model could be adapted to the savanna lands of Africa and Asia.

THE IMPACT OF INFECTIOUS DISEASE ON FOOD SECURITY

Food supplies must be capable of withstanding shocks from weather, economic crises, crop pests, and livestock diseases. Food systems in developed countries are generally resilient while those in developing countries are not (FAO, 2011; p. 4 and pp. 88-91). As the numbers of livestock and poultry produced in the developing world has increased, world trade in foods of animal origin has also expanded significantly, increasing the opportunity for infectious agents to gain a foothold in food systems. As a result, new and re-emerging infectious diseases have appeared almost on an annual basis for the past two decades. Seventy percent are zoonotic and most have come from reservoirs of infection in wildlife. The spread of H5N1 avian influenza, West Nile virus, Severe Acute Respiratory Syndrome (SARS), and Monkey pox provide examples. Collectively, the epidemics they incited drew attention to the lack of coordination between human and veterinary public health services. It was this omission that gave rise to the One Health Initiative now championed by AVMA.

In addition, climate change is altering the range of pathogens, especially when they or their vectors depend upon warm temperatures and high humidity. Bluetongue virus is an example; the virus affects ruminants, especially sheep. In the past ten years bluetongue has spread from its traditional range in North Africa to most of Europe causing massive losses in sheep and disrupting trade (www.fao.org/docs/eims/upload/213041/EW_europe_sept06.pdf).

Extensive systems of livestock farming in many parts of the world have intruded increasingly into wildlife habitat, crowding and stressing wildlife and changing the dynamics of disease transmission. As a result, infectious diseases of wildlife, many of which were previously unknown, have been transmitted to livestock and people. Nipah virus, for example, spread in Malaysia from a reservoir of infection in fruit bats to swine and then to people where it was associated with high fatality rates. As a result, the swine industry suffered high losses and has been severely restricted in that country. There is every prospect that this pattern of disease emergence will continue and it is the task of the veterinary profession worldwide to work with the medical profession, environmental scientists, wildlife biologists, and others to provide surveillance of wildlife health and monitor the emergence of new infections that may threaten human health and the resilience of the food supply.

In Southeast Asia and China, intensive systems of livestock and poultry production are growing rapidly, introducing new opportunities and new niches for infectious disease proliferation and spread, as well as new threats to food safety. These hazards present the veterinary profession in those regions of the world with new challenges and responsibilities. Understanding how to prepare and maintain biosecurity protocols that are essential to controlling infectious disease outbreaks in these operations will be critical, as will be the development of managerial skills geared towards production medicine, efficiencies of scale, nutrition, reproduction, disease surveillance and control, food safety, risk management, water conservation, waste management, and responsible environmental stewardship. Mastering these skills is every bit as important as monitoring wildlife for the emergence of new infectious diseases. The veterinary profession in the developed world can and should play an important role in advancing these goals.

THE IMPORTANCE OF A GLOBAL VETERINARY INFRASTRUCTURE

Foot and mouth disease (FMD), exotic Newcastle disease, African Swine Fever, and Classical Swine Fever infect only animals, but those diseases affect human lives when they reduce animal productivity and compromise the resilience of the food supply system. These diseases are endemic in many parts of the developing world where, for centuries, they have not only damaged animal health and productivity but caused incalculable hunger and suffering among poor rural communities. Research on methods for rapid diagnosis and control for these diseases receives little funding in the developed world, particularly in the United States, but if the growing problems of food insecurity and threats of extremism and conflict in the developing world are to be addressed, this situation must change. Eradication of rinderpest, the most dreaded of all livestock diseases, highlights the importance of veterinary medicine to food security, and the need for the necessary financial support and leadership (Box 8-1).

The veterinary profession has an opportunity to use the experiences gained in the rinderpest eradication program to highlight the potential to address other prevalent, damaging, and destabilizing diseases of livestock and poultry. FMD stands out because it is notorious for spreading widely, devastating lives, reducing productivity, restricting animal movements, and compromising the resilience of food security throughout the world. To control this and other livestock and poultry diseases, national and international agencies should provide more appropriate levels of research support, and the veterinary profession should justify the investment by conducting high-quality studies that can be expected to lead to disease control. Rapid, sensitive field assays for early diagnosis of infectious diseases, vaccines that confer resistance to all susceptible species against different strains of an infectious agent, and heat-stable vaccines that are easy to deliver and marked to distinguish between an agent's vaccinal and field strains would

BOX 8-1
Rinderpest Eradication: A Success Story

Throughout history one of the most feared and devastating animal diseases was rinderpest (cattle plague), a highly fatal infectious disease that affects a broad spectrum of domestic and wild ruminants. The disease was once spread ubiquitously across the planet and, for centuries, its epidemics deprived people of meat, milk, and a means of tilling the land, leading to hunger and starvation, while decimating wildlife populations (Roeder, 2005). Accidental introduction of rinderpest into Sub-Saharan Africa at the end of the 19th Century caused massive loss of livestock and death through starvation of one third of the population of Ethiopia and nearly two thirds of the Masai tribe in Tanzania.

Now, owing to the efforts of veterinarians working with the World Organisation for Animal Health (OIE), FAO, and the Global Rinderpest Eradication Program, the world has been declared free of rinderpest, thirty years after the eradication of small pox. Rinderpest thus becomes the second viral pathogen to be successfully removed from the face of the earth as the result of human intervention (FAO, 2010). In many ways, this is veterinary medicine's greatest single contribution to humankind, saving countless lives while ensuring the security and safety of global food supplies. The accomplishment stands as testimony to the profession's stewardship of domestic animals, wildlife, and human food security.

be transformative developments. In addition, research is needed to improve animal production through better management, better nutrition, genetics, and improved reproductive efficiencies.

In 2010, FAO, OIE (The World Organization for Animal Health), and the World Health Organization (WHO) acknowledged the importance of building a global veterinary infrastructure by announcing a 5-year, international One Health initiative that aims to "strengthen the capacity of public veterinary services in preparation, prevention and response to animal disease occurrence" (FAO, 2010). Global programs that advance these goals are a matter of enlightened self-interest for the industrialized world, including the United States, to defend the public against zoonotic infections; to safeguard the economic security of U.S. livestock and poultry industries; to protect the indigenous wildlife of North America; and, ensure the security and quality of the nation's food supplies. In the past decade, just two cases of bovine spongiform encephalopathy cost the U.S. economy an estimated $11 billion (Doering, 2008); foot and mouth disease (FMD) cost the U.K. Government an estimated $30 billion; and, in eight months, SARS cost the economies of China, Hong Kong, Taiwan, Singapore, and Canada $200 billion (NRC, 2009). The U.S. Congressional Budget Office has estimated that a highly-pathogenic H5N1 avian influenza epidemic in the United States would cost the American economy $675 billion (CBO, 2006; Poland, 2006).

Veterinary participation is also needed in policy development, educational efforts, technical innovation, and the delivery of services in the field. Veterinarians from the developed world, especially the United States, need to demonstrate their capacity to support sustainable and economically-viable food-animal production systems. And they must assume leadership in helping to build effective veterinary public health capacity in the developing world. Understanding local cultures, overcoming illiteracy, and access to information all are needed. Veterinary services should be linked with the value of animals in an area and the capacity of farmers to pay for these services. Veterinary paraprofessionals and trained workers operating in animal-health care teams have been successful in parts of the developing world; they should be directly linked with licensed veterinary practitioners and public veterinary diagnostic and control services. These linkages have not consistently been in place, but the proliferation of smart phones, rapidly expanding cell-phone services, and development of voice recognition technologies now make education and the development of veterinarian/paraprofessional animal health networks a realistic possibility.

Presently, veterinary education in the United States is the envy of the world and the single most valuable asset the profession has to offer. The One Health Initiative has so far paid particular attention to the importance of emerging and re-emerging infectious diseases, especially zoonotic diseases. However, the connections of disease to food production argues for an expansion of that agenda to include urban food security, the sustainable intensification of livestock production, and ecosystem health in the developing world, as these are intertwined. Educational initiatives in public health, production medicine, and ecosystem health are essential to address these challenges in the United States and beyond and require the nation's veterinary schools and colleges to consider their priorities in global health. Scientific discovery, comparative animal research, and environmental health are crucial for global food security. New, international sources of funding should be found to widely expand veterinary research capacity in the United States and create partnerships with institutions in developing countries.

Veterinary students in the United States are increasingly interested in careers in global health, recognizing it as critically important to food security and to the future of the profession they have entered. To gain a deeper understanding of the complexity of the challenges, these students, together with graduates and faculty interested in global health, need to travel abroad and work side by side with veterinarians, paraprofessionals, and community animal-health workers in developing countries. Training veterinarians in the United States on collaborative, One Health solutions to the complex problems described in this chapter can provide an opportunity to build veterinary capacity and advance the profession's role in protecting public and environmental health both in the developed and developing worlds.

The USDA supports these initiatives and provides a roadmap to the programs it fosters at: www.csrees.usda.gov/nea/international/pdfs/vis_guide.pdf. The goal of the partnerships should be to build the capacity of the veterinary profession in the developing world where, regrettably, the profession is commonly held in poor regard, and animal-health regulations, if they exist, may be feebly enforced.

Building capacity at every level is important for without this, advances in science and technology will never reach the ubiquitous small farms where increases in production efficiencies are needed. To expand educational opportunities in the developing world, on-line programs designed to strengthen education in production medicine, public health, epidemiology, immunology, parasitology, microbiology, and pathology that are offered in the United States should be provided with the resources to make them available globally.

American veterinary medicine should also advance food security through research on infectious diseases including parasitic diseases. Thermo-stable vaccines and rapid diagnostic tests are needed for new and re-emerging zoonotic and epizoonotic diseases and resistance to anthelmintics should be addressed. Beyond these areas is the need for research on improving animal productivity in the developing world, improving reproductive efficiency, nutrition, management, welfare, farm hygiene, and profitability. Solving the problems of nutrient management is especially important both in the United States and in the developing world. New sources of funding are needed to support these initiatives together with funds to greatly increase recruitment of veterinary students into high-quality research training programs.

In addition, students need to see opportunities for employment in international veterinary medicine after graduation. In spite of the singularly important services veterinary medicine has to offer, there are presently far too few job opportunities in global health. Jobs will not materialize if veterinary academia does not prepare students to work in the wide realms of global health. Veterinary academia and organized veterinary medicine should recognize the need as an important new dimension of the profession, provide the necessary curricular offerings, and make every effort to secure educational debt forgiveness as well as stipends for graduates interested in global health careers.

Presently, veterinary academia appears reticent about emphasizing One Health and global food security as there are few well-paying job opportunities advertised for graduates. But, because of the incalculable importance of food security and ecosystem health, organized veterinary medicine and the deans of veterinary schools should be encouraged to increase the visibility, standing, and potential of the profession to find solutions to these issues. Failure to do so will ensure that the present dearth of jobs will remain to become a self-fulfilling prophecy and the field will be subsumed by those less qualified to address the needs.

Global hunger, malnutrition, ecosystem health, and the spread of infectious diseases are increasingly becoming issues of public concern and financial resources are beginning to emerge in support of initiatives in these areas. Examples include Feed the Future—the U.S. global hunger and food security initiative, the National Center for Foreign Animal and Zoonotic Disease Defense, and PREDICT—a global system to detect emerging diseases that can move from wildlife to people. Equally important will be funding, possibly from non-governmental organizations, to train veterinarians in the developing world in production medicine, biosecurity, animal welfare, food safety, and environmental sustainability.

As an indication of the concerns in the United States, the Department of Homeland Security is constructing the National Bio and Agro-Defense Facility to improve protection of the nation's food supply and agricultural economy. The Food and Drug Administration is beginning to implement the Food Safety Modernization Act that will require veterinary medical research to prevent food contamination and address issues of food safety on the farm. Beyond these programs are others funded by different agencies addressing the impacts of global warming on ecosystem health, wildlife, and the movement of plant, animal, and human diseases.

To take advantage of these sources of funding, veterinary schools will need to demonstrate an increased commitment to building the kind of faculty that can lead cross-disciplinary studies, as well as finding partners to support graduate training and research projects in these fields.

9

Academic Veterinary Medicine

INTRODUCTION

The gateway to the veterinary profession in the United States is through a university-based veterinary medical education, typically at one of the 28 schools and colleges of veterinary medicine located in 26 states. The schools provide qualifying students (prepared in 2- and 4-year pre-veterinary programs) with a 4-year curriculum culminating in a Doctor of Veterinary Medicine (DVM) or the equivalent[1] degree (BLS, 2010).

The academic faculty for the 28 veterinary colleges in the United States is an elite group of fewer than 4,000 members with the broad responsibility of preparing the U.S. veterinary workforce. In addition to their central obligation to prepare students to be "practice ready" (that is, ready to administer medical care) in 4 years, academic veterinary faculty also conduct research and participate in the post-graduate programs offered by most colleges of veterinary medicine, including the Master of Science (MS), Master of Public Health (MPH), Master of Preventive Veterinary Medicine (MPVM), and Doctor of Philosophy (PhD) degrees, as well as internships and residency programs. The post-graduate programs, which are housed within the veterinary science departments in U.S. colleges of agriculture and comparative medicine departments in U.S. medical schools, are designed to develop additional expertise within students for future positions in academe, industry, regulatory agencies, biomedical research, or specialty private practice.

As has been described in the earlier chapters of this report, there is a growing demand for DVMs with post-graduate training in all of the sectors that employ veterinarians. And the number of DVM graduates who seek additional training in specialty fields also is increasing. According to a 2011 survey of recent DVM graduates, 52% of the students who had accepted a job or position

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[1] Veterinerae Medicini Doctoris (VMD) is the equivalent degree awarded by the University of Pennsylvania.

offer indicated that their acceptance of a position was related to advanced training, up from 43.5% in 2009 (Shepherd and Pikel, 2011).

The 28 U.S. veterinary schools are having increasing difficulty maintaining the high-quality faculty needed to prepare both DVMs and post-graduates. Declining state support for faculty positions and tuition support has meant budgetary cutbacks that have reduced hiring, caused layoffs, and eliminated whole programs (Larkin, 2010). Declining federal funding for research grants in veterinary medicine and animal science have undercut the other sources of support for faculty member salaries. And increased demand for specialty certification, particularly those specialties related to companion-animal care (the largest employment sector), has controlled the focus of the 4-year degree program and de-emphasized training for important, but less-prominent, core disciplines related to the basic sciences and public health, including the training of individuals who would become the next generation of veterinary school faculty. These trends limit the ability of veterinary colleges to fulfill their mission and to respond to important, new initiatives and needs, such as those related to One Health. Moreover, no one veterinary college can provide sufficient depth on the broad range of subject matter that encompasses all of veterinary medicine. For all of these reasons, the veterinary colleges face a crisis in manpower and organization, and to survive, will need to consider new models of education for the future.

This chapter examines existing formats for veterinary education and several alternative models. It explores supply and anticipated needs for faculty members at the colleges of veterinary medicine, the need for graduate academic and specialty training, and the status of veterinary research. Some of the information for this chapter came from the Comparative Database compiled annually by the Association of American Veterinary Medical Colleges (AAVMC). Additional information came from responses to an exploratory questionnaire developed by the committee (and discussed later in the chapter) to collect information about current and projected numbers of faculty members, students, post-graduates, interns, and residents in colleges of veterinary medicine and departments of veterinary science and comparative medicine.

FUNDING FOR VETERINARY EDUCATION

Most U.S. veterinary colleges (with the exception of the University of Pennsylvania, Tuskegee Institute, Tufts, and Western University of Health Sciences) are located at land-grant universities. These colleges were established specifically to address livestock and poultry health issues related to production agriculture. Funding for the land-grant universities was derived from the sale of land given to the states by the federal government in fulfillment of the 1862 Morrill Act. The 1887 Hatch Act authorized matching funds from the U.S. Department of Agriculture (USDA) to support faculty and research. The programs have been highly successful in meeting local needs and providing educational opportunities for the citizens of the respective states.

There is a great deal of heterogeneity across the academic institutions at which schools of veterinary medicine are located, both in terms of size and organization. As a consequence, relationships to other educational units within the institution vary a great deal. For example, some programs in veterinary colleges are shared with departments in colleges of agriculture, and some schools of veterinary medicine are housed within larger institutional units. Opportunities for advanced training, research, and extension vary widely among colleges of veterinary medicine.

Initially, the veterinary colleges were fully funded for all of the activities supporting veterinary education from state and matching federal funds. Beginning in the early 1970s during an economic downturn, federal support for many of the colleges was reduced. The reduction of support coincided with a diversification in veterinary education that went beyond the original state-federal agreements, adding hospital training for companion-animal practice to the existing livestock and poultry programs. Costs increased as additional numbers of faculty were needed to cover training for the new species and to obtain funding for companion-animal research.

During subsequent economic downturns, the states continued to reduce support for their veterinary colleges, as did USDA. During this time, there was federal funding for training in food safety and laboratory animal medicine, primarily to support programs for military personnel. Those programs are no longer available directly through the government, and the responsibility to provide those training activities has fallen to academic veterinary medicine. More recently, the realization that emerging diseases from wildlife, food animals, food, and water originate largely in animals has placed another responsibility on veterinary educators for providing the means of identifying, diagnosing, responding to, and preventing these diseases.

The greatly expanded expectations of society for the profession have not kept pace with the funding that society has been willing to spend. The current deep recession has caused many colleges to lose up to one-half of their state appropriations, and federal support continues to decline (Larkin, 2011). This erosion poses serious challenges to the ability of veterinary colleges to simultaneously address companion-animal health along with agricultural productivity, foodborne illnesses, emerging diseases that affect agricultural production and human health, and animal welfare.

If society wants to prevent diseases that affect the health of humans such as avian flu, bovine spongiform encephalopathy, *E. coli* 0157:H7 and *Salmonella* contamination of produce, then support for veterinary education and research is essential.

THE EVOLVING VETERINARY CURRICULUM

The curriculum in veterinary colleges is influenced by a number of factors including: changing societal needs; the Standards for Accreditation established by the American Veterinary Medical Association's Council on Education, based on recommendations of the Council for Higher Education Accreditation (CHEA) and sanctioned by the U.S. Department of Education (Box 9-1); the U.S. Department of Agriculture's National Veterinary Accreditation Program for Emerging and Exotic Diseases of Animals; and by the national and state licensing boards which administer the licensing examinations (AVMA, 2010c; USDA-APHIS, 2010c).

During the early part of the 20th century, the educational efforts focused on service and support of horses for transport and draft power and later, to increase the productivity of food animals by reducing disease losses and increasing profitability. Foodborne illnesses were also a major issue due to poor sanitation practices in the nation's slaughterhouses. The veterinary profession, with the assistance of academic veterinary medicine, stepped forward to provide training for meat and poultry inspection, eliminating many parasites and infectious agents that contaminated these food products.

At the same time as food animal health and safety improved, the nation's rural population migrated to urban areas. At the turn of the 20th century, 80% of the population lived in rural areas and produced the nation's food, and horse draft power was the primary form of tilling and harvesting crops from the fields. Major changes in agricultural productivity in the United States did not occur until after World War II. The transformation that took place included improved animal health measures that permitted larger farming units, improved nutrition for livestock and poultry that included more grains in addition to pasture feeding, and improved genetics and management of animals which enhanced the welfare and well-being of livestock and poultry (Capper et al., 2009). This migration of people from rural to urban areas provided the opportunity for U.S. society to transform its agrarian workforce into the modern society of today.

BOX 9-1
Standards for Accreditation from the American Veterinary Medical Association

Veterinary colleges are responsible for developing and revising professional veterinary curricula. The curricula needs to meet standards set by the American Veterinary Medical Association's (AVMA's) Council on Education, which is designated by the U.S. Department of Education for official accreditation (AVMA, 2010d). There are 11 standards that need to be addressed to successfully meet full accreditation: Organization, Finances, Physical Facilities and Equipment, Clinical Resources, Library and Information Resources, Students, Admission, Faculty, Curriculum, Research Programs, and Outcomes Assessment. Full accreditation reviews by the AVMA's Council on Education are conducted on a 7-year review cycle with accreditations updates required on an annual basis. Students graduating from accredited veterinary colleges are eligible to take national and state licensing examinations that enable them to practice as veterinarians.

As society became more urbanized, the interest in companion animals became of increasing importance to families. This interest called for more attention to the health and welfare of dogs, cats, pet birds, fish, and reptiles. Many of these pets were (and are today) considered members of the family and their owners now want care comparable to that afforded their children (Harris Interactive, 2011). Today, with more than 72 million dogs and 82 million cats, pet care and pet foods have grown to be a $41 billion industry in the United State (Burns, 2008). More than 75% of the U.S. veterinarians are in companion-animal-exclusive or companion-animal-predominant practices. This change in societal and student interest has greatly impacted the dynamics of curricular offerings in veterinary colleges. The health care of the pet is very similar to that of human medicine with the emphasis on individual animal care, including the ever-expanding disciplines of specialty care. Over the last 25 years, academic veterinary medicine devoted more time to addressing companion animals as the primary clinical program in most veterinary colleges.

More recently, the veterinary profession has expanded its training programs to address other animal species such as captive and free-ranging wildlife. With funding for human health gaining momentum in the last part of the 20th century, the study of natural diseases of animals as models for human disease became of significant interest to veterinary colleges and comparative medicine departments in medical schools.

The shift from primarily large animal medicine involving horses, cattle, swine, and poultry in the last half of the century to companion animals and wildlife has required major shifts in curricular offerings. The creation of larger farm operations resulted in an increased emphasis on population health, preventive medicine, animal welfare, and food safety through management instead of the traditional emphasis on individual animal medicine, which is the hallmark of companion-animal and equine practice (Walker, 2009). The role of veterinary medicine in public health has also added a new dimension to the profession. The fact that 60% of all infectious diseases of humans are of animal origin, and 75% of emerging infectious diseases in the last decade arose from animals underscores the need for veterinarians to be a significant part of public health teams (NRC, 2005a). Veterinary colleges are revamping their curriculums to address these challenges.

However, as previous chapters have suggested, there are many other issues facing the veterinary profession that academic veterinary medicine has not fully incorporated into the veterinary curriculum, including:

- animal welfare
- disaster response
- global health and global food security
- climate change and emerging disease
- ecosystem health
- the role of the profession in mitigating bioterrorism

These areas are largely ignored at this point by academic veterinary medicine because of limited funding and qualified faculty.

Traditional Curriculum Approach

The curriculum commonly used for much of the last century was structured as a lock-step program which offered disciplines focused on animal health in a limited number of species. The first year was devoted to normal form and function, i.e., anatomy, physiology, histology, etc. The second year introduced students to abnormal form and function which included pathology, microbiology, immunology, and pharmacology. The third year included large and small animal diseases, large and small animal surgery, regulatory medicine, and other topics. In some colleges clinical medicine was permitted in the junior year. Most of the entire fourth year was devoted to clinical rotations through all species of animals, both large and small. Most colleges coordinated acceptable extern rotations in veterinary practices so that students would appreciate the type of activities they would be facing when they entered practice.

Core and Track Curriculum Approach

The continuing expansion of the opportunities and species of animals now served by veterinary medicine makes it very difficult to address all of the training needs in a 4-year program. In the 1970s and 80s, some colleges undertook curricular revision. One of the options considered was the core and track curriculum (Pritchard, 1989). The first two years were devoted to normal and abnormal form and function, similar to what had been offered in the curriculum used over most of the previous century. But in addition, the core and track curriculum offered a more comprehensive comparative approach. This was based on the presumption that all students needed to meet a basic understanding of veterinary medicine before they focused on a limited number of species. During the first year, students were able to take a small number of elective courses recommended for their respective track. In the second and third years, the number of electives increased as students completed their preparatory courses and defined a clinical emphasis for their fourth year. Students took courses covering clinical medicine for all species in their third year. The elective courses provided information beyond the core that all students are required to know. The fourth year was devoted to companion animals; equine; food animals; food/small animals; small/large animals; zoological medicine and/or individual programs including additional research, and public health.

Systems Curriculum Approach

Recently, there has been interest in a systems approach that again focuses on a comprehensive core knowledge and competence for all students. The first year focuses on normal form and function with case-based studies with small groups of students and an instructor. The second year is devoted to core abnormal form and function, again with case-based clinical problem solving studies as part of each week's curricular exercise. Approximately, two-thirds of the third year is focused on one of three species that the students select for in-depth study—companion, equine, or food/wildlife tracks. The entire fourth year focuses on the species studied in the third year. If the student wishes to take one of the other two species offerings, they may take those courses in the fourth year. The students would have less clinical experience; however, they will have the didactic lectures and laboratories for the two tracks.

Problem-Based Learning and Distributed Clinical Curriculum Approach

The other curriculum which has been used by a few veterinary colleges in the United States is the problem-based curriculum (http://www.westernu.edu/veterinary-about). Small groups of students start with a clinical case early in the first year. With faculty serving as discussion leaders/facilitators, the students are expected to work through a case each week. Some supplemental lectures are given to provide specific information to assure that students are given the support that may be missing from textbooks. In some colleges, the students begin clinical rotation externships for exposure to veterinary practices during the third year. The fourth year is a distributed clinical program with most of the clinical instruction provided by practicing veterinarians during their clinical extern rotations.

Clinical Training Programs

There are currently two types of clinical training programs to support the various curriculum approaches:

Traditional Clinical Training

The "traditional clinical training" approach is used to support the traditional, "core and track", and the systems approaches to the veterinary curriculum. Traditional clinical training involves a central teaching hospital where the faculty of the college uses client-owned large and small animals to serve as the case material for hands-on clinical training. Students gain experience in taking histories, conducting physical examinations, determining the appropriate diagnostic tests or imaging needs, collecting samples, and then reviewing and analyzing the information prior to making a diagnosis. Once the diagnosis is determined, students consider the appropriate treatment options, including the need for appropriate surgical procedures and the medical therapy that is to be recommended for the patient. Follow-up procedures for continuing therapy or recovery from surgery are prescribed for the owners. The students are expected to act as the lead clinician in these procedures under the faculty member's guidance and supervision. The students are also expected to gain experience in communicating with clients and colleagues. Many of the cases require additional review of the literature by the student and reporting the findings back to the faculty and colleagues. This type of instruction usually involves the entire fourth year of the veterinary curriculum. Most veterinary colleges provide opportunities for fourth year students to rotate out of the academic teaching hospitals to veterinary practices to gain "real world" experience for the more routine procedures. This system has produced graduates with excellent skills in observation and analysis of case information for making diagnosis and treatment of animals. It utilizes the information that is given in the previous three years and provides a uniform educational experience and monitoring of the student's educational experiences. Most veterinary colleges have secondary and tertiary hospitals which further expose students to the challenges associated with more complex cases and is an advantage over those students who do most of their training in private practices.

Distributed Clinical Training

The "distributed clinical training" model is a more recent approach to veterinary clinical training both inside and outside the United States (http://www.westernu.edu/veterinary-about). It was introduced with the problem-based curriculum. For the most part, private practice veterinarians agree to provide instruction to students through a prescribed period of clinical service in their practices. Third year students have 2-week rotations to introduce them to the clinical operations and to gain observational skills and animal-handling skills. Fourth year students spend more time with the practicing veterinarian doing hands-on handling and treatment of animal patients. In some instances, the students rotate through specialty practices. In all of these instances the practices are expected to generate their operating income. The students also report to a faculty coordinator to discuss their cases with the faculty member, usually accomplished by electronic communication. Typically, the cases are primary or secondary level cases, unless there is an unusual specialized case. The distributed clinical model allows the students to see more cases, see a variety of client-veterinarian and business relationships, and as such, students may develop better social interactions with clients.

NEW CONCEPTS IN VETERINARY EDUCATION

The current decline in state budgets to operate veterinary colleges, and the increasing demand for veterinary service including specialty training and exposure to different animal species, prompted the Association of American Veterinary Medical Colleges (AAVMC) to explore other means of facilitating veterinary education which resulted in the Foresight Project report (Willis et al., 2007). The report includes the concept of centers of excellence/emphasis, distance learning, shared virtual curricula, and the utilization of pod casts and itinerant faculty, among other things. To further facilitate these initiatives, the AAVMC has taken the lead in a collaborative effort with a number of other organizations in the North American Veterinary Medical Education Consortium (NAVMEC) that will focus on the transformation in veterinary medical education that many feel is critical for the profession at this time (AAVMC, 2009a). Examples of alternative means of education from the Foresight and NAVMEC reports are discussed below.

Centers of Emphasis

Centers of Emphasis (sometimes called centers of excellence) would be developed in locations where there are appropriate species of animals to provide instructive hands-on experience. For instance, a regional or national food-animal center established where a significant number of a particular livestock species is located, would provide the opportunity for students to gain experience with the rapidly changing management of large, food-animal production units (Miller and Prasse, 2006; Troutt and Osburn, 2008). The centers would not replace instruction in individual food-animal medicine currently taught at veterinary colleges, but would increase the in-depth experiences of students with large-population health practices in production settings. This approach maximizes the benefits of limited resources, locates the training near livestock populations, and concentrates faculty expertise from multiple schools and colleges to focus on the species, permitting one location for a core of faculty rather than only one or two faculty members per institution. The centers would serve as the primary center for training 4th year students for a portion of their clinical (8 to 12-week) rotations, as well as specialists and graduate students. Faculty would be able to conduct research related to the species and regional environment, staying abreast of all things of importance to the species. For instance, the food-animal center could provide more instruction on environmental health, animal welfare, nutrition, food safety, and waste management as well as an understanding of the importance of the economics of the production system.

Similar centers could be developed for companion-animal practices in metropolitan areas where the specialty hospitals would have the case load for residency training and clinical trials, as well as rotating students from veterinary college community practices. These types of practices should be geared toward self-supporting operations with a faculty research component for instructing residents and 4th year veterinary students wishing to be exposed to selective specialty rotations. A center that is situated in a location with a large number of animals would permit clinical trials to be more easily accomplished.

Financial Support for Centers of Emphasis

Given the importance of food animals to the U.S. food supply, economy, and public health, a case can be made that supporting a food-animal center is in the national public interest (and should therefore be partially supported with federal tax dollars). Currently, the cost of the infrastructure to train the veterinary workforce that provides services to maintain the health of food animals across the nation and produce the highest quality and safest food in the world is carried by only 26 states. (Some states with no veterinary college have in the past provided non-resident tuition for a limited number of students for states with veterinary colleges. These numbers and the amount of non-resident tuition dollars have been declining, however).

Other centers could be established for equine health, poultry health, swine health, food safety, public health training, laboratory-animal medicine, and wildlife and marine ecosystems. The success of these centers will be dependent upon the willingness of veterinary colleges to share faculty and administration of these centers, and to pursue creative funding arrangements involving stakeholders.

Distance Learning

The technology for distance learning continues to improve and is serving as a valuable means of delivering education to many students. This form of education for professional schools is now taking shape, particularly for post-graduate education courses such as the Master of Public Health program at the University of Minnesota (http://www.cvm.umn.edu/edu/). As part of the degree requirements, the Minnesota program includes some on-campus courses and some delivered through distance learning. A number of veterinary colleges have joined the University of Minnesota Program. This is particularly helpful to those individuals who cannot afford to leave their job or are doing dual degree work, but can take the courses in the evenings or on weekends.

Distance learning could provide education to large numbers of students across the world. It requires special methods of delivery as well as the ability for students to ask questions during or following lectures. In other instances, where the information is transmitted over long distances, it will require local faculty to serve as discussants as a follow-up to the lectures and to help students apply the concepts delivered in lectures into practice. This means of instruction is best suited for lecture formats, as clinical training requires hands-on involvement. More recently, telemedicine and Internet-based videoconferencing software has become available as adjuncts to clinical case instruction, diagnostics, and even management of clinical cases. Robotic surgical techniques can be conducted on cases located thousands of miles away, again through the use of electronic technology.

Virtual Curriculum

A number of medical school programs are now developing virtual curriculum models. This type of program requires a think tank approach for developing the best course materials and the appropriate teaching delivery, including a well-designed outcomes delivery system. The approach best suited for lecture formats is to use the problem-based learning model and organize discussion sessions through a chat room format. This type of instruction does raise concerns about cybersecurity and copyright infringement; it also cannot provide the type of instruction that requires skills assessments and animal handling. One important aspect is the potential to use groups of experts to provide the information to students globally, providing the latest and most relevant peer-reviewed information to students all over the world. On-line texts that are continually updated with current information would be of significant importance to the profession.

Considerations for Veterinary Educators

A number of new subject matter items have arisen over the years which need attention in the veterinary medical curriculum. NAVMEC is in the process of evaluating these, which include core competencies, new initiatives such as One Health, and pre-veterinary requirements. Some of the new subject matters areas of significant importance to the veterinary profession include animal welfare for all species, disaster response, and a broader set of issues related to public health, including food safety and security, zoonotic diseases, global food production, and ecosystem health. For the profession to grow, it must demonstrate to society that it has a relevant role to play in addressing future societal issues; thus, inclusion of this information in the curriculum is essential.

