

2008 West Virginia University Research Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Faculty in the West Virginia Agricultural and Forestry Experiment Station conduct research in seven program areas including Economic Development and Quality of Life in rural communities, Environmental Quality and Stewardship, Fundamental Plant and Animal Systems, Human Nutrition and Health with an Adequate and Safe Food Supply, Production Agriculture, Production Forestry – Timber Management and Wood Utilization, and Wildlife Management. Needs of state citizens dictate that a large majority of research projects in these programs are related to either economic development in rural communities, improving human nutrition, health and quality of life in rural communities, or protecting and preserving state natural resources.

Economic analyses of several programs which encourage consumption of local goods and the development of local niche markets (pasture finished beef, cool water aquaculture, eco-tourism and recreational activities, organically produced fruits, vegetables, and animal products, Omega-3 enhanced trout, etc.) have shown them to be both profitable and beneficial to local economies. When developed with care, all can also respect local cultures and histories, be protective of natural environments, and contribute to more healthy lifestyles of citizens.

Research efforts to assure the preservation of state natural resources focus on protecting soil and water quality by developing economically effective and environmentally sustainable management practices for agriculture, forestry and other uses of state natural resources. Preventing soil and water contamination with acid drainage from abandoned mines and protecting forest resources from the impacts of diseases and insects are major state concerns, as is the development of optimum methods for restoring disturbed wetlands and remediation of other environmentally compromised areas.

Research involving fundamental, biological systems in plants and animals seeks the basic knowledge needed to address practical problems. Understanding mechanisms which control flower senescence, symbiotic relationships between endophyte fungi and pasture grasses, bacterial response to cold and desiccation stress, genetic control of reproductive processes, factors affecting reproductive efficiency, animal adjustments to levels of oxidative stress, pathways of protein metabolism, methods of gene flow in mycorrhizal fungi, etc., all have practical applications which will benefit rural state citizens and society in general.

West Virginia is among the most overweight states in the nation and above national averages for incidence of diabetes, high blood pressure, and cardiovascular disease, as well as for osteopenia and osteoporosis. Station research in the human nutrition is focused on determining current and potential impacts of diet, nutritional education and dietary intervention on obesity and obesity related conditions (diabetes, elevated cholesterol and plasma lipids, heart attack, stroke and some cancers). The program also is testing the efficacy and safety of bioactive compounds in foods, including krill protein, and is developing omega-3 DHA enhanced diets and educational programs to support their adoption.

Due to a variety of factors, West Virginia farmers do not compete well in standard agricultural commodity markets. Station research therefore is focused on the production of higher value products such as those with ornamental or recreational use, with increasing real or perceived product value in specialty, niche or out-of-season markets, with capitalizing on proximity to large, urban markets, etc. Specific examples include research to develop improved management systems for the production of cool water fish (for food and recreation); organic vegetables, fruits and small animal products; pasture raised and finished beef; and out-of-season lamb. Station research also is concerned with developing new methods of disease and insect control which are effective, economically viable and environmentally friendly.

Forest lands in West Virginia represent an enormous resource in the form of hardwood timber, wildlife habitat, and areas for human recreation and restoration. Station research in timber management and wood utilization seeks enhanced profitability of timber production balanced against protection of wildlife habitats and recreational environments. Both are served by research projects which limit negative impacts of insects, disease and invasive species. Timber management research also is strongly influenced by the fact that a majority of state forest lands are in relatively small tracts, owned by many different individuals coexisting with several relatively large lumber producing companies. Research and outreach programs to serve both types of producers are supported.

The quantity and variety of wildlife in West Virginia are extremely important to the economy and character of the state. Research in this planned program is designed to better understand habitat requirements for wildlife in West Virginia, and to determine the impacts of human activity on wildlife habitat, particularly habitat for fish and song birds. A large majority of the research in this program represents cooperative research between West Virginia Station faculty and scientists with the West Virginia Division of Natural Resources, USGS, US Fish and Wildlife Service, and the Wildlife Management Institute, a group collectively known as the West Virginia Cooperative Fish and Wildlife Unit. While formula funding provides infrastructure for this program, the majority of research in wildlife management is supported by non-formula funds, with very few formula fund projects directly supported over the last several years (currently two projects). Wildlife management therefore will not be continued as a separate, formula funded research program area in future plans of work.

Total Actual Amount of professional FTEs/SYs for this State

Year:2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	36.0	0.0
Actual	0.0	0.0	45.2	0.0

II. Merit Review Process**1. The Merit Review Process that was Employed for this year**

- Internal University Panel
- Expert Peer Review

2. Brief Explanation

Describe Merit / Peer Review Used this Year-

Individuals with expertise in the fields of science addressed in the proposal are selected by the Division Director, Experiment Station Director or designee and asked to judge technical merit, likelihood of achieving stated objectives, and potential impacts for each proposed project. Competitively awarded grants requiring peer review or contract research requiring grantor approval are exempt from this process. A more complete description is available at http://www.cafcs.wvu.edu/wvafes/policies_peer.htm .

III. Stakeholder Input**1. Actions taken to seek stakeholder input that encouraged their participation**

- Targeted invitation to traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Survey of traditional stakeholder groups
- Survey specifically with non-traditional groups

Brief Explanation

Most stakeholder input has been collected in conjunction with West Virginia University Extension (administratively distinct from the College of Agriculture, Forestry and Consumer Sciences) since we share a large majority of stakeholders. We discontinued special meetings which had as their sole purpose, the gathering of stakeholder input and instead, have more recently relied upon input gathered at meetings with other primary purposes (annual or regular meetings of West Virginia Farm Bureau, West Virginia Forestry Association, West Virginia Grasslands Steering Committee, State Aquaculture Forum, Organic Research Project annual meeting, etc. This year we added the West Virginia Shepherd's Association and the newly formed West Virginia Farmer's Market Association.). We find the new procedure much more efficient and, when suggestions from all meetings are combined, to represent a much larger and more diverse segment of our stakeholders. Input also originates from various advisory groups associated with specific interest areas within College Divisions (e.g., Organic Research Project Steering Committee within the Division of Plant and Soil Sciences; Appalachian Hardwood Council Advisory Board in the Division of Forestry, etc.) as well as from advisory groups established at the College/Station level (Davis College Visiting Committee; Experiment Station Advisory Board). Examples ranging from the very specific (Organic Research Project Steering Committee) to the very broad (Experiment Station Advisory Board) will serve to illustrate the process. The Organic Research Project has a Steering Committee of organic producers chosen by the Mountain State Organic Growers and Buyers Association. The Steering Committee, with members from West Virginia, Pennsylvania and Maryland, meets twice yearly to review planned research, develop new research areas, suggest changes to improve farming systems and production practices. The Committee also helps communicate results to other growers.

A majority of suggestions from the Steering Committee are suggestions of research projects which are thought likely to contribute to producer profitability. Examples of suggestions from the Steering Committee acted upon by the project team include suggestions to conduct research trials to investigate the impact of growing disease resistant and susceptible varieties as companion plantings, to study control of insects using compost tea, to compare yields from monocultures and from companion plantings of differing species. A more recent recommendation, which has been acted upon, is to develop and distribute cost-of-production and income budgets for individual vegetables in addition to those for the entire "market garden" as had been the previous practice. The West Virginia Agriculture and Forestry Advisory Board is appointed based on suggestions originating from Divisions in the College to represent the broad range of industries and disciplines served by the Davis College and West Virginia Experiment Station. The Board meets twice annually with an agenda focused on research issues but which usually broadens to include many academic and outreach concerns which are linked to research. A suggestion from the Advisory Board which has been adopted, strongly encouraged Davis College administration to work more effectively with their counterparts in WVU.Extension to develop procedures and processes to better integrate College and Extension programs. Additional suggestions have been to focus on fewer research areas in the College/Station; to incorporate a list of questions provided by the Board to assist faculty in preparing research reports, and to anchor our Station Plan of Work on clearly defined and uniformly understood vision and mission statements from the College/Station and from each Division in the College.

2(A). A brief statement of the process that was used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Use Internal Focus Groups
- Use External Focus Groups

Brief Explanation

Directors of College Divisions along with faculty suggest individuals to serve on College and Experiment Station advisory groups. Individuals on the boards or steering groups of specific industry groups are selected by their membership; we select the groups based on contribution or potential contribution to the state's rural economy.

2(B). A brief statement of the process that was used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Survey of traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Meeting specifically with non-traditional groups

Brief Explanation

As indicated above, a majority of input is solicited at meetings of various industry groups or at meetings of appointed College and Station advisory groups. A smaller but meaningful number of suggestions comes from individual producers.

3. A statement of how the input was considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Research Programs
- In the Staff Hiring Process
- In the Action Plans
- To Set Priorities

Brief Explanation

Stakeholder input which relates to College/Station research portfolio is discussed regularly with College advisory groups and with College administrative groups, particularly when work or strategic plans are being prepared and when staffing decisions are pending.

Brief Explanation of what you learned from your Stakeholders

Although there are strongly competing uses for College/Station resources, with funding and personnel insufficient to meet existing demands, it is important to listen to the requests of new and smaller, but potentially growing interest groups. Most recently we have instituted procedures to routinely gather information from the representatives of state industries producing lamb, organic produce and livestock, and selling products directly to consumers through farmers market, community sponsored agriculture agreements and direct commercial contracts (primarily grocery stores and restaurants).

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	2723800	0

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	0	0	3648602	0
Actual Matching	0	0	4857532	0
Actual All Other	0	0	5074636	0
Total Actual Expended	0	0	13580770	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous years				
Carryover	0	0	924801	0

V. Planned Program Table of Content

S. NO.	PROGRAM NAME
1	Economic Development and Quality of Life in Rural Communities
2	Environmental Quality and Stewardship
3	Fundamental Plant and Animal Systems
4	Human Nutrition and Health with an Adequate, Safe, and High Quality Food Supply
5	Production Agriculture
6	Production Forestry - Timber Management and Wood Utilization
7	Wildlife Management

Program #1

V(A). Planned Program (Summary)

1. Name of the Planned Program

Economic Development and Quality of Life in Rural Communities

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
131	Alternative Uses of Land			10%	
511	New and Improved Non-Food Products and Processes			10%	
605	Natural Resource and Environmental Economics			15%	
608	Community Resource Planning and Development			25%	
704	Nutrition and Hunger in the Population			10%	
804	Human Environmental Issues Concerning Apparel, Textiles, and Residential and Commercial Structures			10%	
806	Youth Development			20%	
Total				100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	6.5	0.0
Actual	0.0	0.0	11.9	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	1157010	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	998002	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1125507	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct research; publish results in scientific journals and popular press. Make presentations at scientific, professional and end-user meetings and workshops.

A significant part of rural employment growth nationwide has occurred in non-traditional economic activities including those capitalizing on natural resources and climatic conditions for recreation and retirement venues. Preliminary results from an on-going analysis of the role of natural and recreational amenities in rural economic growth used county level data from 148 counties in the Northeast US for 1990 – 2005. Effects of amenities examined were both direct effects and those interacting either with proximity to urban areas or with interstate highway density. Preliminary analysis showed amenities alone can contribute to rural economic growth but are more effective when coupled with factors that exploit their existence.

