



AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

*The Kentucky
Agricultural Experiment Station*

111th

Annual Report
1998

To His Excellency,
The Honorable Paul Patton
Governor of Kentucky

I herewith submit the one hundred and eleventh annual report of the Kentucky Agricultural Experiment Station for the period ending December 31, 1998. This is done in accordance with an act of Congress, approved March 2, 1887, entitled, "An act to establish Agricultural Experiment Stations, in connection with the Agricultural Colleges established in the several states under the provisions of an act approved July 2, 1862, and under the acts supplementary thereto," and also the act of Kentucky State Legislature, approved February 20, 1888, accepting the provisions of the act of Congress.

Very respectfully,



C. Oran Little, Director
Lexington, Kentucky
June 30, 1999

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Purpose of the Kentucky Agricultural Experiment Station

As a Land Grant institution, the University of Kentucky is responsible for serving the people of the Commonwealth of Kentucky. The College of Agriculture, with its research, teaching, and extension activities, has developed a structure and organization to provide the mandated Land Grant services in agriculture and related areas.

The Kentucky Agricultural Experiment Station has been providing research results to farmers and rural residents for more than 100 years. The continued advancement of Kentucky agriculture attests to the benefits of applying new knowledge and technology. Much of the research leading to increased quantity and improved quality of Kentucky's agricultural output was performed by the Experiment Station. College researchers also have successfully addressed problems of agribusiness, consumers, international trade, food processing, nutrition, community development, soil and water resources, and the environment.

Although much Experiment Station research has immediate application to agricultural and natural resource-related problems, scientists are also involved in basic research, generating new information to help solve present and potential problems. The ability of Kentucky producers to be competitive in domestic and world markets requires an expanded base of knowledge in emerging areas of research applicable to agriculture, food, and natural resources.

This Annual Report summarizes Experiment Station research highlights for 1998. Lists of the faculty, research projects, and publications completed during the year are also provided.

The research programs of the Kentucky Agricultural Experiment Station have benefited Kentucky's agriculture over the past century, and the results of present and future research will continue to serve Kentucky's primary industry.

Statewide Research

Research activities of the Kentucky Agricultural Experiment Station were conducted at Lexington, Princeton, Quicksand, and Owenton and in counties throughout the state in 1998.

Efforts are constantly made to ensure that the research studies have application to the problems of all Kentucky farmers and other clientele groups. Locations of the experimental facilities provide conditions representative of most sections of the state.

Campus — Laboratories and specialized equipment for all research program areas.

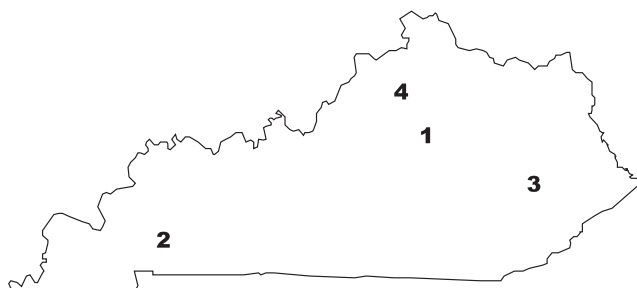
Coldstream — **Maine Chance** — **Spindletop Farms** — Beef and dairy cattle, poultry, horses, sheep and swine, forages and grain crops, tobacco and turf.

South Farm — Fruits and vegetables, ornamentals.

UK Animal Research Center (*Woodford County*) — This farm was purchased in late 1991 as a location for development of state-of-the-art food animal research programs. The farm is in Phase I of development as a research facility.

At Princeton (*Caldwell County*) the **Research and Education Center** facilities and the **West Kentucky Substation Farm** are devoted to research on grain crops, beef cattle, swine, fruits and vegetables, forages, and tobacco.

At Quicksand (*Breathitt County*) the **Robinson Station** is the location of research on fruits and vegetables, orna-



- 1 University of Kentucky, Lexington
- 2 Research and Education Center and West Kentucky Substation Farm, Princeton
- 3 Robinson Station and Forest, Quicksand
- 4 Eden Shale Farm, Owenton

mentals, forages, grain crops, tobacco, and wood utilization. Quicksand is also the headquarters of **Robinson Forest**, which spreads over parts of Breathitt, Perry, and Knott counties and is the site of forestry and watershed management research.

The **Eden Shale Farm**, located in Owen County near Owenton, is where experimental and demonstration studies are conducted on forage crops, tobacco, fruits and vegetables, and beef management.

Agricultural Economics

Research in Agricultural Economics involves diverse subjects including crop insurance, environmental policy, dairy compacts, farm profitability, farm safety, input management, financial analysis, telecommunications, information technology, labor constraints, and credit issues.

Policy Research

Risk

Policy makers are once again debating crop insurance reform. Research conducted at the University of Kentucky was used to inform that debate. It showed crop insurance subsidies favor high-risk regions and high-risk farmers, which has caused crop production to shift from the low-risk to the high-risk regions. In addition, there are up to three percent more planted acres due to risk management subsidies. Prices are also likely to be two to three percent lower than they would be without the risk subsidies.

Environment

A new area of research examined the role U.S. farmers could play in reducing greenhouse gases, a major international objective. Using the market to trade sulfur emissions has been a large success in the U.S. Likewise, a worldwide market for carbon emissions could help reduce greenhouse gases in a more cost-effective fashion than command and control systems. U.S. farmers could be big winners from such a market as they are uniquely positioned to sequester more carbon by adopting more Best Management Practices (BMPs). Adopting more BMPs has the dual effect of cleaning the global and the local environment.

Dairy Compacts

Existing policy allows the formation of interstate dairy compacts only if they are deemed to serve a compelling public interest. One argument used in support of dairy compacts is that consumers will benefit from greater retail price stability. This study estimated demand systems for whole, two percent, one percent, and skim milk using weekly scanner data at the national level from March 1996 to June 1998. Each system includes one of four measures of retail price volatility. The results suggest that price volatility can influence fluid milk demand but does not necessarily systematically depress demand.

Enhancing Farm Profitability and Management Efficiency

Farm Safety

Farm owner-operators and workers tend to make safety decisions from a subjective cost/benefit perspective. Research indicates that farm workers do not recognize the direct and indirect costs associated with work-related injury and thus are not making safety decisions on an accurate basis. Injury prevention interventions requiring farm worker participation relate safe work practices and safety improvements to the economic viability of the farm.

Nonuniform Inputs

An econometric model was developed to improve optimal farm decision-making when inputs are nonuniformly applied to a field such as irrigation water from a sprinkler system, pesticides from an airplane, or manure from a spreader. There are important implications for input-cost minimization and precision agriculture in Kentucky.

Financial Analyses

Two mistakes in a top-tier econometrics methodology journal were corrected. The newly developed econometric methodology permits the economist to analyze time series and cross-sectional data in a simultaneous-equations system. These methods can easily be used to properly analyze the relative financial economic performance of farms in our Kentucky Farm Business Management database or the relative competitiveness of counties in the databases maintained by the TVA Rural Studies Center.

Economic Development

Telecommunications

The ability to use advanced telecommunications technology is critical to the well-being of rural areas. TVA Rural Studies contracted two research projects to this end. The first looked at the availability and quality of central office switches. It found that while most rural areas are served by digital switches, the capacity in terms of advanced services those switches provide tended to be less than in urban areas. Furthermore, any telecommunications user farther than approximately three miles from the switch was unable to receive and use digital (including data processing) services without purchasing expensive "dedicated lines." Thus, many rural areas are not able to enjoy the full benefits of advancing technology.

The second report provided an overview of other barriers that keep rural areas from gaining access and using advanced telecommunications. These barriers include market-based constraints, regulatory constraints, and end-user constraints. Various ways that rural communities can surmount these obstacles were discussed.

Information Technology

A study was conducted to shed light on the extent to which information technologies such as computers, the World Wide Web, telephones, ATM cards, etc., can be used to enhance the delivery of public services into rural communities. The study found that rural residents, the poor, and the elderly were significantly less likely to use such technologies in Kentucky, raising questions about the feasibility of basing the delivery of government services on these technologies in the future.

Rural Southern Labor

There is great concern that areas in the rural South will be unable to compete in the new economy. Advancing technology, globalization, and changes in government policy such as welfare reform all present the rural South with a new set of challenges. Unfortunately, the region does not appear wholly prepared to respond. Poverty, racial discrimination, and poor education all hamper the performance and potential of many workers in the region. These findings and others were presented at a research conference co-sponsored by TVA Rural Studies.

Rural Credit

In most rural places, the bank system provides adequate access to debt capital. However, the availability of equity

capital continues to be a problem. This study found there is no single model for a rural equity institution. Key model determinants included the institution's goals, what weight to put on rate of return versus economic development, targeting decisions, choice of instruments, and exit strategies.

Further, the study found that utility cooperatives—electric and telephone—are viable providers of equity investments in rural America. This research identified several advantages cooperators can offer including access to capital and long-term development interest. Thus, utility cooperatives may be an underutilized resource for rural communities and could provide important start-up capital for economic development projects.

Research Projects

Agricultural Industrialization and Globalization: Implications for Rural Economies — *S. Goetz, D. Debertin, R. Fleming, A. Pagoulatos*
An Evaluation of International Markets for Southern Commodities — *M.A. Marchant, M.R. Reed*
Analyzing Impacts of Structure of U.S. Agriculture on Structure of Nonfarm Rural Communities — *D. Debertin, S. Goetz*
Analyzing the Future International Competitiveness of the U.S. Food Industry — *M.R. Reed, M.A. Marchant, L. Mather*
Economic and Environmental Impacts of Water-Quality Protection Policies on Kentucky Agriculture — *H. Hall, J.R. Skees*
Evaluation of Public Policy Alternatives Designed to Help U.S. Cash-Crop Farmers Manage Risk — *J.R. Skees, H. Hall*
Financing Agriculture and Rural America: Issues of Policy, Structure, and Technical Change — *D. Freshwater*
Fruit and Vegetable Supply-Chain Management, Innovations, and Competitiveness — *T. Woods*
Impacts of Trade Agreements and Economic Policies on Southern Agriculture — *M.A. Marchant*
Rural Economic Development: Alternatives in the New Competitive Environment — *S. Goetz, D. Freshwater*

Agronomy

The Department of Agronomy conducts research in four critical areas: soil science, crop ecology and management, crop genetics, and plant biology. Our work ranges from crop production tests in field plots to cutting-edge laboratory studies. We strive to improve the yield and quality of crops while conserving soil and water resources. Examples of interesting and potentially important research during 1998 are described below.

Plant Breeding

- A new burley tobacco variety, KY 910, will be available to producers in 1999. KY 910's distinguishing characteristics are high resistance to the common strain of black shank and medium resistance to other black shank strains. Because of its moderate yield potential, KY 910 will be most beneficial to burley producers who must grow their crops on black shank-infested land.
- A new soft red winter wheat variety, KY 86C-61-8, was released by the Kentucky Agricultural Experiment Station in 1998 for its yield potential, disease resistance, winter-hardiness, early maturity, and outstanding milling quality.
- Approximately 40 experimental populations of endophyte-free tall fescue were synthesized during 1998. Some of these represent the fourth cycle of selection and are in the early stages of seed increase for possible cultivar release in the near future.
- In 1998, the Kentucky Agricultural Experiment Station released soybean line KY 91-1214 as variety 7499, with marketing rights assigned to UniSouth Genetics. This is a late group IV variety released for its high yield in full-season and double-cropped environments in Kentucky. It is resistant to southern stem canker.
- Variety testing programs are an essential resource for Kentucky grain crop producers. Hybrid corn performance tests were conducted at seven Kentucky locations for feed grain hybrids and at three Kentucky locations for high-oil hybrids. Forty-eight wheat varieties and several hundred wheat breeding lines were evaluated at seven locations. One hundred and thirty soybean varieties and breeding lines were also evaluated in yield trials grown at two locations.

Crop Production

- More than 4,000 corn grain samples were evaluated for chemical composition in the Corn Grain Quality Laboratory, a cooperative effort with the Kentucky Corn Growers Association.
- Corn row width and plant population studies confirmed that 20-inch rows do not give additional corn yield re-

sponse in Kentucky over 30-inch rows. Plant population responses are more consistently observed, with economic yield responses highest at 26,000 to 28,000 plants per acre in 30-inch rows.

- Kentucky growers should soon have opportunities to contract production of novel soybean varieties at premium prices. Designer soybean varieties include high oleics (for vegetable oils), high sucrose (for soy milks), and low saturates (for salad dressings). Quality of grain produced under Kentucky conditions has been quite good, and yields have been comparable to those obtained elsewhere.
- Estimated losses associated with storage and feeding of the 4.8 million-ton hay crop in Kentucky exceed 40 percent of the crop and \$100 million in value. Wrapped, baled silage represents a viable alternative to current practices. Our research shows that high bale density, moistures between 45 and 65 percent, minimum delay before wrapping, and maintenance of anaerobic conditions during storage are important management considerations.
- Perennial broadleaf weeds (dicots) such as common pokeweed, trumpet creeper, and honeyvine milkweed have become more prominent in corn and soybean fields that are subjected to continuous no-till production practices. On-farm studies have been conducted in no-till corn and soybean fields to evaluate weed management tactics for these problem species.
- Maleic hydrazide (MH) residues on tobacco continue to be a concern. Newly developed sucker control programs can reduce residues, yet improve sucker control and increase yields. Random testing throughout Kentucky now indicates a positive trend in residue levels.

Plant Biotechnology

- Solanaceous plants like tobacco respond to pathogens by the production of antimicrobial compounds. Recent investigations of this response have identified specific molecular elements important for control of defense gene expression.
- Rapid curing of tobacco minimizes the accumulation of tobacco-specific nitrosamines (TSNA) and will reduce the amount of these compounds in smoke. Our continuing studies of TSNA accumulation have shown that completely covering tobacco with plastic in outside curing structures will increase TSNA levels in comparison to conventional structures.
- Research completed on soybean transformation has resulted in more efficient gene transfer of useful foreign genes from other organisms into soybean. During the year

we successfully introduced a protein-modifying gene, a fatty acid-modifying gene, and a herbicide-tolerance gene into adapted soybean cultivar backgrounds.

