

Current Perspectives on Curriculum Needs in Zoological Medicine

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ABSTRACT

Advances have been made in expanding veterinary curricula to deliver basic key knowledge and skills necessary for provision of health care to captive and companion non-domestic or non-traditional species in the veterinary colleges of the United States and Canada. These advances were in large part facilitated by the deliberations and recommendations of the White Oak Accords. Though a five-year review of curricular opportunities at US and Canadian veterinary colleges shows that progress has been made in implementing the recommendations of the White Oak Accords, there remains room for improvement. The broadly comparative and health-maintenance basis of zoological medicine contributes critically to the potential for veterinary medicine to make important contributions to the concept of the integrated health of the planet. Emergence of key zoonotic and production-animal diseases derived from and within wildlife populations since 2000 has increased awareness worldwide of the importance of zoological medicine in protecting both production livestock and public health. These areas are addressed in elective curricula at colleges emerging as centers of excellence in zoological medicine, but it is critical that core curricula in zoological medicine at all schools be strengthened to include these important areas to prepare our DVM/VMD graduates to protect companion-animal, production-animal, and public health.

INTRODUCTION

The discipline of zoological medicine, as defined by the White Oak Accords, provides a foundation for the participation of veterinary medicine in the future of development of global health.¹ The necessity of integrating health initiatives across human, public, companion-animal, production, and wildlife health concerns on a global basis is becoming more clear to everyone involved in the health community. It is obvious that individual and population health cannot be achieved without a healthy environment, nor in isolation from consideration of the health of supporting ecosystems. Zoological medicine as a discipline is the overarching umbrella that encompasses the practices of environmental medicine and ecosystem health in the veterinary profession. The specialty of zoological medicine is not, as is often misconstrued by the veterinary profession outside of the discipline, constrained by any species-based limitations; rather, as a founding principle, it eschews the concept of species chauvinism. It is by applying the intellectual practices that form the basis of zoological medicine that the veterinary profession will have its greatest opportunity to play a key role in the evolution of a more effective approach to unified world health. For this to occur, the veterinarian's role needs to evolve. This evolution must be driven by the curricula in the veterinary colleges of the world.

The broad interdigitation of zoological medicine into many diverse and important aspects of veterinary medicine offers both opportunities and dilemmas for veterinary colleges. With many entering students seeking careers that transcend the bounds of domestic animal health, it is crucial that curricula in zoological medicine broaden beyond health care delivery for non-traditional companion species and

captive wildlife. It is important that these curricula provide veterinary students with the knowledge and background to play key roles in the important emerging issues of veterinary public health, biomedicine, and research, in addition to the basic clinical foundations of companion-animal and production-animal health. It is likely that, in addition to stand-alone courses and materials that help define the identity of the discipline to students, integration and incorporation of the broader species concerns of zoological medicine into many aspects of the traditional curricular offerings will be needed. Redirection and investment in resources to expand availability of high-quality zoological medicine curricula for all veterinary students, as well as for those seeking careers in the discipline, need to be seen as a high-yield investment for the future of veterinary medicine.

HISTORY AND BACKGROUND OF ZOOLOGICAL MEDICINE CURRICULUM DEVELOPMENT

The inclusion or exclusion of zoological medicine in veterinary curricula in North America has historically been very dependent on the activities and interests of individual faculty at individual institutions. This resulted in a very uneven approach to the specialty, which, in turn, presented a very real challenge to society with respect to determining what a newly graduated veterinarian should be expected to know about the discipline. In the early 1980s the American Board of Veterinary Specialties formally recognized the discipline of zoological medicine and facilitated the institution of the American College of Zoological Medicine (ACZM), which conducted its first board examinations in 1984. The ACZM provided a needed forum for developing and establishing minimum standards of

post-DVM/VMD training in zoological medicine. The broader base of the discipline in preventive and population health has often been obscured from the causal observer by the more attention-holding aspects of working with charismatic species. There has always been that unfortunate truncation of “zoological” to “zoo,” which radically narrows the perception of an otherwise very broad concept. Training-program guidelines for the college have also focused on clinical skills with non-domestic species from the beginning of the ACZM and, to a great degree, on animals in captivity. However, there has always been provision for research-based career development of future diplomates. ACZM diplomates work actively in areas ranging from policy development to basic research across a broad range of ecosystems. The college has served as a beacon for veterinarians with creative interests in a broadly comparative career in veterinary medicine. As young veterinarians began to establish career goals that included ACZM board certification, their education in the DVM/VMD curriculum became very important to their success in competing for post-DVM/VMD programs.