Different models for a veterinary education program are likely to have pros and cons. Ultimately, the value of the program can be assessed by weighing the costs of providing a curriculum against its ability to serve the broadest needs of society. Since few, if any, programs can meet all needs, collaboration and coordination between schools of veterinary medicine is essential. The AAVMC as the common coordinator for academic veterinary medicine could work more closely with stakeholders and the colleges to assess the workforce needs, including recommending alterations in curricular offerings to assure that academic veterinary medicine is responsible for meeting the diverse needs of the profession. NAVMEC has initiated such a process by holding 3 national meetings with over 400 stakeholders to gain their input on what academic veterinary medicine has been addressing and by considering the societal opportunities that the future holds for the profession.

Chapter 10 discusses the economic considerations related to a basic veterinary education, from the perspective of the educational system and of veterinary students. In the remainder of this chapter, the role of faculty as a source of expertise for advanced instruction and as the foundation for veterinary medicine is discussed in the context of the demand (and need) for veterinarians with advanced training beyond the DVM.

THE ROLE OF VETERINARY FACULTY

As noted earlier, the academic veterinary workforce in the United States consists of about 4,000 faculty members. The responsibility of faculty in veterinary schools is to educate students so that they are "practice ready" at the time they graduate from the 4-year veterinary curriculum. This means that the students are prepared to take licensing examinations in order to enter veterinary clinical practice. In addition to the coursework in the first two years of the curriculum, the last year or 18 months encompasses intense clinical instruction involving 3 to 5 students per faculty member where in-depth instruction and experience with animal patients is provided. For comparison, medical school students have little contact with patients during medical school training (an additional 4-6 years beyond medical school are needed to prepare medical students to enter clinical practice).

Veterinary faculty are also involved in post-graduate education, which includes teaching graduate-level courses, providing instruction on laboratory techniques, analyzing student research data, and student mentoring. These are the kinds of activities that prepare students for future careers as faculty members, research scientists in biomedical sciences, federal and state regulators, and scientific investigators in industries that develop, conduct safety testing, and assess the efficacy of drugs for use in animals and humans.

In 2007, the committee sent a questionnaire (conducted with the online tool, Survey Monkey) to the 28 U.S. colleges of veterinary medicine, to 7 veterinary science departments in U.S. colleges of agriculture, and 7 comparative medicine departments in U.S. medical schools. It is within the departments of veterinary science and comparative medicine that pre-veterinary education is provided to prospective veterinary students and where some of the post-graduate training occurs.

Twenty seven of the 28 colleges of veterinary medicine; 7 of the 9 veterinary science departments; and 5 of the 7 comparative medicine departments responded to the questionnaire. Thus, the responses presented here are based on the majority of veterinary training venues for the basic DVM degree as well as for post-graduate education for the profession. However, the results might not represent the non-responding colleges and departments. Additional information about the survey, including the questionnaire itself, can be found in Appendix G.

Table 9-1 summarizes the responses of the veterinary schools, the departments of veterinary science, and the departments of comparative medicine to the committee's questions about the size of the faculty and student body in 2007, and their anticipated size in 2010 and 2016. As the table shows, in 2007 there were 3,595 faculty members teaching in veterinary colleges and departments of

TABLE 9-1 Current and Anticipated Demand for Faculty in Veterinary Colleges, Departments of Veterinary Science, and Departments of Comparative Medicine that Responded to the Committee Survey

Faculty Type	2007	2010	2016	Percent Growth (2007-2016)
Tenure track faculty	2,479	2,658	2,786	12.3
Non-tenure track faculty - clinical	755	849	959	27.0
Non-tenure track faculty - research	361	429	502	39.0
Total Faculty	3,595	3,936	4,247	18.1
Current and anticipated vacancies due to retirement	260	261	446	71.5
DVM Students	10,534	10,866	12,067	14.5

veterinary and comparative medicine.[2] Of these, 69% were eligible for tenure, 21% were in non-tenure track clinical positions, and 10% were in non-tenure track research positions.

Clinical training of DVM students is taught by tenure-track and non-tenure track clinical faculty, who also provide instruction to graduate students in clinical residency programs. Tenure-track and non-tenure track research faculty provide most of the graduate education for the DVM/PhD, MPVM, and MPH students. The survey results show that 40-50% of the faculty members in the basic sciences hold a PhD degree but not a DVM. In the para-clinical and clinical sciences, 80-90% of faculty members hold a DVM and PhD and/or specialty certificates.

Future Needs for Veterinary Faculty

According to respondents, in 2007 there were 10,534 enrolled veterinary students and 3,877 post-DVM students including masters, doctors of philosophy, interns and residents, resulting in a student-faculty ratio of about 4.0. Respondents anticipated that both the number of faculty and students would increase by 2016, predicting that the number of DVMs involved in post-DVM training would increase by more than twice that of new veterinary students (an increase of 31.4% to 14.5%, respectively, from 2007). The respondents also anticipated that the numbers of non-tenured faculty, who provide more post-DVM instruc-

[2]The size of the tenured and non-tenured clinical and research faculty in individual veterinary colleges responding to the survey ranged from 41 to 173; in departments of veterinary science, from 10 to 34; and in departments of comparative medicine, from 8 to 13.

tion, would grow significantly relative to tenured faculty (27% for non-tenured clinical and 39% for non-tenured research versus 12.3% for tenured faculty).

The predictions of the veterinary schools suggest that demands for a veterinary education are changing. The makeup of the future faculty will be shaped by the availability of funding opportunities. A central question is how the anticipated positions for non-tenured faculty will be supported. Moreover, the implication of greater overall numbers of students in the future, particularly more graduate students, is that adequate facilities will be needed with which to conduct the training that is in increasing demand. For instance, training is needed for future research scientists and students in the use of select agents, ecosystem health, food safety and security, and epidemiology.

The Effect of Retirements

Table 9-1 also shows that nearly 7% of the total faculty positions in 2007 at institutions that responded to the survey were vacant due to faculty retirements. Respondents estimated that by 2016, approximately 10.5% (446 positions) of the faculty would be vacant. A closer look at the expertise that veterinary schools anticipate losing and/or replacing is contained in Figures 9-1, 9-2, and 9-3.

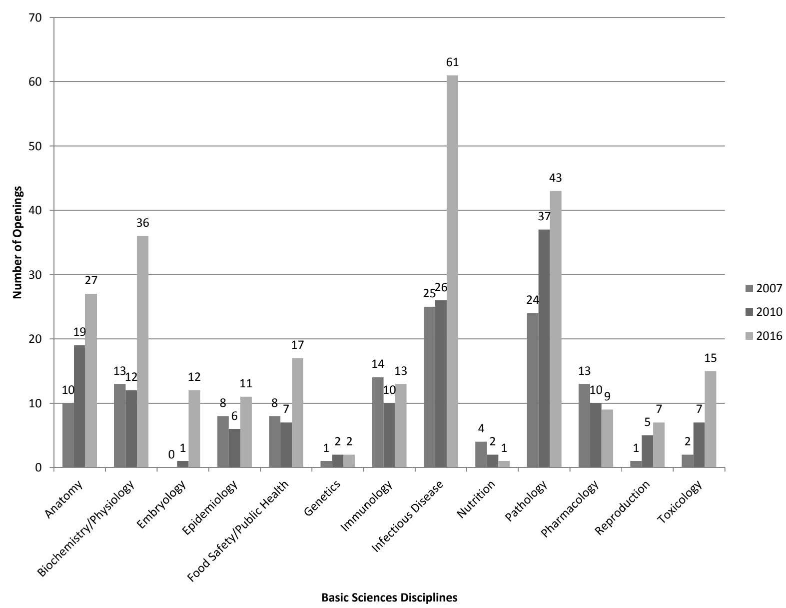

FIGURE 9-1 Survey respondents need for faculty in the basic sciences: Number of vacant positions in 2007 and anticipated vacancies in 2010 and 2016 due to retirements, by discipline.

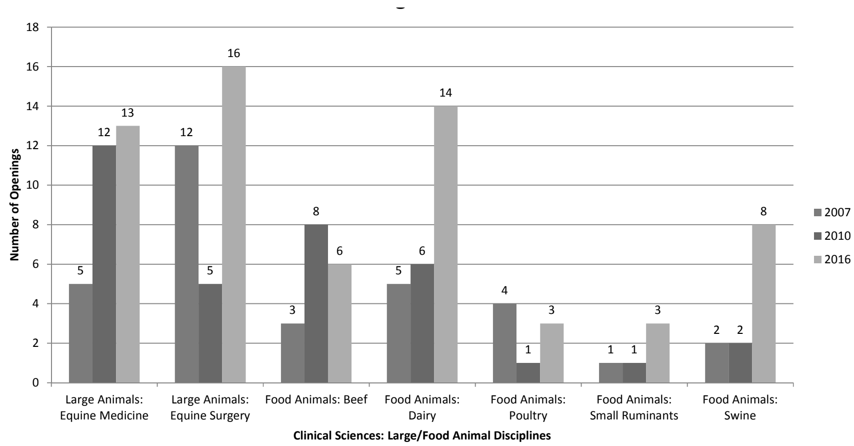

FIGURE 9-2 Survey respondents need for faculty in the clinical sciences: Number of vacancies and anticipated openings due to retirements in large and food-animal clinical positions, by discipline.

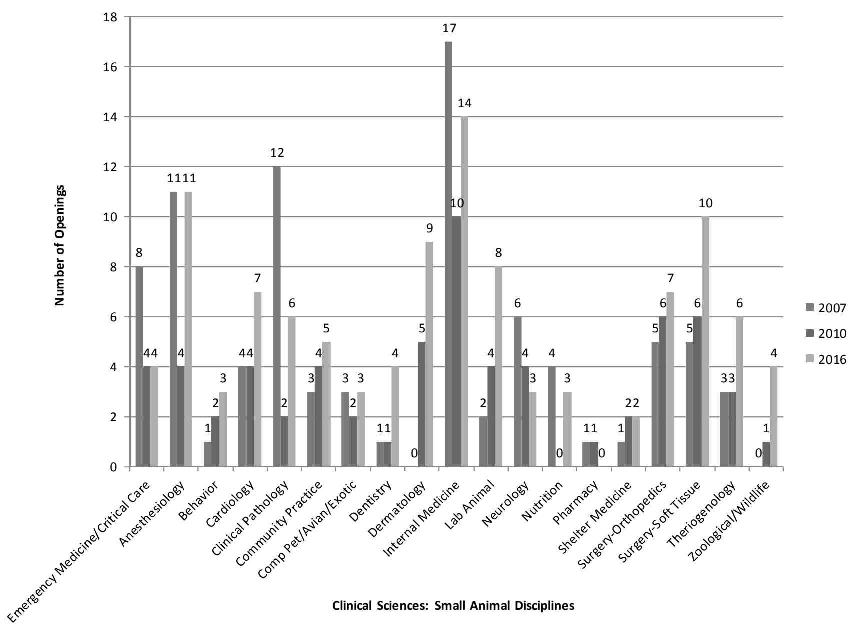

FIGURE 9-3 Survey respondents need for faculty: Number of vacancies and anticipated openings due to retirements in small-animal clinical positions, by discipline.

Figure 9-1 shows current vacancies and positions in the basic sciences which are anticipated to become open in 2010 and 2016 due to faculty retirement. The greatest need will be for individuals with expertise in infectious disease, anatomic pathology, biochemistry/physiology, and anatomy.

Some of those positions can be filled by non-professional degree PhDs, while others are likely to require a DVM plus advanced training, such as a PhD degree. In order to effectively teach veterinary students, it is essential that a portion of the faculty hold DVM/PhD degrees, but it is an open question whether there will be sufficient numbers of DVM/PhDs with this kind of expertise who are willing to join the faculty of veterinary medicine, given other opportunities in the private sector.

Figure 9-2 focuses on faculty openings for the large animal clinical science disciplines. By 2016, the greatest need will be for trained veterinarians in equine surgery and medicine, followed by dairy, swine, and beef cattle. Recent trends in equine populations suggest that the number of trained specialists for equine surgery may be less in demand as equine accessions are falling dramatically in the United States. In any case, all of the anticipated positions are likely to require veterinarians with advanced degree training such as residency and/or PhD degrees. There appears to be little demand for faculty for poultry and small ruminant positions even though the need for research, clinical training, and graduate training remains. There are areas of poultry health such as pre-harvest food safety, epidemiology, and poultry welfare that require attention in the current production environments. A key question is whether there will be individuals with the types of expertise and advanced training required who would be willing to accept positions as faculty members in equine and food-animal veterinary medicine. The discipline areas of increasing importance include nutrition and metabolic disease, production medicine with strong business management skills, preharvest food safety, biosecurity, and animal welfare.

Figure 9-3 addresses the open positions for the small animal clinical sciences for each of the three time periods tabulated in this study. The total number of positions is large as there are many specialties. All of the faculty will require DVM and residency training and/or PhD training.

Faculty Salaries

In 2008, faculty salaries ranged from a mean of $134,780 for full professors; $108,630 for associate professors; to $98,072 for assistant professors, with an overall average of $113,827. Non-tenure track faculty earned an average of $87,019 (M. Pappaioanou, Association of American Veterinary Medical Schools, personal communication, 2008). Increasingly, veterinary faculty are required to obtain a portion of their salaries, purchase their own equipment for their laboratories, and support graduate students from extramural sources and to advance their profession through research. This is particularly true for the salaries of non-tenure track research faculty which are not supported by the university. Their salaries must be obtained through research grants and other sources of support. Competitive research grants from federal agencies such as the National Institutes of Health (NIH), with a success rate of 10-15%, offer one source of such extramural funding. However, as discussed later in this chapter, research support of veterinary medicine is currently waning.

POST-DVM TRAINING AND EDUCATION

Specialty Training

Veterinary specialties initially formed in the late 1940s and early 1950s. A DVM can become a specialist after receiving training and passing a qualifying examination that is either species-based (for example, an avian specialist) or discipline-based (for example, veterinary pathology). Specialty boards and colleges dictate the knowledge required for certification in the specialty by establishing standards for training and administering the certifying examination. The American Veterinary Medical Association (AVMA) oversees the veterinary specialty organizations, and most specialty training takes place at veterinary and medical colleges, but unlike the professional DVM degree programs, there is no overarching federal accreditation agency, such as the U.S. Department of Education, to review and approve accreditation for the professional specialty education programs. Increasingly, there are more specialty practices training specialists required for their programs.

Currently, AVMA recognizes 21 veterinary specialties and 23 sub-specialties (Table 9-2). As of December, 2010, 12% of AVMA members (10,210) were active, board-certified specialists in veterinary medicine, as compared to 8,510 reported in 2006. That represents an increase of 20% in 4 years (AVMA, 2010e).

None of the veterinary colleges surveyed by the committee provided training for all of the specialties; however, many conduct the training that fits their needs and resources. Interest in veterinary specialty training continues to escalate as depicted in Figure 9-4. Respondents indicated that the number of clinical residents receiving board certificates in 2007 was 316, a number they expected to increase to 408 by 2016.

Specialty colleges are similar in many aspects to comparable programs in human medicine and specialties have made significant advances to the practice of veterinary medicine. The rigid certifying examination which follows the in-depth, 2-4 year training programs for residents recognizes the high level of experience and expertise a candidate obtains for each of the specialties. Consequently, the veterinary specialty colleges have been very successful in significantly improving clinical veterinary medicine for both large and small animals and for journeyman applications for many disciplines.

TABLE 9-2 Specialty Boards Recognized by the American Veterinary Medical Association

Recognized Veterinary Specialty Organizations (RVSO):	Number of Diplomates
American Board of Veterinary Practitioners (ABVP)	868
Avian	138
Beef Cattle	12
Canine & Feline	473
Dairy	36
Equine	89
Feline	78
Food-Animal	21
Swine Health Management	19
American Board of Veterinary Toxicology (ABVT)	89
American College of Laboratory Animal Medicine (ACLAM)	789
American College of Poultry Veterinarians (ACPV)	281
American College of Theriogenologists (ACT)	366
American College of Veterinary Anesthesiologists (ACVA)	192
American College of Veterinary Behaviorists (ACVB)	48
American College of Veterinary Clinical Pharmacology (ACVCP)	48
American College of Veterinary Dermatology (ACVD)	213
American College of Veterinary Emergence & Critical Care (ACVECC)	195
American College of Veterinary Internal Medicine (ACVIM)	2117
Cardiology	195
Small Animal Internal Medicine	1075
Large Animal Internal Medicine	480
Neurology	184
Oncology	259
American College of Veterinary Microbiologists (ACVM)	210
Bacteriology/Mycology	41
Immunology	46
Microbiology	60
Virology	63
American College of Veterinary Nutrition (ACVN)	57
American College of Ophthalmology	331
American College of Veterinary Pathologists (ACVP)	1608
Anatomic Pathology	1313
Clinical Pathology	295
American College of Veterinary Preventative Medicine (ACVPM)	659
Epidemiology	63
American College of Veterinary Radiology (ACVR)	390
Radiation Oncology	76
American College of Veterinary Sports Medicine and Rehabilitation	27
American College of Veterinary Surgeons (ACVS)	1334
Small Animal	290
Large Animal	171
American College of Zoological Medicine (ACZM)	126
American Veterinary Dental College (AVDC)	115

SOURCE: AVMA.

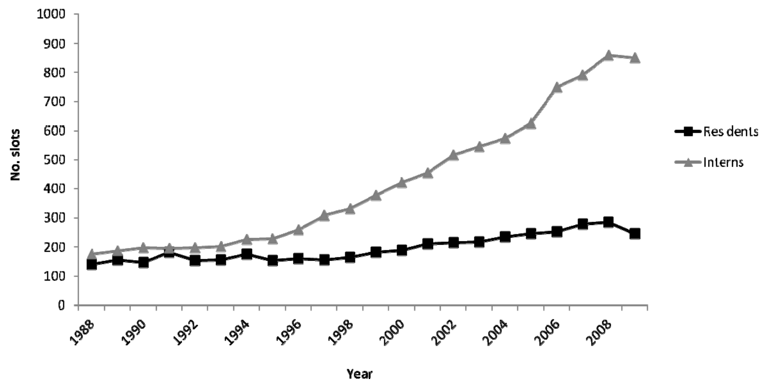

FIGURE 9-4 Residency and internship position notifications submitted to the American Association of Veterinary Clinicians**,** 1988-2009.

However, the current training programs and certifying examinations for residents emphasize clinical procedures rather than the research experience needed to train individuals for academic positions. Research training is an essential foundation skill for faculty to conduct investigations that advance scientific knowledge, develop the major breakthroughs required to address animal health, and study animal models for human disease needs. In addition to academe, credible research training of residents also builds the expertise that private industry and the public sector are clamoring for in job candidates, as described in other chapters of this report.

Moreover, for large animal specialties, there is a need for specialists who are familiar with contemporary livestock practices, nutrition, genetics and animal welfare, as well as an understanding of the economics of the industry, how to assess retail needs, and the biosecurity, food safety, and disaster response issues associated with large populations of animals. In the future, veterinarians need to be familiar with policy issues relating to water and air quality, environmental management of waste, and the impacts of production units on feed and food crops. These subjects must be addressed if veterinary medicine is to remain relevant to producers in the livestock and poultry industries.

Specialty Training is Not Publicly Supported

A major conflict facing the veterinary colleges is that, in spite of the demand, most do not have the funding required to meet the needs for advanced specialty training. On the one hand, veterinary colleges are the most logical place for obtaining specialty training. The academic environment has the diverse caseload and expertise in many core disciplines such as pathology, clinical pathology, imaging, microbiology, cell biology, immunology and epidemiology, which enhances residency training. Veterinary colleges also have the basic scientists who have the research backgrounds and equipment to provide residents with the in-depth guidance in research methodologies and to provide appropriate mentoring for studies on complex clinical diseases. Veterinary colleges are able to train residents to make presentations of the results of their studies in clinical rounds and at national conferences. Some medical schools provide focused areas of expertise in comparative medicine that accommodate comparative medical pathology and laboratory animal training.

On the other hand, the rapid growth of specialties and the need for training has been pursued in the face of inadequate infrastructure support, such as core funding for faculty, and adequate resources and equipment for the training environment. Veterinary colleges are funded using public resources to train entry level veterinarians, with very little support for specialty education. Specialty colleges require two or more faculty mentors to train residents, placing pressure on the schools to hire more faculty, typically an individual with a clinical specialty. In some instances, colleges are located in communities with inadequate caseloads to fully support the appropriate training environment for the specialty, causing some colleges to develop satellite clinics in locations which support specialty training. This has made the advanced training for specialists a viable alternative and has improved clinical experiences for both residents and professional students. But these opportunities are limited. Comparable research experiences are much more limited. Some veterinary colleges use residents as instructors for veterinary students, which can be an important part of residency training, but it also detracts from the specialty training activities due to the considerable time and effort required to adequately supervise and train the professional students.

Although AVMA has been a significant supporter of specialty training, it has done so with minimal consultation with veterinary colleges. This is causing a dilemma with the colleges since they have to provide the infrastructure and faculty to provide this training with little or no funding or infrastructure support. Federal agencies and industry also benefit from having the veterinary colleges train specialists for their respective workforces. Although they sometimes provide stipends for training specialists, they give minimal or no contributions to infrastructure or faculty salaries. From a financial perspective, the colleges are unlikely to have the resources to continue with their post-DVM programs and to provide what is required for entry level DVM training, particularly in light of the declining state support.

Clinical Faculty Expertise is not Being Replenished

A major concern of academic veterinary medicine is the failure of trained specialists to remain in the academic environment. When board-certified specialists join a veterinary faculty, the veterinary teaching hospital clinical practices are enhanced. This trend has been important for moving the teaching hospitals to becoming secondary and tertiary referral centers, increasing income for the hospitals, and providing veterinary students with challenging cases as part of their clinical training. The residency programs would appear to be training adequate numbers of specialists to meet the academic needs, however many of these individuals will be attracted to private companion-animal practice because salaries of specialists in private practice are considerably higher than those in universities, so there is little incentive to stay. In short, the veterinary schools are on an unsustainable trajectory.

In the current climate of decreasing state budgets and a decline in discretionary spending for specialty services, it is increasingly difficult for veterinary schools to continue to be the principal source of specialty training. Until there is a clear indication of state, federal, industrial or philanthropic support, the role of academic veterinary medicine in future training of specialists is at risk.

Veterinary colleges need to be in a dialogue with AVMA and AAVMC to determine the number of specialists needed to supply all employment sectors so planning and acquisition of infrastructure support can be obtained for the training of current and future specialists. Where critical shortages are occurring nationally for trained public practice veterinarians such as laboratory animal medicine, pathology, epidemiology, microbiology, and toxicology, public support to produce those veterinarians is warranted.

Academic (Research) Training

Veterinary medical colleges, veterinary science departments, and comparative medicine departments are the principal academic environments at which DVM/MS/PhDs are trained. A number of veterinarians may also pursue advanced degrees in schools of medicine, public health, law, agriculture, and business. All of these diverse training opportunities are important for the veterinary profession to grow in order to meet societal expectations.

Traditionally, graduate academic programs leading to MS and PhD degrees have been 2- and 4-year programs, respectively, and are discipline-based, for example, microbiology or pharmacology. Because many current scientific and biomedical challenges are complex, programs have begun to emphasize multidisciplinary training, involving two or more disciplines. Regardless, the goal of the programs is to provide graduates with a sound base in one or more disciplines along with the critical analytical skills needed to carry out independent research. Post-graduate training is of great importance for preparing the public practice veterinarians in the federal and state workforce, including the disciplines and practices of critical importance for the health and well-being of animals, the environment, and humans, such as pathology, ecology, epidemiology, virology, infectious diseases, comparative medicine, and public health. Similar specialty or graduate training, especially in pathology, toxicology and laboratory animal medicine, are needed in the pharmaceuticals and biologics industries to perform the critical testing of pharmaceuticals and biologics for safety and efficacy before these products are used in human trials. Veterinary pharmacologists, pathologists, microbiologists, virologists, toxicologists, and laboratory animal veterinarians are needed by these same industries and public agencies like the Food and Drug Administration. In addition, members of the veterinary school faculty must have advanced education before they are in a position to train future veterinarians and post-graduate veterinarians for these critical roles.

However, in stark contrast to the number of DVM graduates entering specialty training, far fewer are seeking advanced academic degrees. Based on the information from the committee's survey of veterinary schools, departments of veterinary science, and departments of comparative medicine, Figure 9-5 shows the total number of students enrolled in educational training programs in those institutions in 2007, as well as the numbers of students expected to be enrolled in 2010 and 2016. Although the numbers of students seeking advanced academic degrees (MS, PhD) would initially appear to be equal or greater than those obtaining advanced training in clinical residencies, that is not the case, because they include not only DVMs but also students with a Bachelor degree.

The proportion of DVM students pursuing a PhD degree can be estimated from the AAVMC Comparative Database (AAVMC, 2009b) which indicates that the number of DVM graduates enrolled in PhD programs from 2007 through 2011 years will be, on average, 83 per year. That would suggest that about one quarter of the total PhD enrollment in the veterinary colleges and associated departments that responded to the survey (Figure 9-5) are DVMs, assuming a 4-year PhD program. That number is reasonably consistent with the responses to the committee's survey indicating that, across all colleges of veterinary medicine, 61 PhD degrees would be awarded to DVM graduates in 2007, a number expected to increase to 101 by 2016. As Figure 9-6 illustrates, that is a much smaller number than the graduates receiving board certification in the same time periods.

Implications of the Lack of Interest in Graduate Academic Training

It is clear that most veterinary students are not seeking academic training to pursue academic careers. Instead they are more inclined to enter clinical residency programs, and veterinary schools are attempting to accommodate that interest. Veterinary educators have not cultivated a sufficient interest among veterinary students, nor provided sufficient training opportunities to prepare the next generation of research scientists for academic, industrial, and public service positions. In addition, there are multiple factors that may dissuade students from entering PhD programs, beginning with the length of time needed to obtain graduate degrees following the previous eight years to attain the DVM degree, the amount of student debt carried by students after graduating from veterinary schools, and the lack of public or private support of graduate student stipends. For students inclined to pursue a career in the academe, there is the difficult

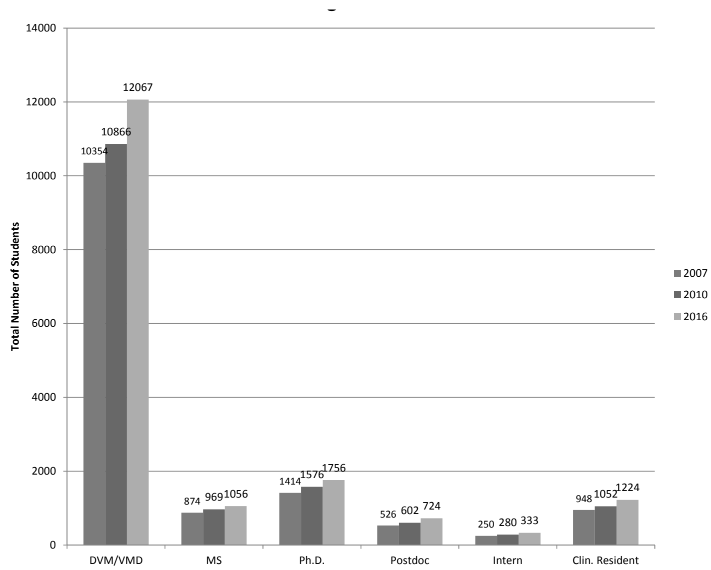

FIGURE 9-5 Total numbers of DVM/VMD and post-graduate students in 2007 and projected for 2010 and 2016, as reported by institutions responding to committee survey.

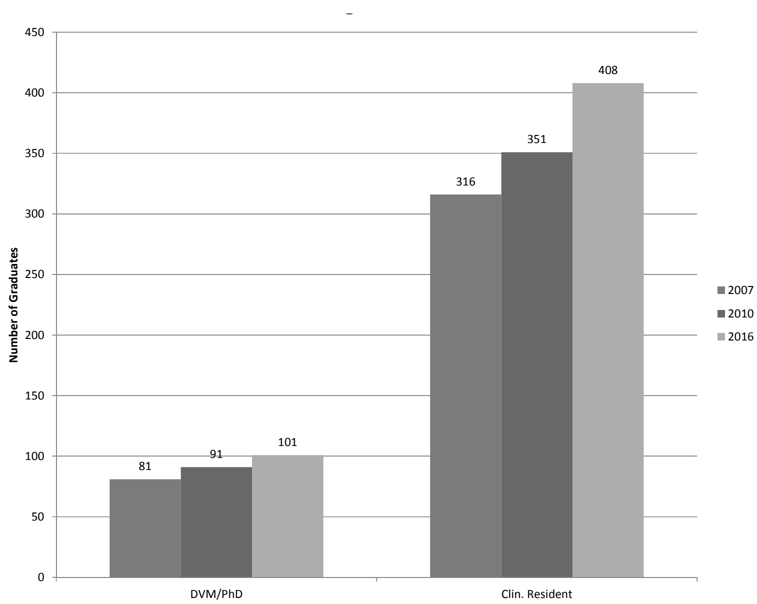

FIGURE 9-6 Number of recipients of PhDs and board certifications (DVMs) in 2007 and projected for 2010 and 2016, as reported by institutions responding to committee survey.

reality of having to obtain external research funding to cover a portion of one's own salary, as well as to support technicians and graduate students. NIH grants for graduate students do not provide faculty salary support, so the costs of training graduate students are drawn from internal resources that could have been used to fulfill the states' commitment to train entry level veterinarians. In some cases, there are issues associated with spousal/partner hires for finding two positions for professional faculty recruitments.

Yet, veterinary schools are in desperate need of trained graduates for faculty positions in structural biology, physiology, pharmacology, pathology, clinical pathology, infectious diseases of animals and zoonotic diseases, virology, microbiology, food safety, epidemiology, and nutrition. The needs include individuals with advanced training with select infectious agents (which require biosecure facilities), alternative immunological or pharmaceuticals for preventing or treating diseases, epidemiological modeling, and comparative medicine. In the near future, the profession will have major setbacks if adequately-trained professionals are no longer available in veterinary colleges.

Within academic veterinary medicine, the demand for veterinarians with advanced training for instructional and research purposes is far outstripping the available candidates. As noted earlier in this chapter, there were 260 vacant faculty positions in 2007. The positions needed by 2016 are projected to be 572 (new positions and replacements for retirees). However, there is little evidence that the academic veterinary community will meet its own needs let alone those required for state diagnostic laboratories, federal research and regulatory agencies, or for high-paying jobs in the pharmaceutical and biologics industry, for positions in research, safety studies, and efficacy trials, among others. A notable bright spot, however, is the increased growth of and interest in MPH and MPVM programs (Box 9-2).

Extramural Support for Graduate Academic Training

The principal source of public funding for graduate training was from the National Institutes of Health (NIH) and in particular, the National Center for Research Resources (NCRR), which provided most support for veterinarians pursuing advanced degrees in research. For example, NCRR provided three year training grants to DVMs pursuing a PhD degree at one of 14 Institutional Training programs around the United States that focus on various aspects of comparative medicine. NCRR offered pre-doctoral and summer training grants as well. At the time this report was released, NCRR programs were being reorganized under NIH's new Office of Research Infrastructure Programs. As noted in Chapter 6, a number of other NIH institutes provide funding for advanced training of veterinarians, and there are some funding and training opportunities available from the Department of Homeland Security (DHS).

BOX 9-2
Increasing Number of Master's Programs

In contrast to the relatively modest growth of DVM/PhD candidates, the number of DVMs pursuing Master's degrees in public health (MPH) or preventative medicine (MPVM) has increased sharply, because the number of veterinary colleges offering such programs has grown from 4 in 2004 to 22 in 2008, and the number of students who enrolled had increased from 30-40 in 2004 to 274 in 2007. Based on the committee's survey, veterinary colleges predict student enrollments in the MPH programs to increase to approximately 500 by 2016. The increase in the number of programs has been a response to the growing awareness of the role of veterinarians in infectious disease-related issues, including zoonotic disease and bioterrorism.

Other agencies, such as USDA, do not provide any support specifically for advanced academic training in veterinary medicine, although a modest level of fellowship support is available, albeit with stipends that are significantly lower than those from NIH. It is a concern that USDA, which employs the largest number of public practice veterinarians and which has longstanding vacancies, due in part to a lack of qualified candidates, does not support graduate research and educational opportunities for veterinarians (GAO, 2009).

The mission of the land grant partnership between states and the federal government has a broader scope than just increasing animal production. Individuals with advanced training are needed to address the multidisciplinary problems and issues facing U.S. agriculture, such as the control of zoonotic diseases, food safety, animal welfare, and environmental quality. Failure to address these issues will lead to losses of sustainable agricultural infrastructure in the United States. Among the needs of USDA, for example, is a future workforce of researchers who are trained to work with pathogens that can threaten human and animal health. Hands-on training would come from work in Biosafety level 3 (BSL-3) Ag and BSL-4 facilities mentored by the experienced workforce with expertise in those fields.