- We are developing new methods for expressing multiple genes in plants. We have tested a strategy for simultaneously expressing several enzymes in different subcellular compartments of plants. We have successfully applied this technology to express antibodies in transgenic plants.
- Research showed that the toxic acyl-loline alkaloids in endophyte-infected tall fescue ingested by cattle were converted into harmless substances during digestion and then excreted. Conversely, the toxic ergopeptide alkaloids were apparently converted into potent derivatives, such as lysergic acid amide.
- We have discovered a novel mechanism for elongation of both branched and straight medium-chain fatty acids in plants. The novel mechanism appears to be restricted to trichome glands.

Environmental Studies

- Laboratory experiments with large undisturbed soil blocks will enhance our ability to classify soils according to transport rates and aid in the development of best management practices for agricultural chemicals applied to partially saturated soils.
- Poultry litter applied to no-till soils could result in increased runoff of fecal bacteria. We examined the effect of residue level and no-tillage on runoff of fecal bacteria from soils during rainfall. Total fecal bacteria losses (but not bacterial concentration) were reduced in no-tillage because surface runoff was minimized and infiltration was maximized.
- Carbon storage in soils is important to forest ecosystems. Analysis of digital soil survey data has produced an estimate of soil carbon storage in forested landscapes of south-eastern Kentucky. More detailed examination of carbon storage will be used to investigate its possible response to changing management practices or climate.
- Laboratory and field leaching experiments with metal-contaminated soils indicated that colloids in flushing solutions may enhance desorption and remobilization of the metals. These findings point to greater potential for groundwater contamination at some sites but to opportunities for more effective remediation at others.

Research Projects

Amount and Quality of Herbage Ingested by Cattle Grazing Tall Fescue Clover Grasslands — *C.T. Dougherty*
 Analysis of mRNA Polyadenylation and Metabolism in Plants — *A.G. Hunt*

Animal Manure and Waste Utilization Treatment and Nuisance Avoidance for a Sustainable Agriculture — *G.L. Cromwell, J.H. Grove*
 Breeding Improved Varieties of Wheat, Oats, and Barley for Kentucky — *D.A. Van Sanford*
 Characteristics of a Plant Poly (A) Polymerase — *A.G. Hunt*
 Characterization, Classification, and Use Interpretations of Kentucky Soils — *A.D. Karathanasis*
 Characterization of Phytoalexin and Sterol Biosynthetic Genes in Tobacco — *J. Chappell*
 Classifying Soils for Solute Transport as Affected by Soil Properties and Landscape Position — *E. Perfect*
 Cloning and Heterologous Expression of Pesticide Metabolizing Cytochrome P450 — *M. Barrett*
 Corn Breeding and Genetics: White Endosperm Breeding, Food Quality Inheritance, and Hybrid Performance Tests — *C.G. Poneleit*
 Determining Rates of Several Nutrient Sources for Optimum Crop Production and Soil — *W.O. Thom*
 Distribution of Constituents within Tobacco Leaf — *H.R. Burton, L.P. Bush*
 Early Maturing Soybean Cropping System: Identifying Appropriate Cultivars — *L.J. Grabau*
 Effect of Tillage and Land Use on Physical and Chemical Properties of Kentucky Soils — *G.W. Thomas, R.L. Blevins, J.A. Thompson*
 Effects of Suckering Practices on Growth Characteristics, Yield, and Quality of Burley, Dark Fire-Cured, and Dark Air-Cured Tobacco — *J.R. Calvert*
 Evaluation of Burley Tobacco Varieties — *J. Calvert, B. Kennedy*
 Evaluation of Perennial Forage Crop Varieties — *R. Spitaleri*
 Evaluation of Soybean Varieties and Breeding Lines for Use in Kentucky — *T.W. Pfeiffer*
 Forage Crop Genetics and Breeding to Improve Yield and Quality — *N.L. Taylor*
 Integrated Management of Arthropod Pests of Livestock and Poultry — *C.T. Dougherty*
 Manipulation and Regulation of Oxylinin Formation in Plant Tissues — *D.F. Hildebrand*
 Mechanisms for Vacuolar Storage/Sequestration of Cd, Zn, Mn, Ni — *G.J. Wagner*
 Mineralogical Controls on Colloid Dispersion and Solid-Phase Speciation of Soil Contaminants — *R.I. Barnhisel*
 Multiplicative (Linear-Bilinear) Models for Genotype X Environment Interaction in Crop Cultivars — *P.L. Cornelius*
 Pest Control Strategies for Grazing Livestock Using Grass-Endophyte Associations — *C.T. Dougherty, F.W. Knapp, L.P. Bush*
 Phenology, Population Dynamics, and Interference: A Basis for Understanding Weed Biology and Ecology — *W.W. Witt*
 Plant Genetic Resource Conservation and Utilization — *N.L. Taylor*
 Regulation of C6-Aldehyde and Alcohol Formation in Plant Tissues — *D.F. Hildebrand*
 Relationship between Photosynthesis, Assimilate Supply, and the Size of the Reproductive Sink — *D.B. Egli*
 Seed Biology and Technology Investigations — *D.M. TeKrony, D.B. Egli, R. Geneve, A. Downie*
 Significance of Loline Alkaloids in Ecosystems Predominated by Grass/Endophyte Associations — *L.P. Bush*
 Soil and Crop Nitrogen Testing to Improve Nitrogen Management for Burley Tobacco — *R.C. Pearce, J.G. Grove, D.C. Ditsch*
 Somatic Cell Genetics of Crop Plants — *G.B. Collins*
 Species and Crop Management Effects on the Yield and Quality of Round Bale Silage — *M. Collins*
 Studies of and Efforts to Engineer the Metabolism in Plant Trichomes — *G.J. Wagner*
 The Role of Ammonium-Potassium-Calcium Exchange Interactions in Regulating Nitrification Rates in Soil — *V.P. Evangelou, M.S. Coyne*
 Understanding Recombination and Modifying Its Frequency in Soybean and Corn — *T.W. Pfeiffer*

Animal Sciences

Income from livestock fluctuates drastically from year to year. The past year was a harsh reminder of this fact. While some commodities fared well, others were devastated by farm gate prices. Through good times and bad, research remains an essential component of successful livestock and food production. We have emphasized efficient utilization of forages, adding value to our animal products, maintaining a safe food supply, increased efficiency of production, and research methods that help ensure sustainable agricultural practices. Livestock makes up more than 50 percent of the total cash receipts from agriculture in Kentucky and is one of the Commonwealth's most vital economic segments.

Nonruminant Nutrition

Research was conducted with a mutant corn that contained a majority of its phosphorus in an inorganic form rather than as phytic acid, which is poorly bioavailable to nonruminants. The phosphorus in low-phytate corn was three to four times as bioavailable to pigs and chicks as the phosphorus in normal corn. In diets containing low-phytate corn, less inorganic phosphorus was needed to maximize performance and bone mineralization. Phosphorus excretion was reduced by 30 to 40 percent in pigs fed low-phytate corn.

The bioavailability of phosphorus in meat and bone meal was found to be 85 to 90 percent for pigs. Particle size, processing temperature, and origin (bovine versus porcine) had no effect on phosphorus bioavailability.

Porcine somatotropin (pST) was found to increase accretion rates of carcass lean tissue and whole body protein in growing pigs. Finishing pigs receiving pST required greater dietary amounts of calcium and phosphorus than control pigs.

Reducing the dietary protein level and adding amino acids reduced the amount of nitrogen excretion in pigs and reduced ammonia release from their manure. Similarly, feeding a low-phosphorus diet supplemented with microbial phytase or feeding low-phytate corn reduced the phosphorus excretion in the manure.

A by-product resulting from the process of extraction of heparin from porcine intestines was found to have excellent properties as a protein source for weanling pigs. Weanling pigs demonstrated a preference for a diet containing the by-product as one of the animal protein sources compared to a diet without it.

Graded levels of five B-vitamins (niacin, riboflavin, folic acid, pantothenic acid, and B₁₂) to a low vitamin diet improved growth rate and carcass lean gain in pigs. Growth rate and lean gain improved with vitamin supplementation.

Potential interactive effects of chromium supplementation with dietary energy level, protein level, or energy source in growing pigs were assessed. There was no effect of, or any interactions with, chromium in regard to growth rate or carcass composition.

Two important environmental problems faced by the poultry industry are excessive ammonia emissions from broiler litter and excess nitrogen in the litter. Reducing protein intake can minimize these problems but can also result in poor growth. Three experiments were conducted feeding broiler chickens low protein corn-soybean meal diets with various supplements of essential and nonessential amino acids and additional dietary energy. The results provided information on the concentrations of essential amino acids required for optimum body weight gain and feed conversion using low protein (17 percent) diets. These can be useful in formulating broiler diets that can lower litter nitrogen concentrations and ammonia levels in the broiler houses.

Ruminant Nutrition

Experiments were conducted evaluating the effect of small intestinal protein on intestinal digestion in ruminants. Infusions were used to control the amount of protein reaching the small intestine. Increasing protein supply to the small intestine increased intestinal carbohydrate disappearance and increased the pancreatic secretion of amylase. These studies suggest protein may have a regulatory role in how nutrients are assimilated in the small intestine of cattle. This information may be key in determining limitations to intestinal digestion and may be useful in optimizing nutrient utilization.

Another effort has been the characterization and cloning of amino acid transport proteins that are expressed in the gastrointestinal epithelia, liver, pancreas, and kidney of cattle and sheep. This is novel research for ruminant species and will be used to improve the efficiency of amino acid absorption and metabolism by designing diets that contain optimized ratios of amino acids, based on a knowledge of amino acid transporter physiology.

Research with calves indicates supplementation with as little as 15,000 IU/d of vitamin A may decrease growth and vitamin E in blood.

Rumen Microbiology

Our rumen microbiology laboratory has confirmed the isolation of a previously unrecognized group of propionate-producing bacteria that use succinic acid as a sole carbon

source. The organisms represent a new species of ruminal bacteria that appear to play a critical role in propionate metabolism in the rumen.

Fibrous carbohydrates in plant material are an important source of carbon and energy for anaerobic bacteria inhabiting the digestive tract of ruminants. In addition, these carbohydrates are found in agricultural, municipal, and forestry waste and could serve as renewable resources for chemical production via bacterial fermentations. The hemicellulose fraction of plant fiber is comprised of pentose sugars such as xylose, but pentose utilization by anaerobes is generally not well understood. Several genes were identified that are responsible for xylose metabolism in the anaerobic thermophile, *Thermoanaerobacter ethanolicus*. A novel xylose binding protein was also characterized that could be useful in the development of thermostable biosensors. These are the first in-depth genetic studies of xylose utilization in a thermophilic bacterium and represent a significant advancement in the understanding of these biotechnologically important organisms. The information obtained from the thermophile studies is currently being used to identify similar xylose utilization genes in several ruminal bacteria that ferment pentose sugars. Since pentose utilization in anaerobic habitats and bioconversion processes is often incomplete, a better understanding of this metabolism will ultimately result in more efficient animal nutritional strategies and chemical production from renewable biomass.

Food Science

Mature cows ranging from three to 12 years of age were used to determine the effectiveness of incorporating an antioxidant and natural beef flavoring agent during product formulation to improve the palatability of raw and precooked restructured steaks. Rancid flavor development was retarded following six months of frozen storage in steaks containing an antioxidant. However, off flavors associated with animal age and high forage intake remained noticeable. The addition of a natural beef flavoring agent masked objectionable flavors typically present in beef from mature cows and improved the overall acceptability of the steaks as determined by a trained taste panel.

The efficacy of the standard industry process used to produce country-cured hams in a safe manner is being determined. This research will attempt to validate the safety of country hams using the normal industry practices. Approximately 10 million hams are country cured each year; therefore, this research will affect the sale of almost 5 percent of the total ham production in the United States.

In our investigation of 2-pentyl pyridine, the strongest documented contributor to the flavor of soy proteins, we demonstrated that holding aqueous protein solutions at pH 7 while preparing protein isolates significantly increased levels. There was approximately a 400 percent increase with Stressland and KS-4694 varieties when compared to pHs of 4.5 and 9.0. Only a 15 percent increase occurred with a soybean variety null for lipoxigenase enzymes I, II, and III.

Physiology and Breeding

Animal breeding emphasis involves evaluation of level of production, measured in terms of weaning weight differences imposed through sire selection, on subsequent reproductive performance of the cow herd.

Holstein cows having an inadequate copper status had higher bacterial numbers and higher somatic cell counts in milk and had more severe clinical reactions than those with adequate copper supplementation during experimental mammary gland infections with *Escherichia coli*. Subclinical copper deficiencies create compromised immune function and increased severity of disease in dairy cattle.

Research Projects

- A Molasses-Based Strategic Supplementation Program to Enhance Beef Cow Reproductive Performance and Calf Weaning Weight from Endophyte-Infected Tall Fescue Pasture — *Don Ely*
- Animal Manure and Waste Utilization Treatment and Nuisance Avoidance for a Sustainable Agriculture — *Gary Cromwell*
- Beef Cattle Grazing: Endophyte-Infected Tall Fescue with Alfalfa and Water Quality in Stream Pastures — *Brian Larson*
- Breeding to Optimize Maternal Performance and Reproduction of Beef Cows in the Southern Region — *Fred Thrift*
- Comparison of Forage Finishing Systems, Carcass Traits, and Processing Technologies — *William Moody*
- Development of Peptide Blockers to Enhance Cheese Production — *Clair Hicks*
- Effect of Additives and Processing Methods on Cheese Agglutination and Cheese Yield — *Clair Hicks*
- The Effect of Dietary Fiber Type and Amount on Large Intestinal Volatile Fatty Acids and Water Balance in Horses — *Laurie Lawrence*
- Enhancing Food Safety through Control of Foodborne Disease Agents — *Bruce Langlois*
- Evaluation of Supplemental Chromium on Glucose Tolerance and Performance of Swine — *Merlin Lindemann*
- The Formation and Treatment of Ovarian Cysts in Dairy Cows — *William Silvia*
- Functional Properties of Food Proteins — *Youling Xiong*
- Impact of Level of Prewaning Performance on Subsequent Cow Herd Reproduction — *Fred Thrift*
- Induction of Puberty Onset in Beef Cattle — *Keith Schillo*
- Lipid-Derived Flavors-Odors and Their Association with Food Proteins — *William Boatright*
- Mastitis Resistance to Enhance Dairy Food Safety — *Robert Harmon*
- Metabolic Relationships in Supply of Nutrients for Lactating Cows — *David Harmon*
- Microbial Strategies for Improving the Efficiency of Ruminant Production by Enhancing Propionate Metabolism in the Rumen — *Karl Dawson*
- Molecular Characterization of Carbohydrate Utilization by Anaerobic Bacteria — *Herbert Strobel*
- Nutritional Systems for Swine to Increase Reproductive Efficiency — *Merlin Lindemann*
- Regulation of Carbohydrate Digestion and Absorption in the Ruminant Small Intestine — *David Harmon*
- Strategies for Improving Ewe Lactational Performance and Predicting Prewaning Growth of Lambs Harvesting the Milk Produced — *Debra Aaron*

Biosystems and Agricultural Engineering

Biosystems and Agricultural Engineering research is directed toward solving existing and emerging engineering-related problems found on Kentucky's farms and forests, as well as developing methods of protecting foods and other farm products that are consumed or used by the public. Six broad areas of interest are pursued.