In early 1999 a group of veterinarians teaching in different capacities at colleges of veterinary medicine across the United States began to examine the challenges of implementing appropriate zoological medicine education into veterinary college curricula. These individuals became a steering committee under the auspices of the ACZM that was tasked to study and implement improvements in the DVM/VMD curriculum.³ In the fall of 1999, this steering committee, which included both ACZM diplomates and non-diplomates, met in Columbus, Ohio. Their charge was to provide groundwork and assist the appropriate parties to define, develop, and adopt a minimum core curriculum, in the DVM/VMD programs of all veterinary colleges in North America, in companion avian, reptile, nontraditional small companion mammal, aquatic, zoological, and wildlife medicines and in environmental and conservation health.

The steering committee recognized the importance of broad input into the issue and decided to organize a facilitated workshop. The ACZM, as the recognized specialty organization for the discipline, was asked to sponsor and accept the recommendations of a workshop that would include participation by senior academic administrators responsible for veterinary curricula, faculty involved in curricular issues, and experts in the broad range of activities encompassed by zoological medicine, most not affiliated with the ACZM. The steering committee and the ACZM recognized that although most ACZM diplomates were focused on broader and larger-scale issues, the heaviest demand for curriculum would likely be perceived to be in the delivery of health care to companion animals, because of the large proportion of graduates pursuing careers in small-animal practice. A broad-based approach to the curricular issue was implemented, recognizing this predisposition in the veterinary colleges. The steering committee was formally established as the ACZM Ad Hoc Committee on Zoological Medicine and charged with conducting a campaign to establish a consensus across US and Canadian veterinary colleges on the implementation of zoological medicine curricula.²

The workshop was held at the White Oak Plantation in Yulee, Florida, on November 9–12, 2000, with the benefit of

funding provided by the Howard Gilman Foundation, the Center for Conservation Medicine, and the Firedoll Foundation. The veterinary colleges of the United States and Canada were invited to send representatives to the workshop who were empowered to speak for, and to obligate their institution to follow, any consensus achieved on the issues of zoological medicine curriculum. A major effort was made to ensure that every AVMA-accredited college of veterinary medicine (31 at the time) was represented. Prior to the workshop, each college representative was asked to summarize the offerings in zoological medicine-related topics at his or her college. These data from each college were compiled and provided to each representative at the White Oak Workshop as a basis for understanding the existing zoological medicine curriculum conditions across the two countries in 2000. Representatives of six allied professional veterinary organizations—the American Association of Wildlife Veterinarians, the American Association of Zoo Veterinarians, the Alliance of Veterinarians for the Environment, the Association of Avian Veterinarians, the International Association for Aquatic Animal Medicine, and the Association of Reptile and Amphibian Veterinarians—were also invited to the White Oak Workshop to lend additional input and specific zoological medicine expertise to the deliberations, as well as to represent the interests of their constituencies. The outcome of the workshop, now referred to as the White Oak Accords, was an unprecedented consensus and agreement to implement curricular offerings based on a framework of guiding principles and identified needs. These accords were returned to the ACZM, which formally accepted them without modification as the official recommendations of the specialty college. The White Oak Accords were then published as a Veterinary Education Perspectives article in the *Journal of the American Veterinary Medical Association* in early 2001.¹

CURRICULAR STATUS IN 2000 AND THE WHITE OAK ACCORDS

One of the first issues addressed at the White Oak workshop was the confusion about the many terms used to refer to veterinary responsibilities to non-domestic or nontraditional animals. There was strong consensus to adopt a single consistently defined term to represent the wide range of activities that relate to non-domestic species. The accords established “zoological medicine” as the appropriate overarching term and urged that it be used consistently at all veterinary colleges in their curricula. The definition of “zoological medicine” established by the White Oak Accords is as follows:

Zoological medicine integrates veterinary medicine and the principles of ecology and conservation as applied in both natural and artificial environments.¹

It is important to note the lack of species specifics in this definition. Within this operational definition, key components of the zoological medicine constellation were identified in the White Oak Accords to illustrate the diverse involvement of veterinarians in different aspects of the discipline and the wide impacts the discipline has

on society. This representative, but not exhaustive, list is provided in Table 1.