RESEARCH IN ACADEMIC VETERINARY MEDICINE

Research in academic veterinary medicine is essential to advance the profession, and to forge progress in animal health, biomedical sciences, and ecosystem health. Research is an important mission of the veterinary colleges that goes hand in hand with developing the next generation of scientists, some of whom will become veterinary faculty. Over the last five years, the amount and diversity of research funding that supports veterinary research has increased significantly, which demonstrates the broader role that veterinarians are now playing in human and animal research. Table 9-3 compares research expenditures of veterinary schools in 2002-2003 to that in 2008-2009 (NRC, 2005a; Buss et al., 2006; AAVMC, 2009a). In that time period, total research funding to veterinary colleges increased by 57%, from $321 million to $503 million. The most significant increase was in funding from the agencies within U.S. Department of Health and Human Services. Support from NIH, the Centers for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA) grew by 81%, from $155 million to $280 million during the same time period. Funding from industry and private sources also grew significantly, as did support from other federal agencies, such as the Department of Homeland Security.

Not surprisingly, however, some colleges of veterinary medicine are able to attract more research dollars than others. As Table 9-4 shows, more than half of NIH funding to veterinary colleges went to 5 institutions. For perspective, the total funds awarded to all veterinary colleges was approximately $171 million, about 0.7% of the NIH extramural funds awarded to all institutions in 2011 (BRIMR, 2012).

TABLE 9-3 Funding for Veterinary Research

	Amount (millions)		Number of Awards	
Funding Source	2002-03	2008-09	2002-03	2008-09
National Institutes of Health; Centers for Disease Control and Prevention; Food and Drug Administration	155.6	280.64	1,247	1,337
U.S. Department of Agriculture	34.4	37.18	595	637
Department of Defense	5.9	5.99	53	64
Environmental Protection Agency	1.8	2.98	31	20
National Aeronautic and Space Agency	2.6	2.7	24	12
National Science Foundation	3.5	3.56	48	43
Department of Interior	0.8	7.25	34	26
Other Federal Agencies	7.6	16.13	116	119
State Agencies	38.8	41.3	558	356
Industry	25.2	36.85	942	1,160
Private	30.4	42.36	1,291	1,961
Other	14.6	26.11	855	523
Total	321.2	503.05	5,794	6,405

SOURCE: NRC, 2005a; AAVMC, 2009a.

TABLE 9-4 National Institute of Health Funding to Veterinary Colleges, 2011

Rank	College	Funding for Veterinary Medicine
1	University of California, Davis	$24,630,734
2	Colorado State University, Fort Collins	$18,641,724
3	University of Pennsylvania	$18,423,516
4	Cornell University, Ithaca	$16,799,182
5	University of Wisconsin, Madison	$9,411,401
6	University of Missouri-Columbia	$8,304,053
7	Michigan State University	$8,132,386
8	Louisiana State University A&M College, Baton Rouge	$7,862,278
9	Iowa State University	$6,869,067
10	Washington State University	$6,446,399
11	Tufts University Boston	$5,398,692
12	Ohio State University	$4,526,233
13	Kansas State University	$4,364,856
14	North Carolina State University, Raleigh	$4,359,214
15	University of Georgia	$3,875,194
16	Texas A&M University System	$3,334,201
17	University of Minnesota Twin Cities	$3,160,379
18	University of Illinois Urbana-Champaign	$2,715,721
19	Purdue University West Lafayette	$2,709,182
20	Oklahoma State University Stillwater	$2,468,411
21	University of Tennessee Knoxville	$2,415,177
22	Virginia Polytechnic Institute and State University	$1,335,146
23	University of Florida	$1,247,198
24	Tuskegee University	$884,127
25	Texas Agrilife Research	$815,048
26	Oregon State University	$794,828
27	Auburn University At Auburn	$375,520
28	Mississippi State University	$337,379
	Grand Total	$170,637,246
	Mean	$6,094,187
	Median	$4,117,204

SOURCE: BRIMR, 2012.

NIH awards data also show that departmental and other units outside of veterinary colleges that provide post-DVM training, for example in laboratory animal medicine and pathology, are more successful in attracting research funding than some colleges (BRIMR, 2012). Heavy teaching and clinical service loads, along with an institutional culture that some would contend does not place a high enough value on scholarship, undermines the competitiveness of veterinary schools in attracting research funding.

There is a very long list of research areas in which the veterinary profession is well-positioned to play a major role. For example, a better understanding of the causes of human cancer, nutritional diseases, genetic diseases, and respiratory diseases are especially relevant to research with companion animals that live in the same environment as humans. The key to assuring that the profession remains a part of the critical research that is in front of us is to have the future workforce recruited and directed towards these issues. However, the sole dependence of veterinary medicine on NIH funding, which only supports animal research related to human diseases, is insufficient. Veterinary medicine has a responsibility to address animal disease for the sake of animals.

As Table 9-3 shows, support from USDA, which has historically played critical roles in food safety research and research to prevent and control infectious diseases in livestock and poultry, was relatively flat in the five-year time period between 2002-3 and 2008-9. It is noteworthy that the agency has not expanded the involvement of veterinary medicine in its pursuit of new research issues related to a litany of concerns: the control of infectious and zoonotic diseases, antibiotic resistance, antibiotic alternatives, changing animal production environments, identification and control of the sources of foodborne diseases in meat and produce (for example *E. coli* O157:H7), the role of animal welfare in food safety, and the interaction of wildlife and natural ecosystems with food animals (NRC, 2005a; Jay, 2007, 2008).

Two National Research Council reports, the "Critical Needs of Research in Veterinary Science" (NRC 2005a) and "Animal Health at the Crossroads: Preventing, Detecting and Diagnosis of Animal Diseases" (NRC 2005b) address the urgency of the need for increased funding and support for veterinary science. Currently, federal funding ranks from poor to modest for addressing animal diseases in production environments, wildlife, and for food safety and human health. Much of veterinary research is directed to the recognition of the cause of diseases; definition and diagnosis of diseases; response in the form of vaccines, pharmaceuticals, and management around the disease; and/or prevention. The latter is critical in the case of One Health as the profession works to prevent the spread of infectious disease to people. In addition to this, animals serve as sentinels of environmental threats, as demonstrated by the recent case of melamine in pet food. USDA, along with counterpart mission agencies that address human and ecological concerns, could provide the spark to ignite the collaborative research activities related to One Health (King et al., 2008).

A major deterrent to the continued advancement of research in veterinary medicine is the lack of interest on the part of any federal or state agency or of industry and commodity groups to provide sufficient support for any of the animal species or their ecosystems. Veterinary medicine is the profession between human and animal health; it works at the interface of food and the environment. Animal diseases that affect the efficiency of food production, the spread of pathogens through ecosystems to fruits, vegetables and nuts, and the emergence of diseases from wildlife are all areas that require attention for funding from government and philanthropic organizations in order for the profession to thrive. This is essential for all of humankind as well as for maintenance of the quality of life and a sustainable global ecosystem.

The forecast through 2016, as reported to the committee, indicates a lack of educational programs devoted to training future academicians, public practice professionals, and biomedical scientists, and the lack of an incentive structure to bring more students into these fields. Additional faculty members are needed to address the diverse curricular, research, service, and outreach activities demanded by stakeholders, and in particular, to fill the roles the profession hopes to play in addressing One Health issues. That includes a need for expertise in ecosystem health, global health, food safety, animal welfare, disease recognition, response, recovery and prevention, and biosecurity. However, this is only likely to happen with national investments in academic veterinary medicine to train the future workforce in these fields, and a commitment on the part of veterinary colleges to give these issues greater priority.

Without new faculty members, the future of veterinary medicine is unsustainable. In the future, trained scientists in the scientific disciplines basic to veterinary medicine will be in critical need of support. Allowing faculty salaries to be supported on federal training grants and making federal facilities available for the type of educational training that addresses national needs are two partial solutions. The concept of Centers of Emphasis related to national needs would also be an ideal means of leveraging expertise across the veterinary schools.

Despite increasing demands for an expansion of veterinary expertise and research over the last decade, the veterinary workforce has not grown significantly (NRC, 2005a). The potential for the profession and its impacts on society will only be reached if there is adequate infrastructure and financial resources to develop a more highly-trained veterinary workforce. Until that occurs, critical national needs will remain unattended.

10

An Economic Perspective on the Veterinary Profession

INTRODUCTION

Previous chapters of this report describe the committee's examination of trends, such as the growth of the U.S. population of companion-animal owners, the consolidation of the cattle industry, and job vacancies in the pharmaceutical industry as indicators of the demand for veterinary services. The supply of available veterinary expertise was examined from the perspective of anticipated retirements, membership in professional associations, and the numbers of student deciding to pursue (or not to pursue) advanced training, for example.

In this chapter, the economic aspects of veterinary medicine are examined as an indicator of how well the supply of veterinarians is matched by the demand for their services. From both a practical and economic perspective, the nation's veterinary workforce is most valuable when the skills, education, and experience of veterinarians match the jobs they hold. Veterinarians who have greater investments in education would expect to be rewarded with higher earnings and anticipate fulfillment in their careers once their hard-earned skills are put to good use. The nation receives the full benefit of its investment in veterinary education through the quality of care available to animals and in improvements in public health.

One would also expect a veterinary education to yield financial returns for graduates comparable to those in other careers that have similar educational requirements and lifestyles and, indeed, with returns on other financial investments of comparable risk. Of course, financial return is just one dimension of the gains associated with education. Many people value the lifestyles and other intrinsic forms of satisfaction associated with education. And of course, many veterinarians value the opportunity to work with animals, to work outdoors, and to work in science.

From an economist's perspective, the veterinarian position match is a two-way street. Employers will seek to take advantage of the available skills in the workplace, moving the more educated and skilled into more demanding roles and using the less skilled when it is more economical. The nation's public and private sectors can construct their programs for animal care and public health to take advantage of appropriate skills in each role.

Mismatches between levels of educational attainment and workforce roles diminish the value of people in all professions, including veterinary medicine. One kind of mismatch can occur, for example, if demand exceeds capacity. Employers raise salaries hoping to attract individuals with the needed skills and as a result, salaries can climb beyond what is warranted relative to the level of education and skills held by job candidates. If there are too few veterinarians (in spite of the high wages offered), the knowledge inherent in veterinary medicine cannot be used widely because there are simply too few veterinarians to serve all needs.

Another kind of mismatch occurs when capacity exceeds demand. Salaries then stay below what is appropriate for the level of education and skills of a DVM. With lagging salaries, veterinarians can be underemployed, causing some to shift to careers that do not make full use of their specific veterinary skills and education. In a sense, they are victims of an overinvestment in veterinary education, meaning that the expensive training of veterinarians will not be fully worthwhile for all who are trained. Many will find their careers unsatisfying because their jobs are not challenging, and many new graduates will have difficulty in repaying their educational loans.

A third kind of mismatch occurs when the education is not attuned to the needed occupational roles. For example, an educational program that prepares many veterinarians for traditional large-animal practice could be a disservice to its graduates, as the demand for traditional large-animal veterinarians is decreasing. A program that fails to select for and develop skills in leadership, teamwork, communication, planning, and budgeting will provide a poor preparation if veterinarians are expected to manage teams of technicians and assistants.

The remainder of this chapter examines economic characteristics of the veterinary profession for signs that these mismatches might be occurring and offers suggestions for ways to establish an economic equilibrium between supply and demand.

THE RATE OF RETURN OF A DVM DEGREE

One way to assess the nation's workforce requirements in veterinary medicine is to consider the level of earnings relative to the investment in a veterinary education. It is then possible to forecast how many veterinarians are likely to be employed in jobs that use their skill at that level of earnings. The number of veterinarians, their earnings, and the cost of education are important for understanding the changes that occur in the profession and for judging how well the number of veterinarians matches the nation's requirements (Getz, 2007).

Using the balance between earnings and the educational investment to assess workforce needs produces different results than other analyses of the veterinary workforce, such as a recent study of veterinary medicine in New England (Koshgarian et al., 2008). That study forecast a shortfall of 650 veterinarians in New England in 2014 and a national shortfall of 4,000. The national forecast in the study predicted 3,000 new openings a year for 8 years (2006-2014) compared to an inflow of 2,700 new DVMs a year, for an annual shortfall of 10%. The study drew on the work of the so-called KPMG study (Brown and Silverman, 1999b), which focused on trends in sectors that employ veterinarians and on the age profile of veterinarians to forecast retirements (assumed to occur at the age of 65 years), but which did not consider the level of earnings associated with a DVM degree.

Planning for future workforce requirements by looking only at the number of veterinarians without considering earnings is likely to be misleading. For example, there are many older food-animal veterinarians in New England. Looking at the average age of veterinarians might lead to the view that more DVMs are needed as replacements for retirees. If the demand for food-animal veterinarians in New England is declining as seems more likely, however, younger DVMs are likely to have switched careers, leaving an aging group of veterinarians whose salaries are stagnating, and are insufficient to attract replacements. Older veterinarians are less likely to switch careers even though earnings have leveled out. They may choose to postpone retirement to reach financial goals. As the aging group of veterinarians ultimately retire, the result is likely to be a smaller number of practicing food-animal veterinarians. A consideration of earnings leads to the conclusion that fewer food-animal veterinarians are likely to be employed in New England in the future. In other words, an aging workforce with sluggish growth in earnings does not signal an impending surge in employment opportunities.

Employing veterinarians requires financial resources, of course. But substantial financial resources also are required for providing training in veterinary medicine. The expected earnings and other rewards should be balanced with the cost of the education. This discussion begins with a focus on the rate of financial return and then considers other values associated with veterinary careers.

The Influence of Education on Earnings

The educational "rate of return" relates the cost of an education to one's future earnings. An increase in earnings that results from of having attained an education is the "financial return" on that investment. As a point of reference, the rate of return on investment in a baccalaureate compared with a high-school diploma is approximately 13-16% (Getz, 2007). Assuming a real rate of interest (after inflation) of 3%, the present value of lifetime earnings for life scientists with a baccalaureate (BS) degree is $1.0 million for men and $0.8 million for women; these reflect average rates of survival and labor-force participation of college graduates of each sex.

To understand the financial return on investment in obtaining the DVM, it is helpful to look at average earnings of DVMs who are in private practice and work exclusively with companion animals. DVMs who work exclusively with small animals in private practice without post-graduate training are the largest group of veterinarians, and their earnings strongly influence the earnings of DVMs in other roles.[1] Of course, veterinarians become seasoned with experience in a particular kind of career and do not easily move among the different categories. There also are important differences in earnings among categories. However, many new DVMs can choose among the categories, and shifting is common in the first years of a career. As a consequence, earnings in the dominant group, small-animal practice, have an important influence on earnings in the others.

Figure 10-1, which is a snapshot of the average income of small-animal practice owners and associates in 2005, shows that male practice owners with more years of job experience enjoyed substantially higher earnings—a phenomenon similar to that seen in many other professions. The earnings profiles for female practice owners and for career associates of either sex, however, are relatively flat with increased experience. Those differences (which can be attributed to various factors; for example, see Box 10-1) mean that the rate of return on investment in obtaining the DVM differs significantly between men and women and between practice owners and career associates.[2]

The simplest method for determining the financial rate of return to a DVM is to compare the earnings of those holding a DVM with the earnings of those who are working as life scientists and engineers and have a BS as their highest degree, separately for men and women (Bell et al., 2007, Figure 2-73). The path to a DVM involves the cost of forgoing earnings as a BS life scientist and paying tuition for 4 years of education after earning a BS degree with earnings beginning in year 5. From the point of view of an individual student, tuition and the forgone earnings are the primary cost of education. Assume that is \$19,000 per year for an in-state student (the 2008-2009 average) (AAVMC, 2009) and \$36,000 per year for out-of-state students. From the perspective of universities and state governments, the full cost of training, including state government appropriations and revenues from other sources, is about \$66,000 per student per year (AAVMC, 2009).

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[1]This analysis assumes that the average DVM is similar to the average BS holder in the life sciences in most respects other than completion of the more advanced degree.

[2]A note of caution: The response rate for the American Veterinary Medical Association compensation surveys is about 25%. If DVMs who are more successful are more likely to respond, the reported rate of earnings may exceed actual averages. Nonresponse may be highest among those who choose not to join the association and who are not in veterinary practice. And response rates may differ by sex in a manner that could distort comparisons.

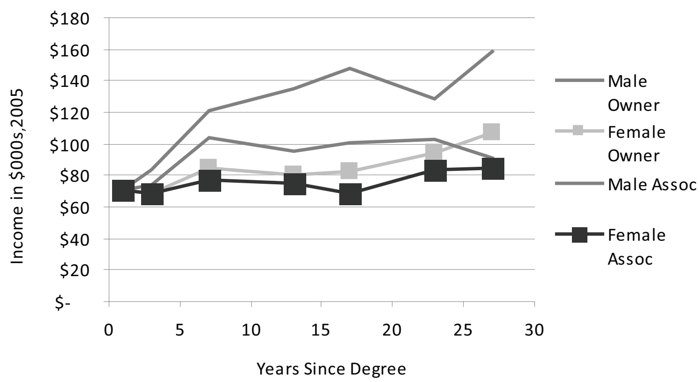

FIGURE 10-1 Mean incomes in small-animal practice. DATA SOURCE: Calculated from AVMA, 2007d.

Assume also that the mean starting salary of veterinarians is $71,000 and of people who have a BS in the life sciences is $35,000. The present value of lifetime earnings of male practice owners net of the present value of the tuition payments is $1.6 million. Comparing that with the earnings of life scientists who have a BS yields a rate of return of 17% on investment in obtaining a DVM, which is comparable with returns for degrees in other programs of higher education. For female practice owners, however, the present value of lifetime earnings net of tuition is $0.9 million—a 10% rate of return compared with the earnings of BS life scientists. For male career associates, the present value of lifetime earnings net of tuition is $1.2 million, for a rate of return of 11% compared with the earnings of BS life scientists. For female career associates, the present value of lifetime earnings less tuition is $0.8 million, for a rate of return of 7% (Table 10-1).

For nonresident students, tuition and fees average $36,000, and rates of return are commensurately lower, as Table 10-1 shows. With out-of-state tuition and fees, the rate of return on the investment in obtaining a DVM is below 10% for all, except for male practice owners, and particularly lower for female career associates, which is 4%.

The figures in Table 10-1 are not adjusted for the number of hours worked per week, which can make a difference in the rate of return on an educational investment. As a group, associates work fewer hours than practice owners, and female associates work fewer hours than male associates. Adjusting the figures relative to hours worked might increase the rate of return of obtaining a DVM for associates relative to practice owners (and women relative to men). However, based on hours actually worked, the total return on investment will be lower for associates and women.

BOX 10-1
Possible Reasons for Differences in the Earnings of Male and Female DVMs

A partial explanation in the salary differences between male and female DVMs may be a greater likelihood that women will work part-time. In a recent survey, about 10% of male DVMs reported working part-time compared with 20% of female DVMs. Women cite childcare and a preference for working part-time more commonly than men (Donlin, 2008). In most professions, workers who withdraw from employment and then return later suffer a decrease in earnings of about 10% for each year out of the workforce (Flyer and Rosen, 1997).

A recent analysis of DVM salaries concluded that variables such as experience, hours and weeks worked, having board certification, having held a residency position, having an equity stake in the business, living in a small or moderate community, and having been married (as a proxy for having children) account for the majority of differences between male and female DVM earnings. When these factors were considered, the difference in earnings between males and female veterinarians was reduced to about 9.0% (Goldin and Katz, 2010).

Estimating the relative importance of several possible causes of the sex differential among private-practice owners will require careful investigation (Smith, 2002). One set of hypotheses involves barriers that are more consequential for women, including access to funds—given student debt—to buy more lucrative practices, the willingness of established practice owners to sell to women, and even the possibility that clients spend differently when obtaining veterinary services from women than from men. A second set of hypotheses involves possible differences in DVMs' preferences. Female practice owners may prefer to work fewer hours, spend more time with each client, and show less zeal for owning practices and maximizing profit. A third set of hypotheses involves possible differences between men and women in responding to surveys. Surveys that request information about income and performance may have relatively low response rates. If the women and men who respond tend to come from different parts of the distribution of outcomes, the reported differences between them will be a distortion of the actual differences. If men are less likely than women to respond because they view their income as less than their expectations, the reported differences will exaggerate the sex differential.

Other hypotheses are related to the maturity of the profession and the timing of women being allowed unbiased access to admission into veterinary colleges. Women began to exceed half the enrollment in DVM programs in the 1990s. As more women began to be admitted into DVM programs, the market for private veterinary services matured. Female graduates found an arena in which there were fewer places to establish new practices and the practices available for sale were generally expensive. Another possibility is that male associates left the profession when earnings stagnated, and this resulted in the observed sex shift in the profession (Miller, 1998). Finally, outright sex discrimination in salary is a possibility. These hypotheses, of course, are not mutually exclusive and therefore need to be considered jointly. Finding and interpreting evidence to test them will be challenging.

TABLE 10-1 Estimated Average Return for Obtaining a DVM

	Average Rate of Return (percent)			
Annual Costs to Obtain DVM	Male Owner	Female Owner	Male Associate	Female Associate
In-state tuition and fees, $19,161	17.0	10.0	11.0	7.0
Out-of-state tuition and fees, $36,055	14.0	7.0	8.0	4.0
Operating cost per student, $66,366	10.0	5.0	5.0	2.0

DATA SOURCE: Calculated from AVMA earnings data and AAVMC, 2009.

From the point of view of the nation as a whole, the cost of schooling is the tuition paid by the students plus the funds budgeted by the government to help to finance the veterinary medical colleges. The benefits from that investment are reflected in earnings. At $66,000 per year, the total cost per student—tuition and fees plus state and other support, means that the rate of return to a DVM that reflects the full cost of the education is lower than the return that is visible to the individual student (AAVMC, 2009). As Table 10-1 shows, for male practice owners, the return that reflects the full cost is 10%; for female practice owners and male career associates, it is 5%; and for female career associates, it is 2%. Those returns are relevant to universities and state governments as they make decisions about where to invest public funds in educational programs, as discussed later in this chapter.

Now that 77% of new DVMs (active AVMA members with 2007 DVMs) and 42% of all DVMs (active AVMA members) are female, the rate of return for women is coming to dominate that of the profession and therefore defines the typical financial return on investment in obtaining the veterinary medical doctorate. More investigation will be needed to understand why female practice owners and associates earn less than male practice owners and associates and to judge whether female practice owners are likely to experience earnings more comparable with those of male practice owners in the years ahead. There appear to be many reasons why the earnings of women differ from men (see Box 10-1).

In addition, as national chains of veterinary clinics (such as Banfield, The Pet Hospital) provide an increasing share of all veterinary care, an increasing proportion of practicing veterinarians will be associates, not practice owners. The return on investment to practicing associates will play a larger role in defining the average return to DVMs than when a higher proportion of veterinarians were practice owners.

Financial returns are only one motive for pursuing a DVM degree. Many people seek a DVM because they value the opportunity to develop and use their skills in a life science to aid animals and their owners. They may value roles in improving public health and sustaining wildlife. Because these motives are important, there is no reason to expect that the financial returns in veterinary medicine will equal those of other health professions that involve similar levels of education. Nevertheless, the financial returns play a significant role in shaping the profession. At least one study on the interests of minorities in veterinary medicine suggests that the lower financial return of a DVM degree relative to an MD degree, and the prospects of carrying a high debt load after graduation might be among the factors that dissuade greater number of minorities from applying to veterinary school, particularly if they do not share the non-financial motivations for pursuing veterinary medicine (Kendall, 2004).

TRENDS IN EARNINGS

The earnings of DVMs had been on an upward trend over the last decade, recouping a decline in the 1980s and early 1990s (Getz, 1997). Figure 10-2 shows earnings for DVMs in private practice in 2006 dollars (that is, adjusted to constant 2006 dollars using the Consumer Price Index). The earnings are averages for veterinarians of all ages (and experience) employed full-time in four types of practice. All four of the practice types shown (and those not shown) experienced a substantial increase in earnings from 1995 to 2005. Equine veterinarians, who make up about 6% of practicing DVMs, showed the highest rate of increase in that time period. Veterinarians exclusively in small-animal practice, about two-thirds of the veterinarians, also showed marked increases.

The change in real earnings from 2005 to 2007, however, was essentially flat for small-animal practitioners, downward for equine practitioners, and upward for large-animal and mixed-practice veterinarians. However, salaries for both large- and mixed- animal veterinarians fell in 2009 while small-animal practitioners gained slightly (AVMA, 2011a). About 8% of AVMA members are in mixed-animal practice, which is more common in rural areas. Less than 2% of veterinarians serve large animals exclusively, and another 7% serve large animals predominantly.

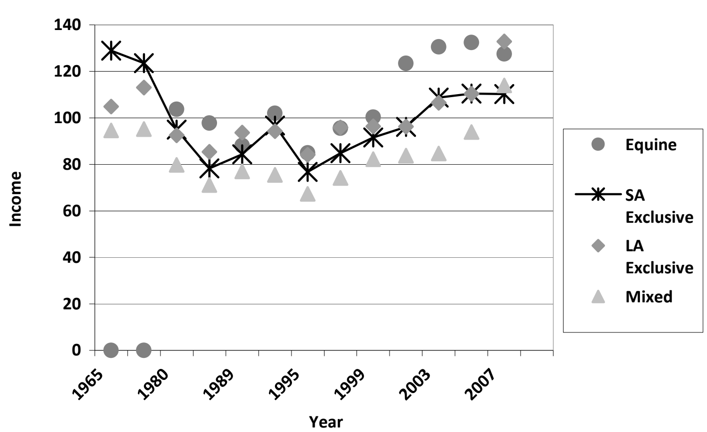

FIGURE 10-2 Mean DVM income (in 2006 dollars) in private practice, 1965-2007. DATA SOURCE: AVMA annual compensation reports.

The trends in mean earnings are also reflected in starting salaries, which began to rise in the late 1990s. Figure 10-3 shows the starting salaries of all DVMs in 1980-1982 and of large- and small-animal DVMs thereafter. The salaries shown are of those who enter each type of practice with a DVM and no further training. The starting salaries of small-animal veterinarians set the pace. The starting salaries of large-animal veterinarians, which numbered fewer than 3 dozen reporting in most years, show substantial year-to-year variability. Figures 10-2 and 10-3, when considered in light of the number of new graduates entering the workforce, discussed later in this chapter, suggests that a surge in the number of new DVMs as in the 1980s led to lower earnings and that constrained growth in the number of new DVMs as in the 1990s led to higher earnings. The current trend is toward increasing numbers of graduates. The starting salaries can be better understood in the context of the flow of new graduates, as shown in Figure 10-4. Some 30-40% of new DVMs who reported their first positions begin their careers in exclusively small-animal practices. Less than 4% begin in exclusively large-animal practices. The biggest change over the last decade, however, was in the share of those who had post-DVM training, going from 16% in 1999 to 49.2% in 2011, the majority of whom pursued post-DVM internships. Advanced training in specialty fields is playing a much larger role in the career paths of DVMs, as is discussed a little later in this chapter.

The Effect of Student Debt on the Rate of Return

Education that generates a high financial return to students might justify student borrowing to pay for some of the education. Borrowing, however, involves two limits. First is the need for an income stream large enough to repay the loans, on average. When the rate of return on the added education is low, the extra income needed to repay loans may not be forthcoming. The second limit on borrowing is on wealth. Some fraction of students will suffer personal reversals, accidents, or illness or discover a mismatch in their career. If they cannot call on other wealth to repay the loans, they will be forced into personal bankruptcy or into earning permanently low incomes, with severe consequences. Students have access to loans that they may not be able to repay. The average debt of new DVMs who had loans (about 90% of all new DVMs) was $142,613 in 2011. The average starting salary was $69,789 for exclusively small-animal veterinarians, the dominant group (Shepherd and Pikel, 2011). The ratio of debt to starting salary was 2.04. At the current (2011) rate of interest on student loans (6.8%), the annual debt service for $142,613 will be in excess of $18,000 per year for a 10-year payoff. This would put the debt at about 25% of the first year of income of an associate. Financial-aid professionals use a rule of thumb that the annual debt service on student loans should not exceed 10% of earnings (University of Minnesota, 2010). By that rule, an annual income of more than $180,000 would be necessary for DVMs to sustain the average annual debt repayment of $18,000 without imposing a difficult burden on themselves. For some fraction of students, particularly those who earn less than the average, the debt load may prove overwhelming. Although the trend toward increased student debt is common in higher education, it is a particular difficulty in veterinary medicine, in which incomes remain low relative to the cost of the education.

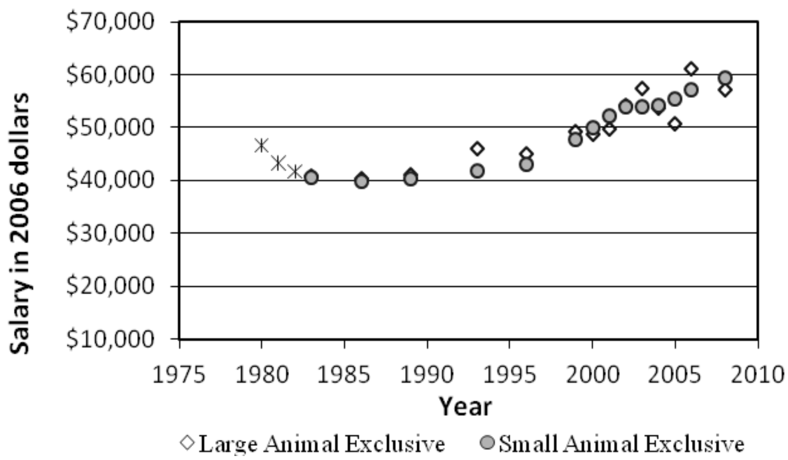

FIGURE 10-3 Mean starting DVM salaries (in 2006 dollars). NOTE: Response rates of annual surveys of graduating DVMs are typically greater than 90%. DATA SOURCE: AVMA Annual Surveys of Veterinary College Graduates.

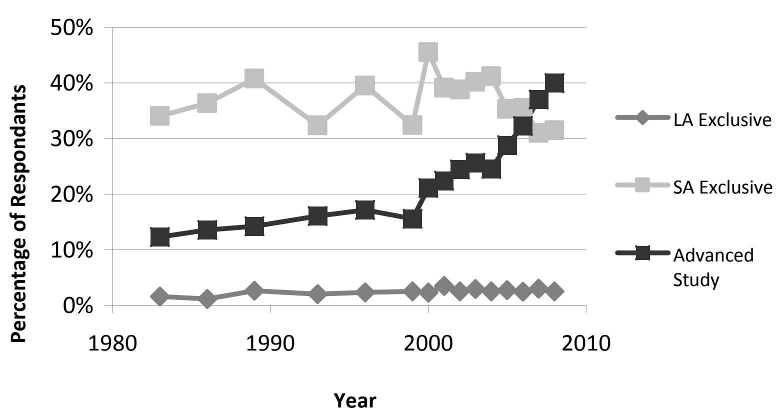

FIGURE 10-4 Positions taken immediately after earning DVM, by percentage of DVM respondents. NOTE: Response rates of annual surveys of graduating DVMs are typically greater than 90%. DATA SOURCE: AVMA Annual Surveys of Veterinary College Graduates.

Comparison of Earnings in Other Health Professions

The experience in other health professions reveals how different levels of education relate to lifetime earnings. There are important roles for 2- and 4-year degree-holders, for master's and doctoral graduates, and for those who have substantial postdoctoral training. The Bureau of Labor Statistics produces its *Occupational Outlook Handbook* every two years and it is the most readily available source of information on careers. The Bureau gathers data on many professions using standard methods so that information on earnings and educational requirements can be compared. That information is supplemented with the annual *Occupational Employment Statistics* (OES) survey. Together with the *Handbook*, the median earnings for health occupations reported in the OES survey gives a picture of the relationship between education and earnings in an array of health professions (see Figure 10-5).

Two-year associate degrees are inexpensive because they require less time of students and are generally offered by colleges that operate at modest cost per student. Holders of associate degrees, on the average, earn a substantial return on their investment in education as measured by the gain in earnings compared with those of typical high-school graduates. In the health professions, 2-year programs that produce registered nurses (RNs) yield very high returns. About three-fourths of new RNs enter their profession with associate degrees. In 2010, RNs had median earnings of $64,688 (BLS, 2011). Another occupation that usually begins with a 2-year degree is that of a dental hygienist. The median earning of hygienists in 2010 was $68,425.

