plored. The role of Federal regulation is to meet an endpoint goal, such as drinking water quality standards. Current and proposed Federal regulations do not dictate specific technologies or alternative uses for excess manure production. However, to meet endpoint goals for water quality, Federal regulations compel animal agriculture to find solutions to excess manure. Because regulatory approaches only impact 5 to 10% of all animal farms, voluntary and incentive based programs are also a vital part of the Federal environmental policy for animal agriculture.

Key Words: Environment, Federal Government, Water Quality

399 Phosphorus recommendations for beef cattle and factors related to their development and use. J.F. KARN*[1], [1] *USDA-ARS, Northern Great Plains Research Lab, Mandan, ND, USA.*

Current phosphorus recommendations for beef cattle will be discussed and research supporting these recommendations will be explored. Although recommendations have generally decreased in recent years, they must still contain some margin of safety, due to the many variables which affect beef cattle phosphorus requirements, especially under grazing conditions. There are many factors which make it very difficult to assess the true supplemental phosphorus needs of grazing cattle. Soil phosphorus levels are a reflection of soil parent materials and vary widely in the United States and around the world. Forage phosphorus levels reflect not only soil phosphorus levels and availability, but also forage species and stage of maturity. Animal affects include rumen microbial requirements; variation in absorption coefficients; interaction of phosphorus with nitrogen and other minerals; bioavailability differences among supplemental phosphorus sources; the availability of body stores of phosphorus and breed differences. Responses of grazing cattle to phosphorus supplementation have been inconsistent among and within geographical locations. Forage tissue phosphorus concentrations, as well as phosphorus concentrations in many animal tissues, have been considered as status indicators; but none have been consistently reliable. The impact of the above factors on phosphorus requirements, and phosphorus status indicators, as well as responses to phosphorus supplementation will be discussed. Additional knowledge is needed on many factors affecting phosphorus recommendations, and their practical application, to minimize production costs and to reduce phosphorus levels in effluent from pastures and feedlots which may affect the ecosystem of adjacent streams, ponds and lakes.

Key Words: Beef cattle, Phosphorus requirements, Supplementation

400 Effects of manipulating protein and phosphorus nutrition of feedlot cattle on nutrient management and the environment. T. J. Klopfenstein* and G. E. Erickson, *University of Nebraska, Lincoln, NE.*

Feedlot nutrition will play a role in meeting challenges such as nutrient management. Nitrogen and phosphorus are two nutrients that are currently studied in this context. One nutritional method is formulating diets to not exceed requirements for nitrogen and phosphorus. Requirements are different for calves versus yearlings. The requirements also change during the finishing period. Phosphorus requirements have not been extensively studied for feedlot cattle between 270 and 600 kg. Therefore, P requirement studies were conducted to determine the P requirement of calves (265 kg) and yearlings (385 kg). The requirement was not detected with P levels as low as .14 (yearlings) and .16% (calves) of diet DM based on performance and bone ash. Compared to NRC-predicted P requirements, P intakes ranged from 76 to 190% (calves) and 71 to 162% (yearlings). In separate nutrient balance experiments, decreasing dietary P to NRC-predicted requirements (.22 to .28%) did not influence gain but decreased P input by 33 to 45% and excretion by 40 to 50% when compared to industry average (.35% P). The metabolizable protein (MP) system was recently adopted and may allow more accurate diet formulation for protein, thereby decreasing N excretion. Compared to industry average (13.5% CP) and formulation with the CP system, using the NRC model and phase-feeding to not exceed MP requirements over the feeding period decreased N inputs by 10 to 20% for calves and yearlings without affecting ADG. Decreasing N inputs led to a concomitant decrease in N excretion (12-21%) and volatilization (15 to 33%) in open-dirt feedlot pens. Nitrogen losses are variable with time of year, with averages of 60 to 70% of excreted N lost during the summer months and 40% lost from November to May feeding periods. Protein requirements are continually being refined as more research data are collected. However, formulation to meet and not exceed protein requirements and removal of P supplements are important nutritional management options to help feedlots become more environmentally sustainable.