At the time of the White Oak Accords, 21 colleges of veterinary medicine in the United States and Canada provided aspects of zoological medicine within the required curriculum, and all 31 reported offering some educational opportunities in zoological medicine, though the scope of these offerings was widely divergent in extent, content, and approach to delivery. A thematic principle quickly established at the White Oak Workshop was that the specific modality of implementation of any recommended educational experiences would vary depending on the institution and that a wide variety of approaches could be used successfully to meet the recommendations of the accords. A second guiding principle was that practical and experiential elective material would vary depending on each school's resources and strengths. However, the accords determined that access to experiential opportunities is critical, regardless of the particular institution's facilities, and that time and resources should be made available to all interested students to pursue elective experiential opportunities in zoological medicine that fit their career aspirations. Minimum expectations for both core and elective materials are delineated in the Accords (Tables 2 and 3). As predicted, the accords emphasize curricular support of students' learning clinical health management of captive zoological species, particularly companion species.

To facilitate implementation of the recommendations of the White Oak Accords, supporting allied professional organizations participating in the workshop were asked to take the lead, along with schools emerging as centers of excellence in zoological medicine, in developing teaching resources covering key issues in their area of expertise. Academic participants were particularly interested in the development of an integrated database of available resources and opportunities for veterinary students across North America.

In the five years after the White Oak Accords, progress was made in zoological medicine curriculum delivery, though larger aspects of implementing even the limited recommendations of the Accords remain incomplete. There is considerable need for further efforts to improve zoological medicine curricula. All the original 31 schools at the White Oak workshop submitted updates of their 2005 curricular offerings in time to be included in this analysis. The newest college of veterinary medicine, Western University of Health Sciences College of Veterinary Medicine (WUHS), which was not represented in the 2000 event, was able to provide its 2005 curriculum offerings and is included as a thirty-second reporting school. All 32 schools offer didactic instruction in some phase of zoological medicine, and 14 of 32 had increased their didactic offerings in the five years since 2000 (see Table 4). Only three schools had decreased their didactic offerings, in two cases associated with increased offerings of experiential opportunities. In 2005 all 32 schools reported offering experiential learning in zoological medicine in some form, and 15 of the schools reported increased offerings of this type. Three of the schools reported reduced experiential offerings since 2000, but all continued to provide some experiential offerings.

As of 2005, 24 of 32 schools reported the inclusion of zoological medicine core material, defined as instruction

Table 1: Major areas encompassed by zoological medicine (White Oak Accords, 2000)¹

Environmental medicine	<ul style="list-style-type: none"> • Free-ranging wildlife medicine • Conservation/preservation medicine • Ecosystem health • Wildlife rehabilitation
Aquatic medicine	<ul style="list-style-type: none"> • Marine mammal medicine • Display and pet fish medicine
Zoo animal medicine	
Companion animal practice	<ul style="list-style-type: none"> • Small mammals • Birds • Reptiles • Amphibians • Fish
Production medicine	<ul style="list-style-type: none"> • Farmed/ranched wildlife • Game birds • Aquaculture

provided to all veterinary students in the college, in their curricula. Six schools had increased the number of core courses in zoological medicine at their institution since 2000; however, five schools reported a decreased number of core courses compared to 2000. Interestingly, the schools with the largest offerings in zoological medicine overall were more likely to be included in this latter group. Although core offerings decreased in these five schools, all five continued to present core material to their students. The full breadth of recommended core topics in the White Oak Accords remained to be well implemented in most colleges of veterinary medicine as of 2005.