Programs that encourage consumption of local foods and promote niche products hold particular promise for contributing to rural economic growth. Analysis of several such programs (i.e., pasture finished beef, cool water aquaculture, organic production of vegetables and small animal products, etc.) has found them to be both profitable and beneficial to local area economic growth, especially when products are direct marketed. Efforts to promote such programs generally have been quite successful in generating product demand such that the factor more often limiting growth is the absence of a regular, consistent and/or high quality product supply.

Previous studies examining the association between area income inequality and area economic growth have found both positive and negative relationships. County level US economic data were used to assess the impact of income inequality on regional economic growth using parameter estimates from simultaneous equations which allowed interaction between income inequality and economic growth. Results showed that counties with higher income inequality experienced slower population growth and slower growth in per capita income, but more rapid growth in levels of employment. This was most likely due to a growth in low wage jobs which increased levels of employment while decreasing per capita income. Growth in well-paying jobs clearly could do the opposite. Policy makers should consider these alternatives and possible impacts on short and long term economic growth.

A study evaluating the demand for Omega-3 fatty acid-enhanced trout was initiated. Surveys were mailed to restaurants and distributors specializing in fish and seafood in 6 states. A subset of restaurants in West Virginia and the surrounding area were shipped fillets from both Omega-3 enhanced brook trout and a control group of brook trout to taste and provide responses regarding flavor and desire to serve the product. Data also were collected regarding willingness to pay for Omega-3 enhanced brook trout. The flavor of Omega-3 enhanced brook trout was considered acceptable, even desirable, to the chefs who tasted it. A number of chefs were interested in purchasing this product and their names were given to aquaculture producers considering production.

In a continuing project to recover protein and lipid material from fish processing waste, we have designed an approximate 1000 sq ft pilot plant facility, under refrigeration, for our patent-pending technology. Detailed technical drawings have been completed. An industrial scale modular bio-reactor systems to process 25,000 and 50,000 lbs of by-products per day have been designed.

Tissue culture methods and protocols for *Cornus canadensis* have been devised, with germplasm protocols being developed from clonal populations. Also, germplasm protocols for *Hibiscus moscheutos* have been developed utilizing mass encapsulation to reduce labor requirements for germplasm storage. Synthetic seed protocols utilizing *Hydrastis canadensis* are also currently being investigated. Mass encapsulation protocols provide foundational information and procedures for clonal nursery production and increased clonal germplasm storage capabilities.

Marketing of ecotourism opportunities seems to be a viable option to promote economic growth in areas having unique histories, cultures, landscapes, etc. Surveys returned by 41 academics in ecotourism and 17 ecotourism site operators estimated a West Virginia ecotourism market of about 11.4 million or 22% of the general travel public to and in West Virginia in 2006.

Understanding why some racial/ethnic minorities participate in outdoor recreation activities while others do not will be an important consideration for natural resource managers in the upcoming decade. Many outdoor recreation areas were designed for traditional US recreationists, often consisting of Caucasian families and friends. Non-traditional users (ethnic/racial minorities, persons with disabilities, etc.) may be overlooked by managers without a concerted effort to pursue these potential recreationists. If the National Forests are to remain relevant to these potential recreation users, their motivations, constraints, and negotiation strategies must be understood. The purpose of an on-going study in the West Virginia Station is to examine the motivations, perceived constraints, negotiation strategies, and the visitor experiences of non-traditional users in forest recreation settings, and potential forest users who do not currently recreate in these settings.

Analysis of survey data from local residents regarding a proposed relocation of a historic mill in rural West Virginia was used in a cost benefit study that examined the economic feasibility of keeping the mill open under private ownership. Several other cost/benefit scenarios also were investigated to determine if public ownership or private ownership with support from a nonprofit organization would allow the mill to stay open at its original location. Results from the benefit-cost analyses suggest that the mill was not financially feasible for the private owner to operate and preserve. However, if social support in terms of a private-public partnership was incorporated, the mill generated a positive net present value. These results also were reflected in other mills that are currently open and supported by the public. For public ownership, the mill generates positive net present value and ratio of benefits to costs greater than one. Thus, for this mill to remain as part of the community the public must be involved either through the collection of funds by a non-profit organization or through government subsidies. The method of

analysis can be beneficially applied in evaluating situations involving a wide potential range of shared public/private ownership.

Efforts are underway to evaluate economic bundling of fishing opportunities with other recreational activities to enhance visitor experiences. Rainbow trout stocked into the Bluestone River, near Pipestem Lodge, during fall 2007 persisted through the winter and into the following spring. Stocked trout survived well in the river until lethal summer temperatures occurred. Rainbow trout generally stayed in the vicinity of the Pipestem Lodge following stocking, making them available almost exclusively to persons staying at the state park. The river appears to be generally habitable by trout from October 1st to about June 1st each year such that stocking expense can be recouped.

Heat tolerant strains of rainbow trout and hybrid striped bass were tested in an effort to develop productive, year round operation using recreationally relevant species. Both strains performed well in the system, showing satisfactory growth rates, acceptable feed conversion, and limited mortality following an acclimation period for the rainbow trout. Unsatisfactory mortality rates were sustained for the hybrid bluegill sunfish. Additionally, both the largemouth bass and the hybrid bluegill sunfish grew poorly during the study

Current recommendations for physical activity fail to capture – either qualitatively or quantitatively – nature’s role in providing a restorative environment needed for healthy lifestyles. On-going research at the West Virginia Station is using Perception Analyzer technology (hand held dials) to measure audience reaction to simulated hiking events. Results to date demonstrate that perceived video events can be quantitated -- the average number of total dial turns (quantity of events) ranged from 19 to 31 per video clip (or approximately 13 to 21 perceived changes per minute of video) in our study trails. Perception Analyzer also was used to examine the validity of a global, real-time measure of restorative character of simulated hiking events. Considering the five components of restorative environments (novelty, escape, extent, fascination and compatibility), we found significant relationships between number of dial turns (real-time) and novelty (post-hoc), average restorative character (real-time) and fascination (post hoc), average restorative character (real-time) and compatibility (post hoc), and minimum restorative character (real-time) and extent (post hoc). The global measure used in this study appears promising.

Land management agencies likely are not being used to their full potential with regards to encouraging healthy activities and lifestyles. The C&O canal National Historical Park (CHOH) project recently completed, revealed better ways to encourage visitors to expand their use of these sites, and to promote use of such sites for health benefits. Although the general results of the CHOH project indicated that the interventions did not increase awareness or walking rates, a variety of limitations were noted, including high awareness and walking rates at the start of the program. However, study participants receiving targeted flyers (sent to half of the participants, selected randomly) reported walking one day per week more than those not receiving the flyer. Finally, participants perceived their walking rates within the Park had increased during the program. Other important lessons learned included the importance of social support through teams that encourage one another, the need to partner with one or more agencies that can help recruit participants, and the value of recognizing achievements of participants (e.g., web highlighting of accomplishments).

2. Brief description of the target audience

Community managers, planners, policy makers, consultants, local development committees or groups

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	4	
2008	0	6	6

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Refereed research manuscripts

Year	Target	Actual
2008	4	6

Output #2

Output Measure

- Presentations to colleagues and end-users

Year	Target	Actual
2008	6	10

Output #3

Output Measure

- Team consultations with community action groups

Year	Target	Actual
2008	2	3

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Expansion of economic activity in targeted state industries: pasture raised beef and sheep, aquaculture, organic vegetables, tourism and outdoor recreational activities; ornamental horticulture, etc. - % growth
2	Customized designs for enhanced economic development adopted and implemented by state rural communities

Outcome #1**1. Outcome Measures**

Expansion of economic activity in targeted state industries: pasture raised beef and sheep, aquaculture, organic vegetables, tourism and outdoor recreational activities; ornamental horticulture, etc. - % growth

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	5	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
131	Alternative Uses of Land
605	Natural Resource and Environmental Economics

Outcome #2**1. Outcome Measures**

Customized designs for enhanced economic development adopted and implemented by state rural communities

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
804	Human Environmental Issues Concerning Apparel, Textiles, and Residential and Commercial Structures
605	Natural Resource and Environmental Economics
608	Community Resource Planning and Development

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Before-After (before and after program)
- During (during program)

Evaluation Results

The ag / forestry / natural resource economic index combines state gross product in several agricultural commodities (broilers, cattle, sheep, turkeys, eggs, turkeys) with inflation adjusted employee compensation in forest management, wood products, furniture manufacturing, and tourism and measures the outcome as index change over years. This index increased 3.98% in 2007 relative to 2006. Average increase over the last two years is a more modest, but still respectable, 3.12%

Key Items of Evaluation

Program #2

V(A). Planned Program (Summary)

1. Name of the Planned Program

Environmental Quality and Stewardship

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources			20%	
102	Soil, Plant, Water, Nutrient Relationships			15%	
133	Pollution Prevention and Mitigation			30%	
403	Waste Disposal, Recycling, and Reuse			20%	
605	Natural Resource and Environmental Economics			15%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	6.7	0.0
Actual	0.0	0.0	6.4	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	656079	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	613203	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	849156	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct research; publish/present results

Research which contributes to the preservation of West Virginia's soil, water, forest and wildlife resources is a high priority in the West Virginia Station. The focus of Station research is on protecting soil and water quality while developing economically effective and environmentally sustainable management practices for agriculture, forestry and other points of interaction between man and environment. Contamination of soil and eventually ground water with acid mine drainage from abandoned mines, and from more recent surface mining, is a growing state concern. Research is being conducted to characterize the nature and scope of these problems and to develop effective and cost effective remediation programs.

The development of environmentally sustainable practices for managing farms and forests is an important component of overall Station goals to position state producers to compete more effectively in organic or "green" markets and to preserve West Virginia lands, forests, wildlife, soil and water resources for future generations.

Developing optimum methods for the restoration of environmentally compromised areas of soil and water is likewise a primary emphasis of Station research. Focus areas include restoration of surface mine sites, areas adjacent to newly constructed and older state highways, impacted state streams and waterways, and areas compromised by agricultural and forest industry waste and activity.

Reforestation is the preferred restoration method for surfaced mined areas in West Virginia. Station research is evaluating tree survival and growth in weathered brown sandstone and in unweathered gray sandstone. Half of each plot was compacted, where dozer tracks completely covered the surface, while the other half had only one pass of a dozer. Percent fines (<2 mm) in the upper 20 cm increased from 51% the first year to 61% for brown sandstone, while the gray decreased from 38% the first year to 34% the third year. Brown sandstone's pH of 5.1 stayed consistent over three years, while gray sandstone's pH was 7.9 the first year and increased to 8.4 by year three. Phosphorus was significantly greater in gray sandstone (24 mg kg⁻¹) than brown sandstone (7 mg kg⁻¹). In March 2005, seedlings of 11 hardwood species were planted on 2.5 x 2.5 m spacing. After three growing seasons, tree survival was 86% on gray sandstone and 74% on brown sandstone, and 78% on non-compacted areas and 79% on compacted. Average volume of all trees (height x diameter²) was significantly greater on brown sandstone (218 cm³) vs gray sandstone (45 cm³) after three years.