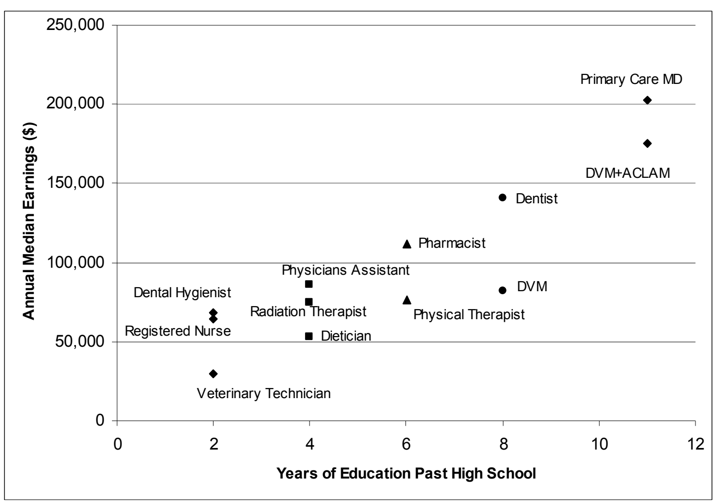

FIGURE 10-5 Median career earnings in the health profession. NOTE: DVM = Doctor of Veterinary Medicine; ACLAM=Diplomate, American College of Laboratory Animal Medicine; MD = Medical Doctor. SOURCE: BLS, 2011 and MGMA, 2011.

Four-year BS programs involve more cost both in student time and, typically, in college funding. BS degree holders generally earn more than 2-year degree holders to justify the added expense. In the health professions, physician's assistants (PAs) generally require at least 4 years of college, including at least 2 years before enrollment in the 2-year PA program. PAs in full-time clinical practice had median earnings of $86,403 in 2010. Dieticians must hold a BS; their median earnings were $53,248 in 2010. Radiation therapists may hold Bachelor of Arts (BA) or associate degrees or certificates; their median earnings were $75,000 in 2010 (BLS, 2011).

Master's degree programs often involve 2 years of education after a BS. Having more expensive education generally leads to higher salaries. Physical therapists (PTs) have a master's degree and averaged $76,315 in earnings in 2010. Pharmacists generally enter a 4-year doctor-of-pharmacy program after completing at least 2 years of college; median earnings of pharmacists in 2010 were $111,571 (BLS, 2011).

Doctoral programs generally involve 4 years of post BS education. Doctoral graduates usually earn enough to justify the higher investment in their education. Dentists, for example, had average salaries of $141,045 in 2010. Primary-care physicians generally have at least 3 years of residency training after receiving an MD or an equivalent degree. Earnings of primary-care physicians were $202,392 in 2010. Specialty physicians (not shown in figure 10-5) had median earnings of $356,885 with 14 to 17 years of post-secondary education (MGMA, 2011).

Veterinary medicine contrasts substantially with the pattern of education and earnings outlined above. Veterinary technicians may begin with 2-year associate degrees or with 4-year BS degrees, much like RNs. In 2010, veterinary technicians had median annual earnings of $29,702 (BLS, 2011). That rate is considerably less than half of the dental hygienists and RNs who had 2-year degrees. There do not appear to be BS and master's-level occupations in veterinary medicine that are comparable with PAs and nurse practitioners.

Veterinarians with a DVM earned a median of $79,050 in 2010 (BLS, 2011). That rate is well below the earnings of pharmacists who have 2 years less education and somewhat more than half of those of dentists who, similar to the DVM, have 4 years of post BS education.

Postgraduate study, however, leads to substantial gains in veterinarians' earnings. Some 49.2% of recent DVM graduates now pursue additional study. The average earnings of a DVM board-certified in laboratory-animal medicine was $175,034 in 2009 (AVMA, 2011a). The advanced training required for board certification yields substantially higher earnings than the DVM degree itself. In 2008, 9,305 DVMs, or about 11% of all DVMs were board-certified in at least one specialty. The DVM degree serves increasingly as preparation for more advanced study. It is difficult to forecast how the rapid increase in new DVMs who pursue advanced study may affect earnings in the decade ahead. It is possible that, as the number of board-certified DVMs increases, the market for specialty services will become saturated, depressing average earnings.

Thus, there is a mismatch between veterinary medicine and the other health professions in the cost of education versus typical earnings. The mismatch causes underemployment, turnover, career-shifting, and substantial financial burdens for graduates who have education loans. Underemployment means that professionals spend large amounts of time performing tasks that could be performed at lower expense by persons who have less education. Because of the underemployment of highly-trained professionals, earnings opportunities for those who have less training are limited; they cannot earn as much as the bottom salaries of the more highly-trained professions in veterinary medicine. Turnover means that employees move from job to job, seeking modest improvements in earnings and prospects. Career-shifting means that people move from occupations for which they had trained to occupations for which their training is less suited. Underemployment, turnover, career-shifting, and extraordinary financial burdens are all symptoms of occupations in which educational programs are not well matched to career opportunities.

SUPPLY OF GRADUATES

The supply of veterinarians has been growing since the late 1990s, as shown in Figure 10-6. The number of veterinary colleges expanded rapidly in the 1970s and early 1980s, and existing colleges expanded their enrollment. The surge in graduates abated in the 1990s, with the number of new DVMs at about 2,200 per year from 1985 through 1995. With the addition of a new college in California and the expansion of enrollment in other colleges, the number of graduates grew by more than 10% from 2000 to 2007, to nearly 2,500 graduates per year. On the basis of the number of students enrolled in 2010, 2,563 graduates were expected to be awarded a DVM from one of the 28 U.S. veterinary schools. The New England study mentioned earlier suggests that the number of graduates will average 2,700 by 2014 (Koshgarian et al., 2008).

Graduates of some off-shore veterinary medical colleges may, under some conditions, enter practice in the United States. Ross University in St. Kitts and St. George's University in Grenada have articulation agreements whereby graduates of baccalaureate (4-year) colleges in the United States gain priority admission to the off-shore unaccredited DVM programs. The Ross program, for example (http://www.rossu.edu/veterinary-school/faculty/), offers dual-degree programs with five U.S. colleges. Ross requires 28 months in residence (three semesters per calendar year) in St. Kitts for seven semesters of education followed by three semesters of clinical training in one of 21 U.S. veterinary medical schools. Non-accredited foreign DVM programs generally require clinical experience in a domestic veterinary medical college for licensure in the United States. The Caribbean schools may add several hundred DVMs to the U.S. supply per year in the years ahead. AVMA has accredited nine veterinary medical colleges in Europe and Australia. Those colleges will award about 125 DVMs per year to U.S. citizens, adding about 5% to the number of U.S. DVM graduates if all of them repatriate. Foreign graduates who achieve licensure in the United States find employment at Banfield, The Pet Hospital, and in many other areas of veterinary medicine. The overseas training programs compete with domestic veterinary programs and are growing.

The combined expansion of domestic DVM graduates and increasing foreign supply of DVMs is likely to increase the number of new DVMs who are beginning careers in the United States to over 3,000 per year within the next 10 years. Those sources of new DVMs would make up for the national shortfall in supply projected in the New England study mentioned above (Koshgarian, 2008).

The Bureau of Labor Statistics forecasts growth in employment in veterinary medicine for 2008 to 2018 (Lacey and Wright, 2010) with a 33% expansion in employment of veterinarians and 36% expansion in employment of veterinary technologists and technicians. The analysis cites expected growth in the pet population with more pet owners seeking veterinary service and the availability of increasingly sophisticated veterinary services. The analysis, however, does not take into account earnings and the likely increases in productivity as average earnings increase.

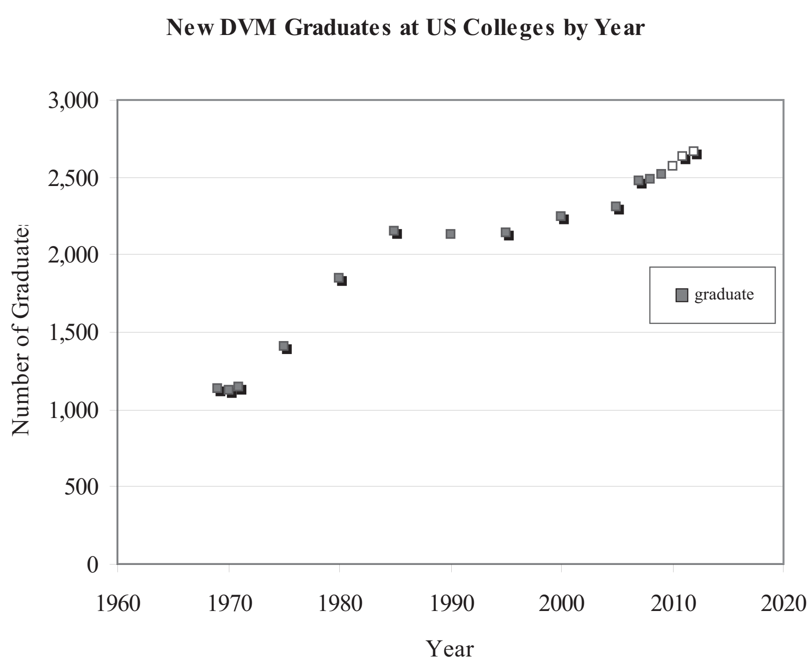

FIGURE 10-6 New DVM graduates by year in the United States. DATA SOURCE: AVMA with extrapolation based on current enrollments.

The role of veterinarians in addressing public health, food safety, biosecurity, animal welfare, and environmental issues will increase when public support for employment of veterinarians to address these problems expands, with compensation levels sufficient to attract and sustain appropriate talents and skills. The Bureau of Labor Statistics doesn't mention growth in employment in these areas. When substantial employment opportunities in these areas are imminent, the veterinary colleges would want to expand the number of graduates. They are also likely to expand their research roles to widen the knowledge base of the profession in these emerging areas.

INCREASING THE RATE OF RETURN OF A VETERINARY EDUCATION

Veterinary education needs to match graduates to opportunities more effectively. The disappointingly low level of earnings of veterinarians as compared with other health professionals and the low rate of return to the DVM without advanced training are important signs that veterinary education is in need of more careful alignment with career opportunities. Also, the current veterinary workforce serves mainly companion animals. However, services related to food animals and wildlife, industry and laboratories, and public health are also important. Demand may be growing more rapidly in some sectors than in others. It will be important to adjust enrollment and veterinary education so that the preparation of graduates matches job opportunities. The challenge to the veterinary colleges is to adjust their faculty, curricula, and tuition fees in light of the changing levels of public subsidy, as discussed in Chapter 9. Several strategies might be considered:

First, holding the rate of growth in the number of graduates to a modest increase would allow the demand for veterinarians to grow more quickly than the supply and lead to an increase in average earnings, which would help to bring earnings for the DVM more into line with earnings of other health professionals.

Second, the regulatory process might be used to restructure the profession. With so many DVMs pursuing advanced training, a DVM degree is no longer the terminal degree in veterinary medicine. DVMs are now among several kinds of professionals who work with animals and public health. The growth of corporate practice, the increasing sophistication and scale of livestock production, telemedicine, and the prospect of elaborate electronic databases to track animals and outbreaks of illness may make it possible for baccalaureate and master's degree holders who have specialized training to play important roles. The regulatory environment can adjust to changing circumstances by recognizing new roles.

Veterinary Technicians

The number of colleges offering 2-year veterinary-technician programs has grown dramatically from 69 in 1997 to 154 in 2008 (18 are 4-year programs), and more will open (Peter Bill, Director, Veterinary Technology Program, Purdue University, 2009, personal communication). Most of the programs are in public and proprietary 2-year colleges. By 2010, students must have graduated from an AVMA-accredited veterinary-technician program if they are to take the Veterinary Technician National Examination, which is a requirement for licensure in 44 states. The 2-year colleges generally offer inexpensive programs and attract students from local areas. There are also distance-education opportunities. As noted earlier, veterinary technicians earn relatively modest salaries. It is possible that underemployed DVMs are performing functions that would be performed by veterinary technicians if the DVMs were fully employed in tasks that required their expertise.

The preceding idea suggests a comparison of the number of veterinary technicians with the number of veterinarians. According to the *Occupational Outlook Handbook*, 79,600 veterinary technicians in 2008 worked with 59,700 veterinarians—1.33 technicians per veterinarian (BLS, 2010). In contrast, 2.6 million registered nurses worked with 661,000 thousand physicians, a ratio of almost four to one. Exploring the relationship between doctor and technician among professions would yield a deeper understanding of differences. There were 1.23 dental hygienists per dentist and 1.58 pharmacy assistants per pharmacist in 2008. With rising incomes of veterinarians, there might be opportunities for more technicians at higher levels of earnings. Some veterinarians see technicians as competition, taking away jobs they do routinely. As veterinary incomes rise, technicians could be valuable assets who expand the practice range to underserved areas, add to the range of services offered by a practice, and increase the earnings of DVMs.

Veterinary Master's Degree

If real earnings for DVMs were to increase, the veterinary medical profession might introduce degree programs between the veterinary technician programs (2 years) and the DVM (8 years), the analogue of nurse practitioners, physician's assistants, and doctors of pharmacy. Such programs might entail 5 or 6 years of postsecondary education, some at the baccalaureate level and some in a professional program. Graduates of less-expensive educational programs would be well-trained professionals who are able to fill roles that are now generally filled in part by associates in veterinary practice. The specific forms and titles to be used could evolve with the programs.

The nurse practitioner profession provides an important analogue. Post-baccalaureate education of 12-36 months prepares nurses to be licensed to practice in a variety of clinical settings.[3] Applicants who have 2-year degrees or baccalaureates not in nursing may be required to complete up to three semesters of

[3]The master's programs at the Vanderbilt School of Nursing provide examples, http://www.nursing.vanderbilt.edu/programs.html.

coursework before beginning the master's program. Much of the master's-level education is tracked to a specific practice arena, for example, pediatrics, midwifery, or psychiatry. The clinical experience that is part of the educational program often uses a dispersed network of sites for a wider range of experiences. Near the top of the group are certified nurse anesthetists, who complete 24-36 months of training and earned an average of $168,000 per year in 2008 (Online Nursing Degree, 2010).

It would be expected that education could be much less expensive than that for the DVM and lead to well-paid roles in clinical, agricultural, and regulatory settings. For example, as the number of livestock producers declines, the demand for veterinary services in an area—that is, the revenue that a practice can generate in an area—probably also declines. Regions that formerly supported a veterinarian can no longer do so. This is a not a sign of a shortfall in the supply of veterinarians but rather of a shortfall in employment opportunities. A limited array of veterinary services might be possible with less-expensive, less-trained personnel. Specially-trained veterinary masters might be successful in rural areas that have less demand than can support a DVM. A veterinary master's service might be tied to a network of providers with telemedicine and coordinated records. An alternative proposal would be to create community health providers: half-time in private practice and half-time in health surveillance of livestock and wildlife. This strategy would be more expensive that using technicians, but it follows the practice used successfully in the past in national bovine tuberculosis and brucellosis programs.

Focused Veterinary Education

The selection of DVM students and the curriculum might focus on talents and skills that are likely to yield higher returns, reflecting lower cost education and higher earnings. In particular, the DVM might be more specialized, branching at some point during the 4-year program to give more emphasis to preparation for advanced study by some, for managerial roles for those pursuing roles as practice owners, and for supervisory and other roles in public health.

Specialization and Centers of Emphasis

The accreditation of the veterinary colleges (Box 10-2) has historically required each college to provide full clinical training for service to all species of domestic animals. Each college incurs the expense of a substantial animal hospital with facilities for species of little interest in a given state. Wisconsin might well prefer a higher level of support for dairy that would be possible by reducing expenditures on swine, small ruminants, and poultry. Given the declining support of state governments for veterinary training, changing the accreditation

BOX 10-2
Accreditation of Veterinary Medical Colleges

The American Veterinary Medical Association Council on Education accredits the veterinary medical colleges (AVMA, 2011d). The accreditation process sets 11 standards for the veterinary medical colleges, including curriculum and faculty. In most states, only graduates of accredited colleges and graduates of foreign programs who have satisfied requirements of the Educational Commission for Foreign Veterinary Graduates (AVMA, 2010f) or the Program for the Assessment of Veterinary Education Equivalence of the American Association of Veterinary State Boards may be licensed to practice.

rules could allow the veterinary colleges to specialize. Each may support training in the most popular areas, such as companion animals, and full training in the core disciplines that would prepare students for entry to advanced training. Each school may choose to offer advanced training in a limited number of specialties. Funding of premier programs in areas of national interest may come from regional consortia, from special tuition charges for advanced training in major areas, and from industry and government.

Because the veterinary medical profession will grow where there are employment opportunities, the veterinary medical colleges should recruit students and prepare them for tomorrow's careers. With some degree of specialization, individual colleges can concentrate on advanced training of higher quality in subject areas that address national needs. That might also improve the financial viability of the colleges and attract new sources of financial support. Developing a "critical mass" of expertise on particular aspects of veterinary medicine could also enhance the research missions of the schools.

The role of veterinarians in promoting public health, including jobs in government (see Box 10-3), might best be pursued by a carefully organized effort to increase the employment of veterinarians and veterinary technicians through support of a Center of Emphasis (described in Chapter 9) to address specific public-health problems. Veterinary training at various levels might then be designed to produce graduates who are prepared to fill the relevant roles. The level of compensation in the public-health roles should reflect reasonable returns on investment in education at each level and would rise as earnings in private practices increase. The aggregate effect will allow each member of a team to be more productive and the whole team to provide a high level of service, perhaps at a lower cost to the public who avail of veterinary services but potentially at higher net earnings for the team of professionals.

However, training more veterinarians without expanding government public-health services will do little to improve public health. There is a compelling case for federal agencies to support training and research in fields for which they are responsible. For example, the U.S. Department of Agriculture needs specialists and research in veterinary medicine that are important for livestock production and food safety. The Department of Homeland Security needs specialists and researchers in biohazards. The Department of Health and Human Services needs specialists and researchers in zoonotic diseases and in the problems and opportunities in the use of laboratory animals. National support for the training and research missions of the veterinary schools and colleges is essential for the intellectual future of veterinary medicine.

BOX 10-3
Addressing Vacancies in Government Service

Veterinarians in government service work primarily in the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service and Food Safety and Inspection Service. Those agencies have many openings for veterinarians. They offer pay below those that are generally offered to private veterinarians and often assign veterinarians to remote locations. Openings for jobs with low pay that remain unfilled are not an indication that the nation has too few veterinarians. When veterinarians command salaries commensurate with the expense of their education, USDA and other government agencies may be compelled to restructure their workforce with veterinarians in leadership and oversight roles and use 2-year and 4-year technicians and perhaps even master's-level personnel for many front-line roles. Master practitioners would be the analogue of nurse practitioners who have 12 months to 3 years of specialty education beyond the baccalaureate and are licensed to provide a variety of services. Because federal and state governments employ a relatively small share—about 6%—of all veterinarians, government agencies must compete with the private sector in order to hire veterinarians. Nevertheless, many agencies offer salaries below those of the private sector and have many vacancies. Thus, new strategies to develop the public practice workforce are needed.

11

Conclusions and Recommendations

THE STATE OF THE VETERINARY PROFESSION: ANOTHER DEFINING MOMENT IN ITS HISTORY

The charge to the committee was "to study the broad scope of issues related to the veterinary workforce in the United States, including a study of historical changes in the size and characteristics of the veterinary workforce; assess the demographics and adequacy of the current supply of veterinarians in different occupational categories and sectors of the economy; and identify incentives, disincentives and other factors that are likely to affect the numbers of veterinarians seeking jobs in different sectors in the future."

At this time in its storied history, the current picture of the profession is one of dynamic change and economic challenges. These conditions are altering the needs for veterinary expertise. The study was initiated at a time when there were concerns that veterinary academe was not producing sufficient U.S. graduates to fill the profession's needs, especially in companion-animal and specialty practice. In response to the perceived future shortages, many veterinary schools have increased their enrollments, and new schools have been created in the United States and beyond, including for-profit schools, some of which have been accredited by the American Veterinary Medical Association (AVMA) Council on Education. Moreover, there are plans to build additional schools in the United States. As a result, the supply of veterinarians is gradually growing. However, since the economic downturn that started in 2008, veterinary schools have lost tens of millions of dollars in public financial support that has increased the cost of a veterinary education to students. To generate much-needed revenue, class sizes have increased, especially with higher-paying non-state residents. Concurrently, there has been an increase in the delivery of companion-animal oriented veterinary education and of graduates seeking companion-animal jobs. These combined changes have brought the profession to a critical juncture.

The committee is concerned that an unsustainable economic future is confronting the profession and calls for veterinary organizations, academe, industry, government, and nongovernment organizations (NGOs) to proceed strategically and with urgency. However, for that support to be forthcoming, society must be convinced that an investment in veterinary medicine is an imperative. The public, policymakers, and even medical professionals are frequently unaware of how veterinary medicine fundamentally supports both animal and human health and well-being. **Broadening the public's understanding will require a commitment by veterinary leadership, the academe, and practitioners to develop and promote the profession as one that offers diverse career paths with many different niches for veterinarians, ranging from traditional companion-animal practice to public- and private-sector positions in biomedicine, animal research, wildlife, the environment, global food production, and public health.**

Taxpayers must receive an adequate return on their subsidy to veterinary education and should be convinced of the benefits of subsidizing veterinary professionals. Most students come to veterinary schools to enter into the companion-animal sector of the profession and instruction in the care of pet animals forms a sound base of biomedical knowledge on which the comparative medicine components of instruction are layered. Thus, dog anatomy is the foundation, and pig, cow, horse, chicken, and wildlife anatomy are efficiently deliverable in a comparative context. The same is true for physiology, pathology, pharmacology, toxicology, medicine, and surgery. The primary shortcomings of the small animal model of instruction relate to its emphasis on comparative management paradigms for diseases related to inbred animals, and the limited focus on population level and environmentally-based disease prevention. Epidemiology, and environmentally-based disease prevention need to be required core courses in veterinary curricula and in certifying veterinary schools.

Many of the positions that veterinarians need to fill will require additional education beyond the Doctor of Veterinary Medicine (DVM) degree. Yet the basic challenge remains funding this education. Thus, while pursuing less-costly approaches to delivering veterinary education and veterinary services is generally required, it is even more essential that the colleges and schools of veterinary medicine engage employers and public and private funders in their efforts to target and strengthen particular fields of veterinary expertise and research.

In this chapter, the committee presents its key findings and conclusions about the state of the veterinary profession and the prospects for its future, and it explores options for how the veterinary schools and colleges can prepare their graduates to better respond to the changing societal needs for veterinary expertise.

CONCLUSION 1: In its review of the profession, the committee found little evidence of widespread workforce shortages in veterinary medicine, although industry and some areas of academic veterinary medicine are experiencing shortages of veterinarians who have advanced training. The committee noted a difference between workforce shortages and unmet needs for veterinarian positions. Societal needs for veterinary expertise are substan-

tial and growing, but the potential contributions of veterinary medicine are not realized because appropriate positions in relevant sectors are lacking.

As the committee examined the question of whether the supply of and the demand for veterinarians were in balance in a given sector, it struggled to rationalize the apparent need for veterinary services with the economics of today's veterinary marketplace. Personnel shortages occur when well-paid positions are not filled. Such shortages exist, for example, in industry, where employers cannot fill high-paying positions with veterinarians who have advanced training in biochemistry, biochemical mechanisms of diseases, basic pharmacology and toxicology, pathology, laboratory-animal medicine, and regulatory toxicology. These experts are in demand and can command salaries that are well beyond those of professorial ranked faculty. Similarly, veterinary colleges are in need of basic scientists who can leverage extramural research support for programs. In the committee's view, opportunities for highly-trained veterinarians in industry and the basic sciences are growing, and the new and vacant positions represent a clear shortage because there are few qualified individuals to fill those jobs. Those shortages can be addressed by equipping future veterinarians with the skills required by these positions and by eliminating barriers to their employment.

In contrast, unmet needs occur in settings where well-paying veterinary positions are lacking. That includes situations in which positions exist, but offer salaries too low to attract candidates, as well as instances in which expertise in comparative medicine might be relevant, but positions that explicitly require veterinary expertise do not exist. By expanding appropriately-paid employment opportunities that use different kinds of veterinary skills, including rethinking how veterinary services are provided, society can better capture the benefits of veterinary expertise. For example, in situations where the low density of small farms with marginal resources cannot financially support positions for full-time food-animal (FA) veterinarians, alternatives to conventional veterinary practice, including an expanded use of technicians under the supervision of veterinarians, will be important. In wildlife and ecosystem health, development of thoughtful measures to manage the health of terrestrial and aquatic wildlife, conservation of threatened and endangered species, and control of emerging infectious and toxicological agents could benefit from greater involvement by veterinarians. Veterinarians are not prevented from entering those fields now, but developing sustained funding for veterinary positions will require efforts to promote a wider understanding of the value of veterinary services among public and philanthropic supporters of wildlife and the environment. As noted in chapter 10, the goal of balancing supply and demand is to match jobs that require particular kinds of skills with persons who have those skills.

Strictly on the basis of financial return on educational investment as an indicator of the market demand for veterinary expertise, there is no substantial profession-wide shortage of veterinarians. Increases in salaries and benefits are smaller than the increases in the cost of a veterinary education for students. According to the 2011 AVMA *Report on Veterinary Compensation*, companion-animal-exclusive practitioners' mean and median incomes are increasing. However, companion-animal-practice income growth has slowed. In recent years, public-practice and corporate-practice incomes have increased slightly. Food-animal exclusive, equine, and mixed-animal practice median incomes were growing before 2007, but in 2007-2009 a sudden decline occurred.

Unmet needs for appropriately-compensated positions exist in the public sector for veterinarians who have specialized training in epidemiology, food safety, wildlife and ecosystem health, and public health. Jobs in those fields generally offer salaries that are much lower than those in the private sector, many have salaries that are too low to attract top candidates, and some are not advertised with a requirement for a veterinary degree, so many of the positions remain unfilled by veterinarians. Public-practice veterinarians are essential for maintaining the safety of foods of animal origin and for controlling diseases of wildlife and livestock, including zoonotic diseases. An insufficient workforce of public-practice veterinarians places at risk the health of American citizens, the well-being of the nation's food-animal industry, the health of U.S. wildlife resources, and the U.S. economy.

Recommendation 1A: Industry veterinary workforce shortages can be addressed by deeper partnerships between academe and industrial employers of veterinarians. Academe should more actively seek industry biomedical research partnerships, student mentoring, and opportunities in the curriculum to expose students to corporate practice.

The establishment of student clubs for pathology and laboratory-animal science at veterinary colleges, as recently initiated by the American College of Laboratory Medicine, the American Society of Laboratory Animal Practitioners, and the American College of Veterinary Pathologists (ACVP) is a favorable development, as is industry support for internships and training positions through the ACVP/STP [Society of Toxicologic Pathology] Coalition for Veterinary Pathology Fellows. Industrial externships could bring greater exposure to career opportunities in pathology, laboratory animal medicine, and toxicology. The Virginia-Maryland Government and Corporate Practice track is another example. Given the limited resources of veterinary colleges, consideration should be given to partnering with such programs or tracking options in veterinary colleges to offer the best opportunity for channeling students into careers in laboratory-animal medicine, pathology, and comparative biomedical research.

Recommendation 1B: To meet the needs for positions for veterinarians in public practice, the committee urges state and federal governments to re-examine their policies on remuneration, recruitment, and retention of veterinarians.

It is encouraging that the U.S. Office of Personnel and Management has formed the Talent Management Advisory Committee to bring agencies together in a forum to discuss a strategic workforce plan regarding current and future federal needs for veterinarians. State and federal agencies, especially ones that target food safety and wildlife and ecologic sustainability, should articulate the full value of the veterinary profession to their missions and take steps to support a coherent plan to strengthen the profession's role in research, food safety, animal welfare, public health, and ecologic sustainability. The public interest is put at significant risk when attention to workforce needs related to these issues is not addressed. A number of personnel policies—from recruitment strategies and hiring practices to retention initiatives, including child care and parental leave that might attract female candidates—should change to improve the federal government's opportunity to employ veterinarians.

Recommendation 1C: The Association of American Veterinary Medical Colleges, American Animal Hospital Association, and American Veterinary Medical Association should develop realistic strategies for meeting companion-animal veterinary medical workforce needs. Building such a strategy requires reliable national data on consumer demand for companion-animal care, the economics of private practice, the role of veterinary technicians in extending companion-animal care, and the implications for the profession of growth in accredited and non-accredited veterinary schools both inside and outside the United States.

The demand for a veterinary education among U.S. citizens remains high, yet the economic reality regarding student educational costs in relation to modest practice incomes is worrisome. Companion-animal veterinary medicine has come to dominate the curriculum and resources of veterinary schools, sometimes to the detriment of other fields of veterinary medicine, so it is important to understand as clearly as possible the demand for needs for companion-animal services, and to plan accordingly by developing a strategy to support the clinical faculty, specialists, and others required to train new companion-animal practitioners and companion-animal paraprofessionals. A growing part of the future companion-animal veterinary workforce will consist of veterinarians who graduated from colleges outside the United States. The impacts of that trend on U.S. veterinary schools, companion-animal practitioners, and the quality of and access to a veterinary education, particularly as the profession attempts to increase the numbers of underrepresented minorities in its ranks, must be studied closely. This analysis must be approached in the context of meeting the need for veterinary services in all sectors of the profession, and seek to balance the actual demand for companion-animal veterinary medical practitioners with the capacity to meet those needs within current and future economic realities.

CONCLUSION 2: The decade-long decline in funding of education and research has jeopardized the profession's future capacity to serve societal needs.

Veterinary medicine has made immense contributions to human well-being but is losing the breadth of its intellectual base as a consequence of reduced public funding for veterinary education and research. The trend jeopardizes the vigor of veterinary medicine, threatens the profession's future, and urgently requires a change in direction. The profession will not be able to fulfill its responsibilities to society without maintaining a pool of high-quality scientific investigators and robust research programs.

The number of students who are exposed to sophisticated fundamental and applied research is declining. Crucial investments in the infrastructure of basic and translational research are not being made, and the creation of new veterinary basic-science faculty is fading. Research is declining in veterinary colleges on such topics as molecular genetics, molecular oncology, gene therapy, stem cells, immunology, virology, toxicology, pharmacology, and epidemiology, and the profession's responsibilities in food safety and ecosystem health are also not being met. It is in those fields that some of the most important advances in comparative medicine can be expected and will define the profession in the years to come.

> **Recommendation 2: Veterinary academe should increase its commitment to research, developing future faculty, and encouraging current faculty to work across disciplinary and professional boundaries. The Association of American Veterinary Medical Colleges is well positioned to take on this challenge.**

Veterinary schools need to demonstrate a commitment to building the kind of faculty that can lead cross-disciplinary and inter-professional studies, to find partners to support graduate training, and to develop collaborations with entities outside the veterinary schools to seek research and other support. Effective research programs require long-term commitments by teams of investigators.

In addition, research-based educational environments draw students to research careers, an essential process for sustaining the profession's intellectual core. The report *National Need and Priorities for Veterinarians in Biomedical Research* (NRC, 2004) offers several suggestions for attracting students to research careers, including acquainting students with research opportunities throughout veterinary school, including in the curriculum, actively seeking students with an interest in research, and working to find support for post-graduate research training.

There are unique opportunities for the profession to build research programs in the biomedical sciences. Comparative veterinary medicine addresses a broad spectrum of spontaneously-occurring diseases that are homologues of diseases in humans and could be funded by the National Institutes of Health (NIH). Many spontaneous tumors in dogs and cats are models of tumors in humans and provide excellent opportunities for studying basic cancer biology and testing cancer therapeutic agents. Spontaneous models of metabolic diseases in pets are also available and uniquely important for gene therapy and stem-cell studies. But these opportunities and resources have been underutilized.

The total NIH funding of the nation's 28 veterinary schools and colleges in 2010 was about $280 million—less than the NIH funding for any one of the nation's top medical schools. Veterinary schools must improve their ability to attract funding if they expect to remain in the mainstream of biomedical research, by hiring more DVM-PhD mentors to attract grants and provide graduate training of veterinarians at the doctoral level, both in the biomedical field and in research projects of primary importance to animals.

CONCLUSION 3: The current return on investment for veterinary education is unsustainable and the cost of veterinary education is at a crisis point. The profession may be at risk for lowering the quality of applicants to the profession and the quality of veterinary education. The veterinary profession has been slow to respond to these challenges.

Starting salaries in private practice increased by 148% beyond inflation in the 20 years from 1987 to 2007, but mean debt increased by 285% in the same period. The financial return on investment in veterinary education is below that of other professions for which students might be qualified. For about the same number of years of training, veterinarians make much less than dentists and about the same as pharmacists, who can graduate with the required PharmD in as little as 6 years. Although there is some risk in using current earnings information to approximate expected lifetime earnings of current students, it is clear that the financial reward for a veterinary education is well below the benchmarks of other types of training in health professions. The committee agrees that a foreboding scenario exists: the ratio of student debt-to-average starting salary is more than 2 to 1 (Figure 11-1).