Key Words: Nitrogen, Phosphorus, Cattle feedlots

401 Livestock odor abatement with plant-derived oils and urease inhibitors. Vince Varel*, *USDA/ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Confined animal feeding operations are under environmental scrutiny for production of large quantities of waste in a small area. The waste can result in odor, global warming gases and the transfer of nutrients and pathogens to water and food sources. An incomplete anaerobic degradation of the carbohydrate, protein, and lipid components in waste is the primary cause of odor emissions. This incomplete degradation results in the formation of short-chain volatile fatty acids (VFA), amines and other nitrogenous compounds, and sulfur-containing compounds. Our objectives are to provide simple, cost effective, and environmentally sound solutions to control odor and pathogens in livestock waste, with nutrient management a top priority. A urease inhibitor, N-(n-butyl) thiophosphoric triamide, was used to reduce urea hydrolysis in beef cattle feedlot pens, conserve nitrogen, and inhibit ammonia emissions which contribute to odor. Laboratory studies with antimicrobial plant-derived oils, thymol and carvacrol, at 2 g kg^{-1} of feedlot waste completely inhibited the production of VFA in flasks over 42 days. Fecal coliforms were reduced from 4.6 x 10^6 to 2.0 x 10^3 cells ml^{-1} 2 days after treatment, and were nondetectable within 4 days. Total anaerobic bacteria were reduced from 8.4 x 10^{10} to 1.5 x 10^7 cells per ml after 2 days and continued to be suppressed to that level after 28 days. These plant oils are not degraded under anaerobic conditions. However, our feedlot studies and the literature indicate these oils are degraded under aerobic conditions. This suggests that these generally recognized as safe (GRAS) chemicals, which are routinely used as preservatives in food and personal care products, should not accumulate in soils to which this waste is applied. It is concluded that chemical additives can be added to animal waste to prevent degradation, which in turn controls odor emissions, reduces pathogens, and conserves nutrients until the waste can be recycled as fertilizer. The economics and environmental effects of using thymol and carvacrol in livestock production facilities need to be determined.

Key Words: Livestock Waste, Odor, Essential Oils

Companion Animal Biology as a Focal Point in the Animal Sciences

402 Issues surrounding the teaching of companion animal biology in an animal science department. Neal R. Merchen* and Linda P. Case, *University of Illinois, Urbana, IL.*

Animal Sciences departments are increasingly faced with decisions about inclusion of courses and training programs related to companion animals in their curricula. Companion animals are economically important through sales of pet food and other accessories and payment for veterinary services. The pet food manufacturing industry uses large quantities of agricultural commodities. Demographics of students have changed such that the majority of students in many Animal Sciences departments are now women, come from urban backgrounds, and target advanced study (veterinary medicine, other professional curricula, graduate study) as goals following completion of their undergraduate programs. These characteristics often reflect students whose primary animal-related experiences and interests are with companion animals. Thus, Animal Sciences departments need to consider curricula additions that include more training in companion animal biology. A curriculum in companion animal biology has been developed at the University of Illinois. Courses are taught in Companion Animal Biology (general survey of all disciplines related to companion animals) and Human-Companion Animal Interactions. A course in Companion Animal Nutrition has been developed and is offered to junior-senior and graduate students. In ad-

dition to traditional course work, opportunities have been established for student internships with pet food companies, animal shelters, and dog training centers. An annual field trip offers students direct exposure to career opportunities in companion animal management, training, and nutrition. Animal Sciences students that have training with companion animals have enjoyed enhanced experiences in veterinary medicine and opportunities for careers in occupations related to companion animals.

403 Research in companion animal biology: Topics of importance, current controversies, and opportunities. Gail Czarnecki-Maulden[1] and John Bauer*[2], [1]*Friskies,* [2]*Texas A&M University.*

Both fundamental and applied research initiatives in companion animal biology are available in university environments. Where Colleges of Agriculture and Veterinary Medicine co-exist on a single campus, interdisciplinary collaborations using clinical case materials provide unique opportunities for creative investigation. In the absence of such combined resources, opportunities for basic research also exist. Initiatives for companion animal research are generally more similar to those of human health rather than animal production and areas ranging from digestive physiology to genomics are of interest to several funding agency sources. Examples of funding sources, key meetings for interaction and development of mutual interests, and examples of several existing programs in companion animal biology focusing on nutrition will be described. Opportunities for developing key programs in other aspects of companion animal health are also ripe for exploration. As for industry, there is a considerable basic research effort in companion animal nutrition. This research is aimed at providing a point of difference vs competitor products and is often targeting visible differences rather than the more traditional indicators of nutritional adequacy used in the livestock industry. The non-invasive policies of most pet food companies also provide unique challenges to the researcher within industry. Career opportunities for animal scientists in the pet food industry and current research topics will be discussed.

404 Outreach efforts in companion animal science: Issues, controversies, and opportunities. Steven Zawistowski[1] and Tim Phillips*[2], [1]*American Society for Prevention of Cruelty to Animals,* [2]*Watt Publishing Co.*.