The forests of eastern North America were once home to the American chestnut (*Castanea dentata*). In 1904, Chestnut blight, a disease caused by a fungus from Asia, was found in New York. The blight spread through the forests so that by the 1950s about 4 billion trees had perished. The disease does not attack the roots so sprouting allows American chestnut to persist in eastern forests, but only as an occasional understory shrub. Since 1983, The American Chestnut Foundation (TACF) has attempted to restore this tree as a canopy tree. By controlling pollinations through a series of backcrosses, TACF is producing backcross chestnuts that incorporate Asiatic chestnuts' blight resistance, while retaining the desirable timber and nut producing characteristics of the American chestnut. Reestablishing chestnut trees on reclaimed surface mines has recently gained attention. We planted five seeds types of chestnut (100% American, 100% Chinese, B1F3, B2F3, and B3F2) into loosely-graded minesoils at the West Cazy surface mine in Boone County, West Virginia, in blocks with and without peat treatment, and with and without tree shelters. Average seedling survival was 72% across all treatments. Chinese was 80%, American was 64%, while the hybrids were around 71%. Chinese and B3F2 seedlings were greatest in height growth at 25 cm, while American was 17 cm.

Declining forest health has been observed over the past several decades in areas of the eastern US, and some of this decline is attributed to acid deposition. Decreases in soil pH and increases in soil acidity are indicators of potential impacts on tree growth due to acid inputs and Al toxicity. The Cherry River watershed, which lies within the Monongahela National Forest in West Virginia, has some of the highest rates of acid deposition in Appalachia. East and West areas within the watershed, which show differences in precipitation, stream chemistry, and vegetative composition, were compared to evaluate soil acidity conditions and to assess the degree of risk they impose on tree growth. Thirty-one soil pits in the West area and 36 pits in the East area were dug and described, and soil samples from each horizon were analyzed for chemical parameters. In A horizons, East area soils averaged 3.7 pH with 9.4 cmolc kg⁻¹ of acidity compared to pH 4.0 and 6.2 cmolc kg⁻¹ of acidity in West area soils. Extractable cations (Ca, Mg, and Al) were significantly higher in the A, transition, and upper B horizons of East versus West soils. However, even with differences in cation concentrations, Ca/Al molar ratios were similar for East and West soils. For both sites using the Ca/Al ratio, a 50% risk of impaired tree growth was found for A horizons, while a 75% risk was found for deeper horizons. Low concentrations of base cations and high extractable Al in these soils translate into a high degree of risk for forest regeneration and tree growth after conventional tree harvesting.

A study is continuing to determine long-term effects of gypsy moth defoliation on forest regeneration and wildlife populations. Data from 15 years were used to construct shape files using GIS procedures. Vegetation structure variables were overlaid on coordinates for long term plots at the Sleepy Creek Wildlife Management Area which was not treated to control gypsy moth. Periodic outbreaks, some very severe, have had a major impact on the vegetation structure and plant species composition of the area. Although analysis is on-going, it is clear, but for unknown reason, that some species of wildlife continue to inhabit the area even with dramatic changes in vegetation. Target species include Ovenbird, Kentucky Warbler, Eastern Peewee, and Scarlet Tanager.

Techniques have been developed to speciate elemental selenium and selenite using selective dissolution and flow injection – hydride generation-ICP. These techniques are being used to quantify the effects of iron corrosion products on the kinetics of selenium removal from simulate mine drainage. A related project has quantitated the effect of soil metal load on the

uptake and distribution of Zn, Pb, Cd, and Cu in radish, spinach, carrot and chicory. Additionally, a grid sampling procedure has been developed and used to estimate the optimal sample number needed to accurately determine soil bulk density and soil carbon on a toposequence of reclaimed mine soils.

Data have been collected which characterize wetlands – natural, restored, mitigated, and created – with respect to animals, birds, invertebrates, vegetation, water quality, litter decomposition rates, and soil parameters. Results are being used to develop an index of wetland biotic integrity and a rapid wetland assessment protocol which can be used to evaluate wetland function for new (restored or mitigated) wetlands and/or to monitor changes in function over time. Results currently are being used to develop state regulatory standards for wetlands. A related project is using aquatic ecosystem evaluation to compare headwater and wetland functions of native streams and streams associated with reclaimed mine sites. The goal is to develop a state-wide stream mitigation trading and banking program which will ensure restoration and maintenance of essential functions such as flood mitigation, provision of quality water, and supplying food, nutrients, and energy to downstream fisheries.

A watershed-scale study in cooperation with the NRCS is continuing with the purpose of assessing soil hydrology across major landforms within a single watershed in the eastern panhandle of West Virginia. Data for the study of saturated hydraulic conductivity (Ksat) on three benchmark soils (Laidig, Clarksburg, Buchanan) that represent regional soil conditions and land use practices (forest, pasture) was collected using compact constant head permeameters (Amoozemeters). Measurements were taken from each soil during both wet and dry seasonal conditions, from both pasture and forest, and from each A/Ap, Bt, and Btx (where present). In general, higher Ksat values were observed in Ap horizons compared to subsurface horizons, and forest sites had higher Ksat values than pasture sites. Laidig Ksat values were higher than Clarksburg, and both are higher than Buchanan. Comparisons of Ksat for a single series (Buchanan) show that only two treatments affect Ksat: horizon and land use. The Ap horizons have lower bulk density, higher organic matter, coarser texture, and fewer rock fragments as compared to subsoil horizons (Bt and Btx). Land use differences are likely caused by compaction from both animals (cattle and horses) and farm equipment. When looking at data from all three soils (wet season only), all treatments and interactions were found to have a significant effect on Ksat. For this reason, individual treatment effects cannot be discussed. Land use by series effects are at least partially explained by compaction from farm equipment and animals, which lowers Ksat on pastures. Drainage class differences associated with the different series may yield the higher Ksat values on well drained Laidig sites, which are not as susceptible to compaction as the wetter Clarksburg and Buchanan soils. Land use by horizon interactions are associated with differences in organic matter (greater in forest Ap), rock fragments (greater in forest Bt), clay content (greater in pasture Bt), and bulk density (higher in pasture Ap and Bt). Series by horizon interactions are evidenced by higher Ksat values for the Laidig samples and may be caused by higher sand and rock fragment contents in the Laidig Ap horizons. Information generated from these studies will be used to document the depth and duration of seasonally-high water tables and improve our understanding of water redistribution across typical landscapes in West Virginia. Results will be used to support forest management planning, revise soil use interpretations, and otherwise characterize water table dynamics for interpreting the presence of redoximorphic features.

The high cost of petroleum based transportation fuels has caused an increased interest in renewable biofuels. One energy crop that is well suited for conversion to biofuels is switchgrass because of its high biomass production on marginal lands and moderate fertility needs. West Virginia has potential to become a center of biofuel production with its large expanses of reclaimed mine lands. Our objective is to identify the best varieties of switchgrass for mined lands in West Virginia, determine planting and management requirements, and document yields, biofuel feedstock potential, capacity for carbon capture and sequestration and other potential revenue streams. Three sites in the state were selected for this experiment. Three varieties of switchgrass were randomly assigned and planted into one-acre plots, which were replicated three times for a total of nine plots at each site. Planting was conducted in May of 2008 at a rate of 10 to 12 pounds PLS per plot. All three sites are reclaimed surface mines and have had topsoil rolled out above the overburden material. Germination success was good with 10-15 plants per 1/4-m² plot. Soil characteristics and biomass yield are being monitored.

Two experiments were conducted in the spring and fall of 2008 to determine factors which limit nutrient uptake and biomass production within a flow-through aquaponics system. Watercress was more effective than lettuce, dill or basil at removing nutrients from aquaculture effluent under all conditions. Moreover, of all treatments considered, increased nutrient concentration was most effective at increasing nutrient removal despite increased loading. Initial harvest was made six weeks post-sowing and then every three weeks afterward, leaving the roots intact for subsequent harvests. Treatments included water at high (0.0076m/sec) and low (0.00076m/sec) velocities. Results show high yields in the initial harvest of the high velocity channels, with low or no harvest in the low velocity channels (1311g vs 399g). Subsequent harvests showed similar characteristics, with a slightly lower overall harvest in the high velocity plants and a slightly higher overall harvest in lower velocity channels.

In a related study, a geotextile bag receiving waste removed from the quiescent zone of a trout raceway effectively captured solid waste. Solids retention was excellent with greater than 98% of the solids removed. Mean particle size was reduced from 379 μm to 70 μm . BOD₅ was substantially reduced.

The West Virginia Station maintains a certified organic farm to evaluate and improve organic production systems for both plants and animals. A recent study conducted at the organic farm compared patterns of antibiotic resistance in 600 E coli isolates from organic and conventionally raised chickens and sheep, and from the soils on which they graze. Compared with organic chickens, more conventional chicken isolates were resistant to ampicillin and cephalothin. All chickens harbored isolates that were resistant to rifampin, streptomycin and neomycin. Conventional and organic sheep isolates were primarily

resistant to rifampin, as were isolates from baseline soil samples. Following eight weeks of grazing by organic chickens, isolates from paddock soils became significantly resistant to tetracycline. Preliminary BOX A1R rep-PCR fingerprints were obtained from the E. coli isolates and subjected to cluster analysis. Results supported a separate baseline soil and organic chicken cluster. Soil isolates obtained following exposure to organic chickens clustered more closely with chickens than with baseline soils. An additional 1000 isolates from soils and pasture-raised beef cattle currently are being analyzed. Future work includes utilization of additional antibiotic sensitivities, improved rep PCR analyses, and modifications of the clustering technique employed. The presence of distinct E. coli strain among organically and conventionally reared chickens, from various experimental systems, suggests that distinct strains are obtained based on the production practice employed which in turn affects populations and persistence of E. coli in soils.

Cost-effective poultry manure transport and processing facility locations were determined within the Chesapeake Bay Watershed. This model was designed to allocate excess manure to land application or processing, in order to minimize the costs of appropriately utilizing all excess manure. Optimal solutions were assessed while examining the impact of farmer's willingness to accept manure, implicit values of manure use in land application and processing, and policies such as manure transport subsidies, energy tax credits and cost-sharing of composting facility construction. Under the base model, the total cost of utilizing excess manure to society is slightly under \$200 million. 84% and 16% of total cost is spent on land application option of manure and processing options, respectively. Even when agricultural land available for manure application was limited with landowners' willingness to accept manure, land application is still the most preferred manure utilization option. The results show that when a manure transport subsidy program is implemented, the total cost of the objective function decreases between 78% and 80% depending on the other components of each scenario. However, about an average of \$1.65 transport subsidy is needed to reduce the total cost of the objective function by \$1. This implies that the cost of the transport program to society is greater than the benefits in terms of cost reduction. High-capacity litter composting facilities are the most economically viable processing option and are built in every model scenario. Only a \$0.54 cost-share for composting facilities was needed to reduce the total cost of the objective function by \$1. Unlike the transport subsidy program, there are substantial cost-savings provided by a cost-share program. Processing poultry litter for energy production, however, is the least economically viable processing option. In the model, the current renewable energy tax credit has no impact on building energy facilities that transform manure into electricity. Unless a state or federal program subsidizes at least 50% of total capital cost, the energy production option will remain economically not competitive with land application and other processing options.