More schools presented elective opportunities than core material, with 30 of 32 reporting schools offering zoological medicine-related elective courses. Sixteen of the schools offering electives were offering more courses in 2005 than they had offered in 2000, and only one school reported a decrease in the number of elective courses offered. No single school provided students with a complete set of elective offerings, as recommended by the White Oak Accords; however, three schools (UC Davis, Missouri, North Carolina State) reported offering at least 90% of the White Oak Accords recommended topics in some form of elective or core instruction. A strict tally of the presence or absence of topics in material reported in the 2005 curriculum survey is misleading in terms of identifying emerging centers of excellence in zoological medicine education because it does not take into account the depth of offerings within a topic or topical specialization. In addition, there was variability in the completeness of curricular update submissions that may have obscured interpretation of breadth of offerings. For example, schools with particularly robust offerings in aquatic animal health in their submissions included Atlantic

Table 2: Minimum expectations of zoological medicine curriculum for every veterinary student (White Oak Accords, 2000)¹

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- It is important that all veterinary students develop an appreciation of the diversity of basic zoological taxa and the ability to recognize the normal biological features and condition for zoological species that are most commonly seen in practice. Students should acquire the ability to identify and relate proper husbandry techniques for these zoological species.
 - Clinical medicine for the individual animal is a stronghold in the required veterinary college curriculum. The expectation that all students be able to obtain a useful history and perform a physical examination should also extend to zoological species common in veterinary practice. Concomitant with these skills, students should develop the ability to understand and interpret the clinical data obtained from these procedures in the context of the most common diseases of birds, reptiles, and small mammals. All students should be able to humanely euthanize the most commonly seen zoological species, using appropriate methods.
 - Zoological medicine should be included in the portion of the curriculum that provides students the opportunity to develop clinical skills. Students should gain an appreciation for the comparative aspects of anatomy and behavior of zoological species. The focus of experiential learning should be directed at principles of restraint and physical examination, with species priority given to birds, reptiles, and small mammals commonly seen in veterinary practice. The experiential modality is well suited to convey principles of safety and humane concerns for the animals being examined and the people involved.
 - Zoonotic and emerging diseases are currently taught within the required curriculum at all veterinary colleges. Zoological species should be included to provide students with an understanding of local and global implications of zoonotic diseases.
 - The concepts of population and preventive medicine are as germane to zoological medicine as they are to production medicine and other areas of veterinary medicine. Every veterinary student should recognize and appreciate the importance of these concepts in zoological medicine. Similarly, students should be aware of the importance of genetic diversity and recognize that the key principles of population management apply to zoological species. Epidemiology instruction should offer veterinary students an understanding of how epidemiologic principles apply to zoological species.
 - Environmental awareness needs to be a part of modern veterinary education, and every student should develop an appreciation of the major environmental impacts on animal health, including zoological species. Students should understand environmentally responsible clinical practices and be aware of the potential impacts of veterinary medicine and agriculture on the environment, including effects on the food supply as well as water, air, and soil quality. Specific issues may vary geographically or as new issues garner public attention. Examples of appropriate issues include the need for proper disposal of discarded therapeutants or the value of energy and resource conservation in hospital operation. Every student should also have the opportunity to develop awareness of the veterinarian's role in dealing with interactions among wildlife, domestic animals, and humans and the concept of ecosystem health.
 - Veterinary ethics and animal welfare concerns apply to issues in zoological medicine and should be included in the required curriculum.
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Veterinary College, the University of Florida, the University of Mississippi, and North Carolina State University; however, updates from some schools did not seem to include aquatic-related courses that this author has good reason to believe are still offered.

Thirty of the 32 schools reported offering some coursework that includes material on small pet mammals, companion birds, reptiles, and amphibians (Table 5). Twenty-seven of 32 offered education in fish health issues, which, interestingly, exceeded the 23 schools reporting courses dealing with captive zoo animal medicine and the 21 schools reporting teaching material in free-ranging wildlife health management. Relatively few schools offered instruction in invertebrate medicine (8 of 32), although a ninth school reported a new course under design. Similarly, only 10 schools reported offering marine mammal medicine in any course offering. This would not be considered too unusual, but more surprising is that only 10 schools reported offerings in zoological pathology. This, again, could be due to a failure of reporting faculty to capture those offerings.

One important point of the White Oak Accords was that schools with major resource availability in zoological medicine should become centers of excellence and offer

learning opportunities to students from other schools. All schools were asked to consider opening course offerings, where appropriate, to students from other schools. In 2005 nearly 75% (23/32) of reporting schools had at least some of their offerings available for students from other schools. Nine institutions had increased the number of courses available to students from other schools since 2000, and only one school had decreased the number of courses available (due to the reduction in course offerings overall at that college). Two colleges have been particularly generous (UC Davis, NCSU), opening 90% or more of their zoological medicine curriculum offerings to students from other schools when space is available.