Machine Systems Design

Machine systems design involves development and evaluation of basic machine systems through the application of theoretical and applied mechanics. A fully automated burley tobacco harvesting and curing system has been developed and is being tested on the Experiment Station. A mechanical burley tobacco spearing machine has been developed and demonstrated to farmers. A commercial version of the wire-strung portable frame system was used on a limited number of farms throughout the burley producing area. An electric-powered tobacco stripping wheel has been developed that saves labor at the rate of three to five cents per pound.

Precision agriculture research is a multi-disciplinary effort involving Biosystems and Agricultural Engineering, Agronomy, Agricultural Economics, farmer cooperators, and agribusinesses. A board of farmers and agribusiness representatives advises departmental personnel on the conduct of this research. A significant effort is in the area of robotics and machine vision as a support technology for machine systems for harvesting, grading, and automated control of field machinery. The effects of soil compaction created by heavy machinery on water infiltration, groundwater movement, and plant growth are being studied.

Bioenvironmental Engineering

Bioenvironmental engineering is the application of principles of mathematics, chemistry, biology, and physics to sustain and improve the quality of our natural resources. The broad goal of current research efforts is to develop technology that improves the compatibility between water/soil resources and activities such as agriculture and mining. Research to minimize erosion and stream quality impacts from mined lands continues to be a productive, highly visible program involving improved detention basin design and continued development of computer-based design aids. Recently initiated research is devoted to assessing and reducing the effects of cattle grazing and tobacco production on runoff and sub-surface quality. Increasing concerns regarding the environmental impacts of lawn care have prompted a study to relate runoff of commonly used herbicides to factors such as application rate, post-application irrigation, and storm severity.

Bioprocess Engineering

Bioprocess engineering involves optimization of equipment, sensors, and control algorithms for processes that use living cells or subcomponents of cells as bioreactors or biocatalysts. The cells typically employed include microbes, plant tissue cells, or mammalian cells and may be modified through biotechnology. Current research in this area includes optimizing the fermentation of *Aspergillus* to produce enzymes for use as additives in animal feeds. The enzymes produced include a cellulase and hemicellulose to aid in cellulose digestion and phytase to increase the efficiency of inorganic phosphorus use and reduce the phosphorus excreted by the animal. The process parameters of solid-state fermentation temperature, substrate water content, and aeration rate were optimized for xylanase production from *Trichoderma reesei* on wheat bran. Media composition for liquid inoculum was optimized for phytase production from *Aspergillus niger*. A multi-disciplinary team is conducting research to quantify the effects of pressurized solvent on ethanol production by the thermophilic bacterium *Clostridium thermocellum*. A chlorothalonil persistence model for tomatoes is being developed by using a rainfall simulator and exposing a known amount of chlorothalonil on tomato plants to controlled rainfall intensities and total rainfall volumes.

Thermal Environmental Engineering

Thermal environmental engineering involves the design of farm structures and environmental control systems for plant and animal production, feed storage and processing centers, residences, and utility buildings. Research efforts are directed toward reducing infiltration into residences, better management of animal waste, improved design of grain storage systems and structures, improved environmental control within poultry and swine-growing facilities, computer-aided design methods for dairy facility design, and the development of alternative structures for curing burley and dark tobacco. A microprocessor system has been developed to control temperature in greenhouses. Researchers are investigating the use of improved feed rations with reduced crude protein, with the objective of reducing ammonia and other gas and odor levels in swine and poultry housing, controlling nitrogen and phosphorus levels in manure, and maintaining current production efficiency.

Crop Processing

Crop processing research involves applying basic engineering sciences, particularly heat and moisture transfer processes, to the processing, storage, and handling of farm

products. Management protocol has been developed for curing burley tobacco in the field under plastic in various types of frameworks. An estimated 15,000 acres of burley tobacco were cured in alternative curing structures in 1998, saving producers an estimated \$1 million in labor costs. The alternative curing structures cost \$500 to \$1,000 per acre compared to conventional barns at \$4,000 to \$5,000 per acre, resulting in savings of more than \$50 million in potential barn replacement costs.

Food Engineering

Food engineering involves applying principles to achieve efficient production and high standards of quality during processing, packaging, storage, and distribution of food products. A milk coagulation sensor has been developed using fiber optics and light reflectance that improves the control of cheese making. The sensor is being evaluated in this country and several foreign countries. Experiments have been conducted that show the applicability of using light reflectance as an aid in making cottage cheese. A fiber optic sensor developed from this research has been installed and is being tested in a cottage cheese-making facility in Winchester.

Other ongoing research that has basic implications in more than one of the areas mentioned above includes developing a profitable beef-forage production system through computer modeling and modeling growing swine. Meteorological research will improve the understanding and use of weather-

related agricultural management models in the southern region. The Agricultural Weather Center provides: (1) weekly Kentucky weather summary for the National Weather Service's Weekly Divisional Averages (WDA) for the Palmer Drought Index Model and dissemination on the National Weather Wire System and (2) Kentucky rainfall, temperature, and deviation-from-normal maps created daily for various time periods using the Geographical Information Systems (GIS) and made available on the World Wide Web. Research is under way to identify ways of reducing the health and accident risk for farm workers and youth.

Research Projects

Development and Application of Comprehensive Agricultural Ecosystems Models — *D.E. Edwards, R.C. Warner, J.L. Taraba*
Farming Technology and Its Economic and Environmental Impacts — *S.A. Shearer, L.G. Wells*
Fiber Optic Sensor Development for Cottage Cheese Processing — *F.A. Payne, S.E. Nokes*
Interior Environment and Energy Use in Poultry and Livestock Facilities — *R.S. Gates, L.W. Turner, D.G. Overhults*
Measuring and Predicting Soil Compaction by Machinery — *L.G. Wells*
Mechanics of Granular Solids — *I.J. Ross, S.G. McNeill*
Residential Air Infiltration and Air Quality — *D.G. Colliver*
A Systematic Approach to Enzyme Recovery from Solid State Fermentation — *S.E. Nokes*
Water and Solute Transport in Soils with Perched Water Tables — *S.E. Workman*

Entomology

Research in the Department of Entomology is directed toward two major goals: (1) understanding the biology of insects and related arthropods and their interactions with plants and animals and (2) developing and implementing safe and effective management tactics and strategies for pest species. Three broad areas of research are pursued, and the highlights of accomplishments under each area are reported here.

Insect Molecular Biology, Physiology, and Genetics

- The action and *in vitro* production of TSP16, a protein derived from teratocytes (cells derived from the extraembryonic serosal membrane of eggs of the braconid parasite, *Microplitis croceipes*, a parasite of the tobacco budworm, *Heliothis virescens*) have been studied.
- Teratocytes do not divide, but excellent viability and production of crude TSP can be maintained for at least 12 days by exchanging the medium every three days. TSP16, which comprises only a small portion of crude TSP, continues to be synthesized during the entire time.
- Parasite larvae do not secrete TSP16 but do produce unknown factor(s) that enhance teratocyte viability and synthesis of TSP16.
- The addition of 10 percent fetal bovine serum (FBS) to the medium promotes secretion of TSP16 without parasite larvae, thus overcoming the deficient condition when parasite larvae are not kept in the medium with teratocytes.
- With the availability of the cDNA for TSP16, using a biorational approach to safely deliver the protein to target pests either via transformed baculoviruses or incorporation into the tissues of the crop plant may be possible.
- Sequence analysis of segments V, B, and I was completed this project year (30.6 kb). Each of these viral DNA segments encodes at least one gene expressed in parasitized insects. The expression and functional analysis of these genes on these segments is in progress. Sequence analysis of segments A2, D, E, G1, G2, G3, H, M1, O1P, Q, S, and U4 was begun and will be completed in the current project year. These analyses will provide the majority of the *Campoplex sonorensis* polydnavirus sequence and allow efficient identification of all expressed viral genes.
- A comparative analysis of polydnavirus genomes in the ichnovirus-containing parasitoids was initiated. Many of these wasps are important parasitoids of economically damaging insect pests.
- The mechanisms of immune suppression were examined by characterizing the inhibition of the melanization response by parasitized insects. Melanization is inhibited by a combination of substrate limitation and reduction of enzyme levels in parasitized insects.

Insect Behavior, Ecology, and Evolution

- Prescribed fire may cause photochemical changes which affect insect herbivores. Herbivore-challenged seedlings on burned sites suffer greater levels of herbivory than herbivore-challenged seedlings on non-burned control sites.
- The potential for evolution of resistance to synthetic pheromones was investigated in the cabbage looper moth. Complete pheromone blends disrupted mating at the highest emission rate tested. However, gene flow between two pheromone strains of cabbage looper was proportionally greater in the presence of the synthetic pheromone, indicating that a new pheromone strain was not likely to gain a selective advantage.
- Electronic expert systems were published (www.uky.edu/~mjshar0). These allow the user to identify specimens of *Braconidae* to the generic level. The *Braconidae* are the most important biological control agents against forest and agricultural pests in Kentucky and in North America as a whole.
- A new species of *Bassus* (Parasitic Hymenoptera), parasitic on many species of skipper butterfly larvae, was described in a paper that also detailed variables of the host range of the parasite.
- Indigenous wolf spiders that immigrate into spring gardens of cucumbers kill enough insect pests to improve cucumber production. Native carabid beetles that immigrate into summer gardens of squash kill enough insect pests to improve squash production.
- By preying upon other natural enemies of squash bugs, immigrating wolf spiders can negate the positive impact of carabid beetles on squash production, so that the complex of beetles and wolf spiders together does not improve squash productivity.
- The complex of carabids and wolf spiders has a net positive impact on cucumber production in the spring.
- Generalist predators have the potential to enhance vegetable production, thereby offering the possibility of reducing reliance on chemical insecticides by intelligent management of generalist predator densities.

Pest Management and Applied Ecology

- Gypsy moth suppression tactics in Kentucky forests negatively impact several arthropod groups, including predatory spiders, ground beetles, detritivorous bristletails, thrips, and short-winged mold beetles, when compared to untreated controls one year post-application.
- The potential for employing semiochemically-based pest monitoring to reduce pesticide input in Christmas tree production is being investigated. Traps baited with host plant volatiles are being used to characterize and monitor a pest complex associated with pines.
- Populations of plant-feeding and beneficial (predatory) insects generally did not differ among plots of conventional versus transgenic (Roundup Ready) soybean plots that had been treated with either pre-emergence or post-emergence herbicides.
- The predatory lady beetle *Coleomegilla maculata* generally survived better and developed faster when reared on sweet corn pollen than when reared on field corn pollen. In field plots, population densities of adult *C. maculata* were higher on sweet corn than on field corn.
- Studies of cannibalism and interspecific predation among three predatory insect species (Hemiptera) commonly found in soybean fields were continued during 1998. When similar-sized individuals of two species were paired, either species was susceptible to attack by the other. When individuals were not of the same size, the larger predator killed the smaller one in 151 out of 169 trials.
- A two-year field study of predatory harvestmen populations in soybean fields was completed in 1998. Laboratory studies are under way to determine the potential beneficial effects of the dominant species, *Phalangium opilio*, which feeds on moth eggs and small caterpillars.
- Migrating potato leafhoppers preferred alfalfa and a fescue meadow containing a mixture of red and white clover over a hardwood forest of oak, hickory, and maple when compared in a side-by-side test. Apparently, the hardwood forest is not a significant factor in the colonization and reproduction of migrating potato leafhoppers.
- Yellow sticky traps, yellow pan traps, and sweep net sampling detected the first arrival of potato leafhoppers. The first adult leafhoppers caught by sticky traps and sweep net sampling occurred on 5 May 1998.
- Biology and host plant relationships of the horned oak gall wasp were studied, yielding a strategy for managing this outbreaking species on horse farms and in urban landscapes.
- Importance of ants as predators in turfgrass was documented, and protocols were developed for selective management of mound-building species that infest golf courses using novel, reduced-risk baits.
- Flowers of geranium were shown to contain light-activated, water-soluble secondary compounds that cause rapid paralysis in Japanese beetles, which showed no food-aversion learning in response to sublethal exposure to these toxins. Identification of the active components may provide botanical protectants useful in pest management.
- Studies indicated that sublethal stress caused by feeding on roots of endophytic grasses does not convey increased susceptibility of Japanese beetle grubs to *Bacillus popilliae*, the causal agent of milky disease.
- Causes for outbreaks of twospotted spider mites on winged euonymus in urban landscapes were documented.
- Organophosphate-impregnated ear tags continue to be an effective means of controlling horn flies in Kentucky, with >85 percent reduction. These tags also reduced face flies between 50 and 75 percent. Pyrethroid resistance in hornfly populations continues to be widespread in the state.
- Infections of the bacteria *Wolbachia* were detected in Kentucky populations of the recently imported mosquito pest *Aedes albopictus* (Asian tiger mosquito). These infections are being examined as a potential means for mosquito control.
- For 1998, 417 nurseries were licensed and 680 nursery dealer licenses were issued.
- In phytosanitary certification, we issued 1,170 Federal Phytosanitary Certificates, 17 Federal Reexport Certificates, 55 processed product certificates, and 13 state phytosanitary certificates.
- Gypsy moth trapping for 1998 saw the placement of 6,238 traps. The areas trapped included eastern and central Kentucky, along with Louisville. Forty-two moths were captured in 41 traps, meaning that there was only one trap that yielded a double catch.