2. Brief description of the target audience

Commercial producers and foresters, managers, consultants, policy makers, governmental regulators.

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	4	
2008	0	6	6

V(F). State Defined Outputs**Output Target****Output #1****Output Measure**

- Refereed, scientific manuscripts

Year	Target	Actual
2008	4	6

Output #2**Output Measure**

- Science-based articles for lay audiences

Year	Target	Actual
2008	4	5

Output #3**Output Measure**

- Presentations of research results

Year	Target	Actual
2008	5	4

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Map Phosporus Adsorption Capacity for West Virginia soils - %
2	Knowledge of soil properties (pH, bulk density, electrical conductivity, etc.) required to grow native species on disturbed land - # new species
3	Use of poultry litter in turf grass culture- %

Outcome #1

1. Outcome Measures

Map Phosphorus Adsorption Capacity for West Virginia soils - %
Not reporting on this Outcome for this Annual Report

Outcome #2

1. Outcome Measures

Knowledge of soil properties (pH, bulk density, electrical conductivity, etc.)
required to grow native species on disturbed land - # new species
Not reporting on this Outcome for this Annual Report

Outcome #3

1. Outcome Measures

Use of poultry litter in turf grass culture- %
Not reporting on this Outcome for this Annual Report

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

Assumptions / understandings regarding the annual collection of data to support soil mapping and poultry litter use outcomes were incorrect. There apparently is no intent to collect these data on a regular basis making the outcomes unmeasurable. Outcomes for this program are altered in the plan of work.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Before-After (before and after program)

Evaluation Results

Key Items of Evaluation

Program #3**V(A). Planned Program (Summary)****1. Name of the Planned Program**

Fundamental Plant and Animal Systems

V(B). Program Knowledge Area(s)**1. Program Knowledge Areas and Percentage**

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			25%	
206	Basic Plant Biology			15%	
301	Reproductive Performance of Animals			25%	
302	Nutrient Utilization in Animals			15%	
304	Animal Genome			10%	
305	Animal Physiological Processes			10%	
	Total			100%	

V(C). Planned Program (Inputs)**1. Actual amount of professional FTE/SYs expended this Program**

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	4.2	0.0
Actual	0.0	0.0	5.7	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	514769	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	774723	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	863419	0

V(D). Planned Program (Activity)**1. Brief description of the Activity**

Conduct research; publish / present results

Research involving fundamental systems in animals is to increase our understanding of reproductive, nutritional and general physiological systems and processes. Practical problems addressed include embryonic mortality in sheep and cattle, performance limiting amino acids in animal rations, health and disease resistance in poultry. In plants, program emphasis varies from determining functions of ubiquitin and other polypeptide tags, to understanding basic mechanisms of flower senescence and cold shock adaptation, to combating the impacts of phytophthora and Chestnut blight, to defining and eliminating negative effects on grazing animals of ergot alkaloids produced by fungi symbiotic with pasture grasses.

The long-term goal of a current research project is to establish models of oxidative stress in birds and determine the efficacy of manipulating plasma uric acid concentrations to modulate oxidative stress, thereby increasing our understanding of how oxidants exert their specific effects on tissues. Allopurinol is a xanthine oxidase inhibitor that has been recently proposed as a therapy to reduce oxidative stress in different human tissues. The effects of xanthine oxidase on oxidative stress are complex, since it forms uric acid (a potent antioxidant) but also catalyzes the formation of reactive oxygen species. These studies investigated the effects of allopurinol on plasma uric acid (PUA) concentrations and oxidative activity in broilers. Feeding allopurinol decreased feed intake and significantly reduced body weight compared to that measured in the control group. As expected, allopurinol reduced PUA at each wk although there was no effect of allopurinol on measurements of oxidative stress over the first 3 wk of study, but at wk 4 oxidative stress measurements were greater than that measured in control birds. The general lack of effect of allopurinol on measurements of oxidative stress would indicate that the increase in oxidative stress caused by the reduction of PUA could have been overcome by a reduction in the formation of reactive oxidative species.

Studies have shown a positive correlation between age and the accumulation of pentosidine in the breast skin of birds. However, previous research has only analyzed skin from deceased birds. The major objective of these studies was to determine if pentosidine concentrations can be determined from skin biopsy collections of living birds. Patagial tags have been placed on many wild birds without serious side effects, which makes the patagium a potential site for skin collection in living birds. Patagial and breast skin samples from deceased Double-crested Cormorants (*Phalacrocorax auritus*), Monk Parakeets (*Myiopsitta monachus*), and living Black Vultures (*Coragyps atratus*) were provided by USDA Wildlife Services in Gainesville, FL and Starkville, MS. These samples were analyzed for pentosidine concentrations according to the procedure published by Iqbal et al. Initial comparisons of Double-crested Cormorants and Monk Parakeets revealed that there were no significant differences in pentosidine concentrations between the breast and patagium for either species. These results indicate that age curves generated from the analysis of breast skin can be reliably used to age birds with skin collected from the patagium. The collection of patagial skin from Black Vultures indicated that skin samples can be collected safely from living birds.

Nucleoplasmin 2 (nPM2), a maternal gene, is essential for early embryonic development, but must be silenced to allow activation of the embryonic genome. Bovine nPM2 has 561 bp, a predicted length of 176 amino acids and 55% homology with Homo sapiens nPM2. Expression was greatest at the GV and MII stages, decreased to the 2-cell stage, remained constant until the 16-cell stage, and was barely detectable thereafter. Protein of nPM2 was constant through the 16-cell stage, but barely detectable in blastocysts. A shift in molecular weight of nPM2 at MII was presumed due to phosphorylation. One possible microRNA site, bta miR181a, showed perfect complementarity with nPM2 in the first 7 bases of pairing (seed region). Real time PCR for miR181a revealed that miR181a was expressed in the oocyte and embryo. Nucleoplasmin 2 and miR181a were cloned and ligated into pCDNA3.1 expression vectors. The microRNA was stably transfected into HeLa cells. Nucleoplasmin 2 was then co-transfected with the stable cells for 24 h. Control cells were transfected with nPM2 only. Co-transfection of miR181a and nPM2 decreased nPM2 expression. Apparently nPM2 is targeted by miR181a for degradation or silencing. This finding may contribute significantly to better understanding embryonic loss in cattle.

Additionally, microarray analysis identified 180 differentially expressed genes ($P < 0.05$) in d4 and 10 CL, confirmed by real-time PCR. Functionally, these genes are involved in cell signaling (13%), metabolism (10%), protein degradation (5%), RNA processing (15%), protein biosynthesis (19%), extracellular matrix and cytoskeletal (6%), DNA replication (2%), antioxidant (3%), miscellaneous (17%), and unknown (10%). Prostaglandin F₂α increased expression of a guanine nucleotide binding protein (G protein), beta polypeptide 1 (GNB1) and the calcium/calmodulin dependent kinase kinase 2 beta (Camkk2) in day-4 and -10 CL, respectively. Thus GNB1 and Camkk2 are candidate genes for roles in acquisition of luteal sensitivity to PGF₂α. Experiments have been initiated in regard to endothelin in CL. One tests the hypothesis that Endothelin 1 through its receptor type A regulates expression of genes involved in structural luteolysis in the ewe during induced regression of the corpus luteum. A second tests whether endothelin receptor type A antagonist prevents luteolysis by endogenous PGF₂α in sheep and increase length of estrous cycle, as shown by progesterone secretion pattern and CL morphology. The third tests, using an oxytocin receptor antagonist, whether oxytocin might be involved in endothelin-independent actions of PGF₂α.

During the most recent reporting period we have continued to collect samples of placental and endometrial tissue from late pregnant (day 70, 90 and 110 of gestation) gilts in a project designed to evaluate variation in reproductive efficiency. We have begun to assay those samples for the expression of a variety of nutrient transporters and stain samples from each fetoplacental unit so that we can estimate the density of blood vessels both in the placenta and adjacent endometrium. We also collected blood samples from ewes treated with growth hormone around the time of breeding, a treatment we have previously demonstrated increases lamb birth weight, weaning weight and reduces lamb response to a growth hormone releasing hormone challenge. These samples were collected every week from treatment (week 0) until week 8 of gestation. We then assayed these samples for IGF-I as a proxy for growth hormone to estimate the duration of the growth hormone treatment

effect. We have also continued feeding dairy cows diets designed to elicit divergent insulin secretion. From these cows we have collected liver biopsies to estimate the activity of progesterone catabolic enzymes and used continuous infusions to estimate the metabolic clearance rate of progesterone and liver blood flow in response to our dietary treatments.

The impact of these research projects has been significant. Relative to placental function in the pig, we have detailed the expression of a variety of nutrient transporters in the placenta and adjacent endometrium from each feto-placental unit in litters collected from gilts on days 70, 90 and 110 of gestation. Real-time PCR was used to determine mRNA expression of nutrient transporters, including: rBAT-1, FAT-1, FAT-2, yLAT-1, CAT-1, ASCT-1 and GLUT-3. On day 90, ASCT-1 was found to be more highly expressed in the endometrium associated with feto-placental units having a higher placental efficiency. On day 110, individual feto-placental units having a lower placental efficiency tended to have a higher endometrial mRNA expression rBAT-1 and FAT-1. Relative to the duration of the periconceptual treatment of ewes with growth hormone, we determined IGF-1 concentrations (as a proxy for growth hormone). For weeks 1, 2, 3 and 4 of gestation, treated ewes had an increased IGF-1 concentration compared to control ewes (3, 5, 4 and 2.5-fold, respectively). Periconceptual treatment with GH causes IGF-1 to remain elevated for the first half of gestation, potentially altering the uterine environment during a crucial developmental period.