In the absence of additional growth in salaries or reduction in costs of a veterinary education, the return on investment in a veterinary education may continue to decrease. Eventually, more students will recognize the disjunction between tuition and income, and the quality of applicants to veterinary schools will decline. Veterinary medicine needs to make a much better case to the public in regard to its value in state and federal budgets and to be more creative and effective in seeking sources of revenue besides increases in tuition and class sizes.

Recommendation 3a: Professional veterinary organizations, academe, industry, and government should work together with a sense of urgency to stimulate the collective actions needed to ensure economic sustainability of veterinary colleges, practices, and students. A national consortium or committee should be jointly supported to

bring together initiatives that focus on the economic sustainability of the profession in all sectors of service, education, and research.

Previous groups have called for change and coordination in the nation's approach to veterinary education and its costs. In 2011, the North American Veterinary Medical Education Consortium report *Roadmap for Veterinary Medical Education in the 21st Century: Responsive, Collaborative, Flexible* provided a wide array of options. To thrive in an era of economic constraints, veterinary schools and colleges must develop innovative teaching methods and new collaborative relationships, and the profession must develop new business models. A consortium of key veterinary organizations, deans, industry, government, and economists is needed to seek solutions that address the sustainability of the profession and of veterinary service to society.

A central issue for the future of veterinary medical education is the role of research in the coming years. New organizational models and methods to address research frontiers will be needed to assure the intellectual integrity of veterinary education. The profession's ability to respond to evolving threats to animal and human health depend on attracting and sustaining outstanding scientists to the disciplines that support veterinary medical education.

Recommendation 3b: As part of a comprehensive strategy to address the economic sustainability of the veterinary profession, the working groups appointed by the consortium should create nationally shared curricula.

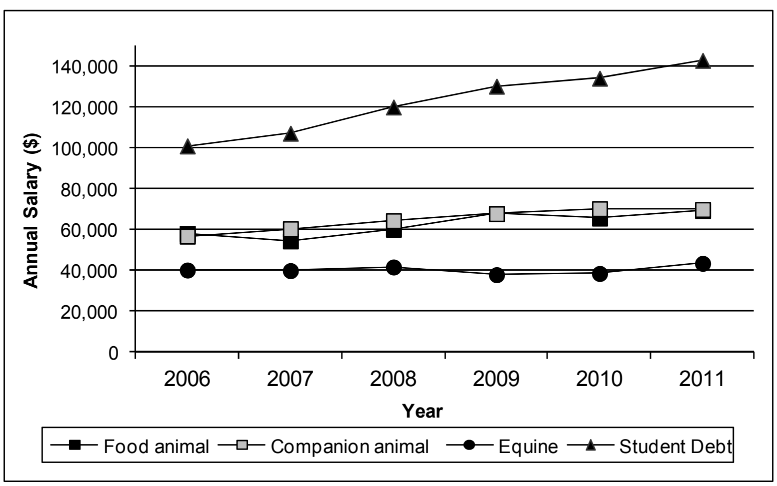

FIGURE 11-1 Student debt and mean starting salary for new DVM graduates. DATA SOURCE: AVMA Market Statistics, 2006-2011.

The growth of distance education and webinars offers an opportunity to achieve this goal. The emerging power of distance education provides the greatest opportunity for advancing food-animal veterinary education at a comparatively modest cost. Webinars and similar technologies can lead to continuing-education credits for veterinarians. Teaching veterinary students from other developed and developing countries should be encouraged to extend the reach of U.S. academic programs and to capture the potential revenue that these sources can generate.

Recommendation 3c: U.S. veterinary colleges should evaluate and implement alternative options for the delivery of veterinary education and research.

Veterinary teaching is evolving and some non-traditional models are now used by AVMA-accredited veterinary colleges. Alternative models for veterinary education, and those that spread the cost of specialty training, in particular, need to be evaluated by inter-professional committees to identify those that hold promise for improving the efficiency of veterinary medical education and research in the United States. Some of the alternatives that should be evaluated further are described below.

An Alternative Model for Teaching Hospitals

Small-animal teaching hospitals have become the profession's secondary-care and tertiary-care centers. Concurrently, they have expanded their roles in training residents for specialty-board certification, which requires the expense of additional equipment and faculty to supervise residency programs. The costs of operating a specialized-care center could be readily passed on to animal owners if veterinary schools provided instructional opportunities at comprehensive small-animal medical centers in sizable urban or metropolitan areas.

High-quality specialty practices developed through university-driven or university-private sector collaborations in which veterinary schools or colleges hold a controlling and standard-setting interest can offer exceptional resources of both infrastructure and highly-trained specialists. Large urban or metropolitan teaching hospitals should provide core services in community and specialty practice. Veterinary faculty of such centers would have more time to pursue basic and clinical research, conduct clinical trials, and teach evidence-based medicine to veterinary students and residents, relying on a great array of cases, state-of-the-art instrumentation, specialized support staffs, and data-retrieval systems made available by the associated university. Likewise, the instruction of veterinary students and residents in equine medicine and surgery would be best accomplished in clinics situated in areas that have adequate populations of horses to ensure the large caseload needed for strong teaching and clinical-research programs.

Alternative Models for Specialty Training

The main rationale for state support of veterinary schools is to train entry-level veterinarians. However, increasing numbers of graduates seek advanced training—whose requirements are dictated by specialty boards—and this causes veterinary schools to assume increased costs. Public support of faculty engaged in specialty training is minimal or nonexistent in most state budgets, and there is essentially no federal support. Therefore, the schools need to become more independent of the influence of specialty boards. In addition, veterinary schools and colleges must work together through partnerships and group efforts, including other organizations and industry, to leverage resources and capabilities for providing alternatives to specialty training in veterinary schools. There are opportunities to meet the clinical challenges through inter-school collaborations; by relying more on talent in private veterinary practices, specialty practices, industry, and agencies; and by enlisting the support of government, NGOs, and other stakeholders.

Alternative Models for Matriculation and Training

Most veterinary students in the United States are admitted to veterinary schools after completing pre-veterinary studies over the course of a 4-year undergraduate program. After graduation from veterinary school, many students seek internships and residencies in the belief that they will increase their earnings. Few students decide to stay in school for another 4 years (or more) in pursuit of a PhD. Although the dearth of support for graduate training is one reason, the overall costs and length of time involved before a person can capitalize on the training are so great as to be deterrents. One potential solution to the problem is to encourage more students to apply to veterinary school after only 1-2 years of undergraduate study. In the UK, students may apply directly after high school and enter a 5-year veterinary curriculum. American students who have sufficiently strong academic records are also admitted directly from high school into 5-year veterinary curricula in the UK. Those students spend 3 years less than the norm in most programs in the United States and this fuels the argument for reducing the length of pre-veterinary education in this country.

Joint Degree Programs

Another recommended approach to address the need for more veterinarians who have advanced degrees is to develop more joint degree programs in veterinary colleges and schools. There are now several joint DVM-MPH, DVM-PhD, and DVM-MBA programs. The University of Pennsylvania's School of Veterinary Medicine illustrates the effectiveness of this approach. It has had a joint VMD-PhD program in place since 1971; of its 63 graduates, 85% are engaged in research and about two-thirds are in academe. Seeking funding to increase the number of such programs would have the combined effect of making a PhD degree more attractive, increasing the pool of potential veterinary faculty, and broadening the base of veterinary medicine. For DVM-PhDs to succeed in academe there is likely to be a need for postdoctoral training of most PhDs pursuing this career path. Facilitating that avenue and exposure to a variety of career options for DVM-PhDs should be core components of such dual-degree programs.

CONCLUSION 4: The veterinary profession is losing its presence in food-animal production and care.

With the changing nature of food-animal production in America, the demand for traditional veterinary services has declined, creating two related problems: how to develop production medicine to serve the dynamically-changing and increasingly-intensive livestock and poultry industries; and, how to provide veterinary services in the rural United States where fewer and more widely dispersed farms make it is difficult for food-animal clinicians to remain in practice.

Veterinary academia has been slow to respond to educational needs in food-animal production medicine. Large producers who dominate the livestock industries seek veterinarians who are either exclusively or predominantly committed to food-animal practice, who can understand production systems, can read farm records and can use them to make decisions aimed at increasing herd health, productivity, and the overall profitability of the farming operation. It is these services producers seek and for which they are willing to pay. At the same time the profession must develop its role in monitoring food safety, drug residues, animal welfare, nutrient management, and stewardship of the environment.

If the profession does not move more deliberately in this direction it is in danger of relinquishing its role in animal production to others who are able to consider the economic needs of producers but who have less understanding of the complexity of animal health and public health.

Recommendation 4a: To increase the economic value of veterinary services to producers, the education of food-animal practitioners should be reoriented towards herd health and interventions aimed at improving the financial health of the farm operation. Veterinary schools and colleges should work together to achieve this goal by creating centers of emphasis on food-animal medicine.

The most compelling case for creating centers of emphasis is in those disciplines where small numbers of students are involved and where it is difficult for each school or college to justify faculty costs. Such is the case for food-animal medicine. As the livestock industry has consolidated, it has also divided production into specialized units. Consequently, no one school or college can afford faculty expertise in all the specialized needs of every species. Schools and colleges should collaborate to create a portfolio of on-line courses on the diversity of specialized educational needs in production medicine. These programs should include all food-animal species including small ruminants. Practical application of this knowledge should take place at centers of emphasis where students can gain experience in management and research in food-animal health and productivity.

There are models of successful centers in which advanced practical training and research is available, such as the Agricultural Research Service Meat Animal Research Center at Clay Center, Nebraska; the Swine Center of Excellence at Iowa State University in conjunction with the Audubon-Manning Veterinary Clinic; the University of California-Davis Dairy Center at the Veterinary Medical Teaching and Research Center at Tulare, California; and the recently formed National Center of Excellence in Dairy Production Medicine Education for Veterinarians funded by USDA that is a collaboration among the veterinary schools of the Universities of Georgia, Minnesota, Illinois, and Kansas State University. Forming centers of emphasis (or excellence) is not a new idea, but it needs to be revisited and nurtured by veterinary leaders and affected stakeholders. In addition to advancing the quality of food-animal education, the committee sees the advantages of a strategically-planned network of cooperating centers for reducing a duplication of effort, faculty salaries, and facilities.

The centers will develop only as entrepreneurial deans and faculty initiate inter-institutional discussion, formulate creative ideas, use distance education, and attract funding from industry, public-health agencies, foundations, international organizations, and federal and international governments. Maintaining flexibility in center programs will be an on-going challenge. A system of regular review or accreditation should be put in place at the time centers are created.

Recommendation 4b: The veterinary profession should formulate new ways of delivering cost-effective services to rural America, using veterinary technicians to extend animal health services to underserved areas.

In rural areas where there are too few farms to support a full-time veterinarian, the profession should develop a system of animal-health care that uses digital and information technologies to integrate licensed clinicians with rigorously trained paraprofessionals. For this to be accomplished, the AVMA and other professional associations will need to enter a dialogue with officials to modify state practice acts to permit credentialed veterinary technicians to administer livestock-health services provided that they are subject to collaborative oversight (and constant communication) with licensed practitioners who may be in distant locations. Veterinary technicians and other paraprofessionals working with food-animal veterinarians in this way have the potential to provide affordable, high-quality care to rural America, and their role should be expanded. Other fields of medicine have developed paraprofessionals, such as nurse practitioners and certified nurse anesthetists, who do not compete with but rather compliment and extend the influence of the professionals overseeing them. In food-animal practice, such a system can also be used to strengthen the nation's capacity for animal-health surveillance and emergency planning in rural America. The system has the potential for private-public partnerships.

CONCLUSION 5: Global food security is one of the most pressing challenges of the 21st century. The food and water security and safety concerns confronting the world today are far more daunting than anything veterinary medicine has previously had to confront. Because these challenges are enormously complex, they will require the veterinary profession to engage in interdisciplinary and interprofessional One Health solutions.

It is increasingly clear that agricultural science, veterinary medicine, and other disciplines must work together to deliver sufficient, safe food to sustain the world's growing population. The problems need to be addressed by a combination of veterinary research, academic program innovation, advances in and adoption of technology, knowledge extension, and veterinary faculty and practitioner professional development. These issues need greater public attention, greater financial resources, and a focused strategic approach.

In 2011, the world's population reached 7 billion, on its way to 9 billion by 2050. Almost all the growth will be in the developing world where urbanization is proceeding with a speed and intensity that is unprecedented in human history. The urban transition is generating wealth, greatly increasing demand for animal protein, and forever changing the developing world's agricultural systems. Presently, rising demand is being met by expanding populations of low-producing animals. This is environmentally destructive and unsustainable. To meet demand, protect the environment, and make systems more sustainable, the veterinary profession in the United States should help to increase the efficiency of livestock and poultry production, increasing animal yields while reducing their numbers. Animal-health hazards that accompany increased intensity of production in warm humid climates must be understood and anticipated and outbreaks of new and re-emerging infectious diseases controlled as they can jeopardize human health and the resilience of food security systems. Issues of waste recycling must also be solved. All of these challenges are immensely difficult and further complicated by climate change. To find solutions will require the widespread collaborations that are embodied in the concept of One Health.

The challenges substantially expand the traditional roles of veterinary medicine and redefine the profession's needed competencies. The veterinary academe appears hesitant to emphasize the One Health initiative and global food security, because few well-paying job opportunities are advertised for graduates. However, the task of meeting the growing needs for safe, nutritious, and affordable food for the world's growing population is urgent and must be accomplished.

> **Recommendation 5: Veterinary medical organizations and the deans of veterinary colleges should work to increase the visibility, standing, and potential of the profession to address global food security. Establishing a One Health think tank with the goal of ad-**

vancing food-animal husbandry and welfare policies, ecosystem health standards, and the capacity of the veterinary profession in the developing world would help future generations of veterinarians to collaborate across professions, disciplines and cultures. A part of this body should also consider the necessary competencies required of U.S. veterinary graduates to address the global challenges of food and water safety and security, and the health of wildlife and ecosystems.

Society tends to view veterinary medicine through the narrow lens of companion-animal medicine. The profession has not done enough to expand recognition of its immense responsibilities in addressing global food security and resilience. Tackling the multiple dimensions of One Health and sustainable food security will require a new, broader definition of veterinary medicine, of its foundational competencies, and of the focus that veterinary research must take. To accomplish that, deans should work together across campuses, organizations, and professions to define key One Health competencies that can be adopted into curricula and research program models.

The Association of American Veterinary Medical Colleges (AAVMC) should lead an effort with the AVMA and other professional organizations, veterinary and otherwise, to change our research and professional development programs to address local, national, and global cross-disciplinary challenges.

Examples of activities to which veterinarians could contribute include Feed the Future, the U.S. global-hunger and food-security initiative, and PREDICT, a global early-warning system to detect and reduce the effects of emerging diseases that move between wildlife, domestic animals, and people. The Food and Drug Administration is beginning to implement the Food Safety Modernization Act, which will require veterinary medical research on ways to prevent food contamination and on issues of food safety on the farm. Other programs are funded by different agencies to address the effects of climate on ecosystem health, wildlife, and the movement of plant, animal, and human diseases.

A Profession with a Unique History and Bold Future

The chaos of interdependent societies of the early 21st century—with soaring human populations, global warming, exotic-species invasions, overharvesting of wildlife, infectious-disease outbreaks, and chemical contamination—has created opportunities for veterinary medicine to be more relevant than at any other time in history.

Veterinary medicine began as a profession that focused on the health and utility of horses; it then helped to improve the productivity and well-being of food animals and the safety of milk, meat, and eggs; later, it undertook basic research and improved animal health and evaluation in concert with academic, government, and private laboratories; it countered diseases of pet animals and helped to sustain the human-animal bond; it enhanced the health and reproduction of zoo animals; and now it is increasingly caring for entire communities of free-ranging wildlife in a host of ecosystems. Times are challenging, but the veterinary profession continues to create its own future and now faces many options for remaining relevant to societal needs and being economically sound. The broad assignment is clear: the profession must collaborate within and beyond its bounds, and it must proclaim and demonstrate its relevance to the public and to decision-makers to ensure its continued success.

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Appendix A

Biographical Sketches of Committee Members

Dr. Alan M. Kelly, ***Chair***
University of Pennsylvania [Emeritus]

Dr. Alan Kelly received his veterinary medical education at Bristol University in England and then came to the University of Pennsylvania on a National Cancer Institute Fellowship to pursue a PhD in Pathology. He joined the faculty in the Department of Pathobiology at the School of Veterinary Medicine in 1968 where he taught pathology and conducted research on neuro-muscular development in the rat and on the pathogenesis of Duchenne muscular dystrophy. In 1994 Dr. Kelly became dean of the School and served in this office for the ensuing 12 years, retiring in December 2005. During his deanship the School's appropriation from the Commonwealth of Pennsylvania increased from $12 million to $38 million. Dr. Kelly also raised $127 million for construction of the Hill Pavilion, a new teaching and research building at the School. Since retiring from the dean's office, Dr. Kelly has introduced a course on global health for veterinary students and undergraduate students at the university and has led the PennVet World Award and Student Inspiration Award competitions.

Dr. Sheila W. Allen
University of Georgia

Sheila W. Allen is the Dean of the University of Georgia's College of Veterinary Medicine. Prior to being appointed dean in 2005, Dr. Allen served as associate dean for academic affairs at the University of Georgia, where she was extensively involved in developing and revising the college's DVM curriculum to give students more flexibility in focusing on their areas of interest. She also guided the faculty in changing college admissions procedures so applicants can be assessed on criteria in addition to academic credentials. Her area of expertise in teaching and research is oncologic and reconstructive surgery and perioperative pain management. She is a Diplomate of the American College of Veterinary Surgeons and has served as an elected member of the organization's Board of Regents and was on the group's examination committee. She was chair of the research committee, which awards Surgeon in Training grants and Diplomate Investigator awards, and she also chaired the publications committee, overseeing publication of the group's journal, Veterinary Surgery. She is also active in the Association of American Veterinary Medical Colleges, serving on the Board of Directors as well as the Government Affairs and Leadership Committees. Dr. Allen also serves on the Council on Education of the American Veterinary Medical Association, which is the accrediting body for veterinary medical education. She is on the board of directors of the Georgia Veterinary Medical Association. Dr. Allen received her DVM and BA degrees from Cornell University and completed her MS in veterinary clinical pathology and small animal surgical residency at the University of Georgia.

Dr. Val R. Beasley
University of Illinois at Urbana-Champaign [Emeritus]

Val R. Beasley is a professor emeritus of comparative biosciences (veterinary, wildlife and ecological toxicology) in the College of Veterinary Medicine at the University of Illinois at Urbana-Champaign. He is also Founder and until recently Executive Director of the Envirovet Program in Wildlife and Ecosystem Health. Envirovet is an international educational program that has provided sixteen highly intensive Summer Institutes. In recent years, the 7-week-long Summer Institute has taken place in multiple locations in the southeastern USA and East Africa. Dr. Beasley was in small animal practice for six years in coastal New Jersey and western Ohio before arriving at the University of Illinois. He helped establish the Animal Poison Control Center there. His research interests have included the pathophysiology and fate in the body of mycotoxins and blue-green algal toxins, the residues and effects of heavy metal contaminants in marine mammals, the potential of brominated flame retardants to trigger thyroid adenomas and hyperthyroidism in cats; and the causes of mass die-offs in flamingos including potential roles of metals, algal toxins, and infectious agents. In recent years, his research has focused largely on causes of amphibian declines. This has included investigations of the direct and indirect impacts of a wide array of ecological and water quality parameters, infectious agents, and contaminants, including nutrients, endocrine disruptors, pesticides, metals and other trace elements. He is a diplomate of the American College of Veterinary Toxicology. Dr. Beasley received his DVM from Purdue University and his PhD in toxicology from the University of Illinois.

Dr. Bonnie Buntain
University of Calgary

Bonnie Buntain is the Assistant Dean of Government and International Relations and a Professor of Public Health at the University of Calgary Veterinary Medicine with a joint appointment in the Faculty of Medicine. She is an expert advisor to the Canadian Food Inspection Agency, Public Health Agency of Canada and the Auditor General of Canada. Prior to joining the faculty in January 2007, Dr. Buntain was the Chief Public Health Veterinarian of the Food Safety and Inspection Service (FSIS), United States Department of Agriculture. At the USDA Dr. Buntain advised the Office of Field Operations of all veterinary issues regarding food safety, humane slaughter and handling and optimizing the use, retention and recruitment of public health veterinarians. During her 16 years in public practice, Dr. Buntain has also held other government positions: a scientific reviewer for the Food and Drug Administration's Center for Veterinary Medicine; the National Program Leader for Veterinary Medicine at the USDA's Extension Service; and the Director of Animal Care at the USDA's Animal and Plant Inspection Service. In 1995, FSIS selected her to establish and manage their first Animal Production Food Safety staff. In 1999 she was promoted to Assistant Deputy Administrator of FSIS's Office of Public Health and Science. Dr. Buntain is the President of the Association of Food Safety Veterinarians and Chair of the United States Animal Health Association's Food and Feed Safety Committee. She was also associated with the University of Virginia-Maryland College of Veterinary Medicine as an Adjunct Assistant Professor, and served on the Advisory Council for the Center for Corporate and Government Practice. She has received numerous awards for her work. In 2000, Dr. Buntain was awarded "Outstanding Veterinarian in Food Safety" by the American Association of Food Safety Veterinarians, and "Outstanding Woman in Veterinary Medicine" by the Association for Women Veterinarians. In 2002, she received a Certificate of Merit for her work on the Food Biosecurity Action Team. In 2004, Dr. Buntain became a Diplomate of the American College of Veterinary Preventive Medicine and was inducted into the American Veterinary Epidemiology Society. In 2006 she was inducted into the National Academies of Practice. Dr. Buntain received her DVM (1977) from Colorado State University, and her BS and MS in Animal Science from the University of Hawaii. Dr. Buntain completed an internship in Food Animal Medicine at the University of Glasgow, Scotland in 1978 and a two-year residency in Large Animal Medicine and Surgery at the University of Missouri in 1980. She owned an equine veterinary practice in Hawaii from 1980-1990, and hosted an award-winning public television show, "Pets and People".

Dr. Henry E. Childers
American Veterinary Medical Association

Dr. Henry Childers, a small animal practitioner in Cranston, Rhode Island, is only the second veterinarian to serve as both president of the American Veterinary Medical Association (AVMA) and the American Animal Hospital Association (AAHA). In addition to his practice, he is an assistant clinical professor in the School of Veterinary Medicine at Tufts University. After earning his veterinary degree from Auburn University, Dr. Childers served two years in the U.S. Army Veterinary Corp before acquiring the Cranston Animal Hospital in 1957. He became a Diplomate in the specialty, American Board of Veterinary Practitioners where he served as a member of their Council of Regents and was chairman of their Continuing Education Committee. Throughout his career Dr. Childers has been active in organized veterinary medicine. In addition to serving two terms as President of the Rhode Island Veterinary Medical Association, Dr. Childers served as their secretary/treasurer, and chaired the Continuing Education Committee for 15 years. He also served as chair of the Rhode Island Veterinary Board of Examiners. Nationally, Dr. Childers served as the president of the AVMA, and served on the AVMA Councils on Education and Public Relations, the Committee on Veterinary Technician Education and Activities, and as a consultant to the National Board Examination Committee. As an AVMA Executive Board member, he represented District I, acting on behalf of veterinarians in Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont, on the AVMA Executive Board. Dr. Childers served as President of the American Animal Hospital Association, chair of their Annual Scientific Meeting, President of the AAHA Foundation, and as a member of the Review Board of the Foundation. His awards include: first recipient of the Rhode Island Veterinary Medical Association Veterinarian of the Year Award; (2006); 2001 Massachusetts Veterinary Medical Association's Distinguished Service Award (2001); the AAHA Practitioner of the Year Award (1992) and AAHA's Northeast Region Practitioner of the Year (1991); 1995 Rhode Island Veterinary Medical Association (RIVMA) Vanguard Award for his services to the Association (1995); 1990 Auburn University College of Veterinary Medicine's Distinguished Alumnus Award (199); 1984 AVMA Veterinary Continuing Educator Award (1984); and the Tuft University School of Veterinary Medicine Childers Award, an annual award established in 1992 in honor of Dr. Childers for sustained and extraordinary contributions to the education of Tufts Veterinary students

Dr. Gary Cockerell
Cockerell Alliances

Gary Cockerell is a private consultant (Cockerell Alliances) and Director of the American College of Veterinary Pathologists and Society for Toxicological Pathology Coalition for Veterinary Pathology Fellows, a unique educational partnership between industry and academia he founded in 2004. From 1998-2003 and until its acquisition by Pfizer, he served as Director of Investigative Toxicology for the Pharmacia Corporation in Kalamazoo, MI. During this time he also founded the Investigative Toxicology Interest Group, an inter-pharmaceutical effort to benchmark strategies and practices used for investigational toxicology and pathology studies in drug development programs. Before joining the pharmaceutical industry, Dr. Cockerell served on the faculty of the Department of Pathology of Colorado State University's College of Veterinary Medicine and Biomedical Sciences (1985-1998), and before that, of the New York State College of Veterinary Medicine, Cornell University (1976-1985). He is a Diplomate of the American College of Veterinary Pathologists. Since 2009 he has also served as a consulting pathologist for Seventh Wave Laboratories, a contract research organization based in St. Louis, Missouri.

Dr. Harold Davis
Amgen, Inc. [retired]

Harold Davis is the former Vice President of Pre-clinical Safety at Amgen, Inc. He also was the Director of Toxicology and Laboratory Animal Resources at Amgen. Prior to his retirement from the Air Force with the rank of lieutenant colonel, Dr. Davis served as the Chief of Ultrastructural Pathology at the Naval Medical Research Institute in Bethesda, MD., and as Chief of Pathology at the School of Aerospace Medicine at Brooks Air Force Base in San Antonio, Texas. He decided to make a career in the pharmaceutical/biotechnology industry and worked at American Cyanamid Inc. in Pearl River, N. Y., until that company was acquired by American Home Products of Philadelphia. Dr. Davis has been actively involved with the Association of Minority Health Professional Schools.. He is a past president of the American College of Veterinary Pathologists, and has served on the Board of Directors of the California Biomedical Research Association and the Science Board to the US Food and Drug Administration. A native of Birmingham, Alabama, Dr. Davis received his PhD in cardiovascular pathology from the University of Alabama, Birmingham, and his DVM (1976) and BS from Tuskegee University.

Dr. Malcolm Getz
Vanderbilt University

Malcolm Getz is an associate professor of economics at Vanderbilt University. He is also the Director of Undergraduate Studies in Economics at Vanderbilt. His research interests are in urban economics, public finance, and higher education. He was Director of the Jean and Alexander Heard Library (1984-94) and Associate Provost for Information Services and Technology (1985-94). He is the author of several books, including Economic Challenges in Higher Education (with Charles T. Clotfelter, Ronald G. Ehrenberg, John J. Siegfried; University of Chicago Press, 1991) and Veterinary Medicine in Economic Transition (Iowa State University Press, 1997). Dr. Getz won the Jeffrey Nordhaus Prize for Teaching in the College of Arts and Science (1998), the Ernest A. Jones Prize for Faculty Advising (1998), and the Madison Sarratt Prize for Undergraduate Teaching at Vanderbilt (2000). His latest book is: Investing in College, A Guide for the Perplexed (Harvard University Press, 2007). Dr. Getz received his PhD (1973) in economics from Yale University, and BA (1967) in economics from Williams College.

Dr. Tracey S. McNamara
Western University of Health Sciences

Tracey S. McNamara is a veterinary pathologist and consultant. She specializes in the recognition and understanding of the diseases of captive and free-ranging wildlife and is best known for her work on West Nile virus. Dr. McNamara held the Schiff Family Distinguished Scientist in Wild Animal Pathology endowed chair at the Bronx Zoo/Wildlife Conservation Society (1987-2003). She received the President's Award from the American Veterinary Medical Association in recognition of "her contributions and dedication to animal, human, and public health [for] overcoming obstacles and resistance to identify West Nile Virus [and for utilizing] the facilities of zoos to establish surveillance and monitoring programs to control and combat the disease". She is a Diplomate of the American College of Veterinary Pathology and Vice President of the Charles Louis Davis, DVM Foundation for the Advancement of Veterinary and Comparative Pathology. Dr. McNamara was a Visiting Assistant Professor in the Department of Pathology at Albert Einstein College of Medicine of Yeshiva University, Associate of the Consortium for Conservation Medicine (Harvard Medical School's Center for Health and Global Environment, Tufts University School of Veterinary Medicine's Center for Conservation Medicine and Wildlife Trust), a Visiting Fellow in the Department of Population Medicine and Diagnostic Service, College of Veterinary Medicine, Cornell University, and Adjunct Professor in the Department of Pathology of Purdue University. Dr. McNamara received her DVM from the New York State College of Veterinary Medicine at Cornell University, and her BS in psychology and French literature from St. Lawrence University.

Dr. Gay Y. Miller
University of Illinois at Urbana-Champaign

Gay Y. Miller is a professor with appointments in the Departments of Pathobiology and Veterinary Clinical Medicine in the College of Veterinary Medicine, and the Department of Agricultural and Consumer Economics in the College of Agricultural, Consumer, and Environmental Sciences at the University of Illinois at Urbana-Champaign. She is also an adjunct professor in the Department of Population Medicine, in the College of Veterinary Medicine, and the University of Minnesota. Her professional interests are in the economic impact of disease prevention and control in food animals. This has been an expanding area of interest for the veterinary profession in the last three decades. She has worked on computer modeling and estimating the economic impact of disease prevention and control programs for food animal producers at the farm level. In 2006-2007, Dr. Miller did an AAAS Science and Technology Policy Fellowship, and was placed to work in the USDA, Veterinary Services, National Center for Animal Health Emergency Management, National Veterinary Stockpile. As a result of these experiences, she has maintained on-going working relationships with Veterinary Services and has had cooperative agreements with them since that time. Her research and service work now is focused on Foreign Animal Disease Preparedness and Response, the economic impacts of FADs and how to cost effectively and efficiently manage FAD preparedness and response. Dr. Miller received her PhD (1991) in agricultural economics, DVM (1981), and BS (1977) degrees in agricultural economics from the Ohio State University, and MS (1982) in agricultural economics from the University of Missouri-Columbia.

Dr. Bennie I. Osburn
University of California, Davis [Emeritus]

Bennie I. Osburn is retired Dean of the School of Veterinary Medicine at University of California (UC), Davis and was interim executive director of the Association of American Veterinary Colleges. His scientific career focused on the health and welfare of food animals, particularly cattle and sheep. He has been involved in key discoveries about food animal viruses, developmental immunology, congenital infections and more recently, food safety. He has published more than 285 peer-reviewed publications. Dr. Osburn is a member of the Johns Hopkins Society of Scholars, Fellow in the American Association for the Advancement of Science, Diplomate of the American College of Veterinary

Pathologist (ACVP) and Past President of ACVP, the American Association of Veterinary Immunologists, Association of American Veterinary Medical Colleges, and Chair of USDA's Agricultural Biotechnology Research Advisory Committee. Dr. Osburn served as head of the Infectious Disease and Immunology Unit at the California Regional Primate and Research Center from 1975 to 1983 and as Associate Dean for Research and Graduate Programs at UC Davis from 1975 until he became dean in 1996. Dr. Osburn earned his BS and DVM degrees at Kansas State University, and his PhD (1965) in Comparative Pathology at the University of California, Davis. From 1964 to 1968 he served on the faculty at the College of Veterinary Medicine at Oklahoma State University.

Dr. Mark V. Pauly
University of Pennsylvania

Mark Pauly received a PhD in economics from the University of Virginia. Dr. Pauly is a former commissioner on the Physician Payment Review Commission and an active member of the Institute of Medicine. One of the nation's leading health economists, Dr. Pauly has made significant contributions to the fields of medical economics and health insurance. His classic study on the economics of moral hazard was the first to point out how health insurance coverage may affect patients' use of medical services. Subsequent work, both theoretical and empirical, has explored the impact of conventional insurance coverage on preventive care, on outpatient care, and on prescription drug use in managed care. He is currently studying the effect of poor health on worker productivity. In addition, he has explored the influences that determine whether insurance coverage is available and, through several cost effectiveness studies, the influence of medical care and health practices on health outcomes and cost. His interests in health policy deal with ways to reduce the number of uninsured people through tax credits for public and private insurance, and appropriate design for Medicare in a budget-constrained environment. Dr. Pauly is a co-editor-in-chief of the International Journal of Health Care Finance and Economics and an associate editor of the Journal of Risk and Uncertainty. He has served on Institute of Medicine panels on public accountability for health insurers under Medicare and on improving the supply of vaccines.