Research Projects

- Biological Control of Selected Arthropod Pests and Weeds — *K.V. Yeargan, B.C. Pass*
- Biology and Management of Insects Attacking Urban Landscape Plants — *Daniel A. Potter*
- Characterization of Selected Proteins Derived from Insect Parasitoids — *Douglas L. Dahlman*
- Development and Integration of Entomopathogens into Pest Management Systems — *Grayson C. Brown*
- Ecology and Management of European Corn Borer and Other Stalk-Boring Lepidoptera — *Grayson C. Brown*
- Evolutionary Genetics of Developmental and Age-Related Changes in Social Signals — *Allen J. Moore*
- Impacts of Spiders in Food Webs of Crop and Forest-Floor Ecosystems — *David H. Wise*
- Insect Management for Emerging Agricultural Technologies and Variable Environments — *Kenneth V. Yeargan*
- Integrated Management of Arthropod Pests of Livestock and Poultry — *Stephen L. Dobson*
- Mating Disruption and the Evolution of Pheromone Communication in Moths — *Kenneth F. Haynes*
- Molecular Dissection of Polydnavirus Functional Activities — *Bruce A. Webb*
- Physiological Effects of Herbivore Feeding Guild Interactions: The Impact of Bud Herbivory on Gypsy Moth Success — *Lynne K. Rieske-Kinney*
- Simple Dynamical Models for Incorporating Biological Control Agents into IPM Decision Making — *Grayson C. Brown*
- Spatial Dynamics of Leafhopper Pests and Their Management on Alfalfa — *B.C. Pass, John C. Parr*
- Systematics and Biodiversity of Biological Control Agents with Special Reference to the Braconidae — *Michael J. Sharkey*

Forestry

Until recently, Kentucky's forest land was virtually ignored. It was recognized as a place to hunt game, an area for recreation, or a supplier of clean water, but the timber was virtually ignored as a valuable resource. Timber is now recognized as a commodity that has great potential for value-added production capabilities for economic growth in the state. Traditionally Kentucky exported most of its high quality logs and timber to other states or nations with little or no secondary manufacturing. This is rapidly changing and is becoming a very important part of the state's economic growth. The other nontimber amenities have continued to grow and become more important with increasing demands being placed on water, wildlife, recreation, and other societal amenities.

The effects of single and repeated prescribed fire on upland oak-pine forest sites were examined. Prescribed fire is being used by the U.S. Forest Service on upland sites in the Red River Gorge Geological Area of the Cumberland Plateau to return the role of fire to the ecosystem and maintain the natural diversity of forest communities. It was documented that single prescribed fire achieves the immediate goal of killing regeneration by invasive tree species with minimal combustion of the forest floor and significant but minor increases in soil nutrients.

A related project examines the socio-cultural underpinnings of fires in eastern Kentucky from an interdisciplinary perspective. Residents in Floyd County were interviewed to learn about their relationships to the woods, its meaning in their lives, and the relationship between the socio-cultural meanings of the woods and of forest fire. In addition, Floyd County Division of Forestry employees were interviewed, whose views of the woods relate primarily to management needs for developing more productive forests. Finally, newspapers in Floyd County were analyzed for changes in treatment of fire and forests over a 60-year period. The same things are now being examined in McCreary County.

A third project being conducted during this year is a study testing the hypothesis that vegetation change may significantly alter the ability of northern hardwood forests in the Catskill Mountains, New York, to retain N added by atmospheric deposition. It is hypothesized that differences among Catskill Mountain watersheds in the concentrations of NO_3 in stream water are caused by differences in species composition of the watersheds. There have been two field seasons thus far, and N fertilizer has been applied for one year. Preliminary results indicate that sugar maple and American beech differ significantly in litter lignin, decomposition rate, forest floor mass, forest floor C:N, N mineralization rate, and nitrification rate. This research is important in that it may explain an ecosystem-level phenomenon (NO_3 in stream water) with changes in species composition, a community-level phenomenon.

A study was conducted to examine the availability and feasibility of using wood waste biomass to cofire with coal for power generation. Such a practice can reduce the sulphur content in the emissions of power-generating facilities and could provide a market for a currently low-value product that is often a disposal liability. The study concluded that sufficient biomass quantities and technology exist for cofiring with up to five percent wood, and that such a practice could be economically feasible. However, utilities require large, reliable fuel supplies and long-term price contracts. Given the fragmented nature of the wood industry, significant developments in wood accumulation and delivery systems would be necessary for cofiring to become a reality on this scale.

In a western Kentucky study on an abandoned coal-washing site, the economic efficiency of various organic soil amendments in producing black locust biomass was examined. The entire study area was limed prior to any treatment. The control (i.e., lime but no organic mulch) was the most effective and efficient producer of black locust biomass. Since acidity, not compaction, was the most limiting factor on this site, the production of biomass under organic soil amendments could not be justified by their substantially greater establishment costs.

A study examining the economic efficiency of soil bioengineering for slope stability on abandoned mined lands concluded that this technology has excellent potential as an alternative reclamation method. Soil bioengineering offers significant structural/mechanical support of the slope, long-term cost effectiveness due to low maintenance requirements, and compatibility with the environment.

Recent evaluation of statewide survey results indicates that while timber management is not the only reason for management of private forest lands in Kentucky, income generation from timber is still a driving force in nonindustrial private forest management, especially when it can be coordinated with nontimber objectives. Other survey work also indicates that timber harvests on public lands are strongly opposed by a minority of the public. However, public confidence in environmental protection during timber harvests on public lands is low.

Continued work in maximizing the revenue from timber management focused on new markets for low-quality hardwoods in the central Appalachian region. Research indicates that these new markets can increase immediate revenue from low- and average-quality timber stands and actually increase the amount of high-quality sawtimber available in the future.

Studies on diurnal roost selection and foraging behavior of red bats are complete. Bats were radiotracked in the northern and southern portions of the Cumberland Plateau in eastern Kentucky in 1996 and 1997. On average, bats day roosted 16.5 m above ground in the outer foliage of the canopy of 13

different species of hardwood trees. No conifer or snag was used as a day roost. Most roost trees (77.3 percent) were situated near ridge tops in upland forests, often in the vicinity of canopy gaps. Each bat used an average of 3.1 roost trees, with bats switching roost trees approximately every 2.3 days. On average, day roosts were 277 m from the forest edge, with no roost < 50 m from any edge. Logistic regression analysis showed that bats chose roosts in stands of trees with a lower tree density, a larger stem diameter, and a greater basal area due to large trees (≥ 25 cm d.b.h). These data indicate that choice of day roosts by red bats inhabiting tracts of mature contiguous forest is different from that of red bats in fragmented habitats.

A project to determine the genetic consequences of silvicultural practices in eastern Kentucky has three objectives: (1) to evaluate the effects of timber harvests on gene frequencies in white oak (*Quercus alba* L.) populations of eastern Kentucky, (2) to evaluate the influence of timber harvests on mating system parameters (including inbreeding coefficients) in white oak populations of eastern Kentucky, and (3) to evaluate the impact of pollen and seed migration, from unharvested stands into harvested stands (or among harvested stands), on the genetic composition of white oak populations of eastern Kentucky following timber harvests.

To address the project objectives, highly variable "genetic markers" in white oak populations are being investigated. During 1998 each of a large number of seedlings and their maternal parents were studied to verify the Mendelian inheritance of these genetic markers. This verification ensures that the observed variability has a genetic (rather than an environmental or artifactual) basis. Moreover, the inheritance data revealed that the genetic markers are indeed sufficiently variable for our examination of diversity, inbreeding, and migration in white oak.

Experiments were conducted to (1) evaluate horizontal and vertical positioning precision of GPS observations made under tree canopies, (2) measure horizontal stakeout accuracy determined by GPS navigation and land survey, and (3) compare two intensive plot-based inventory results.

With regard to GPS positioning precision, it was found that differential GPS was, on the average, 15 times more accurate than autonomous GPS and that, using either autonomous GPS or differential GPS observation mode, vertical positioning error was 1.5 to three times larger than horizontal error. Statistical test results revealed that (1) separations in plot centers determined by the two stakeout methods were statistically significant and (2) traditional land surveying technique could more accurately allocate inventory plot centers than autonomous GPS land navigation. Two timber inventories yielded the same commercial timber volume estimates.

Statistical test results showed that differences in cubic-foot volume, board-foot volumes, and stand-density estimate (number of trees/acre) were statistically insignificant, despite significant plot separation found in this experiment. The finding is significant because it implies that it is unnecessary to achieve sub-meter GPS positioning accuracy when allocating statistical sampling plots for commercial timber inventory.

A study on the ecological characteristics of an elk reintroduction in eastern Kentucky examines the feasibility of restoring this large ungulate to a portion of its former range. Although elk were reportedly abundant in Kentucky during colonial times, they were all but gone by the turn of the 19th century. In addition, extinctions of large carnivores such as mountain lion, black bear, gray wolf, and red wolf, and the loss of the American chestnut, have created environments that are distinctly different from the elk's original landscape. This research, which employs the use of satellite and radio telemetry technologies on 400 elk, examines the natural and anthropogenic factors that influence reestablishment. A post-doctoral scholar, a Ph.D. student, an M.S. student, and a full-time technician are conducting the field work on this project, which has been funded by the Rocky Mountain Elk Foundation and the Kentucky Department of Fish and Wildlife. The study is funded for three years but has the potential to continue for several more years. This project represents the largest elk restoration research project ever undertaken in North America.

A five-year study of soil invertebrates in minimally disturbed forests on the Cumberland Plateau was completed. Relationships between landscape and soil features and the occurrence and dominance of various invertebrate taxa were determined, and relative abundances of invertebrates in terms of biomass were compared among landscape positions. This study collected baseline information on soil invertebrate populations and will serve as the starting point for future work dealing with the effects of various types of disturbance on soil invertebrates.

Research Projects

- Conservation, Ecology, and Restoration of Large Mammals in Eastern Kentucky — *D.S. Maehr*
- Economic Assessment of Surface Mine Reclamation Alternatives — *J.M. Ringe*
- Effects of Forest Management Practices on Forest Nutrient Status — *M.A. Arthur*
- Indicators of Ecosystem "Quality" in the Mixed Mesophytic Forest — *P.J. Kalisz*
- Intraspecific Phytogeography of Plant Mitochondrial DNA — *D.B. Wagner*
- Roost Selection of Bats in Forests in Eastern Kentucky — *M.J. Lacki*

Horticulture and Landscape Architecture

The Horticulture and Landscape Architecture faculty conducts mission-oriented research, combining basic and applied approaches related to the production and use of horticultural crops and landscape architecture. Research activities are concentrated in the broad topics of production and marketing systems, natural products in plant defense, plant productivity, and landscape architecture.

Production and Marketing Systems

Nursery crops research suggests that early chemical pruning (CuCO_3) of red oak liners improves root quality and shoot and root dry weights in 14-cm deep containers. Cooperative regional research concluded that total production cost per salable crape myrtle (3-year production cycle) was similar between field (\$23.73), aboveground containers (\$23.71), and pot-in-pot systems (\$21.52). Over a wide range of nursery crops, production costs in 1997 ranged from 139 percent to 145 percent greater than in 1985. Thiazopyr, a new experimental pre-emergent herbicide, provided good weed control of annual grasses and most broadleaves while resulting in minimal injury to most groundcovers tested in a landscape setting.

Yield of cut flowers from the greenhouse-grown tropical plants *Otacanthus caeruleus* and *Angelonia angustifolia* was commercially acceptable during summer conditions but not under winter conditions. Post-harvest life of *Angelonia* was 14 to 18 days and of *Otacanthus* was 12 to 14 days.

High-density planting of apples appears to be suited for Kentucky and can result in early production. However, research is needed to determine the optimum training method for Kentucky. The first year of a long-term study on a vigorous site indicates 60 percent of time required for training occurs in the first five weeks of the growing season, but some time is required weekly for optimum training.

Cooperation in a regional research project provides continued identification of improved rootstocks and cultivars required by the Kentucky tree fruit industry. Currently, rootstock effects on high-density apple, peach, and plum production are being evaluated.

Cultivar evaluations in production systems suitable for Kentucky are critical for the continued expansion of the fruit and vegetable industries. Vegetable trials in 1998 were focused on spring fresh-market cabbage, sweet corn, pumpkins, peppers, and tomatoes. Small fruit variety trials included strawberries in a matted-row system, strawberries for fall planting in plasticulture, wine grape lines from eastern Europe, and blueberry for west Kentucky.

The Controlled Water Table (CWT) irrigation system was used successfully to grow several cultivars of bedding plants in 96 cell trays and to grow 10- to 15-cm flowering pot plants. The system is automatic; plants determine the rate of water application; therefore, the labor cost is reduced. No runoff occurs, so the system is compatible with environmental regulations.

Natural Products and Plant Defense

Studies on E-2-hexenal, a natural volatile compound found in the human diet that may function as an alternative to synthetic pesticides to control post-harvest diseases on foods, resulted in control of *Botrytis* on table grapes for three months in cold storage. Fruit quality parameters, including color, firmness, and soluble solids, were acceptable, and flavor is being investigated. Studies on the foodborne bacterium *E. coli* 0157:H7 showed strawberry is a suitable host for this human pathogen. The microbe emits a series of volatile compounds including indole and ketones that may provide a basis for its detection on fruits and vegetables.

Research of natural products in crop plants identified novel compounds in secretions of *Solanum berthaultii* and *S. melongena* that confer resistance to spider mites through mechanisms of antibiosis and repellency. Small differences in these compounds related to a 1,000-fold difference in repellent activity.