Additionally, gilts were randomly assigned to ovario-hysterectomy on day 70, 90 or 110 of gestation. Fetal, placental, liver and heart weights and placental efficiency were recorded for each fetus. Endometrial and placental samples were collected and used for determination of the mRNA expression of nutrient transporters by real time RT-PCR. Placental, fetal, heart and liver weights, as well as placental efficiency increased with gestational age. Placental and fetal weights were positively correlated with heart and liver weights for day 70, 90 and 110. Heart and liver weights exhibited a positive relationship for day 70, 90 and 110. Placental efficiency was negatively correlated with heart and liver weights on days 70 and 90. On day 70 heart weights were negatively correlated with placental expression of yLAT-1 and CAT-1 as well as endometrial expression of CAT-1. Liver weights were negatively correlated with the placental expression of CAT-1 and the endometrial expression of CAT-1 and rBAT-1. The endometrial expression of yLAT-1 and placental expression of CAT-1, ASCT-1 and rBAT-1 showed a positive relationship with heart weight on day 90 while the endometrial expression of ASCT-1 exhibited a negative correlation. Positive relationships were observed on day 90 for liver weights and the placental expression of yLAT-1 and ASCT-1 and the endometrial expression of yLAT-1. Negative relationships were present for the endometrial expression of ASCT-1 and FAT-1. On day 110, both heart and liver weight exhibited a positive correlation with the endometrial expression of GLUT-3. Liver weight and placental expression of GLUT-3 exhibited a negative relationship. The relationship of heart and liver weight to nutrient transporter expression during a critical developmental period may have resulted in altered placental function resulting in an altered uterine environment, which may possibly explain the negative relationship of heart and liver weight to placental efficiency during gestation. In late gestation, during the time of greatest fetal growth, endometrial expression of glucose transporters and heart and liver weights exhibited a positive relationship, while the placental expression of GLUT-3 exhibited a negative relationship with liver weight. Though no relationship was observed between placental efficiency and heart or liver weight, a negative relationship did exist between the endometrial expression of GLUT-3 and placental efficiency.

Relative to the nutritionally mediated regulation of progesterone catabolism, holstein dairy cows ($n = 11$) were randomly assigned to a high starch or high fiber diet in a cross-over experimental design consisting of two 14 d periods. Dry matter intake, milk yield and milk lactose yield were not different between the two diets. Insulin concentrations were increased by 22% in cows fed the high starch diet, and both cytochrome P450 2C and cytochrome P450 3A activities were decreased by 50%. Liver blood flow was not different between the two diets. Metabolic clearance rate of progesterone tended to be lower in cows fed the high starch diet versus the high fiber diet. The half-life of progesterone was increased in cows fed the high starch diet versus the high fiber diet. In addition, twenty-two Holstein cows were trained to acquire feed from the Calan gate system and randomly assigned to either a high corn starch or high fiber diet in a cross-over experimental. Dry matter intake was similar for the high starch and high fiber diet, as was milk yield and milk lactose yield. Insulin concentrations at the time of liver biopsy were elevated by 47% in cows consuming the high starch diet versus the high fiber diet. Cytochrome P450 2C activity was decreased by 45%, while cytochrome P450 3A activity tended to be lower by 34% in cows consuming the high starch diet. Insulin was elevated by 19% in cows consuming the high starch diet. The half-life of progesterone tended to be longer in cows fed the high starch diet versus the high fiber diet. In summary, cows with elevated insulin concentrations and lower enzyme activity showed a decrease in progesterone clearance without any changes in liver blood flow, dry matter intake or milk yield. This relationship between insulin and enzyme activity may be a useful approach to decrease high rates of progesterone clearance during pregnancy.

A proteomic analysis of expression patterns in cryopreserved semen of bulls of known low fertility identified three seminal plasma proteins: 1) Seminal plasma protein PDC-109 precursor, MW 15.4 kDa, pI 4.76, 2) Spermadhesin-1 precursor, MW 15.0 kDa, pI 4.93, and 3) Spermadhesin Z13, MW 13.4 kDa, pI 5.50. Low fertility of dairy bulls was associated with higher expression of Spermadhesin Z13 isoforms in accessory gland fluid (Moura et al., 2006). Therefore, identification of that protein and its precursor in seminal plasma of low fertility bulls strengthens its potential use as a marker of low fertility in bulls.

Nuclear proteins, including transcription factors and chromatin remodeling proteins, are required for initiation of transcription in early embryos prior to embryonic genome activation. Full-length cDNA sequence for a novel oocyte transcript with sequence similarity to the importin-alpha family of genes. Full-length cDNA sequence for this gene was obtained by RT-PCR and 5'RACE. Sequence analysis revealed that the cDNA (1817 bp) has an open reading frame encoding a protein of 522 amino acids. A search of the Pfam protein database revealed that the protein contains a conserved importin β binding domain (IBB) and 7 armadillo (ARM) motifs, typical characteristics for importin α proteins. RT-PCR analysis revealed that the novel gene is predominantly expressed in ovarian tissues and mature oocytes. Quantitative real time PCR analysis

demonstrated that the expression of this novel importin α gene in GV stage oocytes is over 30 to 2000 times higher than other known importin α genes. Analysis of temporal expression of the novel gene during early embryonic development showed that the transcript is abundantly present in GV and MII stage oocytes as well as in 2-cell, 4-cell, and 8-cell embryos, but barely detectable in morula and blastocyst. Western blot analysis using antibodies against this novel protein showed a similar expression pattern at the protein level. A GST pull down assay revealed that the novel importin α protein has a much stronger binding affinity with a nuclear protein, Nucleoplasmin 2, compared to other bovine importin α proteins. RNAi experiments demonstrated that knockdown of the expression of the novel importin α in bovine embryos results in a decrease of the proportion of embryos developing to the blastocyst stage. We suggest that this novel importin α might be responsible for nuclear transport of certain key transcription factors and/or other essential nuclear proteins required for activation of the embryonic genome during early embryogenesis. Recently, with the updating of the bovine genome database, we were able to identify a predicted bovine transcript that matches the partial JY-2 cDNA we isolated from the bovine oocyte library. Cloning of the full-length cDNA for this gene was therefore successfully completed by overlapping RT-PCR. The cDNA codes for a protein of 507 amino acids. Analysis of the predicted protein sequence revealed that the novel protein has conserved coiled-coil domains, a functional motif typically found in proteins involved in the regulation of gene expression such as transcription factors.

A project recently completed investigated the association between male age and the frequency of sperm with de novo structural chromosomal abnormalities. Semen specimens collected from two groups of 10 healthy, nonsmoking men, aged 22-28 and 65-80 years were analyzed with the use of a multicolor fluorescence in situ hybridization assay for detecting breaks, segmental duplications and deletions, and aneuploidy and diploidy involving chromosome 1. Significant increases in the frequency of sperm carrying breaks and segmental duplications and deletions of chromosome 1 among older men compared with younger men. Older men carried twice the frequency of sperm with segmental duplications and deletion of chromosome 1. The frequency of sperm carrying breaks within the 1q12 fragile-site region nearly doubled in older men. In contrast to female gametes, there was no effect of age on the frequency of sperm with numerical chromosomal abnormalities. Our findings suggest that advancing male age is associated with a gradual and significant increase in the risk of fathering children with various chromosomal defects such as segmental aneusomy syndromes.

Experiments were conducted to determine the effect of dietary lysine on indices of lysine metabolism in the chicken. Focus was on establishing whether or not the initial enzyme of saccharopine-dependent lysine degradation, lysine α -ketoglutarate reductase (LKR), is regulated by post-translational processes. Results showed that decreases in dietary lysine reduce LKR activity and that although there was a small decrease in LKR mRNA, it appears as if the regulation of enzyme activity is largely mediated through post-translational processes. We also developed procedures to measure messenger RNA levels for mitochondrial transport proteins involved in basic amino acid transport in mitochondria. Over the last year this has been complicated by the finding of two different transporters that may contribute to the process.

Two different ergot alkaloid-eliminating gene knockouts inserted in the perennial ryegrass endophyte *Neotyphodium* sp. LP1, were compared with respect to their effects on nematode reduction, mammalian feeding deterrence and satiety, insecticidal effects, and seed transmissibility. One of the mutants carried a disruption in *dmaW*, the first gene in the ergot alkaloid pathway, and accumulated absolutely no ergot alkaloids. In the second mutant, the gene *lpsA* which encodes a later pathway step, was knocked out. The *lpsA* knockout accumulated clavine alkaloids, which are intermediates from the early part of the ergot alkaloid pathway, but not ergovaline or other lysergic acid derivatives. Perennial ryegrass plants infected with either of these two mutants, the wild-type fungus (producing all ergot alkaloids), or no fungus (endophyte-free) were compared in a variety of trials. In the absence of ergot alkaloids, endophyte infected grass (containing the *dmaW* mutant) was favored by rabbits (used as a model mammalian herbivore) over endophyte-free grass. Accumulation of clavine ergot alkaloids as in *lpsA* mutant, and to a lesser extent in the wild type fungus, counteracted the endophyte appeal and deterred rabbit feeding. In satiety tests, consumption of ergovaline (the ergot pathway end product) but not clavine-type ergot alkaloids reduced the appetite of rabbits. Tests with black cutworm (*Agrotis ipsilon*), performed in collaboration with Dr. D.A. Potter (University of Kentucky), showed that ergovaline and lysergic acid derivatives which accumulated in grasses containing the wild-type fungus were effective feeding deterrents and caused larval mortality, whereas clavine ergot alkaloids (which accumulated in the *lpsA* knockout) were ineffective against this insect. Collectively the data showed that ergot alkaloids from different parts of the pathway are required for anti-mammalian and anti-insect properties. In experiments with lesion nematodes (*Pratylenchus scribneri*), nematode population growth on perennial ryegrass roots was greatly inhibited by wild-type endophyte presence. However, elimination of ergovaline and lysergic acid derivatives (as in the *lpsA* mutant) or all ergot alkaloids (as in the *dmaW* mutant) did not significantly reduce the endophyte-associated population suppression. These data indicate that ergot alkaloids can be eliminated from grass-endophyte symbioses without compromising lesion nematode resistance. Factors other than ergot alkaloids are responsible for the documented effects of *Neotyphodium* sp. endophytes against lesion nematodes. Similarly, seed transmissibility of endophytes was approximately 100% in plants infected with either mutant and in wild-type infected plants, indicating that vertical transmission of endophytes is unaffected in the mutants. In further basic studies on the ergot alkaloid pathway, knockout mutations in the ergot alkaloid-producing fungus *Aspergillus fumigatus* showed the involvement of four additional early pathway genes. Biochemical functions for three of the genes were deduced by chemical analyses. Homologues of each of the four genes have been identified in endophyte genomes.

Previous work with *Enterobacter sakazakii*, an opportunistic pathogen, demonstrated its ability to endure prolonged stress in aquatic environments. We have continued our studies on the survival, detection, recovery, and physiological adaptations of this pathogen. Part of this effort was directed toward an evaluation of the recovery efficiency of various media modifications to a

commercially available selective/differential medium for detection of *E. sakazakii*. Our current studies show that the commercially available culture medium is relatively ineffective in permitting detection of the target bacterium. However, we were able to modify the standard medium by addition of certain compounds and other adjustments in the routine isolation procedure to achieve substantially enhanced recovery of *E. sakazakii* while coincidentally inhibiting nontarget antagonists. Ten strains of potentially antagonistic bacteria as well as two strains of the target microorganism, *E. sakazakii*, were subjected to these newly modified media. The most effective culture conditions which simultaneously inhibited the growth of unwanted potential competing organisms and permitted detection of the target opportunistic pathogen was a medium formulated with 0.25 molar sodium chloride, 0.1 percent pyruvate, and 10 milligrams of vancomycin per liter. This newly developed medium was then used in a modified membrane filtration procedure (0.22 micrometer porosity filters) to reliably and successfully isolate *E. sakazakii* from water samples containing antagonistic bacteria that could possibly confound and compromise detection of the target opportunistic pathogen. Our newly modified procedure requires rigorous field testing in the future to determine its suitability as a reliable technique to detect environmentally stressed *E. sakazakii*.