Dr. Fred W. Quimby
The Rockefeller University [retired]

Fred Quimby is the former Associate Vice President and Senior Director of the Laboratory Animal Research Center at Rockefeller University, positions he held until 2007. Before arriving at Rockefeller, he was a Professor of Pathology at Weill Medical College of Cornell University and the New York State College of Veterinary Medicine. He was a faculty member in the Graduate Schools of Veterinary Medicine, Immunology, and Environmental Toxicology with primary research interests in immunotoxicology and immune mediated diseases of animals. He was also the Director of the Division of Laboratory Animal Services and the Cornell University Center for Research Animal Resources. Since retirement Dr. Quimby has consulted for several academic institutions and corporations. He previously served on eight NRC/ILAR committees including the Committee on Increasing Veterinary Involvement in Biomedical Research (2004) and the Committee for the Update of the Guide for the Care and Use of Laboratory Animals (2011).

Dr. Stephen F. Sutherland
Pfizer Animal Health

Stephen F. Sutherland is the Senior Director of U.S. Regulatory Affairs at Pfizer Animal Health's Veterinary Medicine Research and Development organization. He served as a private practitioner in companion and food animal practices for five years. He entered the animal health pharmaceutical industry as a Technical Services veterinarian for Bristol-Myers Animal Health. He has also served as a Director of Technical Services and Director of Product Development for Fort Dodge Animal Health. He has held a variety of positions over the past 15 years while employed by Upjohn, Pharmacia and Upjohn, Pharmacia, and now Pfizer, with positions including Manager of New Business Development, Director and Senior Director of Global Regulatory Affairs, and Senior Director of U.S. Clinical Development. Dr. Sutherland received his DVM and BS degrees from the College of Veterinary Medicine at Michigan State University.

Appendix B

Survey of Companion-Animal Practice Owners

The participants for the Companion-Animal Practice Owners Survey were selected from the 2008 membership directory of the American Veterinary Medical Association (AVMA). The membership of the AVMA does not include all practicing veterinarians, but AVMA estimates that 90 percent of the veterinarians are members, since an advantage of membership is the insurance AVMA provides. There are 17,886 regular or honorary members who identify themselves as owners of a veterinary practice that is either companion-animal-predominant (over 50% companion-animals) or exclusive (over 90% companion-animals). Since the survey was to be conducted over the internet, the sample frame was reduced to 10,197 members with e-mail addresses. Also, in compiling the directory, the AVMA gives members the option of not having their information given to another party for advertising or other purposes, and in the construction of the subpopulation for the survey these individuals were not included. This reduced the pool to 5,651 members. This was too large a group to survey, so the subpopulation was stratified by gender, age group, and location (state and urban or rural). The stratification was done by determining the percentage of members from the 5,651 pool in each of the stratification variables, and selecting about 10% of the total pool. This resulted in a survey sample of 596 members. An e-mail letter was sent to each person in the sample asking them to go to a website where they could complete the questionnaire. There were several follow-up e-mails sent to members who did not respond to the survey: an additional e-mail from the National Research Council, a letter from the AVMA president and e-mails from the Executive Directors of the State Veterinary Medical Associations. With these efforts to increase the response rate there were 286 completed questionnaires after removing duplicate responses from the same practice and responses where only a few questions were completed. The data from the survey are available to researchers after names and demographic identifiers are removed.

This survey is being conducted by the National Research Council, the operational component of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, to examine various aspects of the veterinary medical profession. The study will explore historical changes in the size and characteristics of the veterinary workforce; assess the demographics and adequacy of the current supply of veterinarians in different occupational categories and sectors of the economy; and identify incentives, disincentives, and other factors that are likely to affect the numbers of veterinarians seeking jobs in different sectors in the future. The study will also examine trends affecting the kinds of jobs available to veterinarians and assess future demand for veterinary expertise in existing and new employment sectors. The study will examine the current and future capacity of universities and colleges to provide sufficient numbers of adequately trained veterinarians and identify training needs relative to the demand for specific expertise. Data on past trends and the current status of the workforce are not available from national databases. To gather the necessary data the Committee for the study is conducting surveys in various sectors. The questions in this survey are designed to collect information on the employment of veterinarians in the companion-animal practice sector.

Responding to this questionnaire is very important, since it is being sent to only a sample of companion-animal practice owners and having a good response rate will provide information about the entire population.

By completing this questionnaire, you are providing information that will: 1) help the NRC identify the characteristics of the veterinary workforce; 2) enable the NRC to analyze trends in the composition of the workforce; 3) will provide data that will inform the profession and educational institutions on the status of the veterinary workforce.

Your participation is voluntary. You may refuse to answer any question or discontinue participation at any point. There is no risk to you or your practice in responding to this questionnaire. The data will be reported in an aggregate form and your identity will be known to only the National Research Council. Your willingness to provide the answers to the questions indicates your informed consent to participate in this study.

1) The following demographic information will assist us in analyzing responses to the survey. You are not required to provide this information, but it will let us know who has responded and you should not receive follow up reminders.

Name: ______________________________

Company: ______________________________

Address: ______________________________

Address 2: ______________________________

City/Town: ______________________________

State: ______________________________

Zip code: ______________________________

Email: ______________________________

Phone Number: ______________________________

2) How many animal clinics do you own or have a share in (excluding partial ownership of an emergency clinic)?

____

For the clinics identified in Question #2, provide the following information for the 5 largest in terms of the number of veterinarian pet visits per week and if you operate more than 5 clinics, provide the average of the information for the additional clinics in the last row.

A "veterinarian office call" is defined as each time a pet is seen by a veterinarian, whether that visit results in the pet being admitted to the hospital or not. Please do not include any visits seen by specialists other than those who are ABVP certified.

3) On average, how many veterinarian office calls are there per week in each clinic?

Clinic #1: ______________________________
Clinic #2: ______________________________
Clinic #3: ______________________________
Clinic #4: ______________________________
Clinic #5: ______________________________
Additional Clinics: ______________________________

4) How many veterinarians staff your clinics? Count veterinarians that work in multiple clinics multiple times.

Clinic #1: ______________________________
Clinic #2: ______________________________
Clinic #3: ______________________________
Clinic #4: ______________________________
Clinic #5: ______________________________
Additional Clinics: ______________________________

5) How many veterinarian FTE's (full-time-equivalent) does it take to see the cases in the clinic? In other words, the number of veterinarians working full time who see that many cases indicated above. For example, if two veterinarians are working full time and one is working halftime to see the patients indicated, the number is 2.5.

Clinic #1: ______________________________
Clinic #2: ______________________________
Clinic #3: ______________________________
Clinic #4: ______________________________
Clinic #5: ______________________________
Additional Clinics: ______________________________

6) On average, how many technician office calls are done per week? A "technician office call" is defined as each time a pet is seen by a technician only.

Clinic #1: ____________________________
Clinic #2: ____________________________
Clinic #3: ____________________________
Clinic #4: ____________________________
Clinic #5: ____________________________
Additional Clinics: ____________________________

7) What is the average time period, in minutes, scheduled for each office visit? Please indicate the entire time scheduled, including the time spent with a technician or assistant before or after the veterinarian.

Clinic #1: ____________________________
Clinic #2: ____________________________
Clinic #3: ____________________________
Clinic #4: ____________________________
Clinic #5: ____________________________
Additional Clinics: ____________________________

8) What is the annual gross revenue for these clinics?

Clinic #1: ____________________________
Clinic #2: ____________________________
Clinic #3: ____________________________
Clinic #4: ____________________________
Clinic #5: ____________________________
Additional Clinics: ____________________________

9) How many of the veterinarians in your employ work in one or in multiple clinics?

One clinic only: ____________________________
Two clinics: ____________________________
Three clinics: ____________________________
Four or more clinics: ____________________________

10) How many of the veterinary technicians in your employ work in one or in multiple clinics?

One clinic only: ____________________________
Two clinics: ____________________________
Three clinics: ____________________________
Four or more clinics: ____________________________

Please fill in the following tables with the total number of staff currently working in all the clinics you own (current). Please indicate how many additional personnel you plan to hire this year (2008). Please estimate the number you will hire in subsequent years.

11) Veterinarians

	Full-Time	Average Full-Time Hours Per Week	Part-Time	Average Part-Time Hours per Week
Current				
2008				
2010				
2012				
2014				
2016				

12) Registered Technicians

	Full-Time	Average Full-Time Hours Per Week	Part-Time	Average Part-Time Hours per Week
Current				
2008				
2010				
2012				
2014				
2016				

13) Veterinary Assistants (Include animal care assistants only, not caretakers or others who take care of facilities etc.)

	Full-Time	Average Full-Time Hours Per Week	Part-Time	Average Part-Time Hours per Week
Current				
2008				
2010				
2012				
2014				
2016				

14) Office Staff

	Full-Time	Average Full-Time Hours Per Week	Part-Time	Average Part-Time Hours per Week
Current				
2008				
2010				
2012				
2014				
2016				

15) If you hire a veterinarian within the next year, how much do you expect to pay in annual compensation (not including benefits)?

New Graduate: ____________________
Veterinarian with 1 to 5 years experience: ____________________
Veterinarian with 5 or more years experience: ____________________

16) For a veterinarian you would hire within the next year, what would you consider paying as a signing bonus?

New Graduate: ____________________
Veterinarian with 1 to 5 years experience: ____________________
Veterinarian with 5 or more years experience: ____________________

Appendix C

Supporting Material for Chapter 4

The following disclaimer is for Figures C-1, C-3, C-4, C-5, C-12a, C-12b, C13a, C-13b, and C-14a.

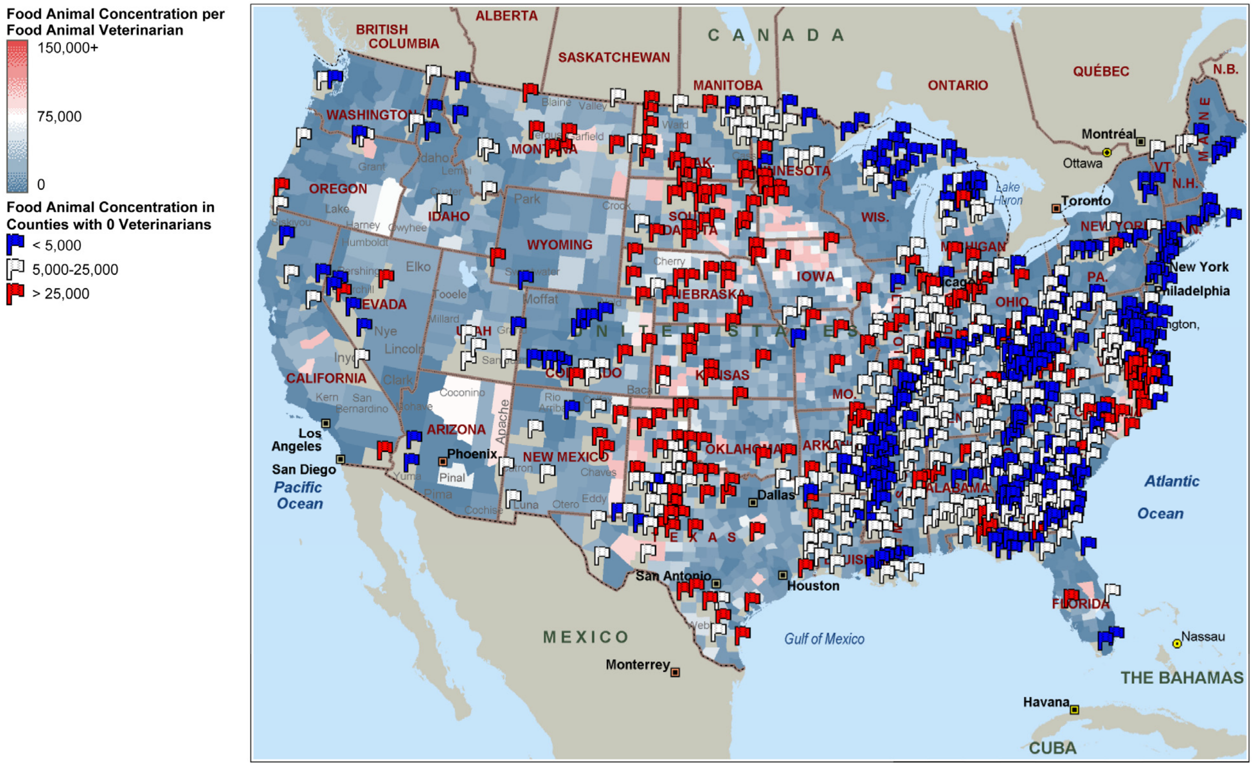

FIGURE C-1 Food-animal concentrations in counties that have no veterinarians. SOURCE: American Veterinary Medical Association (2006b).

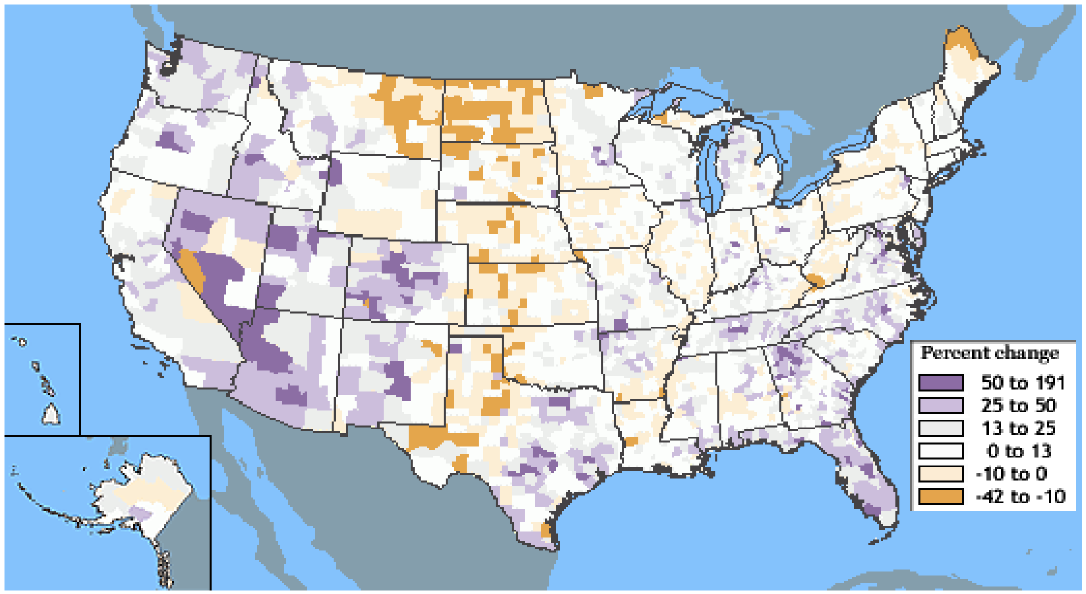

FIGURE C-2 Changes in population growth between 1990 and 2000 for the 3,141 counties and equivalent areas in the United States.[1]
SOURCE: National Atlas of the United States. 2011. Adapted from U.S. Census Bureau, Population Change and Distribution: 1990 to 2000. M.J. Perry and P.J. Mackun (with J.D. Baker, C.D. Joyce, L.R. Lollock, and L.S. Pearson) in Census 2000 Brief Series. 2001.

[1]A band of counties that lost population—in some cases declining more than 10 percent—stretches across the Great Plains States from the Mexican border to the Canadian border.

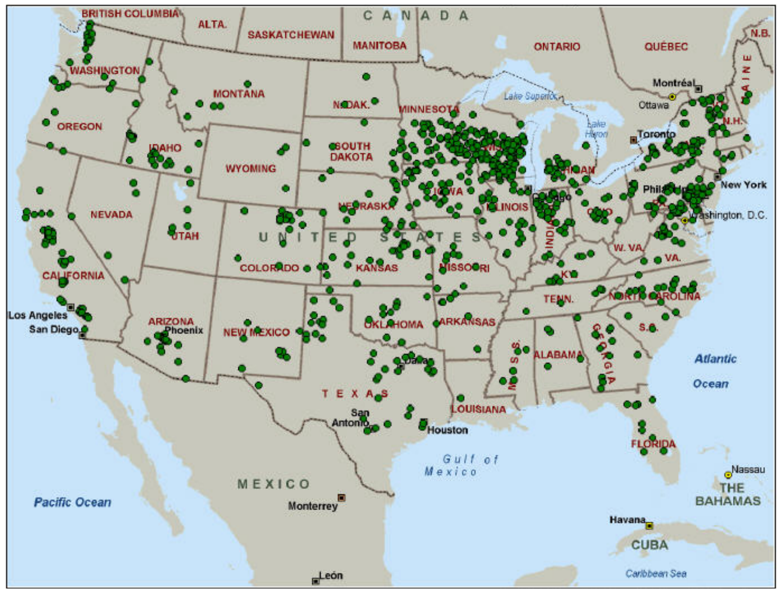

FIGURE C-3 Distribution of the 1,011 food-animal-exclusive veterinarians in the United States, 2007.[2] SOURCE: American Veterinary Medical Association (2008).

[2]Distribution is not uniform but is concentrated in areas of the country with high animal densities, particularly in traditional dairy states. Some 46% are in six leading dairy states: California, Wisconsin, New York, Pennsylvania, Minnesota, and Idaho. That suggests that FA-exclusive veterinarians are mainly dairy practitioners. Populations of FA-exclusive veterinarians in Iowa, Illinois, Missouri, and North Carolina correspond to concentrations of swine industry, those in Georgia and neighboring states to broiler industry. Because of low animal densities, there are very few FA-exclusive veterinarians in North Dakota, Montana, and Wyoming.

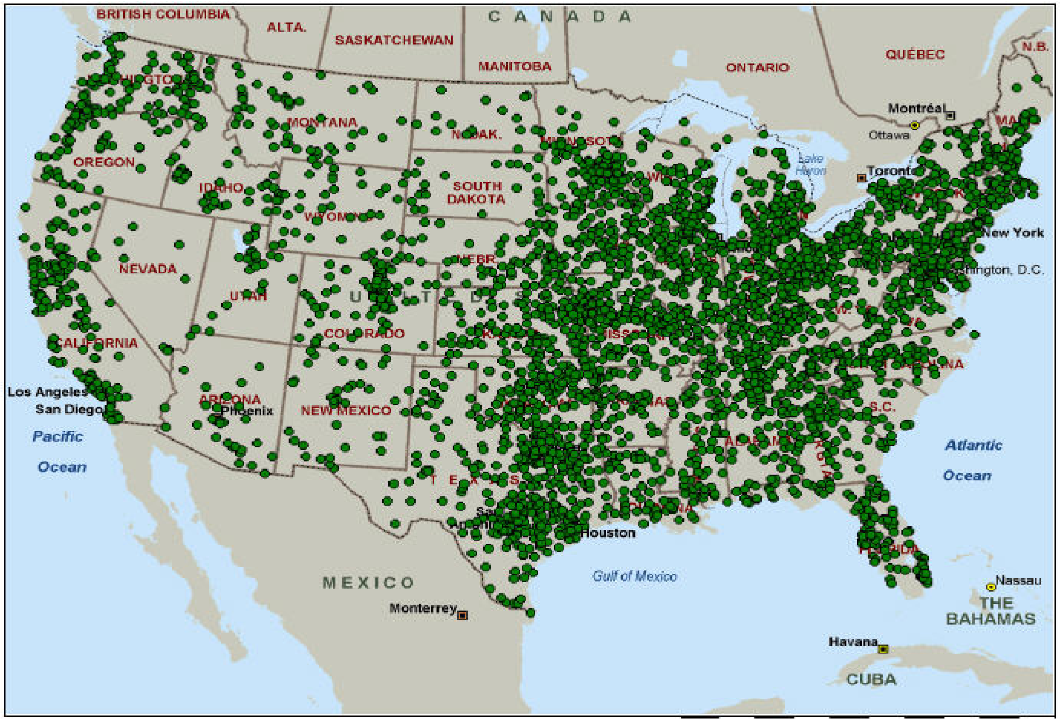

FIGURE C-4 Distribution of the 4,200 mixed-food-animal veterinarians in the United States, 2007.[3] SOURCE: American Veterinary Medical Association (2008).

[3]Distribution closely parallels that of US population.

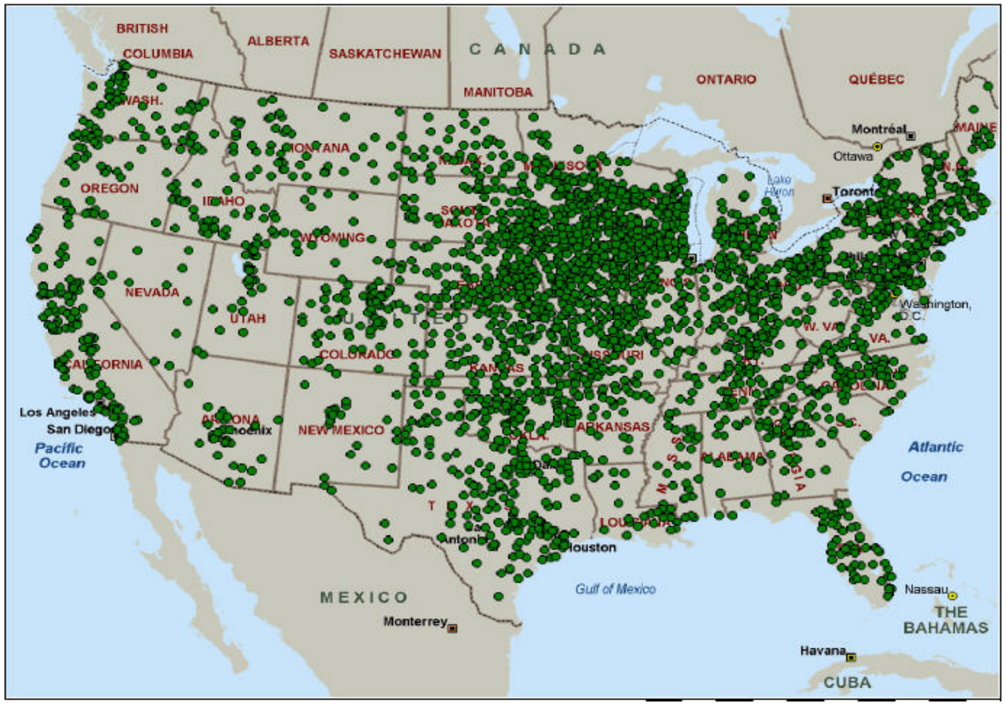

FIGURE C-5 Distribution of the 3,861 food-animal-predominant veterinarians in the United States, 2007.[4] SOURCE: American Veterinary Medical Association (2008).

[4]FA-predominant veterinarians are most numerous in the grain states of Midwest. Largest numbers are in Iowa and Minnesota.

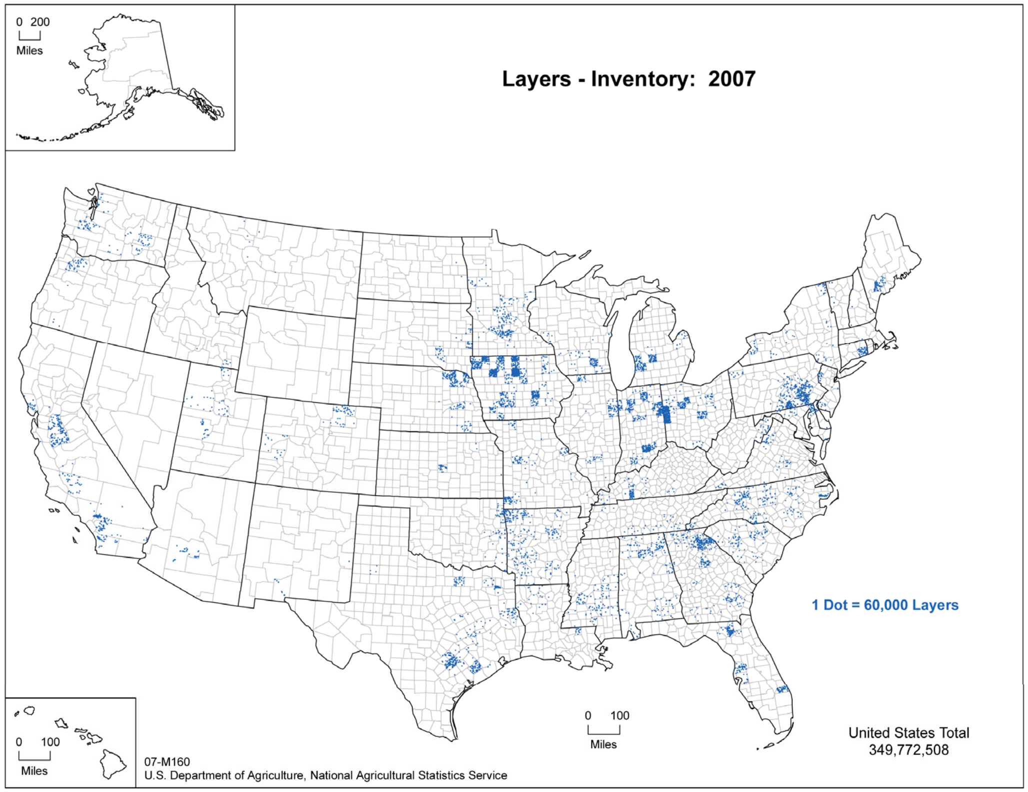

FIGURE C-6a Distribution of egg-laying industry in the United States, 2007. SOURCE: USDA.

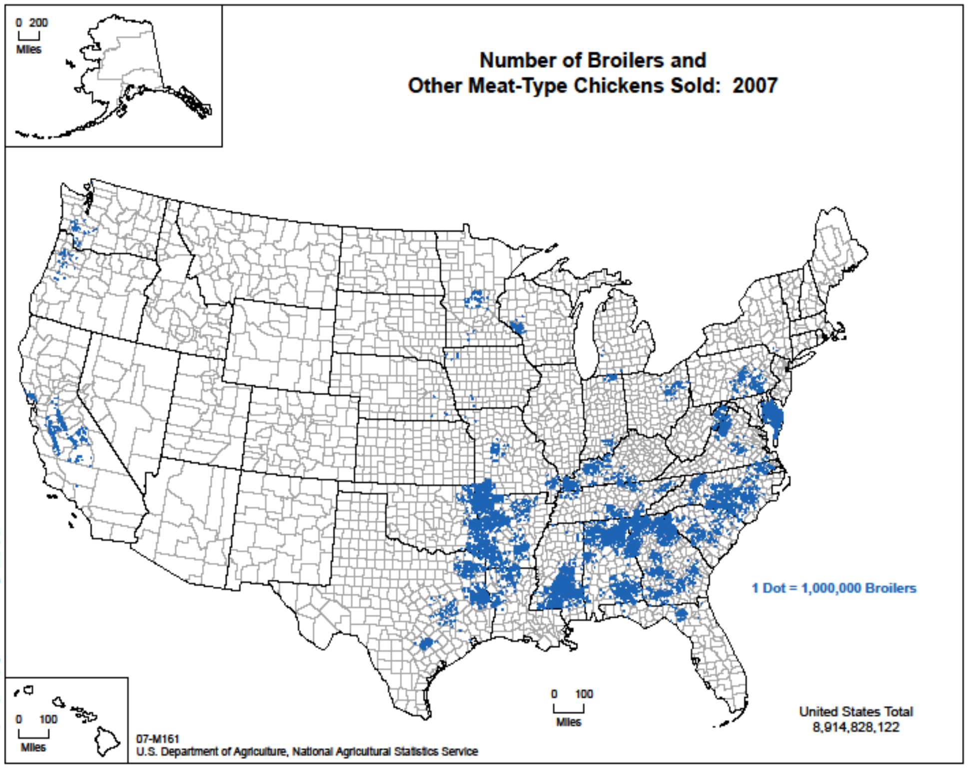

FIGURE C-6b Distribution of broiler industry in the United States, 2007. SOURCE: USDA.

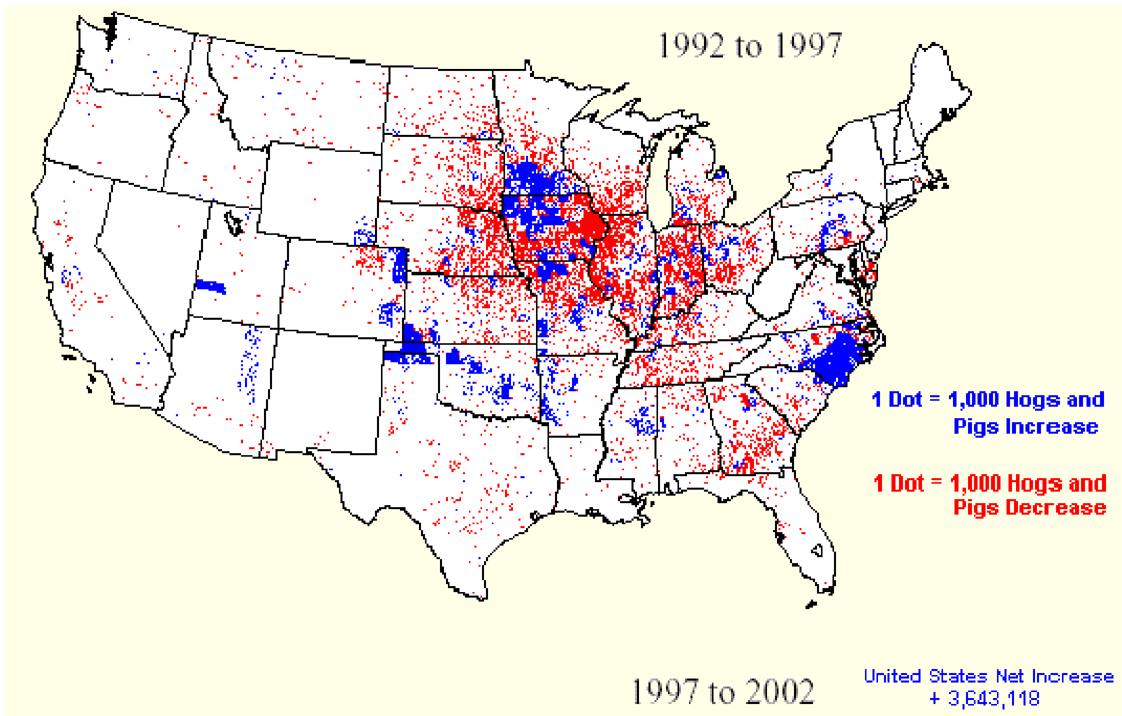

FIGURE C-7 Changes in the U.S. hog and pig inventory, 1992-1997. SOURCE: USDA.

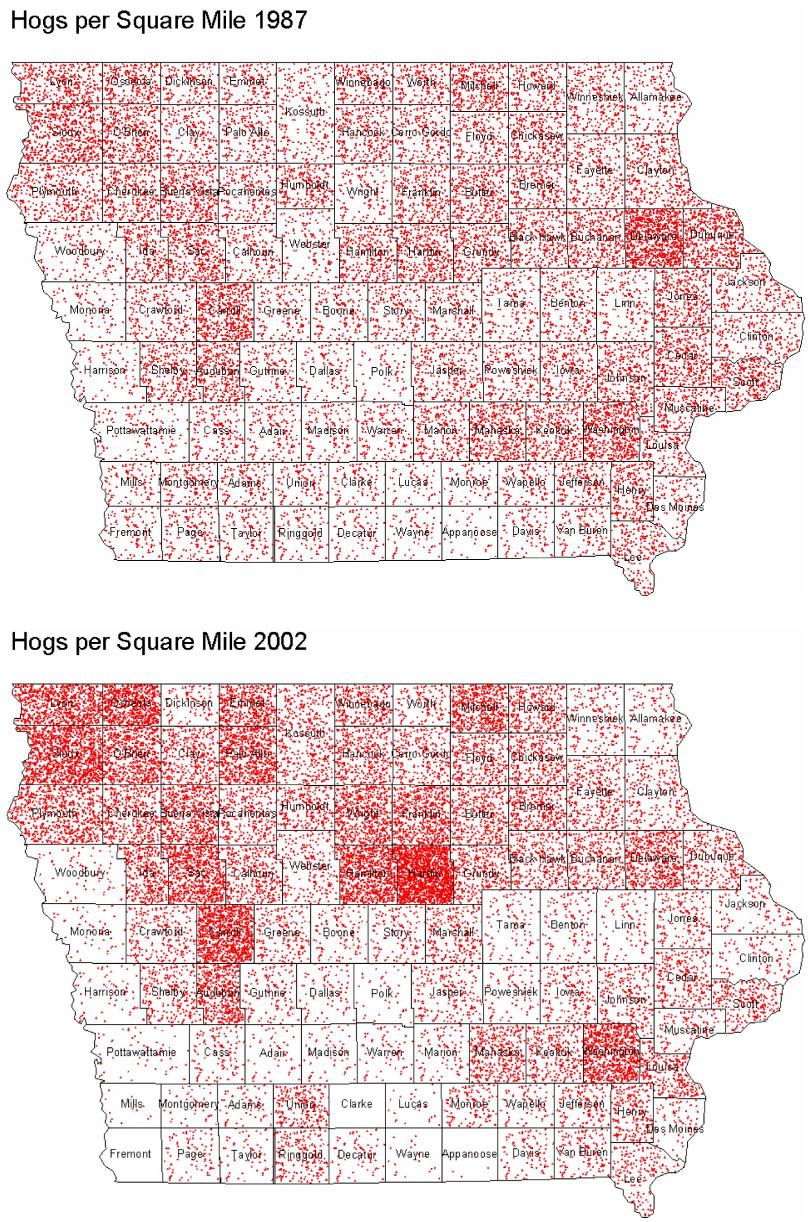

FIGURE C-8 The changing pork industry in Iowa, 1987 and 2002. SOURCE: Honeyman and Duffy, 2006. Reprinted with permission of M. Honeyman, Iowa State University.