Plant Productivity

The protein N-methyltransferase, responsible for the formation of trimethyllysyl-14 in the large subunit (LS) of Ribulose Biphosphate Carboxylase/Oxygenase (Rubisco), Rubisco LSMT (EC 2.1.1.127), has been purified and characterized, and cDNA sequences have been obtained from tobacco, pea, and, surprisingly, spinach. The entire gene for tobacco and spinach Rubisco LSMT, including the promoter region for the tobacco gene, has been sequenced and cloned. Rubisco is the primary enzyme in photosynthetic CO_2 fixation. These results open the way for the potential manipulation of Rubisco activity with subsequent increases in crop productivity.

Divergent physiological responses to drought and heat stress between, and among accessions within, native *Fragaria* species have been found. These traits can make significant contributions to the development of new strawberry cultivars with greater adaptability and productivity in adverse environments. The Kentucky *F. virginiana* population may provide a source of heat tolerance traits for development of commercial cultivars with such attributes.

Landscape Architecture

Work on the Geographic Information System database related to land use planning has focused on keeping the data current, developing a user interface, and incorporating new sources of data, including the NRCS SSURGO county soils maps. The database will help local decision makers address land use planning to optimize the use of natural and human resources for economic and social development.

Research Projects

Antimicrobial Properties of Naturally Occurring Volatile Compounds from Plants — *T.R. Kemp*
Controlled Water Table Irrigation for Container Plant Production — *J.W. Buxton*
Arthropod Repellency and Host-Plant Resistance in *Lycopersicon hirsutum* — *J.C. Snyder*

Developmental and Environmental Influences on Carbohydrate Partitioning in Fruit Crops — *D.D. Archbold*
Evaluation of Cut Flower Species for Adaptability to Improved Greenhouse Production Practices and Extended Post-Harvest Life — *R.G. Anderson*
Interaction between Ethylene and Polyamines during Seed Germination and Early Seedling Growth — *R.L. Geneve*
Mechanism and Significance of Post-Translational Modifications in the Large Subunit of Ribulose Bisphosphate Carboxylase/Oxygenase — *R.L. Houtz*
Land Use Planning for Rural Development in the Coal-Producing Counties of Eastern Kentucky — *T.J. Nieman*
Rootstock and Interstem Effects on Pome and Stone Fruit Trees — *G.R. Brown*
Technical and Economical Efficiencies of Producing and Marketing Landscape Plants — *R.E. McNeil*
The Role of Alleopathy in Weed Suppression: Physiological and Genetic Responses in Agroecosystems — *L.A. Weston*

Nutrition and Food Science

The Department of Nutrition and Food Science is supported by the Agricultural Experiment Station (AES) at the University of Kentucky through supplies and salary of four faculty members and one chairperson, each with joint appointments and approved projects in the Agricultural Experiment Station.

Based on the following finding—"For the two out of three adult Americans who do not smoke and do not drink excessively, one personal choice seems to influence long-term health prospects more than any other: what we eat" (DHHS, 1988)—the Department of Nutrition and Food Science strives to maximize quality of life and human potential at the state, national, and international level through prevention and reduction of nutritional deficiencies and diet-related noncommunicable diseases by the improvement of dietary practices and other related behavior.

The main thrust of AES-supported departmental research includes nutrition in relation to cardiovascular disease, cancer, eating disorders, nutrient-drug interactions, antioxidant status, and alcohol abuse. Department goals are to support the design, implementation, and evaluation of basic studies of nutrition and dietary modulation of gene expression and cellular and metabolic processes that can affect outcomes to prevent both nutritional deficiencies and nutrition-related chronic disease. Interdisciplinary collaborations are sought with other units since the National Academy of Sciences has recognized nutrition and food sciences as the most interdisciplinary of all sciences.

Interaction of Diet and Drugs

Human nutrition research strategies include basic studies of nutrition and dietary modulation of gene expression and cellular and metabolic processes. Drug-nutrient interactions can affect bionutrition, physiological and neurological performance, and other health problems. Understanding the role of specific dietary factors, and their relationship to drugs, improves health promotion and disease prevention throughout life. Acetaminophen or acetaminophen-containing drugs are commonly used analgesics and antipyretics. Although acetaminophen is a safe drug at the therapeutic dose, overdose or long-term use can cause chronic hepatitis or necrosis. The mechanism by which acetaminophen produces hepatotoxicity remains unclear. It has been suggested that oxidative stress may be a possible mechanism. Thus, the possible protective effects of antioxidants and glutathione (GSH) precursors against the APAP-induced alterations of antioxidant defense enzymes in hepatocyte culture were studied. The results suggest that vitamin E, vitamin C, or GSH precursors can lessen APAP toxicity through modulation of APAP-induced depression of antioxidant defenses.

Antioxidant Vitamins

The rise in self-diagnosis and supplementation has led to many new questions: What is the range in intake of nutrients and other food components that will optimize health and reduce chronic disease risk at different physiological stages? What patterns of food intake, dietary supplements, and physical activity will provide the nutrition standard and appropriate energy balance to improve individuals' health and productivity and to minimize their risk of disease? At what points do nutrients interact with human genes to alter disease risk, what are the natures of these interactions, and how can they be modified? How can scientific knowledge of optimal nutrition, appropriate food intake patterns, energy balance, and physical activity be translated into community interventions that modify behavior and improve the health and nutritional status of the U.S. population? These studies are giving new insights into the effects of vitamin supplements and their potential for harm or improvement.

Cancer

Dr. Glauert's laboratory is examining the role of oxidative stress in liver carcinogenesis induced by chemicals such as peroxisome proliferators and PCBs. Hypolipidemic drugs, plasticizers, and other chemicals induce hepatic peroxisome proliferation and hepatocellular carcinomas in rats and mice. The mechanisms by which these agents act in some species but not in others is unclear but may be related to the induction of cell proliferation, the inhibition of apoptosis, or the production of active oxygen. The production of active oxygen could lead to changes in gene expression in the cell, including the activation of NF- κ B and other transcription factors. The peroxisome proliferator ciprofibrate has been found to activate hepatic NF- κ B in rats and mice through a mechanism that is mediated by active oxygen. We are currently examining whether dietary antioxidants can inhibit NF- κ B activation by peroxisome proliferators, which hepatic cell types have increased NF- κ B activation in response to peroxisome proliferators, and if NF- κ B activation is necessary for changes in gene expression seen after the administration of peroxisome proliferators.

Cardiovascular Disease

Cell injury, or any event which disrupts endothelial integrity and thus endothelial permeability properties, may be involved in the early events leading to atherosclerotic lesion formation. There is evidence that individual nutrients or nutrient derivatives may either provoke or prevent metabolic and

physiologic perturbations of the vascular endothelium. Diets high in fat and/or calories are considered a risk factor for the development of atherosclerosis. Our research has shown that certain diet-derived lipids and their derivatives can disrupt normal endothelial integrity, thus reducing the ability of the endothelium to act as a selectively permeable barrier to blood components. We suggest that dietary fats rich in certain unsaturated fatty acids can be atherogenic by enhancing the formation of reactive oxygen intermediates. Our data also suggest that certain nutrients, which have antioxidant and/or membrane-stabilizing properties, can protect endothelial cells by interfering with lipid/cytokine-mediated endothelial cell dysfunction. Our findings contribute to the understanding of the interactive role of dietary fats with inflammatory components, as well as with nutrients that exhibit antiatherogenic properties, in the development of atherosclerosis.

Energy Balance/Eating Disorders

Studies show that the prevalence of overweight in the United States has increased by 8 percentage points over the past decade. Nationally, 31 percent of men and 35 percent of women are overweight, and more than 45 percent of non-Hispanic Black and Mexican-American women are overweight. Twenty-one percent of adolescents ages 12 to 19 years are overweight, an increase of 6 percent over the last decade, and the prevalence of overweight for children ages 6 to 11 is approximately 22 percent, which represents a 7-percentage point increase in the last 10 years.

Mercer et al. have accomplished several goals producing new findings placing the central H1 receptor in the hierarchy of regulation of food intake: the central H1 receptor is involved in physiological responses to nutrient-imbalanced and restricted intake diets; food intake is inversely proportional to central H1 concentration in male rats fed diets varying in energy content, protein content, and protein quality; female rats normally have higher H1 receptors than male rats; diet composition affects H1 receptor levels in a gender-specific manner; bioperiodicity is present in central H1 receptor trafficking; parameters of periodicity are gender-specific and modified by diet. Preliminary findings in our lab carried out on animal tissues received from other laboratories indicate that tumor-bearing mice have increased H1 receptors (consistent with anorexia); cigarette-smoking rats have increased H1 receptors (consistent with weight loss); Zucker obese rats have impaired H1 response to dietary manipulation (consistent with obesity).

Research Projects

Dietary Vitamin E/Fat and Oxidative Damage — *Ching K. Chow*
The Histaminergic System and Eating Disorders — *L. Preston Mercer*
Mechanism of Hepatocarcinogenesis by Peroxisome Proliferators and
Influence of Dietary Antioxidants — *Howard Glauert*
Nutrient-Alcohol/Oxidative Drug Interaction — *Linda Chen*
Zinc Nutrition and Vascular Endothelial Integrity — *Bernhard Hennig*

Plant Pathology

Research endeavors in plant pathology increase understanding of the nature of disease in plants while providing the information base essential to developing improved disease management recommendations.

Plant-Microbe Interactions

- Plant viruses, particles of remarkably stable nucleoprotein associations, must undergo the structural alterations necessary to release their genomes at the onset of infections. Investigations of the *in vivo* disassembly of tobacco mosaic virus revealed that the process is bidirectional and that a virus-encoded replicase protein is involved in the release of the viral genome from its protective protein coat.
- Viruses in the genus *Potyvirus*, which cause serious diseases of Kentucky's major crops, are spread by aphids and are very difficult to control. Aphid species transmit only particular potyviruses, a phenomenon known as vector specificity. This specificity is regulated by the so-called helper component (HC) protein, a potyvirus gene product. Aphids not normally able to spread a particular virus become vectors when they first acquire HC of a virus which they can naturally transmit.
- Peanut stunt virus (PSV) is widespread in red and white clover in Kentucky and is considered a major cause of pasture decline. PSV subgroup II strains induce the formation of unusual cytoplasmic inclusions in infected tobacco cells. In addition to their diagnostic value, these novel inclusions may prove valuable in understanding virus-host interactions. Another recent discovery associated with PSV infections is the isolation of a small defective interfering (DI) RNA composed only of untranslated viral sequences. The DI RNA may be useful in constructing vectors for the transient expression of foreign genes in plants.
- Phylogenetic analysis of *Helminthosporium victoriae* totivirus indicated that it is more closely related to the totivirus infecting the parasitic protozoan, *Leishmania*, than to totiviruses infecting yeast. A putative double-stranded RNA-activated protein kinase gene overexpressed in virus-infected *Helminthosporium victoriae* was isolated, and its complete nucleotide sequence was determined. Activation of the protein kinase is proposed to trigger disease in the fungus.
- Laboratory bioassays were developed and refined to monitor spore germination in *Colletotrichum graminicola*, the primary causal agent of corn anthracnose, as well as to measure the aggressiveness of the fungus to corn pith tissue. Spore germination was responsive to two different stimuli, namely adhesion to a firm surface and the presence of external nutrients. Insertional mutagenesis of *C. graminicola* allowed recovery of three morphological mutants, two pathogenicity mutants, and one germination mutant. Genetic analysis of mating compatibility between two self-sterile strains of *Glomerella graminicola*, the sexual stage of *C. graminicola*, indicated that the two strains are hermaphroditic and that compatibility is controlled by two genes.
- Despite the challenges of obtaining DNA from an obligate parasite, a partial library of random genomic DNA fragments of the tobacco blue mold pathogen, *Peronospora tabacina*, was constructed in a plasmid vector. Ninety-six clones were characterized. A number of clones have been used to identify Restriction Fragment Length Polymorphisms between different isolates of the fungus.
- In recent years, *Magnaporthe grisea* has caused a severe disease problem (gray leaf spot) on perennial ryegrass fairways at golf courses in the Bluegrass and throughout the central United States. Molecular and genetic studies of isolates from eight states indicated that strains specialized to perennial ryegrass are genetically very homogeneous, yet are distinct from isolates adapted to other grasses. Progress continued on developing sound strategies for proper selection and timing of fungicides for management recommendations.
- *Magnaporthe grisea* is also an important rice pathogen. To address potential mechanisms underlying pathogenic variability, the genetic and molecular bases of frequent chromosomal deletions occurring during meiosis were investigated. Deletions occur only when the homologous chromosomes are heteroallelic for the unstable region. Molecular characterization of the unstable chromosome region revealed that it contains at least five different transposable elements absent in the homologous chromosome. These observations have important implications not only for plant pathogenicity but also for human genetic disease.
- Livestock toxicoses are often caused by fungal symbionts (endophytes) present in common pasture and forage grasses. Ergot alkaloids produced by the symbiotic fungal endophyte, now called *Neotyphodium coenophialum*, cause seasonal, debilitating illness to large animal herbivores consuming infected tall fescue. A gene encoding a key enzyme in ergot alkaloid biosynthesis, 4-dimethylallyl-tryptophan synthase, was recently cloned from *Claviceps* species. Oligonucleotide primer mixtures were made to facilitate amplification of the gene from *N. coenophialum*, and a single product of expected size was obtained.
- Distinct from the ergot alkaloids, loline alkaloids produced in endophyte-infected grass evidently provide anti-insect

protection to the plant. Nearly complete killing of two aphid species was observed when loline alkaloid levels were 90 micrograms per gram plant dry weight. Even levels below 30 micrograms per gram dry weight gave significant anti-aphid activity. A log-linear dose response was indicated for reduced aphid survival on plants containing 30 to 200 micrograms of loline alkaloids per gram dry weight.

- Chinese x American Chestnut F2 hybrids were designated resistant or susceptible to blight based upon canker size induced by standardized inoculations with the causal pathogen, *Cryphonectria parasitica*. The amount of chitinase induced after three or five days' incubation with the wound hormone, ethylene, was significantly greater in resistant than in susceptible hybrids. However, overlay activity gels of isoelectric-focused chitinase isoforms did not reveal consistent qualitative differences between the set of resistant and susceptible hybrids studied.