In a related study, we examined the influence of desiccation on subsequently thermally stressed *E. sakazakii*. Possible physiological changes associated with the desiccation of *E. sakazakii* were monitored with the BIOLOG microplate system, a substrate utilization profile testing system (panel of 95 different potential carbon sources). Desiccation resulted in increased thermotolerance of survivors compared to non-desiccated cells. In addition, notable differences in utilization of specific substrates were observed between desiccated and non-desiccated *E. sakazakii*. These findings should provide valuable information on the possible public health significance of pathogenic *E. sakazakii* in aquatic and food-associated environments. Equally important, the identification of key substrates required for the detection of desiccation-stressed *E. sakazakii* with the BIOLOG microplate system suggests the possibility of modifying the currently available growth medium to enhance the sensitivity and selectivity of the detection procedure, thereby leading to a better understanding of the ecology and etiology of this opportunistic waterborne pathogen. Successful completion of the objectives and goals of the project should contribute to improvement in the quality of surface water and ground water.

In vitro cell callus lines of *Panax quinquefolius* (American ginseng) have been successfully established. The three tissue types (root, leaf and in vitro callus) for generating the three cDNA libraries of *Panax quinquefolius* have been prepared for generating cDNA libraries. The cDNA libraries will be generated as well as expressed sequence tags (ESTs) established at the University of Arizona under the direction of Dr. David Gang. This will be completed early in 2009. A protocol has been developed for utilizing flow cytometry for estimating the size of the *Panax quinquefolius* genome. Genome size estimation will be completed early in 2009.

Understanding flower senescence at a molecular level will enable future efforts to increase the economic value and productivity of agricultural crops through genetic engineering. Delaying flower senescence will lead to higher crop productivity through the increased window of opportunity for flower pollination and increase their economic value as shelf life of floriculture crops increases. Inducing full or partial flower senescence may lead to more efficient breeding efforts by alleviating emasculation of flowers and may be used to decrease the invasiveness of crop and ornamental plant species. Our efforts have focused on elucidating the trigger of flower senescence and on providing evidence for a possible regulatory and/or functional role of CEBP, a nuclear-encoded chloroplast protein, expressed throughout flower development and senescence. We also wanted to more closely examine changes in chloroplast number and chlorophyll content in petals of carnation flowers. Since limited information is available on chloroplast development and function in petals, measuring and possibly correlating these changes with previous results on CEBP expression and cellular localization in petals should lead to a better understanding of flower senescence. In addition, we expect that results of these experiments will impact our hypothesis that chloroplasts have a central role to play in flower senescence. In our current work we showed that chlorophyll accumulation, and the number of chloroplasts decreased throughout development and senescence in epidermal cells in the lower part of the petals, in a pattern reminiscent of CEBP accumulation and localization.

We have constructed a rainbow trout high density oligo-array representing 37,394 unique TCs using Agilent's SurePrint technology. Performance of the array has been evaluated by analyzing expression of genes associated with vitellogenesis-induced muscle atrophy in rainbow trout. To add single nucleotide polymorphisms (SNPs) to the growing number of genome tools in rainbow trout, we have evaluated multiple bioinformatic pipelines for their ability to detect SNPs from expressed sequence tag data. Candidate SNPs were evaluated and 9 SNPs representing 7 genes were successfully genotyped on the broodstock panel from the NCCCWA selective breeding program. To identify miRNAs that might be important for early embryogenesis in rainbow trout, we constructed a miRNA library from a pool of unfertilized eggs and early stage embryos. Sequence analysis of random clones identified 14 miRNAs. Distinct expression patterns were observed during early embryogenesis and some miRNAs showed up-regulated expression during embryonic genome activation.

Trap cultures from eight grassland sites (160 total) have been harvested and over 20 sporulating arbuscular mycorrhizal fungal (AMF) species have been identified and have been started as monospecific cultures. Representative species of all genera of AMF except *Pacispora* were recovered from pot cultures. *Glomus* species dominated, and most putative undescribed species were found in this genus.

A rhizohyphatron was invented which consists of mycorrhizal plants growing in opposite chambers connected by a slide chamber containing agar-coated slides (onto which only hyphae will grow from plants at both ends). This system is being used to test the hypothesis that gene flow occurs within asexual AMF species via hyphal anastomosis. Ideal conditions for hyphal development have been achieved and criteria for visually distinguishing vegetative compatible versus incompatible reactions

have been defined. So far, self-anastomosis has been characterized in isolates of ten AMF species, and species showing no self-anastomosis under more artificial conditions did so with the highest frequency in the rhizohyphatron. The beta-tubulin gene of *Gigaspora gigantea* and *Glomus clarum* was the first full-length tubulin gene to be cloned and sequenced from AMF. The gene in both species was organized into five exons and four introns, for former encoding a 447 amino acid protein. The amino acid sequence was most similar to that of fungi in the *Chytridiomycota* but nucleotide sequences indicated greater phylogenetic affinities with other fungal phyla. Unique to AMF β -tubulin genes was the absence of any intron before codon 174. Using an 800 bp region of the beta-tubulin gene, a phylogeny was reconstructed from 50 isolates of 45 AMF species. This phylogeny was concordant with that of the 18S rRNA gene at the family and species level, but it was not informative at the order level. Paralogous sequences in *Glomus* species likely contributed to phylogenetic ambiguity. Trees generated using different fungal phyla as outgroups yielded concordant topologies. The 25S rRNA gene sequences from 77 AMF species and additional isolates (5 per selected species) generated a phylogenetic tree that correlated well with morphology at the genus and species levels. These data complemented morphological characters in taxonomically placing nine ambiguous or undescribed species with closest relatives and providing evidence for publishable descriptions. Intraspecific sequences clustered within the boundaries of morphological species as well. A collaboration with Dirk Redecker resulted in identification of haplotypes of *Glomus intraradices* from a global sampling of isolates in our culture collection (INVAM) and elsewhere. Primers to selectively amplify intron regions of beta-tubulin, ITS, FOX2 and TOR2 genes were designed to genotype single spore isolates of two AMF species to be used in anastomosis studies of paired isolates.

The ubiquitin/26S proteasome pathway of selective protein degradation is essential for proper plant growth and development. It is responsible for the degradation of many short-lived regulatory proteins including those involved in hormone responses, light perception, and cell cycle progression. Efforts in this project have focused on the ubiquitin-specific proteases (UBPs), the enzymes involved in dismantling polyubiquitin chains and detaching ubiquitin from target proteins. We and others have shown that these enzymes are essential for proper ubiquitin pathway function. Whereas, the general functions of the UBPs in the ubiquitin pathway are known, the specific roles performed by each of the 27 UBPs in Arabidopsis remain largely unknown. We have identified mutant plants that do not synthesize specific UBPs and have compared their phenotypes to wild-type plants. We have assembled a collection of UBP mutants in Arabidopsis that we distribute upon request. We concentrated our efforts on the UBP3/4, UBP12/13, and UBP15/16/17/18/19 subfamilies because mutant plants display aberrant phenotypes.

This year, we continued to focus our attention on the ubiquitin-specific protease subfamilies UBP3/4, UBP12/13, and UBP15/16/17/18/19. Single gene and higher order mutant plants were compared to wild-type plants at the phenotypic level. The UBP3/4 subfamily was found to be essential for pollen transmission and important for pollen mitosis II in the male gametophyte. We have assembled several modified UBP3 expression constructs to investigate the role of N-myristoylation and nuclear localization on UBP3 function. Some of these constructs have been introduced into Arabidopsis and analysis is forthcoming. UBP12/13 double mutant pollen appears to be less successful than UBP12 or UBP13 single mutant pollen at fertilizing wild-type ovules. Ovule transmission appears to be normal. UBP12/13 double homozygous mutant plants are dwarfs, never set seed, and produce abnormal flowers. Introduction of a UBP12 cDNA construct expressed under the control of the Cauliflower Mosaic Virus 35S promoter restored seed production in double homozygous mutant plants. A genetic analysis of the five member UBP15/16/17/18/19 subfamily has been complicated because many double homozygous mutant combinations are possible and a UBP19 T-DNA insertion mutant is unavailable. UBP15/16 double homozygous mutants produce perhaps one or two viable seeds per plant, have irregular, elongated leaves, and produce very little pollen. The phenotype of these mutants have been analyzed and documented carefully with regards to seed yield, silique length, leaf shape, and flower morphology. We are in the process of generating a quadruple homozygous mutant in which UBP19 is the only UBP of this subfamily that can be expressed. The ubiquitin conjugating enzymes (UBCs) are also an important class of enzymes in the ubiquitin pathway. Earlier, we attempted to disrupt the expression of UBC subfamilies UBC4/5/6 and UBC15/16/17/18. We had great hope for success because of the availability of T-DNA insertion lines for all seven of these genes. We generated triple homozygous UBC4/5/6 mutants and quadruple homozygous UBC15/16/17/18 mutants. However, we observed no phenotype in either case. We discovered that one or more of the T-DNA insertions did not disrupt the expression of the desired gene.

Work continued on the molecular characterization of cold shock proteins (CSP) in Arabidopsis. We observed the first described putative localization of plant cold shock domain proteins to P-bodies in the moss model system. We also confirmed that plant CSPs are targets of sumoylation. Using site-directed mutagenesis, we were able to identify the critical target residue for sumoylation. We confirmed that rice CSPs are regulated on a gene and protein level in a very different manner than plants that are capable of cold acclimating. We also showed for the first time that CSPs are seasonally regulated in an extremely freeze tolerant perennial woody plant (red-osier dogwood). These correlative data suggest that CSPs might be involved in the process of cold acclimation in woody plants.