Another important component of the White Oak Accords was the charge to allied veterinary professional organizations to help through the development of curricular materials specific to their organizational focus and the call for a centralized database of resources. Though individual organizations have generated some specific curricular materials, these efforts have not been to the scale hoped for by participants in the White Oak Workshop. To date, no organization has taken on the challenge of the curricular database, though consideration of implementing this initiative by the ACZM is being discussed.

Table 3: Minimum expectations of zoological medicine curriculum to be available to every veterinary student with an interest in zoological medicine (White Oak Accords, 2000)¹

Didactic elective material should be available in the areas of	<ul style="list-style-type: none"> • avian medicine • reptile medicine • aquarium fish medicine • zoo medicine • small mammal medicine
Elective didactic subject areas strongly encouraged:	<ul style="list-style-type: none"> • aquaculture • ecosystem health/conservation medicine • marine mammal medicine • wildlife medicine • amphibian medicine • population management • zoonotic diseases • environmental concerns • epidemiology • game farming • primate medicine.
Recommended practical and experiential learning:	<ul style="list-style-type: none"> • companion avian medicine • reptile medicine • small mammal medicine • wildlife medicine/rehabilitation • zoo medicine • marine mammal medicine • aquarium fish medicine • aquaculture
Strongly encouraged practical and experiential learning:	<ul style="list-style-type: none"> • wildlife pathology • invertebrate health • research in zoological medicine • exposure to regulatory agencies, government, and industry

Table 4: Educational offerings by format and availability to students

Courses, including	Number of Schools Reporting Offerings in Category in 2005	Number of Schools with Increased Offerings in Category over 2000	Number of Schools with Decreased Offerings in Category over 2000
Didactic offerings	32/32	14/32	3/32
Experiential offerings	32/32	15/32	3/32
Core courses	24/32	6/32	5/32
Elective courses	31/32	16/32	1/32
Alternative-format courses	3/32	2/32	1/32
Courses open to students from other schools	23/32	9/32	1/32

Table 5: Offerings of teaching (all forms and styles combined) that include instruction in at least one course related to health management of a particular species/subject group

Species/Subject Group	% (#/N)
Small mammals	94 (30/32)
Companion avian	94 (30/32)
Reptile/amphibian	94 (30/32)
Fish	84 (27/32)
Invertebrates	26 (8/32)
Marine mammals	31 (10/32)
Wild birds	66 (20/32)
Captive zoo medicine	72 (23/32)
Free-ranging wildlife	66 (21/32)
Wildlife rehabilitation	50 (16/32)
Wildlife/environmental policy	50 (16/32)
Zoological pathology	31 (10/32)
Zoological basic sciences (anatomy, physiology, pharmacology, etc.)	75 (24/32)
Zoological clinical sciences (anesthesia, radiology, surgery, etc.)	69 (22/32)

CHANGES IN THE WORLD PERSPECTIVE SINCE THE WHITE OAK ACCORDS

The White Oak Accords was a major achievement. The philosophical themes of cooperation and multiple approaches to implementation of consensus goals will continue to serve both the zoological medicine and academic veterinary communities well as they refine zoological medicine curricula that meet the needs of students and society. However, major events in North America and around the world have shifted societal focus to issues that demand improved delivery of qualified and skilled zoological medicine veterinarians in a wide range of areas. Those events accent the strong imperative to expand the recommendations of the White Oak Accords. Emerging diseases of wildlife have had devastating economic and public-health impacts repeatedly in the last five years. The rapid invasion of West Nile Virus into North America through contributions of wildlife vectors,³ the implications of bush meat in emerging zoonotic disease outbreaks,⁴ the association of SARS outbreaks with Asian wildlife,⁵ the accidental introduction of monkey pox,⁶ and small clusters of lymphocytic choriomeningitis virus mortality in transplant patients in North America⁷ are just a few examples of the public-health concerns that require extensive understanding of key zoological health principles to be successfully managed.⁸ The lessons have not been confined to terrestrial ecosystems. The challenges of emerging diseases in aquatic environments, the potential roles of wildlife as sentinels of environmental degradation, and the impacts of natural disasters are clear, as is the potential for wildlife to serve as reservoirs of infectious disease and