Plant Disease Control

- Improvements in disease management strategies were sought through studies of fungi colonizing soils supporting a variety of vegetable crops, including tomato, pepper, cucumber, squash, and bean. Crop rotation can disrupt fungal communities in soil. In order that sustainable crop production be less reliant on toxic chemicals (e.g., methyl bromide), identification and exploitation of beneficial fungal species in soil will be essential.
- Research into Integrated Pest Management practices benefited apple growers through the use of apple scab models to predict disease and the intensities of management required, reducing fungicide applications wherever practical.
- Soybean mosaic virus (SMV) and bean pod mottle virus (BPMV) are the major viruses of economic importance infecting soybeans in Kentucky. Double infections result in significant yield losses. Incorporating SMV resistance increased double-cropped soybean yields by 14 percent. Cloning and sequencing of BPMV genomic RNA indicated at least four distinct viral subgroups. Knowledge of BPMV genetic diversity is essential for developing broad virus resistance.
- This past year marked the fifth of a study to determine the effects of various crop sequences on soybean cyst nematode (SCN) egg densities and soybean yields. Results indicate that SCN resistance begins to break down the third time an individual SCN-resistant variety is grown and continues to deteriorate with each subsequent crop of the same variety. Despite this, yield reductions in the resistant varieties were not evident until the fifth year. Apparently, extensive resistance breakdown is necessary before yield reductions are evident.
- Research continued in western Kentucky to optimize management recommendations for fungicide use in wheat. A new applied research effort was begun in wheat as part of the National Fusarium Head Blight Initiative.
- The role of current production practices in increasing black shank problems in tobacco was explored in several long-term plots maintained around the state. Data indicated that severe losses from black shank epidemics are related to high soil pH.
- Evaluation of computerized weather monitoring and forecast systems in the timing of foliar fungicide applications, monitoring of fungicide resistance, testing of experimental fungicides, assessing the potential for overwintering of *P. tabacina*, and characterizing isolate virulence were all investigated in pursuit of enhanced control strategies for tobacco blue mold.
- Applied research efforts to evaluate fungicides and cultural practices to limit diseases in tobacco float and greenhouse systems were conducted in hopes of identifying better management protocols, including those reliant on new fungicide labeling.
- Alfalfa field trials in which germplasms were evaluated for their reaction to Sclerotinia crown and stem rot revealed how little progress has been made by commercial breeding programs in identifying resistance to this disease. Such awareness, however, is likely to foster increased interest in screening germplasms under Kentucky conditions.
- Trials of turf disease control products continued. Identification of disease-resistant varieties and of disease-suppressing cultural practices were also pursued so as to reduce unnecessary fungicide use.

Research Projects

- Biological Control and Management of Soil-Borne Plant Pathogens for Sustainable Crop Production — *J.W. Hendrix*
- Biological Improvement of Chestnut and Management of the Chestnut Blight Fungus — *L. Shain*
- Forage Legume Viruses: Identification and Genetic Resistance for Improved Productivity — *S.A. Ghabrial*
- Genetic Analysis of Avirulence/Virulence in *Magnaporthe grisea*, a Pathogen of Rice and Other Grasses — *M.L. Farman*
- Genetic Analysis of Bioprotective Alkaloids Produced by Grass Symbionts — *C.L. Schardl*
- Genetic Determinants of Parasitism and Pathogenicity in *Colletotrichum graminicola* — *L.J. Vaillancourt*
- Host-Pathogen Interactions between *Castanea* Sp. and the Chestnut Blight Fungus — *L. Shain*
- Managing Plant-Parasitic Nematodes in Sustainable Agriculture with Emphasis on Crop Resistance — *D.E. Hershman*
- Mechanisms of Transmission of Plant Viruses That Have a Nonpersistent Vector Relationship — *T.P. Pirone*
- Mechanisms of Virus Particle Disassembly during the Establishment of Plant Virus Infections — *J.G. Shaw*
- Mycovirus-Host Interactions in Diseased Isolates of *Helminthosporium victoriae* — *S.A. Ghabrial*
- Plant-Fungal Endophyte Interactions: Potential for Cultivar Improvement in Species of *Festuca* and *Lolium* — *M.R. Siegel*

Regulatory Services

The Division of Regulatory Services administers state laws pertaining to the manufacturing, processing, labeling, and marketing of commercial feed, fertilizer, seed, and raw milk. Its purpose is to protect farmers and other consumers from poor quality, mislabeled, or misrepresented products and to protect agricultural businesses from unfair competition from those who might take short cuts in the quality of their products.

Feed, fertilizer, and seed are monitored in the manufacturing or retail channels for reasonable and acceptable compliance with state laws through label review, product and facility inspections, and product sampling and analysis. Raw milk is monitored during marketing to assure an accurate and equitable exchange between producers and processor and to ensure the integrity of milk from farm to processor.

Ten regulatory inspectors and one auditor cover the state, collecting samples, inspecting facilities, and auditing records. Additionally, a specialty products inspector checks and samples small-package and specialty feed, fertilizer, and seed products throughout the state.

The Division also offers to growers and homeowners seed testing, soil testing, poultry litter and animal manure testing, and water and nutrient solution analyses for greenhouse production and float-bed systems of seedling production.

Auditing Program

H.S. Spencer

Audits of sales and fee payments were made on 224 of 641 milk, seed, feed, and fertilizer businesses in Kentucky to verify check-off and tonnage fees. Fees assessed to help pay the costs of inspecting, sampling, and analyzing commodities in accordance with Kentucky laws are: fertilizer, 50 cents per ton; feed, 35 cents per ton; and seed, 4 to 24 cents per unit. During May, raw milk is assessed a check-off fee of 3 cents per 100 pounds.

Income from Fees in 1998:

Feed	\$700,285
Fertilizer	661,850
Milk	60,010
Soil testing	162,830
Seed tags, testing, and licenses	379,664
TOTAL	\$1,964,639

These cash receivables were substantiated on 2,696 fertilizer tonnage reports, 3,112 feed tonnage reports, 796 seed reports, and 14 milk reports. These reports were checked for accuracy and compared with field audits of the firms submitting them.

Milk Regulatory Program

C. D. Thompson

The milk regulatory program administers the Kentucky Creamery License Law and Regulations. The program's primary objective is to ensure the proper payment for milk produced in Kentucky. These payments must be based on a series of accurate weights and tests. The program provides a marketplace environment that is fair and equitable for all individuals and firms involved in the dairy industry. In 1998, the Division:

- reviewed and issued licenses to 13 milk buyers, 50 testers, 389 sampler-weighers, and eight raw milk transfer stations.
- analyzed and administered action on 4,640 official samples.
- analyzed 540 samples submitted by licensed testers for comparison purposes.
- conducted nine producer pay record audits.
- conducted 40 inspections at 15 milk laboratories.
- trained and examined 54 new sampler-weighers and 10 new testers.
- conducted 460 inspections of 218 sampler-weighers.
- conducted 10 inspections of raw milk transfer stations.

Feed Regulatory Program

C.E. Miller

The feed regulatory program provides consumer protection for the purchasers of livestock feed and pet foods, maintains a marketplace environment that promotes fair and equitable competition for the feed industry, and helps ensure the safety and wholesomeness of animal products as human food. In 1998, the program:

- administered actions on 4,563 official samples of commercial feed involving 27,755 official tests to monitor about 3 million tons of commercial mixed feed and feed ingredients distributed in Kentucky.
- administered a cooperative program with the FDA to inspect five feed mills that mix restricted drugs in feed and to inspect 35 feed mills for compliance with FDA's national BSE regulation, which prohibits the feeding of certain mammalian proteins to cattle and other ruminants. An additional 55 state inspections were conducted on mills that mix non-MFA drugs in feed to ensure compliance with medicated feed regulations. Forty-four mills that mix no drugs were inspected to ensure compliance with labeling, manufacturing, and storage practices.

- conducted 7,500 label reviews and maintained product registration for about 15,000 products from 900 companies.
- continued implementation of the new Kentucky feed labeling requirements for livestock and poultry feeds.

Fertilizer Regulatory Program

D.L. Terry

The Kentucky Fertilizer Law ensures that fertilizers sold in Kentucky are clearly and accurately labeled so that consumers can make informed purchases of fertilizer and be assured of its quality. The law also protects the legitimate fertilizer industry from unfair competition. In 1998, the program:

- administered actions on 3,646 official and 304 unofficial samples of fertilizer involving 11,961 tests of the approximately 1 million tons of fertilizer distributed in Kentucky.
- reviewed labels and registered 3,839 products from 472 firms, including 220 who manufactured custom blends of fertilizers.
- conducted three educational seminars on the fertilizer regulatory program for the fertilizer industry.
- conducted a bag-sampling study to validate a new sampling probe.

Inspection Program

F. Herald

The inspection program aims to achieve industry compliance with the consumer protection laws that the Division is charged with administering. Inspectors strategically located throughout the state, each with an assigned area to cover, carry out this responsibility. They inspect manufacturing plants, processing facilities, storage warehouses, and retail stores; collect official samples of feed, pet food, fertilizer, milk, and seed; review records; and offer assistance to clientele in improving their operations to achieve compliance with the laws. In 1998:

- a team of nine inspectors performed 5,122 inspections of the processing, manufacturing, and marketing of feed, fertilizer, and seed. They inspected 51 feed mills for compliance with FDA's new regulation to prevent the establishment of bovine spongiform encephalopathy (BSE) in the United States. One inspector traveled throughout the state to inspect and sample small-package and specialty feed, fertilizer, and seed products in urban areas. Another inspector covered the state to administer the Creamery License Law.

- inspectors collected the following numbers of official samples for laboratory verification of appropriate constituents and quality:

Feed	4,563
Fertilizer	3,646
Seed	3,092
Milk	4,640

Seed Regulatory Program

D.T. Buckingham

The seed regulatory program assures Kentucky farmers and urban consumers of quality seed and promotes fair and equitable competition among seed dealers and seedsmen. In 1998, the program:

- collected and tested 3,092 official seed samples.
- issued stop-sale orders on 531 official seed samples and 453 violative seed lots at seed dealer and seed processor locations.
- cooperated with the USDA-Seed Branch regarding shipments of seed into Kentucky that were in violation of the Federal Seed Act.
- issued 257 permits to label seed and registered 416 seed dealer locations.
- performed inspections and sampling of agricultural seeds at 470 locations and lawn, turf, and garden seeds at 400 locations.

Seed Testing Services

E.E. Fabrizio

The seed testing program provides the seed industry and seed growers of Kentucky with competent, reliable, and timely analyses of their seeds for labeling requirements and quality assurance. In 1998, the seed laboratory tested the following number of samples:

Official seed samples (regulatory)	3,092
Regular seed samples (service)	4,220
Certified seed samples (service)	434
Tobacco seed samples (service)	1,399
TOTAL	9,145

In addition to routine testing for purity, germination, and noxious weed seed, the laboratory offers testing for seed vigor (accelerated aging and cold test), seed moisture, seed size (seed count), and germination following fungicide application. The laboratory also provides tests to seedsmen and livestock farmers for the presence of the fungal endophyte in tall fescue seed and live fescue tillers.

Soil Testing Service

F.J. Sikora (Lexington)

D.L. Kirkland (UKREC, Princeton)

Soil testing provides farmers, homeowners, greenhouse operators, surface-mine specialists, and others with scientific information about the fertility status of their soils. In partnership with the Cooperative Extension Service, it also provides them with lime and fertilizer recommendations based on soil tests. We also offer analyses of poultry litter and animal wastes for farmers and farm advisors, water and nutrient solution analyses to greenhouse operators and float-bed seedling producers, and non-routine soil tests for University of Kentucky researchers.

Samples analyzed in 1998 were:

Type	Number	% Increase
Agriculture	34,246	1
Home lawn and garden	6,209	2
Strip-mine reclamation	40	14
Commercial horticulture	514	-17
Greenhouse	52	8
Research	18,004	76
Atrazine residue in soil	149	3
Animal waste	127	-47
Nutrient solution	209	115
TOTAL	59,550	16

Rural Sociology

The Rural Sociology research program addresses the dynamic changes occurring in rural society. Subject matter includes both the social structure of rural communities and institutions and the social processes that operate within rural society and link it to national and global institutions and change. Through an integrated program of research, extension, and instruction, faculty focus on initiatives organized around the three major areas of community, agriculture, and social change.

Community

Faculty research explores the relationships of public policy, social and physical environments, and community structures and processes. Community and culture-environment relationships as well as the application of sociological principles to community and rural development are also emphasized. One current research project is looking at factors associated with acceptance or rejection of hazardous waste siting in three locations, while another project is focusing on structural and interactional factors associated with adoption of sustainable community development programs in 173 rural communities.

In collaboration with the Kentucky Cabinet for Economic Development and Bell South, sociology faculty are participating in applied research focusing on Kentucky business retention and expansion that provides a community process and survey tool for assessing and responding to local business needs and future plans. Results are used by local communities to help determine local resources that can be utilized for economic development planning. Other ongoing projects focus on public conflict analysis and resolution and analyzing and interpreting sociodemographic trends as an input to community visioning, strategic planning, and leadership development.

Rural sociology is providing leadership in introducing the use of Geographic Information Systems (GIS) technology to the College of Agriculture. A project that develops the spatial context of the psychographic and demographic patterns of Kentucky's tourism market is one example. An effort to assist in the identification of priority watersheds throughout Kentucky for nonpoint source pollution evaluation associated with agricultural, natural resources, and social activities over the Kentucky landscape is another. The Social, Natural, and Agricultural Resources Information Laboratory has been developed by sociology faculty. The laboratory's data server provides a variety of social, economic, and agricultural data to users with access to the World Wide Web. Users are able to perform basic interactive mapping and GIS functions from their desktop computers. The interactive mapping component is nationally unique in the

depth of variables that may be mapped as well as the methods available for mapping.

Agriculture

Rural sociologists are exploring critical factors influencing how agricultural producers respond, individually and collectively, to a dynamic world economy. A comparative approach emphasizes agricultural social structures across time and space.