2. Brief description of the target audience

Primarily researchers; professional practitioners, regulators, some producers

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	5	
2008	0	17	17

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Research presentations

Year	Target	Actual
2008	7	8

Output #2

Output Measure

- Refereed scientific manuscripts

Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Reduced embryonic mortality in cattle and sheep %
2	Increased efficiency of amino acid utilization in ruminants %
3	Identify genes coding for cold shock proteins in plants
4	Identify and map genes affecting flower senescence
5	Decrease mortality in poultry production %
6	Develop ergot alkaloid deficient grasses with wild-type vigor
7	Successfully develop and employ hypovirus as a biological control agent for Chestnut blight

Outcome #1**1. Outcome Measures**

Reduced embryonic mortality in cattle and sheep %
Not reporting on this Outcome for this Annual Report

Outcome #2**1. Outcome Measures**

Increased efficiency of amino acid utilization in ruminants %
Not reporting on this Outcome for this Annual Report

Outcome #3**1. Outcome Measures**

Identify genes coding for cold shock proteins in plants

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
206	Basic Plant Biology

Outcome #4**1. Outcome Measures**

Identify and map genes affecting flower senescence

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
206	Basic Plant Biology
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #5**1. Outcome Measures**

Decrease mortality in poultry production %

*Not reporting on this Outcome for this Annual Report***Outcome #6****1. Outcome Measures**

Develop ergot alkaloid deficient grasses with wild-type vigor

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
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206	Basic Plant Biology
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #7**1. Outcome Measures**

Successfully develop and employ hypovirus as a biological control agent for Chestnut blight

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

3c. Qualitative Outcome or Impact Statement**Issue (Who cares and Why)**

{No Data Entered}

What has been done

{No Data Entered}

Results

{No Data Entered}

4. Associated Knowledge Areas

KA Code	Knowledge Area
206	Basic Plant Biology
201	Plant Genome, Genetics, and Genetic Mechanisms

V(H). Planned Program (External Factors)**External factors which affected outcomes**

- Natural Disasters (drought, weather extremes, etc.)
- Appropriations changes

Brief Explanation

Measurement of outcomes # 1, 2, and 5 are not supported by data collection and will be replaced in future plans of work.

V(I). Planned Program (Evaluation Studies and Data Collection)**1. Evaluation Studies Planned**

- Before-After (before and after program)

Evaluation Results**Key Items of Evaluation**

Program #4**V(A). Planned Program (Summary)****1. Name of the Planned Program**

Human Nutrition and Health with an Adequate, Safe, and High Quality Food Supply

V(B). Program Knowledge Area(s)**1. Program Knowledge Areas and Percentage**

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
501	New and Improved Food Processing Technologies			10%	
502	New and Improved Food Products			10%	
702	Requirements and Function of Nutrients and Other Food Components			20%	
703	Nutrition Education and Behavior			30%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins			30%	
	Total			100%	

V(C). Planned Program (Inputs)**1. Actual amount of professional FTE/SYs expended this Program**

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	1.6	0.0
Actual	0.0	0.0	2.7	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	279224	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	361360	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	157134	0

V(D). Planned Program (Activity)**1. Brief description of the Activity**

Conduct research; publish results in scientific, peer reviewed research journals and popular press; make presentations to colleagues at professional meetings and to end-user meetings and workshops

West Virginia is among the most overweight states in the nation and above national averages for incidence of diabetes, high blood pressure, and cardiovascular disease, as well as for osteopenia and osteoporosis. Station research in the human nutrition aspect of this program is focused on determining the current and potential impacts of diet, nutritional education and dietary intervention on obesity and obesity related conditions (diabetes, elevated cholesterol and plasma lipids, heart attack, stroke and some cancers). The program also is testing the efficacy and safety of bioactive compounds in foods, including krill protein, and is developing omega-3 DHA enhanced diets and educational programs to support their adoption.

A second focus to this program includes research to enhance the safety and quality of the food supply for our state and nation. Emphasis is on processing and cryopreservation with electronbeam treatment of fish, muscle foods and fresh vegetables which are difficult or impossible to heat sanitize. Also under development are industrial scale methods to efficiently use fish processing wastes in the production of protein and lipid by products.

Krill offers a novel and sustainable human food source yet less than 12% of that harvested is consumed by humans. Our overall aim is to assess the health effects and safety of bioactive components in foods with initial emphasis on Krill protein. Krill (order Euphausia) are pelagic crustaceans that have been estimated to be one of the most numerous multicellular organisms on the planet. Previously, we determined that krill protein concentrate (KPC) provides a source of high quality protein compared to the milk protein, casein. However, kidney weights were lower ($P < 0.001$) in KPC compared casein fed rats. Renal injury alters kidney function that may facilitate mineral losses. This in turn may lead to negative Ca and P balances that can adversely affect bone health. The objective of this study was to evaluate the safety of consuming KPC in regards to renal and bone health. Most studies investigating the role of protein in the development of renal disease have used high protein diets. In the present study, rats were fed 10% protein to determine whether protein source, rather than amount, effects renal and bone health

In our study, rats fed KPC had significantly lower kidney total mineral content, Ca, and P concentrations compared to rats fed casein which may explain their lower kidney weights. This is important because mineral deposits in the kidneys play a role in nephrolithiasis. The pathogenesis of nephrolithiasis involves fixation of calcium (Ca) crystals to the injury site and subsequent deposition of insoluble Ca salts to form kidney stone. In our study, histological evaluation of the kidneys showed that rats fed casein had an average of ~77 Ca deposits per kidney section. On the other hand, no Ca deposits were observed in any of the kidney sections of rats fed KPC. Nephrolithiasis appears to develop after an initial renal injury occurs. Therefore, renal injury may directly result in the accumulation of crystals to form kidney stones. In our study, rats consuming KPC had lower ($P = 0.03$) urinary excretion of NAG, an indicator of early renal injury, compared to rats fed casein. Rats fed KPC also showed higher urine volume output than casein fed rats. Despite increased urinary output there was no difference in urinary Ca or P balance between KPC and casein fed rats. Additionally, there was no effect on femur total bone mineral content, Ca, P, and bone strength in KPC compared to casein fed rats. The results showed that the consumption of KPC, a novel protein source, was safe as indicated by the absence of detrimental effects on renal and bone health. In fact, reduced renal injury and Ca deposits in KPC compared to casein fed rats suggested that KPC may actually be beneficial to kidney health. Based on the study results, it is important not only to consider the amount of protein but the source when addressing nutritional options for renal health.

The role of lipids on the kidneys should be considered as well since KPC contains 8.1% lipids. KPC is rich in the omega-3 polyunsaturated fatty acids (omega-3 PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Studies have reported that rat diets supplemented with ω -3 PUFAs had decreased calcification of the renal tubules. However, it is not known whether protein, ω -3 PUFAs or both are the dietary component in seafood that is responsible for reducing the risk of nephrolithiasis. Preliminary studies showed that even the small contribution of 0.9% lipids in the total diet from KPC increased ($P < 0.01$) EPA and DHA while decreasing ($P < 0.01$) the ω -6 PUFA, arachidonic acid, content in adipose and liver tissue. However, there was no significant difference in brain tissue deposition of ω -3 PUFAs. Total antioxidant capacity and lipid peroxidation were not significantly different between groups. The preliminary results indicated that omega-3 PUFAs associated with KPC intake resulted in increased EPA and DHA tissue incorporation without changing oxidative stability.

The heterotrophic marine alga *Cryptothecodinium cohnii* is an important source of docosahexaenoic acid (DHA) because *C. cohnii* can accumulate lipid greater than 20% of their biomass with a large fraction of DHA (30-50%). Currently, DHA generation by *C. cohnii* is accomplished using large, environmentally controlled stirred tanks, referred to as bioreactors. The process uses a time-intensive batch processing method. The objective of our study was to explore continuous cultivation methods and manipulate currently reported processing parameters to develop a new process for high cell density cultivation of *C. cohnii* for the purpose of DHA production. Continuous cultivation of *C. cohnii* was conducted in two 15 L computer controlled bioreactor vessels. Temperature of both vessels was maintained at 30°C during the growth mode of the study and standard media (25g/L glucose, 5.5g/L yeast, and 25 g/L salt) was administered to both bioreactors. After 40 h, the system was switched to "continuous" mode where one vessel was maintained as a growth vessel at 30°C, and the other as a lipid accumulation vessel at 15°C. In continuous mode, a standard medium was administered to the growth vessel. Results showed that *C. cohnii* growth could be maintained in continuous production; however, biomass, lipid and DHA yields did not exceed values reported by cultivation in batch mode.

Brook trout fed a diet in which menhaden oil was replaced with flax oil grew and converted feed equally well as fish fed a control diet. Fatty acid profile was influenced by diet. Fillets of fish fed the diet treated with flax oil had more omega 3 fatty acids than fish fed the control diet. There were no initial differences between treatment and control fillets for proximate composition,

color, Tbars, or texture. In triangle tests, panelists could not reliably select the odd sample. In preference tests, fillets of fish fed the treatment diet were preferred by panelists 64% of the time. Sensory analysis showed that fillets of fish fed the control diet had a greater fish odor, oxidized odor, fish flavor, vegetable oil flavor, and aftertaste. Fillets of fish fed the treatment diet had greater juiciness and stickiness. Panelists and restaurants preferred the treatment fish to control fish.

Trout feed was supplemented with a dried inactive yeast product containing the pigment astaxanthin (ASTA). Four diets with different levels of pigment (Control, Low, Medium, and High) were fed to Rainbow Trout. Trout with an average weight of 150 g were fed the diet for 140 days. A second batch of feed was milled and fed to the rainbow trout for an additional 40 days. At the end of the experiment, ASTA concentrations in the fillets was 0.04, 1.41, 1.62, and 2.8 ppm for the C, L, M, and H treatments, respectively. There was no difference in average weight among treatments. External coloration of control and treatment fish was visually different.

A high molecular weight anionic flocculent at 65 ppm resulted in excellent protein separation (10 min reaction in a jar tester) during isoelectric protein recovery from fish processing waste. The optical density of the supernatant was comparable to that of clear water. This flocculent could be injected into the bio-reactor during the continuous adjustment of pH to 5.5, resulting in increased size of proteins, and therefore, more efficient separation during subsequent centrifugation in a decanter-centrifuge. The effluent water from the decanter-centrifuge could be re-used in the homogenization step.

A research trial was conducted to test the effect of altered dietary fatty acid profile on the ability of conjugated linoleic acid to reduce body fat and stimulate lipolysis. Results indicated that mice raised from weaning on coconut oil-diets lost more body fat when fed conjugated linoleic acid (CLA) than mice raised on soy oil-diets. The increased response to CLA in coconut oil-fed mice appears to be due to increased basal rates of lipolysis, that is not observed in soy oil-fed mice. Maximally stimulated rates of lipolysis was not altered however. We also found no difference in the expression of perilipin, a protein that surrounds the lipid droplet in adipocytes. The activation of perilipin by phosphorylation, a required step for lipolysis, tended to be increased by CLA in soy oil-fed mice but decreased by CLA in coconut oil-fed mice. This may indicate that the CLA administered to coconut oil-fed mice had already maximally stimulated lipolysis and the effect was trending downward by day 12 of CLA feeding. We also determined that skeletal muscle lipid content of the mice was reduced in addition to total body fat.

The CDC Youth Risk Behavior Survey indicates that 13% of 9th to 12th grade students in the United States are obese. In West Virginia, the rate of obesity in this age group is nearly 15%. Obesity during adolescence often tracks into adulthood and leads to an increased risk of obesity-related chronic diseases such as diabetes, hypertension, and cardiovascular disease. Obesity has proven difficult to treat, requiring an interdisciplinary approach that includes the family.