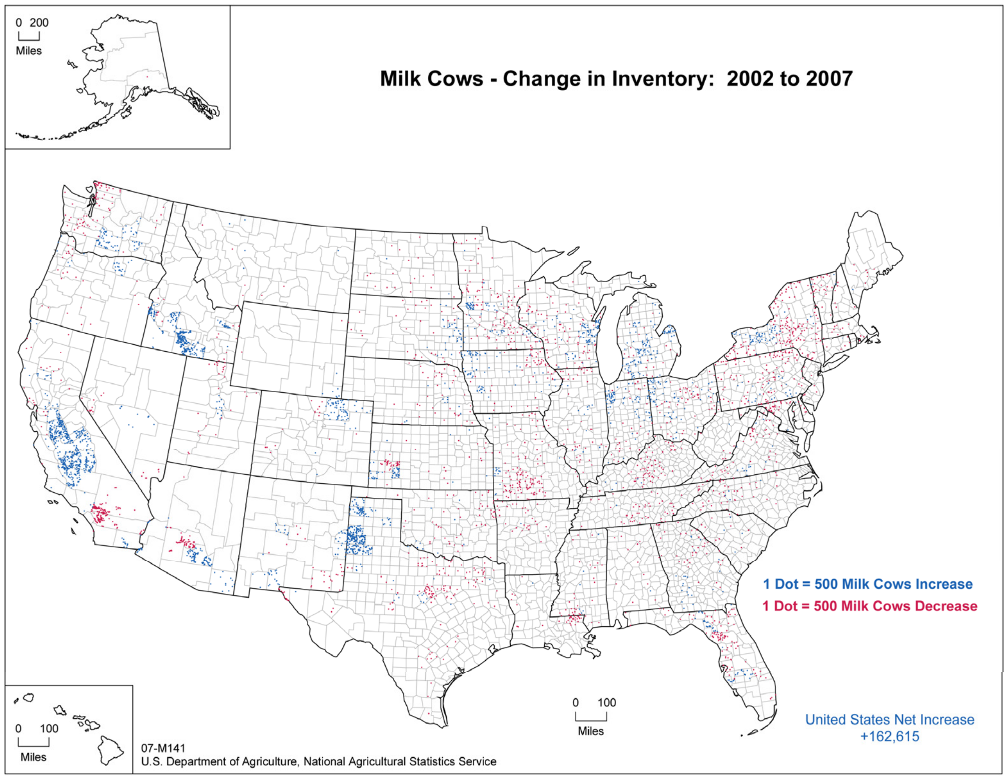

FIGURE C-9 Milk-cow population, change in inventory, 2002-2007. SOURCE: USDA.

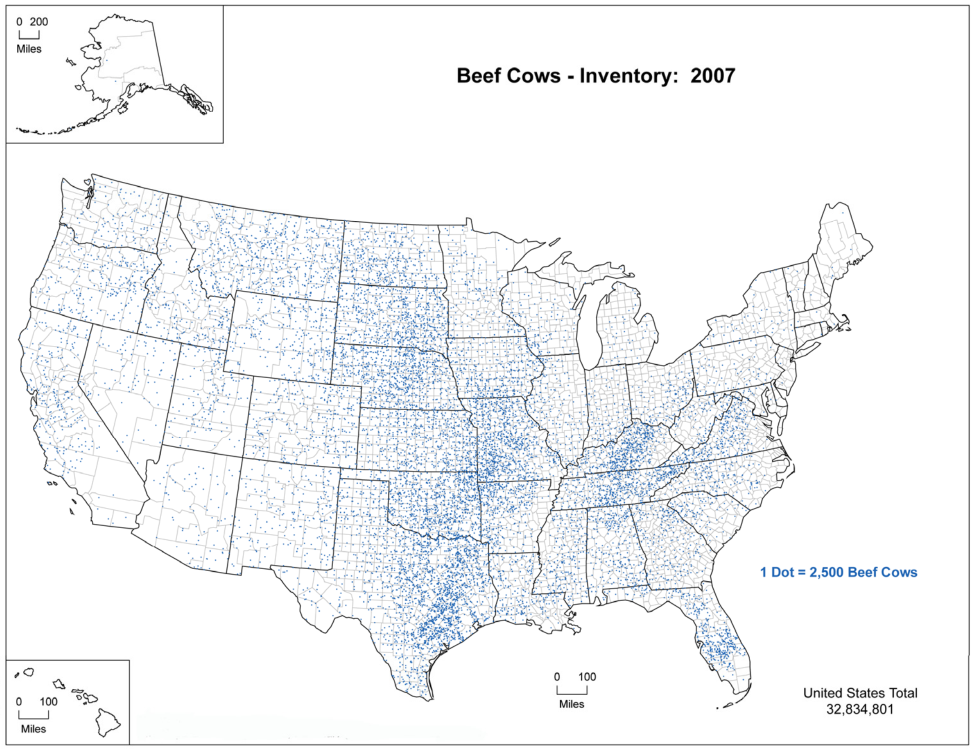

FIGURE C-10 Beef-cows inventory, 2007. SOURCE: USDA.

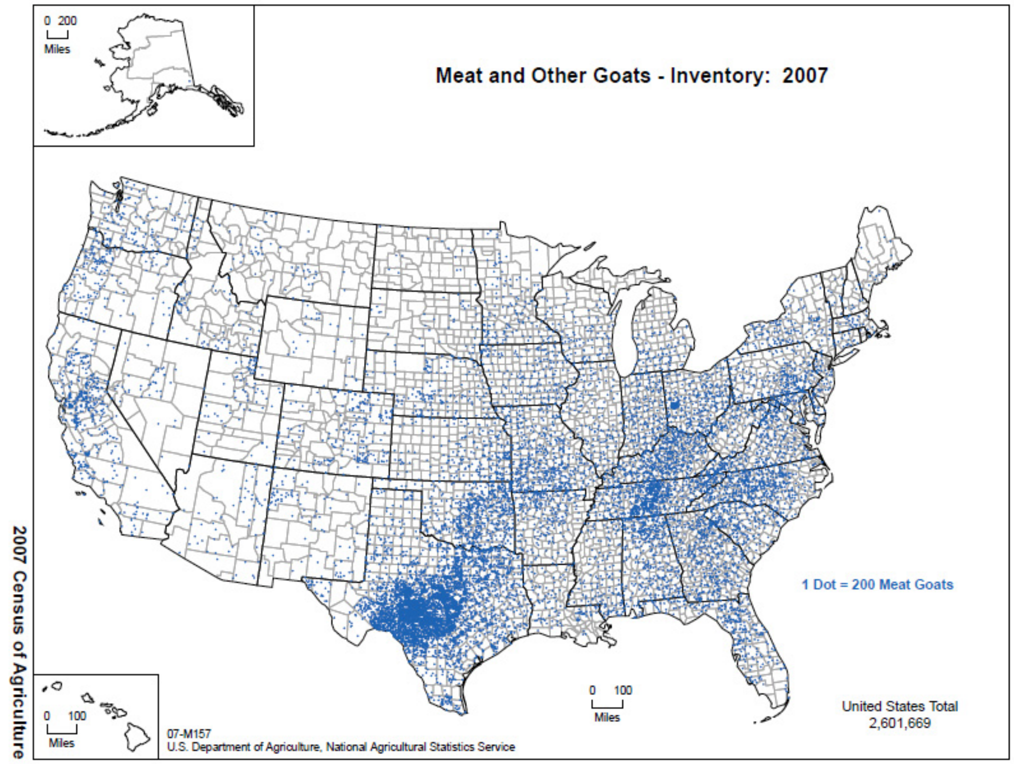

FIGURE C-11a Meat-goat and other goat inventory, 2007. SOURCE: USDA.

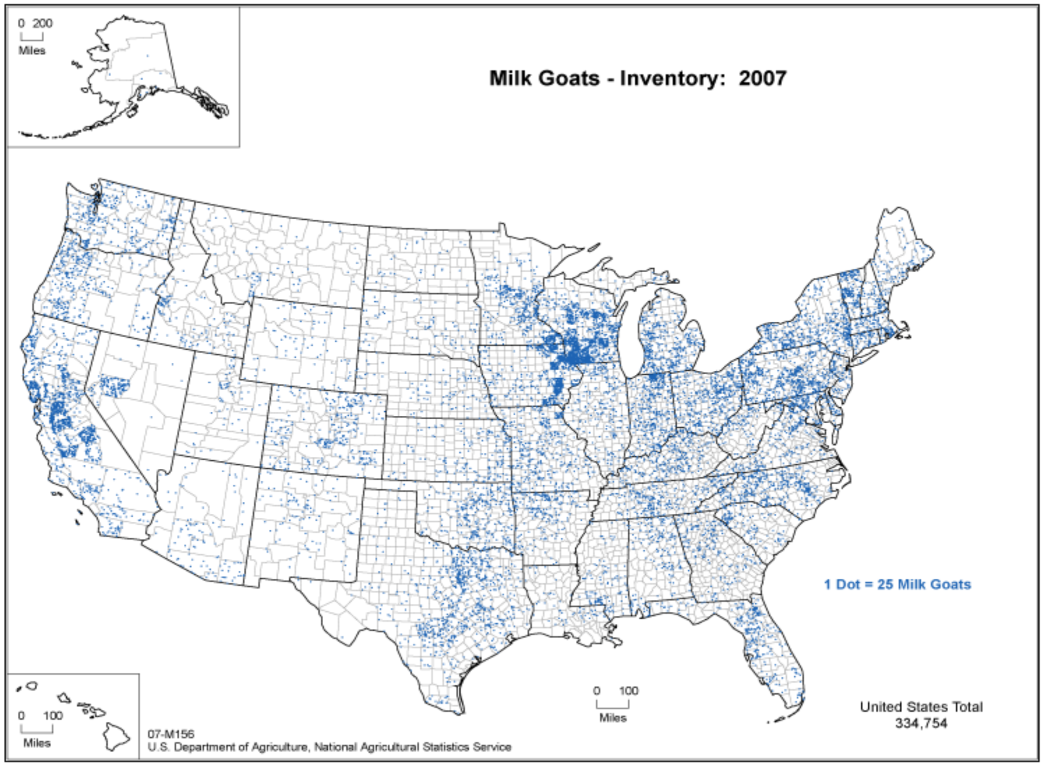

FIGURE C-11b Dairy-goat inventory, 2007. SOURCE: USDA.

TABLE C-1 Food-Animal Workforce, 2001-2007, by State

State	Food-animal exclusive and food-animal-predominant veterinarians				Mixed-food-animal veterinarians			
	Year				Year			
	2001	2007	Change	% change	2001	2007	Change	% change
AL	42	27	-15	-36	70	67	-3	-4
AR	46	44	-2	-4	82	87	5	6
AZ	58	51	-7	-12	35	38	3	8
CA	304	261	-43	-14	151	195	44	29
CO	176	155	-21	-12	100	115	15	15
CT	22	18	-4	-18	18	28	10	55
DE	2	6	4	200	4	4	0	0
FL	99	85	-14	-14	101	114	13	13
GA	73	69	-4	-5	99	100	1	1
IA	439	382	-57	-13	118	132	14	12
ID	110	110	0	0	62	64	2	3
IL	175	133	-42	-24	123	158	35	28
IN	136	102	-34	-25	96	104	8	8
KS	193	162	-31	-16	153	172	19	12
KY	106	93	-13	-12	111	114	3	2
LA	42	35	-7	-16	64	69	5	8
MA	30	24	-6	-20	30	33	3	10
MD	54	42	-12	-22	40	55	15	37
ME	18	17	-1	-5	27	29	2	7
MI	137	122	-15	-11	104	97	-7	-6
MN	350	320	-30	-8	84	109	25	30
MO	217	174	-43	-20	168	178	10	6
MS	35	35	0	0	72	76	4	5
MT	113	97	-16	-14	55	69	14	25
NC	92	90	-2	-2	71	79	8	11
ND	71	72	1	1	21	27	6	28
NE	259	225	-34	-13	64	75	11	17
NH	14	12	-2	-14	32	34	2	6
NJ	25	16	-9	-35	14	24	10	71
NM	45	36	-9	-20	53	55	2	4
NV	20	23	3	15	21	19	-2	-9
NY	203	179	-24	-11	118	128	10	8
OH	170	148	-22	-7	141	170	29	21
OK	161	134	-27	-16	147	154	7	4
OR	85	70	-15	-17	92	120	28	30
PA	204	208	4	2	114	141	27	24
RI	2	1	1	-50	1	3	2	200
SC	20	23	3	15	41	35	-6	15
SD	145	144	-1	0	29	34	5	17
TN	73	66	-7	-9	117	117	0	0
TX	340	289	-51	-15	444	452	8	2
UT	40	40	0	0	25	45	20	80
VA	82	78	-4-	-5	69	73	4	6
VT	41	40	-1	-2	25	48	23	92
WA	108	94	-14	-12	106	103	-3	-2
WI	496	460	-36	-7	89	110	21	23
WV	20	19	-1	-2	20	23	3	15
WY	54	43	-11	-20	57	63	6	10
Total	5747	5074	671	-12	3878	4339	460	11

SOURCE: American Veterinary Medical Association.

TABLE C-2a Food-Animal-Exclusive Veterinarians: Mean Ages and Percentage Over Age 50, by State

State	Total	Mean Age	Count over 50	Percentage over 50
LA	1	31.00	0	0
MA	1		0	0
NJ	1	47.00	0	0
VI	1	47.00	0	0
WV	2	28.00	0	0
AL	4	40.75	1	25.0
CT	4	43.00	1	25.0
MN	74	43.97	22	29.7
ID	36	44.89	11	31.4
GA	12	46.83	4.	33.3
KY	12	44.75	4	33.3
NC	21	50.67	7	33.3
SC	3	49.00	1	33.3
AZ	17	45.41	6	35.3
NE	22	46.36	8	36.4
MD	16	46.81	6	37.5
MI	29	45.03	11	37.9
CA	89	46.13	34	38.2
CO	33	47.82	13	39.4
PA	74	44.95	30	40.5
NM	11	45.82	5	45.5
WI	159	47.66	74	47.1
IA	53	46.47	25	47.2
IL	26	46.19	13	50.0
ND	4	45.75	2	50.0
SD	12	46.92	6	50.0
TN	6	48.93	3	50.0
WY	3	47.00	1	50.0
OH	15	47.00	8	53.3
OK	13	50.38	7	53.8
KS	25	49.60	14	56.0
WA	25	50.12	14	56.0
TX	48	49.67	27	56.3
NY	49	48.90	28	58.3
OR	12	51.67	7	58.3
VT	17	50.82	10	58.8
FL	10	48.60	6	60.0
MS	5	43.80	3	60.0
IN	40	49.18	24	61.5
VA	19	52.74	12	63.2
ME	3	45.00	2	66.7
NH	3	53.33	2	66.7
MO	13	52.38	10	76.9
AR	5	55.40	4	80.0
UT	5	52.60	4	80.0
MT	7	56.86	6	85.7
PR	3	58.67	3	100
Total	1048	47.41	484	46.5

SOURCE: American Veterinary Medical Association.

TABLE C-2b Food-Animal-Exclusive Veterinarians: Mean Ages and Percentage Over Age 60, by State

State	Total	Mean Age	Count over 60	Percentage over 60
AL	4	40.75		0
CT	4	43.00		0
LA	1	31.00		0
MA	1			0
ME	3	45.00		0
MS	5	43.80		0
ND	4	45.75		0
NE	22	46.36		0
NH	3	53.33		0
NJ	1	47.00		0
TN	6	48.83		0
UT	5	52.60		0
VI	1	47.00		0
WV	1	28.00		0
WY	3	47.00		0
MD	16	46.81	1	6.3
OH	15	47.00	1	6.7
IL	26	46.19	2	7.7
KS	25	49.60	2	8.0
MN	74	43.97	6	8.1
KY	12	44.75	1	8.3
SD	12	45.92	1	8.3
NM	11	45.82	1	9.1
MI	29	45.03	3	10.3
WI	159	47.66	18	11.5
WA	25	50.12	3	12.0
CO	33	47.82	4	12.1
PA	74	44.95	9	12.2
ID	36	44.89	5	14.3
IN	40	49.18	6	15.4
GA	12	46.83	2	16.7
NY	49	48.90	8	16.7
CA	89	46.13	15	16.9
IA	53	46.47	9	17.0
FL	10	48.60	2	20.0
TX	48	49.67	11	22.9
MO	13	52.38	3	23.1
OK	13	50.38	3	23.1
AZ	17	45.41	4	23.5
NC	21	50.67	5	23.8
OR	12	51.67	3	25.0
VA	19	52.74	5	26.3
VT	17	50.82	5	29.4
PR	3	58.67	1	33.3
SC	3	49.00	1	33.3
AR	5	55.40	2	40.0
MT	7	56.86	3	42.9
NV	6	53.17	3	50.0
Total	1048	47.41	148	14.2

SOURCE: American Veterinary Medical Association.

TABLE C-3a Food-Animal-Predominant Veterinarians Over Age 50, by State

State	Total	Mean Age	Count over 50	Percentage over 50
RI	1	49.00		0
VI	1	43.00		0
PR	11	46.00	2	18.2
CT	14	45.21	3	21.4
NH	9	46.00	3	33.3
NV	17	47.41	6	35.3
WV	18	46.78	7	38.9
NM	25	51.24	10	40.0
TN	60	49.70	26	43.3
NC	69	47.35	31	44.9
SC	20	51.25	9	45.0
VA	59	48.64	27	45.8
NJ	15	49.67	7	46.7
LA	34	48.44	16	47.1
KY	81	49.35	39	48.1
PA	134	48.37	64	48.9
AL	23	49.55	11	50.0
AZ	34	49.29	17	50.0
MD	26	48.81	13	50.0
ND	68	48.43	34	50.0
FL	75	49.76	38	50.7
AR	39	49.41	20	51.3
MI	93	49.29	48	51.6
OH	133	49.58	69	52.3
IN	62	49.87	32	52.5
SD	132	49.73	70	53.4
KS	137	50.44	73	53.7
NY	130	49.43	70	53.8
UT	35	49.91	19	54.3
GA	57	50.61	31	54.4
NE	203	49.77	112	55.7
WI	301	50.07	169	56.1
OK	122	51.51	69	56.6
ME	14	48.64	8	57.1
MS	30	51.00	17	58.6
CO	122	51.99	73	59.8
CA	172	50.80	104	60.8
VT	23	50.35	14	60.9
MO	161	51.98	100	62.1
MT	90	51.24	56	62.9
MN	246	51.81	155	63.0
IA	329	52.27	209	63.5
WA	69	51.12	44	64.7
TX	241	52.08	156	64.7
ID	74	52.01	48	64.9
IL	107	52.28	69	65.1
DE	3	44.33	2	66.7
OR	58	52.50	39	67.2
MA	23	51.78	16	69.6
WY	40	54.58	31	77.5
AK	1	51.00	1	100.0
HI	1	67.00	1	100.0
Total	4042	50.58	2289	56.8

SOURCE: American Veterinary Medical Association.

TABLE C-3b Food-Animal-Predominant Veterinarians Over Age 60, by State

State	Total	Mean Age	Count over 60	Percentage over 60
AK	1	51.00		0
DE	3	44.33		0
NH	9	46.00		0
RI	1	49.00		0
VI	1	43.00		0
PR	11	46.00	1	9.1
WV	18	46.78	2	11.1
VT	23	50.35	3	13.0
CT	14	45.21	2	14.3
NC	69	47.35	10	14.5
LA	34	48.44	5	14.7
WA	69	51.12	10	14.7
VA	59	48.64	9	15.3
WI	301	50.07	48	15.9
MI	93	49.29	15	16.1
ND	68	48.43	11	16.2
NE	203	49.77	34	16.9
NV	17	47.41	3	17.6
AR	39	49.41	7	17.9
IN	62	49.97	11	18.0
AL	23	49.55	4	18.2
NY	130	49.43	24	18.5
MD	26	48.81	5	19.2
CA	172	50.80	33	19.3
OH	133	49.58	26	19.7
KS	137	50.44	27	19.9
FL	75	49.76	15	20.0
NJ	15	49.67	3	20.0
SC	20	51.25	4	20.0
UT	35	49.91	7	20.0
PA	134	48.37	27	20.3
AZ	34	49.29	7	20.6
OR	58	52.50	12	20.7
KY	81	49.35	17	21.0
GA	57	50.61	12	21.1
ME	14	48.64	3	21.4
IL	107	52.28	23	21.7
MA	23	51.78	5	21.7
TN	60	49.70	14	23.3
MT	90	51.24	21	23.6
MO	161	51.98	38	23.6
IA	329	52.27	79	24.0
MS	30	51.00	7	24.1
CO	122	51.99	30	24.6
SD	132	49.73	33	25.2
MN	246	51.81	63	25.6
TX	241	52.08	65	27.0
OK	122	51.51	33	27.0
ID	74	52.01	22	29.7
NM	25	51.24	8	32.0
WY	40	54.58	16	40.0
HI	1	67.00	1	100.00
Total	4042	50.58	855	21.2

SOURCE: American Veterinary Medical Association.

TABLE C-4a Mixed-Food-Animal Veterinarians Over Age 50, by State

State	Total	Mean Age	Count over 50	Percentage over 50
MD	55	43	14	25.9
ND	27	42	7	25.9
SD	34	42	9	26.5
NC	79	44	23	29.1
WV	23	43	7	30.4
LA	69	44	22	32.4
HI	9	47	3	33.3
PA	141	46	46	33.3
RI	3	44	1	33.3
NH	34	45	12	35.3
KY	114	45	40	35.4
IL	158	46	57	36.1
UT	34	45	13	38.2
OH	170	46	66	38.8
CT	28	47	11	39.3
AK	15	46	6	40.0
GA	100	48	40	40.0
NY	128	47	52	40.9
VA	73	47	30	41.1
MN	109	47	45	41.3
OR	120	47	50	41.7
AR	87	47	37	43.0
ID	64	47	28	43.8
FL	114	48	50	44.2
NE	75	48	32	44.4
AZ	38	47	17	44.7
TN	117	46	52	44.8
CO	115	47	52	45.2
KS	172	47	78	45.9
MO	178	49	82	46.6
MS	76	48	35	46.7
OK	154	48	73	47.4
MT	69	48	33	47.8
IA	132	49	63	48.1
NM	55	49	26	48.1
ME	29	49	14	48.3
SC	35	47	17	48.6
DE	4	49	2	50.0
NJ	24	48	12	50.0
VT	22	48	11	50.05
TX	452	48	227	50.2
AL	67	48	227	50.7
IN	104	49	52	51.0
CA	195	50	100	51.5
WI	110	47	56	51.9
NV	19	47	10	52.6
WA	103	49	54	52.9
MA	33	47	17	53.1
MI	97	49	52	53.6
WY	63	49	34	54.0
Total	4345	47	1908	44.2

SOURCE: American Veterinary Medical Association.

TABLE C-4b Mixed-Food-Animal Veterinarians Over Age 60, by State

State	Total	Mean Age	Count over 60	Percentage over 60
DE	4	49		0
WV	23	43	1	4.3
WI	110	47	5	4.6
MD	55	43	3	5.6
SD	35	42	2	5.9
KY	114	45	8	7.1
ND	27	42	2	7.4
SC	35	47	3	8.6
TN	117	46	10	8.6
UT	34	45	3	8.8
VT	22	48	2	9.1
ID	64	47	6	9.4
MA	33	47	3	9.4
VA	73	47	7	9.6
FL	114	48	11	9.7
CO	115	47	12	10.4
OR	120	47	13	10.8
HI	9	47	1	11.1
WY	63	49	7	11.1
OH	170	46	19	11.2
NC	79	44	9	11.4
NH	34	45	4	11.8
PA	141	46	18	13.0
MT	69	48	9	13.0
LA	69	44	9	13.2
IL	158	46	21	13.3
AK	15	46	2	13.3
AL	67	48	9	13.4
KS	172	47	23	13.5
WA	103	49	14	13.7
ME	29	49	4	13.8
AR	87	47	12	14.0
CT	28	47	4	14.3
MN	109	47	16	14.7
NM	55	49	8	14.8
OK	154	48	23	14.9
NY	128	47	20	15.7
NV	19	47	3	15.8
NJ	24	48	4	16.7
TX	452	48	76	16.8
GA	100	48	17	17.0
MI	97	49	17	17.5
AZ	38	47	7	18.4
MS	76	48	14	18.7
NE	75	48	14	19.4
MO	178	49	35	19.9
CA	195	50	39	20.1
IA	132	49	28	21.4
IN	104	49	23	22.5
RI	3	44	1	33.3
Total	4345	47	1908	44.2

SOURCE: American Veterinary Medical Association.

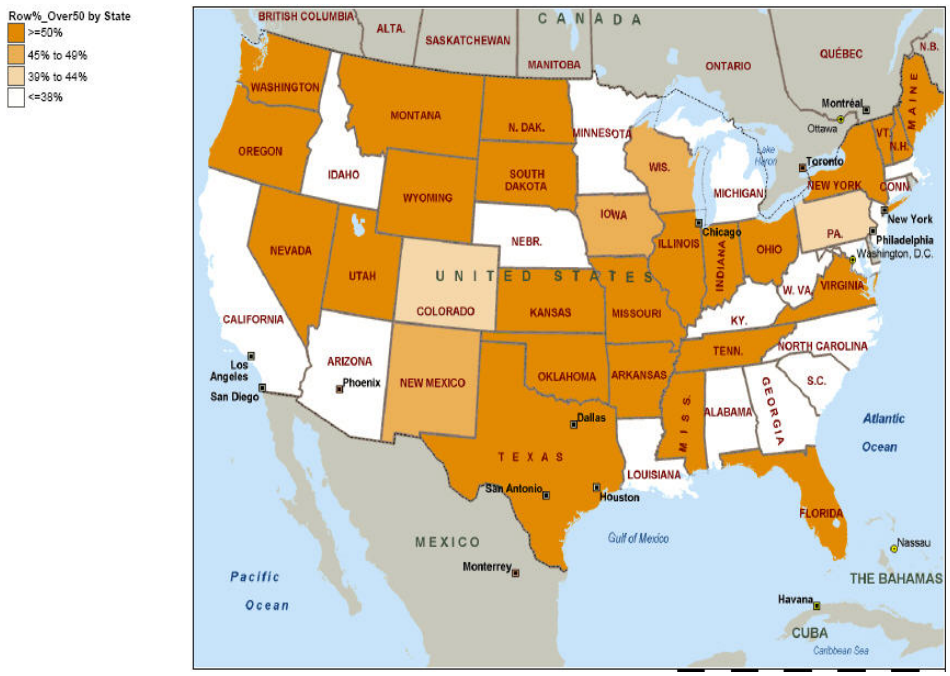

FIGURE C-12a Distribution of food-animal-exclusive veterinarians over age 50.[5] SOURCE: American Veterinary Medical Association (2008).

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[5]States vary widely in food-animal-veterinary populations; in 24 of 48 coterminous states, over 50% of food-animal-exclusive veterinarians are over 50 years old.

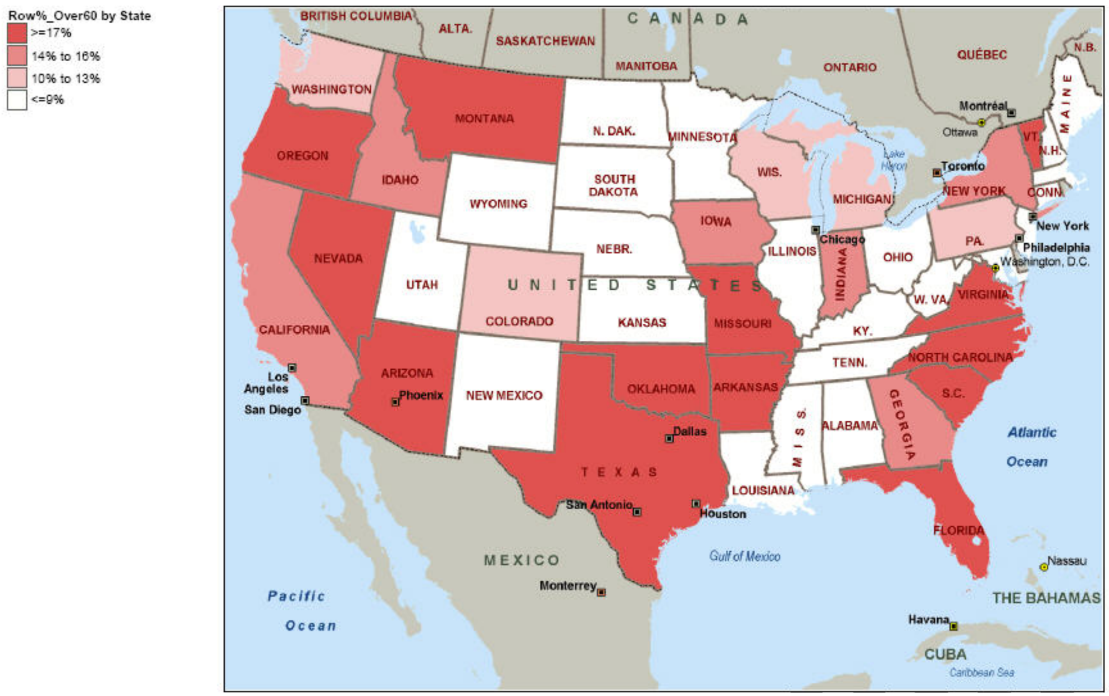

FIGURE C-12b Distribution of food-animal-exclusive veterinarians over the age 60.[6] SOURCE: American Veterinary Medical Association (2008).

[6] In 13 states, over 17% of food-animal-exclusive veterinarians are over 60 years old.

FIGURE C-13a Distribution of food-animal-predominant veterinarians over 50.[7] SOURCE: American Veterinary Medical Association (2008).

[7]There is considerable uniformity in age across the United States. In 36 states, more than 50% of food-animal-predominant veterinarians are over 50 years old.

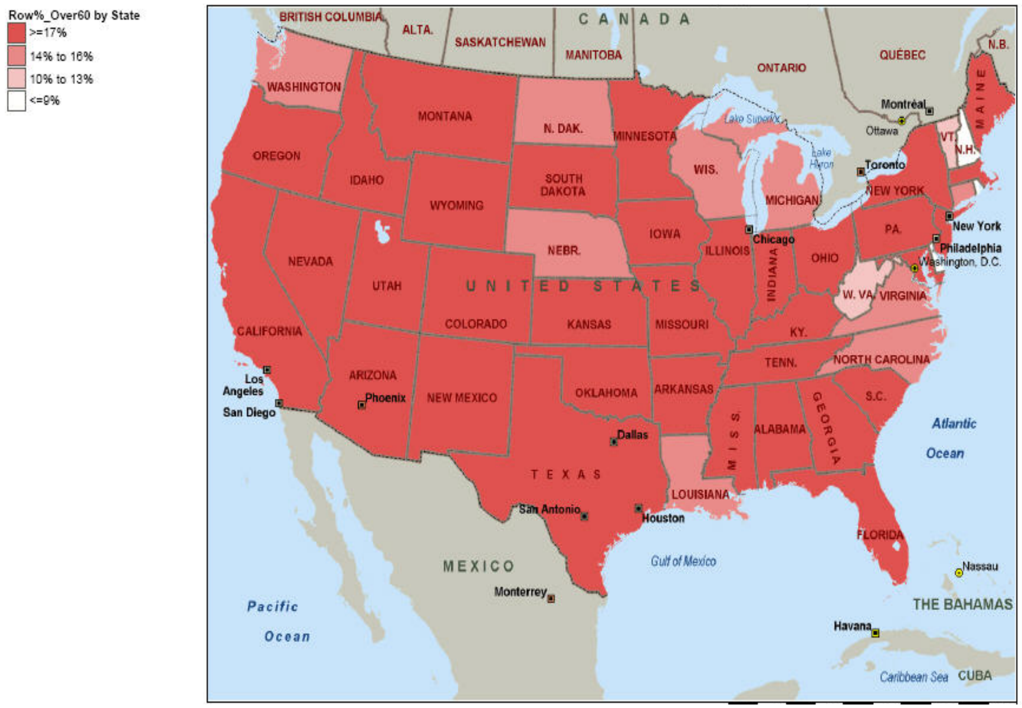

FIGURE C-13b. Distribution of food-animal-predominant veterinarians over age 60.[8] SOURCE: American Veterinary Medical Association (2008).