Many of the external forces that impact Kentucky agriculture stem from such global dynamics as changes in international trade, increased volume and volatility of international capital flows, and international labor migration. Since East Asia is one of the largest American agricultural export markets, current faculty research on agricultural restructuring in that region is providing important insights into changes that ultimately will impact Kentucky farmers. Restructuring in the swine industry provides an example of the effects of globalization, and sociology faculty are conducting a cross-state comparative analysis of regulatory debates and initiatives by focusing on the management of perceived socioeconomic risks inherent in large-scale production systems.

Kentucky's dairy industry is confronting both a changing marketplace and changing conditions of production. Faculty research is collecting survey data and conducting in-depth interviews of Kentucky dairy farm families as part of a regional comparative analysis of how family factors shape orientations toward agriculture and quality of life. Kentucky data will be combined with data collected from other participating states to present regional analyses of the changing structure of the dairy industry. Results will be used to determine educational needs of farm families for planning and adapting their operations to meet future conditions.

Social Change

The nature, causes, and consequences of social change in rural society are important concerns of the University of Kentucky's rural sociologists. Research on changes in labor force participation, educational opportunities, and family life enable faculty to explore how the well-being of rural children, youth, families, and households is influenced by the interrelationships among social, political, demographic, economic, and environmental factors.

Faculty conduct research in conjunction with the Kentucky Kids Count Consortium which publishes an annual data book of various indicators of the demographic and socioeconomic status of Kentucky's children and families. Faculty research also is assessing the needs of rural Kentucky youth

and examining the relationship between economic growth and/or decline and individual mental health in four rural communities. Other projects are investigating the influence of human and social capital on youth outcomes and developing an extensive model of individual, family, school, and community factors that influence educational and occupational outcomes. An effort is being made to identify successful implementation of services to families in need, equip the state's area development districts with the self-evaluation tools to monitor ongoing programs, and develop effective action plans for Kentucky's families and children. Results are influencing the future directions of state agencies that serve families of the Commonwealth.

With the current changes associated with welfare reform, sociology faculty are directing their attention to issues of rural poverty and the changes associated with reform. Research is looking at the ways people within rural households meet basic livelihood needs in the wake of economic changes peculiar to rural regions. Related research is examining the spatial distribution of welfare caseloads in Kentucky, regionally, and nationally. Results are being used to inform policy and programming decisions at the state and Federal levels.

A study by rural sociology faculty determined the wages necessary for an employed single mother with two children to make ends meet without assistance in rural Kentucky. Results are being used across the Commonwealth and have received considerable media coverage in radio, television, and print. The research is being replicated in several other states. In addition, faculty are involved in two multi-state

research projects designed to examine the impact of welfare reform on families, children, and communities. Plans are under way to track the changing policy context within which rural families function and to conduct a series of ongoing, in-depth interviews with limited-resource families in two rural Kentucky communities.

Research Projects

- Assessing the Impacts of Welfare Reform on Individual, Family, and Community Well-Being — *J. Zimmerman*
- Community Connections for Children: Outcomes Assessment, Model Programs, Technical Assistance, and Training — *P. Dyk*
- Environmental Protection, Economic Development, and Waste Disposal Gridlock — *J. Bridger*
- Impacts of Structural Change in the Dairy Industry — *L. Garkovich, P. Dyk*
- Kentucky Kids Count — *L. Garkovich, G. Hansen, J. Zimmerman*
- Reexamining East Asian Land Reform: Culture and Class in Action — *L. Burmeister*
- Rural Economic Development and Individual Well-Being — *J. Bridger*
- Rural Low-Income Families: Monitoring Their Well-Being and Functioning in the Context of Welfare Reform — *G. Hansen*
- Rural Restructuring: Causes and Consequences of Globalized Agricultural and Natural Resource Systems — *L. Burmeister*
- Service Sector Penetration and Household Earning Processes: A Comparative Study of Rural Communities — *R. Harris*
- Social Capital Attributes of Families, Schools, and Communities — *P. Dyk*
- Sociological Perspectives on the Restructuring of the U.S./Kentucky Swine Industry — *M. Curran, L. Burmeister*
- Structural Change in South Korean Agriculture — *L. Burmeister*
- Sustainable Community Development: Barriers and Opportunities — *J. Bridger*

Veterinary Science

The importance of conserving the health and well-being of Kentucky's animal industry remains a primary focus of the diagnostic, investigative, and research programs of the Department of Veterinary Science. The needs of that industry continue to be met through a variety of programs provided by the department's Livestock Disease Diagnostic Center, Maxwell H. Gluck Equine Research Center, and the Equine Blood Typing and Research Laboratory. Of singular importance in 1998 was the granting of full accreditation status to the Livestock Disease Diagnostic Center by the American Association of Veterinary Laboratory Diagnosticians. This past year has seen continued growth in the service and research programs of the department, with the Equine Blood Typing and Research Laboratory testing more than 40,000 blood samples for the first time in its history.

Maxwell H. Gluck Equine Research Center

The Gluck Center remains preeminent internationally based on the continued success of its various equine research programs. The latter have been significantly strengthened by the addition of new faculty appointments in virology and molecular cytogenetics.

Immunogenetics—Mapping the horse genome continues to be a major focus with the cloning and localization of an increasing number of genes to specific chromosomes. The hereditary basis of certain infectious and noninfectious diseases and their relationship to the major histocompatibility gene complex remains a field of active investigation.

Infectious Diseases—The changing paradigm of international trade in equids and equine semen in recent years has refocused attention on the economic impact that various viral, bacterial, and other diseases continue to have on the horse industry, both in Kentucky and nationally.

Current emphasis of the research program on **equine herpesvirus-1 (EHV-1)** is on identification of the viral protein antigens that stimulate cytotoxic T-lymphocyte immune responses in the horse. Determination of the specific components of protective immunity, both humoral and cellular, at the mucous membrane surface of the respiratory tract is under current study.

The research program on **equine influenza** continues to play an important role by providing active surveillance and molecular characterization of the isolates of virus in current circulation in the United States and various South American countries. Evaluation of a novel candidate equine influenza vaccine with respect to its infectivity, pathogenicity, and immunogenicity in horses is close to completion.

Research on **equine infectious anemia** has encompassed a range of studies, from development and characterization of

an *in vivo* pathogenic molecular clone of equine infectious anemia virus to the application of newer technologies to the development of improved diagnostics for this disease. The feasibility of developing a DNA vaccine against equine infectious anemia is currently being explored.

The research program on **equine arteritis virus** has focused on the molecular evolution of the causal virus during long-term persistence in the stallion. A collaborative study with colleagues at the University of California-Davis on the behavior of equine arteritis virus during a natural outbreak of the disease has revealed that the virus is genomically stable during horizontal and vertical transmission in sharp contrast to the situation in the carrier stallion. Ongoing studies have confirmed the significance of imported frozen semen as a potential source of virus for future outbreaks of equine viral arteritis.

In addition to ongoing research on the M-like proteins of *Streptococcus equi* and *S. zooepidemicus* and their role in virulence and immunity, extensive efforts are being made to come up with more effective means of stimulating protective immunity to infection with these respective pathogens in the horse. Various vectors and modes of antigen presentation are being evaluated for their ability to invoke both a mucosal and a systemic antibody response to the protective M protein of *S. equi*.

Parasitology—The molecular basis of acquired resistance of selected populations of equine nematodes to specific anthelmintics is the subject of an ongoing collaborative study with researchers at the University of Georgia. Extensive research on different species of equine tapeworms has provided new information of the prevalence of these internal parasites in Kentucky. A related study has confirmed the efficacy of praziquantel on the cecal tapeworm in the horse.

Research on **equine protozoal myeloencephalitis** has confirmed that as high as 41 percent of trapped feral opossums in Kentucky harbor *Sarcocystis* sporocysts in the small intestine. The opossum has been found to be capable of serving as a host for several *Sarcocystis* sp. Work on selected immunoreactive surface proteins of *S. neurona* has led to the development of an ELISA which may provide a more definitive ante-mortem diagnostic test for this disease.

Pharmacology and Experimental Therapeutics—Studies on analytical/pharmacological "thresholds" for residues of local anesthetics have been completed. An increasing number of equine drug metabolites that form the basis of standardized testing for residues of therapeutic medications have been synthesized and released to the industry. Experimental studies have confirmed that diclazuril is of value for the treatment of equine protozoal myeloencephalitis.

Reproductive Physiology—Research continues on the host and environmental factors that influence seasonal breeding

in mares with specific reference to the interaction between metabolic signals and photoperiodic cues in the control of reproduction. The phenomenon of continued estrous activity during the nonbreeding season is observed more frequently in overweight mares that have not foaled for several years and in mares with elevated concentrations of thyroxine.

Ongoing research on the causes of embryonic loss in the mare has documented the changes in gene expression of the equine estrogen and progesterone receptors in the uterus throughout the estrous cycle and in the early stages of pregnancy. Phospholipase A₂ and calyculin have been identified as products of genes differentially regulated between days 12 and 13 of development of the equine conceptus.

Livestock Disease Diagnostic Center

The department's Livestock Disease Diagnostic Center continues to play a major role in safeguarding the health integrity of the state's animal industry by providing a comprehensive service program to all counties in Kentucky. The program was significantly strengthened during the year by the establishment of a molecular biology section, the initial goal of which will be the development of improved diagnostic tests for several of the more important livestock diseases. In 1998, 68,967 accessions involving 334,416 assays were examined. Of 5,076 necropsies performed, 36 percent were equine and 35 percent were avian. Several isolations of a previously undescribed bacterium closely resembling *Taylorella equigenitalis* were reported from the state's equine population during the year. Gram positive nocardioform bacteria were found to be a very significant cause of placentitis in the mare.

Equine Blood Typing and Research Laboratory

The Equine Blood Typing and Research program had a highly successful year in terms of number of samples received for parentage analysis testing and number of breed registries/associations having formal contracts with the program. Collaborative involvement in development of a gene map for the horse continues to be considerable. Identification of genetic markers for specific heritable equine diseases remains an ongoing area of research, as does gene mapping of New World camelids, which is being carried out in collaboration with researchers in Chile.

Research Projects

Age Dependence of Horse/Foal Immunization for Viral Infectious Diseases — *T.M. Chambers*
 Amantadine/Rimantadine Prophylaxis of Equine Influenza — *T. Tobin*
 Analysis of Class I and Class II Genes of Equidae — *E. Bailey*
 Analytical Methods Development — *T. Tobin*
 Application of New Technology for the Diagnosis of Equine Infectious Anemia — *C. Issel*

Characterization of the Pyrogenic Mitogen of *Streptococcus Equi* — *J.F. Timoney*
 Chemotherapeutic Control and Prevalence of Natural Infections of Internal Parasites of Equids — *E.T. Lyons*
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 Use of Avirulent Salmonella Vectors for Stimulation of Mucosal and Systemic Antibody Responses to the Protective M Protein (SeM) of *Streptococcus equi* — *J.F. Timoney*
 Use of Microencapsulated Antigens for Stimulation of Nasopharyngeal Mucosal Responses in the Horse — *J.F. Timoney*

Robinson Station

Research and demonstration trials at the Robinson Station at Quicksand are primarily conducted by the departments of Agronomy, Horticulture, and Plant Pathology. Horticulture research consists of trials with fruit, vegetable, and ornamental flower and shrub cultivars for both commercial production and home garden use.

Horticulture

Kentucky growers produce an estimated 700 acres of spring cabbage for sale to fresh and slaw markets. Twenty-six cabbage cultivars were evaluated for spring production at the Robinson Station. The top five green cabbage cultivars were 'Gideon', 'Bronco', 'Ramada', 'Atlantis', and 'Morris'. They produced heads that were firmer, more attractive, and better sized than the industry standard 'Bravo'. The cabbage cultivars 'Atlantis' and 'Morris' were also earlier (8 to 10 days) than 'Bravo' and should be tested further to see if they could be used to expand our market window.

As a fall crop, jack-o-lantern pumpkins allow Kentucky growers to extend their marketing season and take advantage of labor used to cut and house tobacco. As a result, a pumpkin cultivar trial was conducted at the Robinson Station. Seventeen cultivars, six of which were small or miniature pumpkins, were evaluated in 1998.

The two best-looking large jack-o-lantern pumpkins in the trial were 'Pro Gold 510' and 'Gold Strike'. They produced good yields of 20-pound pumpkins that were blocky and dark orange with excellent stems. Appalachian also gave excellent yields of large, attractive fruit, but it was not as attractive as 'Pro Gold 510' or 'Gold Strike'.

Kentucky growers currently produce about 1,200 acres of staked, vine-ripened tomatoes for both local and national markets. Kentucky tomatoes have an excellent reputation for quality in market areas like Chicago. We began fresh market tomato trials in 1998 in order to evaluate new commercial cultivars and to identify a variety which might be featured in supermarkets as a premium "Kentucky Tomato." Sixteen determinate tomato varieties were evaluated at two locations, South Farm in Lexington and the Robinson Station. The top five yielding tomato varieties at Quicksand included 'Fabulous', 'Sunbeam', 'Emperor', 'Enterprise', and 'Sunleaper'. The industry standard 'Mountain Spring' was lower yielding and very susceptible to early blight. Future fresh market tomato trials are being planned at both locations for 1999.

The final year of a six-year study involving fall cole crops (broccoli or cabbage) as scavengers of residual fertilizer nitrogen was jointly conducted by Agronomy and Horticulture faculty to evaluate the use of fall cole crops to recover residual fertilizer N following high-value summer annual cash crops. Summer crops, tobacco and sweet corn, were managed

according to University of Kentucky recommendations and received a fertilizer N application of 300 lb N/acre and 148 lb N/acre, respectively. In 1998, immediately following sweet corn and tobacco harvest, broccoli, winter rye, and fallow treatments were established. Fertilizer N was applied to broccoli at rates of 0, 50, 100, and 150 lb N/acre. Soil nitrate-N and plant total N uptake were also measured to determine the usefulness of cole crops (compared to winter rye and fallow) in recovery of residual N and their potential for preventing N loss to the environment. Fall broccoli and cabbage have been found to be as effective as winter rye in capturing residual nitrogen that might otherwise be lost due to leaching.