Well over half of all American homes have a companion animal, and the purchase and care of these animals is a multi-billion dollar business. In addition to direct expenditures associated with companion animals are the additional monies associated with enhanced health care when animals are employed as therapeutic partners or, conversely, the billion dollars in insurance claims made each year due to dog bites. Surveys of pet owners consistently show that a majority celebrate their pet#s birthday and buy gifts at holiday time. At the same time, millions of abandoned animals die in animal shelters each year. These contrasts are linked by a common theme. There is a lack of consistent high quality information on pet acquisition and care, and this is partly due to limited opportunities for education and training of specialists and professionals to participate in the field. Pet care businesses, animal shelters, and extension efforts all require individuals with a background in animal sciences that incorporate the most up-to-date information on nutrition, behavior and management skills. Opportunities in companion animal biology include positions at biomedical facilities, petfood companies, petfood industry suppliers, diagnostic laboratories, colleges, humane societies, animal control facilities, veterinary practices, drug companies, and the military. According to the American Veterinary Medical Association, the areas of greatest potential are molecular biology, toxicology, laboratory animal medicine, immunology, diagnostic pathology, environmental medicine and other specialties, including nutrition. Evidence of a strong interest in companion animal education can be found in the growth of Petfood Forum, an international symposium for those involved with the petfood industry. Since 1993, attendance has grown from 319 to over 1,000 people.

405 Role of animal science departments and the American Society of Animal Science (ASAS) in fostering companion animal programs. Maynard Hogberg*[1] and Ellen Bergfeld[2], [1]*Michigan State University,* [2]*American Society of Animal Science.*

Companion animal programs appear to be on the increase in animal sciences departments in the United States. The changing structure of animal agriculture has caused the traditional student pipeline from livestock farms to diminish greatly. As a result, departments are struggling to maintain enrollments and retain resources. It is critical that departments study and understand the implications that companion animal programs can have upon the following: departmental mission, student enrollment and student credit hours generated, type of students enrolled, departmental resources, fundamental research programs, relationship with Colleges of Veterinary Medicine and placement opportunities in the companion animal field. Companion animal programs can have a very positive impact on traditional animal science programs if properly planned and administered. As for ASAS, the companion animal area represents a vast opportunity for increasing membership and providing information to the public at large regarding animal science. The ASAS mission is "to discover, disseminate and apply knowledge for the sustainable use of animals for food and other human needs". Companionship of animals is a perceived need by many in today's society. ASAS membership and clientele demographics continue to change. A look forward suggests greater numbers of members with non-food animal interests and a shift from "food animal" to "animal". ASAS needs to recognize and embrace companion animal research and education as a legitimate component of animal science; foster greater collaboration with AVMA, veterinary medical colleges, and other related companion animal interest groups; develop educational materials for K-12 (K-life) distribution; and plan symposia, workshops, and other educational events that will be valued by both our members and the general public.

Future U.S. Swine Industry

406 The U. S. Swine Industry: Where we are & how we got here. R. L. Plain*, *University of Missouri-Columbia.*

Hog prices fell below the cost of production in November of 1997 and stayed there until February 2000. During this unprecedented period, hog producers lost over $4 billion. Producers responded to the record red ink as they always have, by reducing hog numbers. Only this time, the liquidation was less than history would have predicted. Structural change has given us a hog industry that is geared for growth and reluctant to downsize itself. Ten trends are shaping the U.S. swine industry: 1. Improved herd performance: Over the last 20 years, the nation's hog farms have produced 3% more pork per breeding animal per year. 2. Fewer & Bigger Hog Farms: The number of U.S. hog farms has declined from over 1 million farms in 1967 to only 85,760 in 2000 with 235 operations owning 52% of the hogs. 3. Specialization: In 1920, 75% of all U.S. farms raised hogs. Today, only 5% have hogs. 4. Fewer & Bigger Packing Plants: Just as hog farms have become fewer and bigger, so have hog slaughter plants. The concentration ratio for the top four firms increased from 33% in 1980 to 56.2% in 1999. 5. Geographic Shift in Production: Unlike the past, recent growth in production has been in grain deficit regions. 6. Integration of Production & Packing: Four major packers are on the list of the nation's 6 largest hog producers. Packers currently own 25% of the nation's hogs. 7. Integration of Packing & Processing: Packers are rapidly expanding their ability to further process and brand their pork. 8. Contracting: Over 32% of hogs were finished under production contracts in 1999. In January 2001, only 17% of hogs were purchased on the spot market. 9. Globalization: World trade in pork is increasing by about 8% per year. Last year, we exported over 6% of U.S. pork production. 10. Not In My Back Yard: There is growing community aversion to hog production and packing.

Key Words: Swine, Economics

407 The view from an integrated system. J.D. Lehenbauer*, *America's Best Pork®, Farmland Foods, Inc., Kansas City, MO.*

Three key factors will be the primary drivers of future change in the pork industry: 1) customer demands for specific pork quality characteristics; 2) reduction of food safety risks; and 3) the ability to coordinate and trace the identity of market hog deliveries that satisfy pork quality and food safety requirements. To address these changing dynamics in the pork industry, Farmland Foods developed America's Best Pork®