[8]In 36 states, 17% are over 60 years old.

FIGURE C-14a Distribution of mixed-food-animal veterinarians over the age 50.[9] SOURCE: American Veterinary Medical Association (2008).

[9]In contrast with food-animal-predominant veterinarians, only 12 states have more than 50% of mixed-food-animal veterinarians over the age of 50 years.

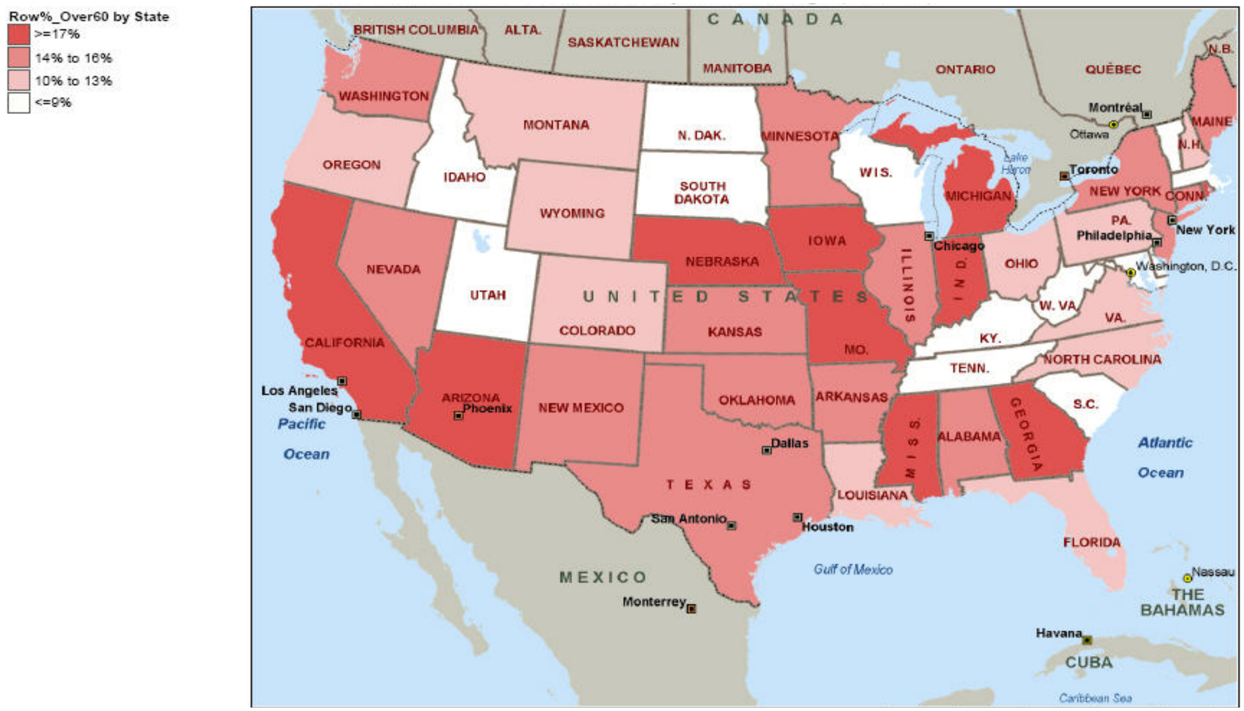

FIGURE C-14b Distribution of mixed-food-animal veterinarians over age 60.[10] SOURCE: American Veterinary Medical Association (2008).

[10]Nine states have more than 17% of mixed-food-animal veterinarians over the age of 60 years.

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Appendix D

Inquiry to Selected Companies

The purpose of the inquiry was to collect information about the current veterinary positions and future projected positions at selected companies in the animal feed, animal health, animal supply, biotechnology, chemicals, contract research organizations, diagnostics, and pharmaceutical industries. The companies were known by study committee members to employ veterinarians.

An e-mail letter was sent to contact persons at the companies asking them to go to a website where they could complete the questionnaire. There were several follow up e-mails from the National Research Center (NRC) sent to individuals who did not respond to the questionnaire. As a result responses were received from 59 of 118 companies.

The data are available from the NRC after removal of identifiers.

VETERINARY INDUSTRIAL PERSONNEL QUESTIONNAIRE

This survey is being conducted by the National Research Council (NRC), the operational component of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, to examine various aspects of the veterinary medical profession. The study will explore historical changes in the size and characteristics of the veterinary workforce; assess the demographics and adequacy of the current supply of veterinarians in different occupational categories and sectors of the economy; and identify incentives, disincentives, and other factors that are likely to affect the numbers of veterinarians seeking jobs in different sectors in the future. The study will also examine trends affecting the kinds of jobs available to veterinarians and assess future demand for veterinary expertise in existing and new employment sectors. The study will examine the current and future capacity of universities and colleges to provide sufficient numbers of adequately trained veterinarians and identify training needs relative to the demand for specific expertise. Data on past trends and the current status of the workforce are not available from national databases. To gather the necessary data the Committee for the study is conducting surveys in various sectors. The questions in this survey are designed to collect information on the employment of veterinarians in the industrial sector.

Your participation is important. By completing this questionnaire, you are providing information that will: 1) help the NRC identify the characteristics of the veterinary workforce; 2) enable the NRC to analyze trends in the composition of the workforce; 3) will provide data that will inform the profession and educational institutions on the status of the veterinary workforce.

Your participation is voluntary. You may refuse to answer any question or discontinue participation at any point. There is no risk to you or your company in responding to this questionnaire. Your identity will be known to only the National Research Council. Your willingness to provide the answers to the questions indicates your informed consent to participate in this study.

This web based survey is designed so that you can stop answering the questions at any time and return to the survey to answer more questions or change answers to already completed questions. The only constraint is that you use the same computer while answering the questions.

1) Demographic Information

Name: ______________________________
Company: ______________________________
Address: ______________________________
Address 2: ______________________________
City/Town: ______________________________
State: ______________________________
Zip code: ______________________________
Email: ______________________________
Phone Number: ______________________________

2) Please check all business areas from the following list that apply to your work. The data you provide in Question 1 should correspond to the information provided in subsequent sections. Please answer for operations in the USA only.

Business	Operation
Human pharmaceuticals and/or vaccines	
Veterinary pharmaceuticals and/or vaccines	
Biotechnologies	
Human diagnostics	
Veterinary diagnostics	
Crop protection	
Animal foods:	
Livestock feed	
Pet foods	
Human food	
Laboratory animal supplier	
Contract management of lab animal facilities	
Contract research laboratory:	
Toxicology	
Pathology	
Clinical	
Other (please specify) ________________________	

<u>For each of the following questions, please answer only for the area or areas that you checked above.</u>

3) For the following areas, please indicate the number of veterinarians CURRENTLY EMPLOYED FULL-TIME by your company.

Major activity of veterinarian(s)	DVM (or equivalent)	DVM and PhD	Board Certified	Board Certified and PhD	DVM and MBA
Preclinical Discovery Research					
Clinical Research/Development					
Safety R&D *Toxicology*					
Safety R&D *Pathology*					
Research support *Laboratory animal medicine*					
Regulatory Affairs					
Technical services/customer services					
Marketing					
Sales					
Senior Management					
Other (please specify) _______					

4) For the following areas please indicate the number of CURRENTLY OPEN ADVERTIZED FULL-TIME positions for veterinarians.

Major activity of veterinarian(s)	DVM (or equivalent)	DVM and PhD	Board Certified	Board Certified and PhD	DVM and MBA
Preclinical Discovery Research					
Clinical Research/Development					
Safety R&D *Toxicology*					
Safety R&D *Pathology*					
Research support *Laboratory animal medicine*					
Regulatory Affairs					
Technical services/customer services					
Marketing					
Sales					
Senior Management					
Other (please specify) _______					

5) For the following areas please estimate the number of NEW veterinarian positions (not included in questions #3 or #4) you will need between now and 2016.

Major activity of veterinarian(s)	DVM (or equivalent)	DVM and PhD	Board Certified	Board Certified and PhD	DVM and MBA
Preclinical Discovery Research					
Clinical Research/Development					
Safety R&D *Toxicology*					
Safety R&D *Pathology*					
Research support *Laboratory animal medicine*					
Regulatory Affairs					
Technical services/customer services					
Marketing					
Sales					
Senior Management					
Other (please specify) _________					

6) Do you have licensed veterinary technicians working in your U.S. operation?

yes □ no □

If yes,

How many veterinary technicians do you employ? ______

How many of your veterinary technicians are licensed? ______

If no, would you consider employing such technicians in the future?
yes □ no □

7) What percentage of the veterinarians in your company will reach 65 in the next 8 years? ________________

8) Globalization: How is globalization affecting the number of veterinarians you employ in your operation?

- No affect
- Hiring more US trained vets
- Hiring more foreign trained vets
- Unable to recruit US trained vets

9) Education:

a. For positions requiring a DVM only, does the current educational system in the U.S. adequately train veterinarians for the needs of your company?
yes □ no □

If no, what areas need improvement? ___________________

b. For positions requiring advanced training, does the current post DVM educational system in the U.S. adequately train veterinarians for the needs of your company?
yes □ no □

If no, what areas need improvement? ___________________

10) What trends in your companies' business activities will affect the hiring of veterinarians in the future? ______________________

11) Other comments. ________________________

Appendix E

Federal Recruitment Tools

Recruitment Incentive (formerly referred to as "Recruitment Bonus") provides newly appointed employees with a lump sum payment up to a maximum of 25% of basic salary (including locality pay) and may be paid annually for up to four years.

Relocation Incentive covers current Federal employees who accept a position requiring relocation; provides for positions that would be difficult to fill. A one-time lump sum payment is given up to a maximum of 25% of basic annual salary (including locality pay).

Retention Incentive can be given to current Federal employees who are essential to retain, who perform work that satisfies an essential and critical need, or who have unusually high or unique qualifications and who would likely leave Federal service. It provides for positions that would be difficult to fill in the absence of such an incentive and is a one-time lump sum payment up to a maximum of 25% of basic annual salary (including locality pay).

Flexible Work Schedules can be offered that include job sharing, part time employment and flexible hours to attract employees who have other personal and professional commitments. Due to the bureaucratic management complexities of job sharing and flexible hours, many regulatory agencies are reluctant to offer this, especially to field frontline veterinarians. However, there are examples where if there is the will, a way has been found. As a result, more veterinarians with children, eldercare, and other responsibilities are more willing to work in government when such flexibilities are routinely offered.

Travel and Transportation Expenses to First Duty Station can be paid to cover actual costs incurred as a result of travel and transportation of household goods to the first post of duty. As of 2009, USDA FSIS has blanket authority to offer this incentive to all VMO 701 Series nationwide.

Payment of Travel for Pre-Employment Interview can be used when a hiring manager needs to conduct a face-to-face interview for a critical position. It often is not used due to a lack of adequate budget allocations.

Student Loan Repayment covers new Federal employees and former employees with at least a 90 day break in service. This may be used as *retention flexibility* for employees who, if they left, would affect the agency's ability to carry out an activity or perform a function deemed essential to the Agency's mission. It also may be used as a *recruitment flexibility* based upon shortages and difficulty in recruiting individuals with high or unique qualifications, or a special need of the agency.

Superior Qualifications Appointment may be used when an applicant possesses outstanding/high qualifications and for which the agency has a special need, such as an MPH or Board Certification in a relevant mission-specific specialty. This powerful tool enables the agency to set the rate of basic pay above the minimum level of the applicable civil service grade.

Highest Previous Rate may be used to set pay at a rate equivalent to the highest rate previously received when employed.

Creditable Service for Annual Leave Accrual covers new Federal employees and former employees with at least a 90 day break in service and may be used, for example, when the employee's background is unique or demonstrates that the employee will contribute significantly to the mission and is highly qualified for the position. It provides for accruing more annual leave per pay period.

Referral Bonus Award can be paid to employees who successfully recruit new talent needed by the agency.

Dual Compensation Waiver for Reemployed Annuitants covers retirees wishing to be reemployed and provides a reemployed annuitant to receive both full salary and an annuity when reemployed with a Federal agency. A justification must be made explaining the uniqueness of the situation.

Physicians Comparability Allowance is provided specifically to physicians because the government has determined that they are a shortage profession and there is a significant pay gap between private and public pay scales. Currently the American Veterinary Medical Association has a policy stating that the government should provide veterinary medical officers GS-701 Veterinary Medical Officer the same comparability allowance as physicians as well as the same pay to a veterinarian performing the same job as a physician (Refer to DCVMA HOD Resolution). Currently, physicians receive more pay than veterinarians performing the same job if the physician is employed as a new and current Federal employee in the GS-602 Medical Officer series and who perform work associated with planning, formulating, and establishing public health programs aimed at controlling the incidence of foodborne disease. Both veterinarians and physicians are in government jobs that perform work that has materially and measurably improved the health outcomes of the target population; that has substantially improved policy development or made a significant scientific or regulatory advancement; have achieved substantial, documented efficiencies in the design or implementation of projects to maximize health care quality and better serve beneficiary needs; and have demonstrated exemplary performance in improving health outcomes of the agency's target population as evidenced by two or more "Outstanding" performance ratings. However, only physicians receive the additional pay benefits.

The physicians who agree to one or two years of service with these terms of employment can receive:

- Payments of up to $14,000 per annum paid in bi-weekly installments with less than 24 months of creditable Federal service.
- Payments of up to $30,000 per annum paid in bi-weekly installments with 24 months or more of creditable Federal service.

SOURCE: Recruitment and Retention Flexibilities and Authorities (USDA, FSIS, Office of Management, August 2008)

Appendix F

Intensive Short Courses that Help Prepare Veterinary Students and Veterinarians for Careers in Wildlife and Ecosystem Health

Envirovet

The Envirovet Program in Wildlife and Ecosystem Health (http://vetmed.illinois.edu/envirovet/) was established by Dr. Val Beasley of the University of Illinois in 1991 and has always been a collaborative effort with other universities and a wide array of faculty members. The first Envirovet summer course was organized in concert with the University of Minnesota-Duluth and the University of Wisconsin-Superior and the U.S. Environmental Protection Agency Freshwater Ecology Laboratory in Duluth and was oriented solely to aquatic animal health and ecotoxicology. Beginning in 2000, with partnership from University of California at Davis (UC Davis) and in collaboration with Tufts University, the Summer Institute incorporated terrestrial animals and developing country concerns. Developing countries that hosted sessions to date have included Kenya, Brazil, South Africa and Swaziland, and Tanzania.

The overall Envirovet Program today is a group effort that relies on diverse forms of support, and has two main thrusts, the Summer Institute (http://www.cvm.uiuc.edu/envirovet/ and http://www.cvm.uiuc.edu/envirovet/webvideo/index.htm) and the development of regional initiatives, the first of which is Envirovet Baltic (http://www-cru.slu.se/CRUre15.pdf). Current partnering institutions for the Summer Institute include the Wildlife Health Center of UC Davis, White Oak Conservation Center, Harbor Branch Oceanographic Institution, Sokoine University, and Tanzania National Parks. The Director of the White Oak (largely terrestrial) portion is Dr. Kirsten Gilardi of the Wildlife Health Center at UC Davis; the aquatic unit at Harbor Branch is organized by Dr. Beasley; and the Director of the developing country portion in Africa is Dr. Deana Clifford who works in concert with Dr. Jonna Mazet also of the Wildlife Health Center, Dr. Rudovick Kazwala of Sokoine University, and Dr. Titus Mlengeya of Tanzania National Parks. In recent years, the Envirovet Summer Institute has received financial support from student course fees, the U.S. Fish and Wildlife Service Wildlife Without Borders Program, the Nathan Cummings Foundation, the Geraldine R. Dodge Foundation, Eli Lilly and Company, the Russell E. Train Educational Fund for Nature of the World Wildlife Fund, the Wildlife Conservation Society, and the U.S. Agency for International Development. In addition, the Summer Institute benefits from the donated time of the U.S.- and Canada-based faculty members and generous in-kind support from White Oak Conservation Center.

The Envirovet Summer Institute begins in mid-June at White Oak Conservation Center in northeastern Florida (http://www.wocenter.org/) with two weeks of immersion-style learning about the big drivers that undermine health and biodiversity. Also included are proven intervention methods to yield positive short- and long-term gains. This unit includes: the value of biodiversity, ecosystem economics, and environmental law and policy; epidemiology; and the basis for disease emergence and resurgence, including efficient diagnostic tools. It addresses methods for restoration of populations of threatened or endangered species in the wild, including wildlife capture and translocation—and provision of ample habitat. It also focuses on counteracting overharvest, poaching, invasive exotic species, and predator-prey imbalances.

Throughout this unit, ways to reduce risks to public, domestic animal, and wildlife health from shared infectious diseases are strongly emphasized. The Summer Institute continues with two-weeks of intensive instruction in aquatic animal health, ecotoxicology, and ecosystem rehabilitation at Harbor Branch Oceanographic Institution (http://www.hboi.edu/index_05.html). This unit begins with instruction on the dynamics of aquatic ecosystems and how they are assessed. It focuses on the sources, fate, detection and control of contaminants, explains the causes of—and solutions for—declines in major ocean fish communities, as well as fisheries impacts on the food supply of marine mammals. It provides contact with environmentally-beneficial aquaculture, teaches the causes of marine mammal strandings, and first-hand experience in forensic studies. The aquatic unit stresses opportunities for better stewardship of aquatic ecosystems and animal populations to enable recovery of aquatic biodiversity, cleaner water supplies, and more and safer fish and shellfish for human consumption. The third unit of each Summer Institute takes place in a developing country (e.g. Kenya, Brazil, South Africa) and emphasizes ways to accommodate the economic and food security needs of people in the poorest regions of the world through better stewardship of lands, water, wildlife, and domestic animal populations. The unit addresses prevention of diseases shared between wildlife and humans, as well as between wildlife and either livestock or poultry. It demonstrates proven methods to re-establish self-sustaining wildlife populations in ways that improve the lives of nearby human groups. Leading biomedical scientists, conservation biologists, and environmental managers work side-by-side with the Envirovet group in hands-on work.

Tribal leaders share first-hand knowledge about wildlife/livestock conflicts. Throughout this unit, the need to look holistically at the challenges—and solutions—lying at the human/wildlife/domestic animal/environment interface are emphasized.

A number of participants in Envirovet courses have assumed full time careers, with several in leadership positions, in a range of relevant disciplines. An important component of the Envirovet Program is outreach to veterinarians concerned with wildlife and ecosystem health around the world. The following is based on a concerted effort to document the current activities of participants in Envirovet programs. To date, 339 individuals of 38 nations have participated in Envirovet's intensive summer courses. In addition, three former Envirovet students have also worked in three additional nations for periods of time exceeding two years, thus 41 countries have directly benefited from the training. A total of 239 Americans and 100 individuals from other countries have participated in Envirovet summer courses. As of this writing, 42 former students of the program are still in veterinary school. Of these individuals, three previously completed health-related MS degrees, two have completed MPH degrees, and two are concurrently enrolled in MS and DVM programs. Of the 339 former participants, 86 are in domestic animal practice, with 75 of these being Americans. Some of these individuals include a focus on exotic species and others undertake outreach addressing environmental concerns for their regions or to the developing world apart from their regular work schedules. Several of those in private practice are recent graduates of DVM or equivalent programs who hope to enter into wildlife/ecosystem oriented careers after honing their clinical skills and retiring educational debt. Of former students of the program, at least 23 are engaged primarily in public health, and 46 are focused on some aspect of toxicology (includes ecotoxicology and wildlife toxicology, with smaller numbers involved in diagnostic toxicology, poison control/clinical toxicology, and regulatory toxicology). Of 38 individuals who completed an Envirovet course and are engaged largely in aquatic animal health, 28 came from the 126 participants who participated in the 1990s when the program focused solely on aquatic ecosystems and species, whereas only 10 of 213 participants have become involved almost exclusively on aquatic issues since the program began to focus more than half of its content on terrestrial animals and ecosystems in 2000. At least 43 former participants of the summer programs are largely engaged in some aspect of wildlife epidemiology. Eighteen of the individuals have become, or are in training to become, pathologists (includes one clinical pathologist), with nearly all of them focusing on wildlife, zoo, fish, and/or toxicologic pathology. Fourteen of the 340 participants are involved in some aspect of aquarium (1) or zoo (13) medicine, and more than half of these individuals are either in zoo medicine internships or residences as of this writing. Twenty-three of the remaining participants work in wildlife practice with part-time in research, mostly in national parks of the developing world. Five former participants work in laboratory animal medicine, one is involved full time in public education regarding wildlife, two are in the army (includes one of the toxicologists), one became a high school teacher, another became a wildlife photographer, one entered business, two retired, and two are deceased. We are unaware of the job activities of 21 former participants in the program. Although a reliable estimate cannot be assigned based on available data, a number of the former students of the program contribute to the refinement and implementation of environmental and wildlife policy, both in the US and around the world.

A regional offshoot of Envirovet, termed Envirovet Baltic, recently teamed with the Baltic University Programme, a network of over 180 universities (http://www.balticuniv.uu.se/ http://www.balticuniv.uu.se/), in the development of three new books on the topics of Ecosystem Health and Sustainable Agriculture (http://www.balticuniv.uu.se/ehsa/index.php). A number of additional countries, veterinarians, and other scientists have drawn upon concepts developed through the Envirovet Summer Institutes, Overall, Envirovet Summer Institute and Envirovet Baltic have offered information, skill sets, and insight to over 430 individuals of at least 47 nations.

Aquavet®

Aquavet® was perhaps the first program in veterinary medicine to offer an annual course to expand veterinary medical expertise in a direction beyond domestic animal and human health (http://www.aquavet.info/). Established in 1977 through a collaboration between the University of Pennsylvania and Cornell University, it was led principally by Dr. Donald Abt for many years. Aquavet® is currently led by Drs. Donald Stremme, Paul Bowser and Laurie Landeau, and is hosted each year at the Marine Biology Laboratory at Woods Hole, Massachusetts. The program has provided Aquavet® I, An Introduction to Aquatic Veterinary Medicine, to approximately 900 students to date and Aquavet® II (advanced courses, topics vary) to approximately 400 students to date, and of these roughly 300 have taken both courses. The program directors estimate that about 200 of the overall students of the program are involved in aquatic animal health on a full time basis.

Marvet

Marvet was established in 1999 by Drs. Raymond J. Tarpley and Christine A. Curry. The goal of Marvet is to introduce veterinary students and veterinarians to the field of marine veterinary medicine with an emphasis on marine conservation, oceanaria, aquaria, zoological parks, rehabilitation units, wildlife organizations and universities, as well as federal and state governments. The role of veterinarians in the development of effective marine animal conservation policy at national and international levels is introduced. The program emphasizes marine animal taxonomy, ecology, anatomy, physiology, pathology, diagnostic methods and clinical medicine, with emphasis on marine mammals, sea turtles and marine birds, and some attention to fish species. The annual Marvet course has been staged each year at Mote Marine Laboratory in Sarasota, Florida, and includes participation in a long-term study led by Dr. Randy Wells. The study investigates wild bottlenose dolphins in Sarasota Bay and, at 30 years overall, is the longest-running study of its kind. Marvet students also witness and participate in selected Mote Marine Laboratory activities including work with the Whale and Dolphin Hospital and the Sea Turtle Hospital that focus on care and rehabilitation of stranded marine mammals and turtles. Marvet also offers workshops on marine mammals and sea turtles at other locations in the Americas and the Caribbean. To date, Marvet courses have been held in Florida (10), California (2), Grenada (1), Costa Rica (1), Mexico (1), and the Caymans (1). The courses have served a total of 256 participants to date. Of these 48 were from countries other than the United States and 31 were American students attending veterinary schools in the Caribbean (Ross, St. George's, or St. Matthew's). Other countries represented included Canada, Mexico, Costa Rica, Brazil, Peru, England, Germany, Italy, Norway, Australia, Thailand, and China. To date, all sessions have been in English. Of the 256 individuals who took the courses, twenty participated in two workshops, and two completed three workshops. At the time of their enrollment in Marvet, 51 were veterinarians, 203 were veterinary students, and two were rehabilitation biologists.

Aquamed

Aquamed, led by Dr. Ron Thune of Louisiana State University, is organized by the Gulf States Consortium for Aquatic Animal Pathobiology (http://www.vetmed.lsu.edu/aquamed.htm). The program, which lasts about 3.6 weeks, is offered in June of even-numbered years and is open to participation by veterinarians, veterinary students, and graduate students without the DVM or equivalent degree. The program emphasizes the culture and health care of ornamental fish, commercially important fin fish, and shellfish. An overview of reptiles, marine mammals, and aquatic laboratory animals is also included. Instructors are nationally and internationally recognized experts. Weeks 1, 2, and 4 are held at the Louisiana State University School of Veterinary Medicine, while week 3 takes place at the Louisiana Universities Marine Consortium facility in Cocodrie, Louisiana. Aquamed has been hosted annually from 1993 to 2004, as well as in 2006 and 2008, training a total of 224 participants.

Wildlife Center of Virginia

The Wildlife Center of Virginia offers an internship for a graduate veterinarian as well as training opportunities for veterinary students (http://www.wildlifecenter.org/wp/veterinary-training/). The internship offers opportunities to work in ongoing conservation medicine research projects as well as interaction with local or allied institutions that include the National Zoo, University of Virginia, Virginia Department of Game and Inland Fisheries, U.S. Geological Survey Patuxent Wildlife Research Center, Virginia Marine Science Museum, and Virginia-Maryland Regional College of Veterinary Medicine.

South African Programs for Veterinary Students and Veterinarians

Programs in South Africa educate a number of veterinary students and lesser numbers of veterinarians from the United States and other nations. Among these, the best known is Wildlifevets.com, which is operated by Dr. Cobus Raath, former head veterinarian of Kruger National Park (http://www.wildlifevets.com/). Dr. Raath operates a large practice dedicated primarily to African wildlife owners and conservation. He serves wildlife producers, managers of game farms, ecotourism facilities, nature preserves, and a range of governments in Africa and the Middle East. He is also a principal in Wildlife Pharmaceuticals, and specializes in development of drugs for wildlife immobilization, transport, anesthesia, and appropriate reversal of the active agents (http://www.wildpharm.co.za/). Dr. Raath as well as Dr. David Hunter of Turner Endangered Species Fund and Turner Enterprises, Inc. are adjunct professors at the School of Veterinary Medicine of Purdue University and at the College of Veterinary Medicine of Texas A&M University. Participants in the courses offered by Wildlifevets.com benefit from participation in a range of lectures, discussions, and hands-on projects related to his veterinary practice. Another organization, Brothers Safaris, assembled by veterinarian Dr. Peter Brothers, offers educational and safari experiences for veterinary students and veterinarians. Partnering institutions include De Wildt Cheetah and Wildlife Centre and the University of Pretoria (http://www.brotherssafaris.com/wildlifeandimmobilsation.htm).

Appendix G

Academic Survey of Veterinary Personnel

The purpose of the survey was to collect information about the numbers of current and projected faculty and students at U.S. colleges of veterinary medicine, veterinary science departments, and comparative medicine departments. The sample consisted of the 28 U.S. colleges and schools of veterinary medicine, 9 veterinary science departments within U.S. colleges of agriculture and 7 departments of comparative medicine at U.S. medical schools. The list of colleges and schools of veterinary medicine, veterinary science departments and departments of comparative medicine were provided by the American Association of Veterinary Medical Colleges (AAVMC).

An e-mail letter was sent to each person in the sample asking them to go to a website where they could complete the questionnaire. There were several follow up e-mails from the National Research Council (NRC) sent to members who did not respond to the survey. The two members of the study committee who were deans of veterinary colleges also contacted the non-responders. As a result responses were received from 27 of 28 colleges/schools of veterinary medicine, 6 of the 9 veterinary science departments, and 5 of the 7 comparative medicine departments.

The data are available from the NRC.

The AAVMC has enlisted the National Academy of Sciences/National Research Council to convene a panel to study the broad scope of issues related to the veterinary workforce in the United States. The study will explore the historical changes in the size and characteristics of the veterinary workforce; assess the demographics and adequacy of the current supply of veterinarians in different occupational categories and sectors of the economy; and identify incentives, disincentives, and other factors that are likely to affect the numbers of veterinarians seeking jobs in different sectors in the future. The study will also examine the trends affecting the kinds of jobs available to veterinarians, and assess the future demand for veterinary expertise in existing and new employment sectors. The study will also examine the current and future capacity of universities, colleges, comparative medicine and veterinary science departments to train in all sectors adequately and to identify training needs relative to the demand for specific expertise.

This questionnaire is to request that you assist in planning for the future of academic veterinary medicine by sharing information that will help in formulating the current and planned academic workforce needs and/or options for meeting requirements of a national veterinary workforce.

This web based survey is designed so that you can stop answering the questions at any time and return to the survey to answer more questions or change answers to already completed questions. The only constraint is that you use the same computer while answering the questions.

1) Demographic Information

Name: ______________________________
Company: ______________________________
Address: ______________________________
Address 2: ______________________________
City/Town: ______________________________
State: ______________________________
Zip code: ______________________________
Email: ______________________________
Phone Number: ______________________________

2) The responses to this questionnaire apply only to the part of the institution indicated below:

- □ Veterinary college (All Units)
- □ Comparative medicine departments
- □ Veterinary science departments
- □ Other: ____________________

3) Provide the number of current faculty and students.

	2007
Faculty - tenure track	
Faculty - non tenure track clinical	
Faculty - non tenure track research	
DVM professional students	
Graduate students - masters	
Graduate students - doctoral	
Postdoctoral associates	
Clinical interns	
Clinical residents	
Masters in Public Health	
Master of Preventive Veterinary Medicine	

4) Estimate the number of faculty and students you expect in your program in 2010.

	2010
Faculty - tenure track	
Faculty - non tenure track clinical	
Faculty - non tenure track research	
DVM professional students	
Graduate students - masters	
Graduate students - doctoral	
Postdoctoral associates	
Clinical interns	
Clinical residents	
Masters in Public Health	
Master of Preventive Veterinary Medicine	

5) Estimate the number of faculty and students you expect in your program in 2016.

	2016
Faculty - tenure track	
Faculty - non tenure track clinical	
Faculty - non tenure track research	
DVM professional students	
Graduate students - masters	
Graduate students - doctoral	
Postdoctoral associates	
Clinical interns	
Clinical residents	
Masters in Public Health	
Master of Preventive Veterinary Medicine	

6) Identify, by discipline/specialty, the number of vacant faculty positions in 2007 within existing programs and what is anticipated in future years due to retirements in 2010 and 2016.

		2007	2010	2016
BASIC SCIENCES:	Anatomy			
	Biochemistry/Physiology			
	Embryology			
	Epidemiology			
	Food Safety/Public Health			
	Genetics			
	Immunology			
	Medicine			
	Microbiology/Virology/			
	Parasitology			
	Nutrition			
	Pathology			
	Pharmacology			
	Reproduction			
	Surgery			
	Toxicology			
CLINICAL SCIENCES:	Large Animals:			
	Equine Medicine			
	Equine Surgery			
	Food Animals:			
	Beef			
	Dairy			
	Poultry			
	Small Ruminants			
	Swine			
	Small Animals:			
	Anesthesiology			
	Behavior			
	Cardiology			
	Clinical Pathology			
	Dentistry			
	Dermatology			
	Emergency Medicine			
	Critical Care			
	Internal Medicine			
	Lab Animal			
	Neurology			
	Nutrition			
	Pharmacy			
	Shelter Medicine			
	Surgery			
	Soft Tissue			
	Orthopedics			
	Theriogenology			
	Zoological/Wildlife			
	Other ____________			

7) Is your Unit planning to add or delete training/educational programs?

yes □ no □

If yes, please specify the designated program(s) and identify faculty needs and proposed enrollments.

8) For the planned programs identified in Question # 7, please list the number of new graduates from the proposed program(s):

	2009	2010	2011	2012	2013	2014	2015	2016
DVM's								
DVM/Ph's								
PhD's								
MPH								
MPVM								
MSc								
MBA								

9) Is your college/school/department planning a "Center of Emphasis" (special training for 4th year students who desire in-depth training with species, disciplines, i.e. food safety/public health, etc.)?

yes □ no □

If yes, please describe, indicate the collaborating institutions, identify faculty areas needed, the number of faculty needed and proposed enrollments.

10) Does your College/School have or participate in a Registered Veterinary Technician Program?

yes □ no □

If yes please briefly describe the number of graduates per year and whether it is for small animal or large animal, i.e., equine, livestock/poultry or both.

11) If your answer to Question #10 is no, do you intend to add such a program at your institution?

yes □ no □

If the answer is yes, when do you plan on establishing such a program and what is your estimate of the number of students in each class year?

Thank you.