Agronomy

A 27-acre educational site has been developed on the Laurel Fork of the Robinson Forest to demonstrate the agricultural potential of reclaimed surface-mined land. Field trials addressing mined land revegetation for livestock forage production, wildlife habitat, and the land application of animal waste are currently being studied. A herbaceous species/variety identification garden is also available for evaluation and study. Production practices for apple, blueberry, blackberry, and hydrangea production are also demonstrated at this site. In cooperation with Kentucky State University, utilization of irrigation ponds for rainbow trout and channel catfish production is being monitored.

Use of ammonium sulfate (AS) for surface application of nitrogen (N) onto no-till corn has been reported to improve yields by increasing the proportion of fertilizer N as ammonium (NH_4) as compared to nitrate (NO_3), and possibly due to a response to sulfur (S).

A study was initiated in 1997 and continued in 1998 on a Pope silt loam soil at the Robinson Station to determine what effect AS in an N fertilization program would have on no-till corn grain yields. The study tested rates of N (0, 80, 160, and 240 lb/acre), sources of N (ammonium nitrate (AN), half AN and half from AS), and AN plus S (from granular elemental S). Treatments tested provided NH_4/NO_3 ratios of 3/1 and 1/1 at three rates of N application. Additionally, S was tested for a yield response at three rates of S application. All fertilizer was broadcast over the corn about five weeks after emergence, and all treatments were replicated four times in a complete randomized block design. Corn (var. Pioneer 3140) was no-till planted at 25,000 seeds/acre on 18 May 1998 into corn residues from the previous year. Ear leaf samples were taken at silking and tasselling to measure content of N and S. Grain yields were taken 13 October, at a moisture content of 17.5 percent. Neither varying NH_4/NO_3 ratios nor applying S significantly affected yields or N and S content of the ear leaves. Grain yields were increased at 80 and 160 lbs N/acre with no

significant increase at the 240 lb N/acre rate. This study will be continued in 1999.

Corn and soybean are grown in alternate years under a continuous no-tillage management system at the Robinson Station on a Pope silt loam. The experimental design consists of four rates of fertilizer phosphorus and four rates of fertilizer potassium, both in the absence and the presence of poultry litter. Poultry litter is applied prior to corn establishment (last done in the spring of 1997) and the performance of the crop, nutrient removal, and nutrient bioavailability are monitored for a two-year period prior to renewed application of the poultry litter. Poultry litter was applied at a rate of 1,800 lb dry matter/acre prior to planting corn.

In 1997, corn grain yield responded to fertilizer P and K applications, as well as manure amendment. Yield responded slightly more to fertilizer K than P. Manure application was beneficial to yield. Nutrient removal, especially that for P and the heavy metals copper (Cu) and zinc (Zn), is an important component of the "phytoremediation" of waste-amended soils by growing crops. When fertilizer K addition caused the yield response, removal of P, K, and Cu tended to be covariate but that for Zn was generally not. Manure use resulted in greater nutrient removal at both locations

In the spring of 1998, soil samples revealed considerably greater levels of bioavailable P but not K in the surface 3 inches of soil as a result of fertilizer and/or manure addition to the soil. Bioavailable Zn, first evaluated in 1998, was greater with manure application and tended to be so with fertilizer P and K addition, reflecting Zn's contamination of these materials.

The 1998 soybean yield responded positively to fertilizer P and manure but not fertilizer K at this location. Again, nutrient removal was well related to grain yield. Phosphorus and K removals were more strongly related to yield in treatments where these nutrients were limiting yield, reflecting the fact that soybean grain concentrations of these nutrients was being reduced under these conditions. Soybean P and K removal, relative to corn, was greater than relative yield levels would suggest because of the greater average concentrations of these nutrients in soybean grain tissues. Copper and Zn removal in grain were fairly modest in amount and generally unrelated to fertilizer or manure treatments.

In 1998, a no-till burley tobacco study was initiated at the Robinson Station to evaluate cured leaf response to a drip/fertigation system. Drip fertigation is commonly used in the vegetable crop industry to increase the efficient use of irrigation water and improve plant nutrient uptake.

Due to a very wet spring, tobacco transplants (cv. TN-90) were no-till planted into a chemically killed winter rye cover crop on 10 July 1998 on a Pope silt loam soil. Four treatments were tested and replicated four times in a randomized complete block design. Treatments consisted of (1) 100 lb N/acre side-dressed/nonirrigated, (2) 300 lb N/acre side-dressed/irrigated, (3) 100 lb N/acre/fertigated, and (4) 300 lb N/acre/fertigated. All fertilizer N was applied as ammonium nitrate. Drip irrigation was applied throughout the growing season when soil tensiometer readings reached 30 centibars.

Tobacco was harvested on 27 September and barn cured until 20 January 1999. The highest cured leaf yield (2614 lb/acre) was produced with 300 lb N/acre fertigated. The lowest yield was produced with 100 lb N/acre nonirrigated. Providing irrigation water through a drip system improved N use efficiency during a very dry growing period compared to no irrigation at the same N rate. This work will be repeated in 1999 with a conventional tillage comparison.

Five field experiments were initiated at the Robinson Station during the 1998 growing season to evaluate various methods of blue mold control in burley tobacco. The objectives of each experiment are: (1) comparison of a Dithane fungicide in blue mold control when applied with a high-pressure sprayer versus a low-pressure sprayer, (2) evaluation of experimental fungicides for blue mold control, (3) evaluation of a biological control for blue mold control, (4) evaluation of burley tobacco cultivars for susceptibility to blue mold, and (5) measurement of the impact of systemic blue mold on yield of burley tobacco. Unfortunately, all experiments were destroyed due to excessively high spring rainfall and subsequent flooding.

The incidence of blue mold has been observed to be worse on burley tobacco fertilized with muriate of potash (KCl). In a greenhouse experiment, blue mold lesions were on average larger for plants fertilized with muriate of potash than for plants which received only sulfate of potash. To test the response of tobacco in the field, a plot was established at the Robinson Station to test the effect of three sources of potash on the growth of tobacco and its susceptibility to blue mold. Due to the dry conditions, very little blue mold was observed in these plots during the 1998 growing season.

A long-term study was initiated in 1998 to evaluate management tactics for control of tall ironweed in pastures. Management strategies to be evaluated include frequent mowing alone and in combination with late summer herbicide treatments. These treatments will be evaluated for control of tall ironweed and/or reducing the plant population in 1999.

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- Crop Response to Manure and Fertilizer P and R Application — *J.H. Grove*
- Cured Leaf Response of Burley Tobacco to Drip Irrigation and N Rate — *R.T. Jones, D.C. Ditsch, C. Lindon, J.W. Turner, R. Pearce*
- Effect of Ammonium N to Nitrate N Ratio and S on Yield of No-Till Corn — *K.L. Wells, D.C. Ditsch, J.E. Dollard, J.W. Turner*
- Fall Cole Crops as Scavengers of Residual Fertilizer N — *R.T. Jones, D.C. Ditsch, J.W. Turner, C. Lindon, R. Pearce*
- Floral Hydrangea Cultivar Evaluation — *R.T. Jones, S. Bale, B. McNiel*
- High Bush Blueberry Cultivar Evaluation — *R.T. Jones, C. Lindon*
- Pumpkin Cultivar Trial — *R.T. Jones, C. Lindon*
- Spring Fresh-Market/Slaw Cabbage Cultivar Evaluation — *R.T. Jones, C. Lindon*
- Tall Ironweed Control for Livestock Forage Production — *J.D. Green, D.C. Ditsch, J.W. Turner*
- Vegetative Establishment of Kura Clover — *D.C. Ditsch, J.W. Turner*
- Yield, Disease Resistance, and Quality of Staked Tomato Cultivars — *B. Rowell, R.T. Jones, W. Nesmith, J.C. Snyder, J. Pfeiffer*

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Other Research Publications

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Ph.D. Dissertations

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Xiao, Mei. Political economy of European Union dairy policies.

Agronomy

Crotser, Michael P. Effects of soybean cultivar interference on the growth of eastern black nightshade (*Solanum ptycanthum*): Impact of light manipulation.

Gutierrez-Boem, F.H. Multiple stresses in plants: Phosphorus deficiency and water stress.

McDonald Jr., Louis M. Cosolvent effects on the sorption of Sr²⁺, Zn²⁺, and Cd²⁺ to a bentonite clay.

Sorokina, Marina N. The effects of soil management history on soil physical and chemical properties of four Kentucky soils.

Tang, Shande. Survival characteristics of hybrid corn seed during constant storage.

Wang, Rui. Tissue enriched expression of a glutamine binding protein-metallothionein fusion gene in vascular versus cortical/epidermal cells and its effect on cadmium uptake and tissue distribution.

Animal Sciences

Bohnert, David Wayne. Nutritional evaluation of poultry by-product meal as a supplemental protein source for ruminants.

Eyigor, Aysegul. Detection and analysis of cytolethal distending toxin (CDT) genes in *Campylobacter jejuni* and *Campylobacter coli* isolates by polymerase chain reaction and determination of the prevalence of CDT genes and CDT activity in campylobacters isolated from chicken carcasses.

Fernandez, David Louis. Effects of monosodium glutamate on luteinizing hormone and growth hormone, and monoamine neurotransmitter antagonists on luteinizing hormone, growth hormone, prolactin, and testosterone in prepubertal beef bull calves.

Fichter, Seth. Intra-gastric protection of vitamin A orally dosed in coconut oil to ruminant animals.

Biosystems and Agricultural Engineering

Brown-Brandl, T.M. Bioenergetics and growth of high-lean-growth swine under thermal stress.

Sun, Suichu. Heat transfer and soil thermal stability as related to a plate-type heat exchanger in ground coupled heat pump systems.

Williams, Robert M. Application of Superfund risk assessment techniques to production agriculture.

Entomology

Cottrell, Ted Eric. Factors affecting abundance of, and predation by, *Coleomegilla maculata* (Degeer) (Coleoptera:Coccinellidae) in sweet corn.

Veterinary Science

Fraser, Darrilyn G. Studies on the organization and polymorphism of equine MHC class II genes.

Liang, Fangting. Characterization of the 16 and 14 kDa immunoreactive surface proteins of merozoites of *Sarcocystis neurona*.

M.S. Theses

(Unpublished)

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Diallo, Papa Boubar. An analysis of the determinants of farm sales distribution.

Johnson, Owen. A simulation model of growth in Kentucky.

Kosty, Lynn L. Risk within the beef industry and the role of insurance.

Kumari, Vadivel Gurusamy. Extent and impact of hospital outshopping in rural Kentucky.

Patton, Julia Mary. The environmental and economic potential of poultry litter as a by-product in Kentucky farm production.

Schimmel, Robert J. Analysis of the wheat harvest basis and wheat flow patterns in western Kentucky.

Tang, Haibo D. Supply, demand, and import relationships in the Japanese poultry industry.

Agronomy

Chappell, Mark A. Soil ternary cation exchange reactions: Influence of potassium on ammonium mobility and nitrification.

Coopriider, Mary. Factors affecting fecal coliform reduction by a grass filter strip.

Elliott, Barbara J. Characterization of a putative plant polyadenylation factor.

Hagan, Carla. Establishment and persistence of perennial ryegrasses in Kentucky.

Hendrick, Timothy M. Vertical distribution of soil carbon and nitrogen as affected by tillage and nitrogen rate.

Prewitt, Mary Elizabeth. Effect of overseeded legume species and sod disturbance on subsequent yield, seasonal dry matter distribution, and forage quality of tall fescue renovated sod.

Woolsey, Paul B. Measuring intake of beef cattle grazing tall fescue.

Animal Sciences

Evans, Jeffrey W. Growth and maturation of freshwater prawns *Macrobrachium rosenbergii* raised under controlled conditions.

Lou, Xingqiu. Storage stability and gel-forming characteristics of paddlefish meat.

Noel, David Christopher. Textural and sensory characteristics of low-fat beef sausages with added water and polysaccharides at various pH levels.

Rokuroda, Saori. The effects of warm-up on exercising horses.

Villalba, Abigail. Effect of exposure to selected volatile compounds on selected bacteria *in vitro* and on the natural microbial flora of strawberry and blackberry fruits during post-harvest storage.

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Moss, Christopher G. Runoff of TRIMEC from fescue plots.

Ridder, Elizabeth R. The production of xylanase by solid-state fermentation with *Trichoderma longibrachiatum* on wheat bran.

Spruill, Crystal. Hydrological assessment and calibration of the SWAT model for small watersheds in central Kentucky.

Tao, Nan. Sunlit plant growth chamber with vapor pressure modification.

Udal, Michael C. GPS tracking of cattle on pasture.

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Keathley, Craig Phillip. Determinants of host plant selection in the Japanese beetle.

Kunkel, Brian A. Effects of Halofenozide and Imidacloprid, two novel insecticides, on beneficial invertebrates in turf.

Forestry

Hamner, P.C. Jr. Soil bioengineering as a method for slope stability on abandoned mine lands in eastern Kentucky.

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Ahn, Byung Chul. Standardized methodology for single radial hemolysis (SRH) test to detect antibody against equine influenza virus.

Ferguson Jr., Eugene M. Analysis of equine-specific Mx sequences.

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Financial Statement

Statement of Current General Fund Income and Expenditures Fiscal Year 1998

Income

Federal Funds:	
Hatch Amended	\$ 3,687,727.00
Regional Research	770,007.00
McIntire-Stennis	390,830.00
Animal Health	64,873.00
Total Federal Funds	\$4,913,437.00
Non-Federal Funds	21,496,217.00
Total Funds	\$26,409,654.00

Expenditures

	Federal	Non-Federal	Total
Personal Services	\$4,066,943.00	\$14,104,077.00	\$18,171,020.00
Travel	87,621.00	119,938.00	207,559.00
Equipment	203,261.00	549,461.00	752,722.00
Other Operating Expenses	555,612.00	6,722,741.00	7,278,353.00
Total Expenditures	\$4,913,437.00	\$21,496,217.00	\$26,409,654.00

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Agricultural Experiment Station

October 1, 1997 — September 30, 1998

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