vectors of food-borne disease.^{5,6,9} Worldwide, concerns about *Vibrio vulnificus*, SARS, and H5N1 avian influenza have been major drivers of North American health policies that require properly educated veterinary input for success.^{10,11} Chronic wasting disease of deer has created a major challenge for public-health officials and wildlife agencies alike, affecting the multi-billion dollar deer hunting industry with ramifications on the travel and tourism industries.^{12,13} Foot-and-mouth disease outbreaks in Europe and the United Kingdom have underscored the important concerns of wildlife in the control of important production livestock diseases.¹⁴ No less important, the 9/11 terrorism attacks have heightened our society's awareness of the vulnerability of developed nations to all forms of terrorism, including the possible destruction or adulteration of water and food supplies. There is an intense need for veterinarians to be able to serve their communities as knowledgeable resources for guidance and facilitators of decision making in the face of emerging impacts on, and interactions between, wildlife and society and their domestic animals. This need must be met by veterinary curricula and continuing-education opportunities.

WHERE DOES CURRICULUM IN ZOOLOGICAL MEDICINE NEED TO GO IN THE FUTURE?

Recommendations from the 2000 workshop address many of the curricular needs in zoological medicine from the perspective of a large segment of the veterinary community, the private companion-animal practice.¹ Advances have been made in expanding curricula to deliver basic key knowledge and skills necessary to provide health care for captive and companion non-domestic or nontraditional species, and these advances need to be maintained and further developed. However, efforts to address global needs and recent world events demand a careful reassessment of the priorities and the direction of zoological medicine curriculum development. In large part, these demands suggest that the role of zoological medicine in veterinary medicine needs to be perceived as more central to the profession, with broader delivery of the principles of clinical ecology, environmental medicine, and ecosystem health to all veterinary students, making the clear point that these approaches apply to all species, not just to wildlife. Another core principle that must be taught is that achieving true health for any individual, species, or population is necessarily dependent on achieving an integrated health of the environment, the attendant ecosystems, and the planet. Zoological medicine curriculum development needs to address the need for all veterinarians to understand the intricate interconnection of zoological species health management to domestic-animal and human health. Above this core need, students interested in careers in zoological medicine need opportunities to develop their non-clinical zoological medicine skills.

Additional resources and redirection of existing resources in the veterinary colleges will be needed to fully accomplish these goals. Though numbers of zoological faculty are increasing gradually, more faculty will be needed to serve as role models and to create, develop, and deliver the curricular components needed to meet the future requirements of veterinary medicine. The basic White Oak principle that there will be many different ways to

accomplish the goals still applies, as does the principle that each college must work within its available resources to optimize curriculum, but key aspects of zoological medicine important to the future of the profession are currently receiving minimal attention in the curricula of most veterinary colleges. Many of these were identified as core concepts in the White Oak Accords. One potential strategy to address the urgency of preparing young veterinarians to play the role they are capable of fulfilling in the changing environment of world health is to apply the strategy of integration of the ecological and environmental health principles of zoological medicine into as many aspects of existing instruction as the creativity of the faculty allows. This is possible and necessary in the allied disciplines of epidemiology, public health, preventive medicine, pathology, and toxicology. Greater integration of zoological medicine into the research components of the veterinary curriculum also offers a relatively immediate impact on the genesis of the veterinarian of the future. Greater development of alternative teaching methods, ranging from intensive course structures to Web-based instruction, also offers potential for optimizing the impact of the limited resources available to veterinary colleges for curriculum delivery. Sharing of materials among colleges, thereby reducing the need to “reinvent wheels,” along with better utilization and partnership with the allied professional organizations of zoological medicine to develop curricular materials, offers yet other ways to leverage existing resources. There are many creative ways to add value to the investment of veterinary colleges in zoological medicine curriculum, but that investment must be made if veterinary medicine is to play its appropriate pivotal role in the challenge of creating an integrated global health.

NOTE

- a Members of the steering committee were Michael K. Stoskopf, NCSU (Chair); Joshua Dein, US Geological Survey; James H. Johnson, Texas A&M University; Gretchen Kaufman, Tufts University; Suzanne Kennedy-Stoskopf, NCSU; Julie Langenberg, University of Wisconsin; Jonna Mazet, University of California, Davis; and Joanne Paul-Murphy, University of Wisconsin.

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