Camp NEW You is a year-long program to help obese adolescents and their families develop healthier lifestyle patterns through education and motivation in a group setting. Participants came to the WVU campus for a two-week stay during the summer of 2008. During those two weeks, they participated in learning activities related to food choices and preparation, physical activities for one or two persons, goal setting, and self-monitoring. Parents of the participants learned to assess their food and nutrition environment and to support their children. Baseline data were collected on dietary intake, degree of physical fitness, readiness for change, and physiological markers of risk. After the camp, counselors contacted the participants and their parents on a weekly basis for help with motivation and problem-solving. During October of 2008, participants and parents came to a follow-up weekend at a state park and additional follow-up weekends are planned in March and June of 2009.

Effect of harvest endpoint, sex condition, and cooking temperature on collagen content and fillet texture was determined for Rainbow Trout. Three fish from each of 3 sex conditions (immature male, IM; precocious male, PM; and female, F) were collected at 2 endpoints (June and July). Texture (Kramer Shear) of raw and cooked fillets (65 degrees C) was measured, and cook yield was determined. Additionally, sample extraction temperature (25, 45, and 65 degrees C) was considered to improve accuracy in determining collagen content. Based on hydroxyproline analysis, soluble and insoluble collagen, total collagen, and percent soluble and insoluble collagen content were determined. Sex condition affected texture (weight, g/ force, g); PM fillets were firmest (259.61 g/g) followed by F (235.68 g/g) and IM (210.89 g/g) fillets. Cook yield was not affected by sex condition in June; however, in July, cook yield followed this order: IM > F > PM (82.16 > 77.81 > 74.73 percent, respectively). Raw fillets were firmer (294.06 g/g) than cooked fillets (176.72 g/g). Highest total collagen was determined in raw and cooked samples extracted at 45 degreeC. Highest percent soluble collagen was obtained at 25 degrees C in raw samples (28.45 percent) and at 65 degrees C in cooked samples (25.67 percent). Increased percent soluble collagen corresponded with decreased percent insoluble collagen at 25 and 65 degrees C (71.55 and 74.33 percent, respectively). The amount of soluble, insoluble, and total collagen was not affected by sex condition. Sex condition impacts fillet quality, and accurate determination of collagen is a function of sample processing protocol.

2. Brief description of the target audience

Families, dieticians, consultants, policy makers, researchers

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	2	
2008	0	10	10

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Refereed journal articles

Not reporting on this Output for this Annual Report

Output #2

Output Measure

- Presentations at scientific meetings

Year	Target	Actual
2008	2	7

Output #3

Output Measure

- Workshops and meetings to end-users

Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Reduction in state incidence of obesity -%
2	Reduction in state incidence of osteoporosis and similar disorders - %
3	Adoption of electron beam technology for food safety

Outcome #1**1. Outcome Measures**

Reduction in state incidence of obesity -%

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	3	4

3c. Qualitative Outcome or Impact Statement**Issue (Who cares and Why)****What has been done****Results****4. Associated Knowledge Areas**

KA Code	Knowledge Area
702	Requirements and Function of Nutrients and Other Food Components
703	Nutrition Education and Behavior

Outcome #2**1. Outcome Measures**

Reduction in state incidence of osteoperosis and similar disorders - %

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	3	0

3c. Qualitative Outcome or Impact Statement**Issue (Who cares and Why)****What has been done****Results**

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior
702	Requirements and Function of Nutrients and Other Food Components

Outcome #3

1. Outcome Measures

Adoption of electron beam technology for food safety

Not reporting on this Outcome for this Annual Report

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

State incidence of osteoporosis and similar disorders not reported by early March, 2009.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Before-After (before and after program)
- During (during program)

Evaluation Results

Key Items of Evaluation

Program #5

V(A). Planned Program (Summary)

1. Name of the Planned Program

Production Agriculture

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
133	Pollution Prevention and Mitigation			15%	
202	Plant Genetic Resources			5%	
205	Plant Management Systems			15%	
211	Insects, Mites, and Other Arthropods Affecting Plants			10%	
212	Pathogens and Nematodes Affecting Plants			10%	
301	Reproductive Performance of Animals			15%	
302	Nutrient Utilization in Animals			10%	
303	Genetic Improvement of Animals			5%	
304	Animal Genome			5%	
307	Animal Management Systems			10%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	10.0	0.0
Actual	0.0	0.0	9.8	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	548737	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1206142	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	1249221	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct research; report results in scientific manuscripts and technical presentations; provide technology to users in popular publications and lay presentations

Both plant and animal agricultural production units in West Virginia are poorly positioned to compete in commodity markets for fruits, vegetables, field crops and livestock products due to a variety of circumstances including small acreages and generally limited land resources, difficult terrain, relatively high prices for land suitable for row crops, limited availability and high cost of labor, etc. To remain viable, West Virginia producers typically must improve production efficiency either by increasing the value of what they produce, or by producing at a meaningfully lower price, or both. Specific strategies, reflected in the West Virginia Station's research portfolio, include avoiding enterprises which require extensive amounts of mechanical tillage or harvest; reducing costs of major inputs such as feed, labor and facilities; focusing on higher priced products such as those with ornamental or recreational use; increasing real or perceived product value in specialty, niche or out-of-season markets; diversifying product offerings; taking advantage of proximity to large urban markets, etc. Said another way, our research activities focus on economic activities for which West Virginia producers have competitive advantage or at least are not competitively disadvantaged. Specific examples include cool water aquaculture, pasture raised and finished beef, out of season lamb production with predator control and internet marketing, organic production of vegetables and livestock, etc.

Digital soil mapping is a rapidly growing area of soil research that has great potential for advancing soil survey activities, and knowledge of soil-landscape relationships. Current activities in support of soil survey work in West Virginia include (i) soil property mapping using legacy data and pedometric techniques, and (ii) examination of scale effects on terrain attribute calculation and their use as environmental covariates for digital soil mapping. Work is being conducted to create detailed soil property maps across the Northeast and North Central United States by developing generalized models using both point and polygon data sources. Point measures are derived from NRCS Soil Survey Division pedon data and Forest Service Forest Inventory and Analysis (FIA) program sample data. Polygon data come from the NRCS US General Soil Map (US GSM, or STATSGO2) and the Soil Survey Geographic Database (SSURGO). Various pedometric techniques, such as multivariate linear regression and regression trees, are used to develop statistical models from point data and complementary environmental covariate data. Soil property predictions from polygon data were generated using measure-and-multiply approaches and spatial disaggregation techniques using environmental covariates. These two spatial predictions are combined to produce raster soil property maps. Current studies on the effects of scale on terrain attributes include evaluation of systematic effects of varying both grid and neighborhood size on terrain attributes computed from high-resolution DEM, and examination of how the correlations between soil and terrain attributes vary with neighborhood size, so as to provide an empirical measure of what neighborhood size may be most appropriate. Results suggest that the overall representation of the land surface by terrain attributes is specific to the land surface, but also that the terrain attributes vary independently in response to spatial extent over which they are computed. Results also indicate that finer grid sizes are more sensitive to the scale of terrain attribute calculation than larger grid sizes.

The application of this research has great potential for advancing soil survey activities and knowledge of quantitative soil-landscape relationships, primarily through the development of strategies for incorporating quantitative spatial procedures into soil survey methods. In the next generation of soil survey updates for West Virginia, the availability of digital elevation models, particularly those at fine resolutions, provides the base to apply terrain regressions that describe the functional relationships of terrain characteristics (e.g., elevation, slope gradient, slope aspect, slope curvature) to soil physical and chemical properties, soil classes, and soil climate characteristics. In particular, the methodologies used are able to successfully identify soil-landscape relationships at the watershed scale using a relatively small number of samples.

Limited information is available regarding sustainability of pasture raised beef production, especially for winter grazing periods. The focus of this project is on generating new knowledge regarding spatial variation of soil properties in pasture soils, and its relationship with forages and pasture productivity and sustainability. Results to date indicate a relationship between soil properties and pasture development and yield. There is spatial variability in the soil properties inside each paddock, however differences in soil properties between paddocks are also evident, with differences in soil properties and pasture yield between paddocks/plots seemingly related to landscape position. Preliminary data evidence suggests interactions between landscape, soil, pasture and seem to support the hypothesis that soils in the Appalachian region have certain physical characteristics (e.g. Gilpin series) that might favor winter grazing and sustained pasture production.

Previous laboratory incubations have shown that soil organic matter facilitates the reduction of iron oxides and subsequent phosphorus solubilization. We now have field data to confirm that a sideslope pasture soil was sufficiently reduced in June 2008 for this reaction to occur. We analyzed over 1000 E. coli isolates obtained from feces of winter-grazing cattle and from the soil of the grassland they grazed. Isolates were compared using antibiotic resistance analysis. Sixteen antibiotics were tested using the Kirby Bauer procedure. Antibiotic zone diameters were determined by principle component analysis. Repetitive element PCR (rep-PCR) DNA fingerprints were generated and PCR banding patterns were assigned strain identities and similarities among strains were investigated by Unweighted Pair Group Method with Arithmetic mean analysis. There was greater diversity among fecal isolates compared with those obtained from soil. Some fecal isolates could be detected in soil, but in general did not persist. Preliminary soil base-line data were taken at Reedsville Experiment Farm on six paddocks grazed by winter stockers for the previous 3 years. The geospatial position of soil sampling points was recorded using a GPS unit, and differentially processed using specialized software. Soil information collected was: penetration resistance using a RIMIK logging penetrometer, soil moisture content, bulk density, and soil texture. Soil penetration resistance was collected for 40 to 50

points/paddock, in 2 cm increments from 0 to 50 cm depth, and at different times of the year. We found an increase in penetration resistance after winter grazing (fall to spring), however, the persistence of this "compaction" was variable, depending on soil properties. Preliminary data indicate that there is a relationship between soil properties and pasture development and herbage accumulation. Spatial variability in soil properties within each paddock support the hypothesis that soils in the Appalachian region have physical characteristics (e.g. Gilpin series) that favor winter grazing and sustained pasture production.

Year 4 of the winter-forage stockering systems was initiated 11/07/07 and completed 4/08/08. Four winter forage-feedings-systems, designated as naturalized grassland (NG), orchardgrass hay (OGhay), orchardgrass haylage (OGhaylage), and tall fescue (TF) were evaluated. The OGHaylage averaged 0.56 kg/hd/d gain with only stockpiled forage and orchardgrass haylage. The NG, OGHay, and TF averaged 0.51, 0.43 and 0.47 kg/hd/d gain, but with some soyhull supplementation. We have developed simple-to-use Excel computer models that enable farmers to evaluate economic risk for forage species and mixtures used on farms in the region. Weather data bases for all states in the region were developed as well as generalized rainfall probabilities for use in these models. These models show how local weather, due to location (elevation, position relative to mountains), determines when cool- and warm-season forages on different paddocks reduce economic risk.

The overall objective of this project is to re-establish the sheep industry in West Virginia. A major new effort in 2008 was the addition of performance testing of young male goats using the Grow Safe System to obtain values for residual feed intake (RFI) and usual traits of growth, carcass quality and breeding soundness. More flock pregnancy diagnosis, shearing schools, talks to producers and ram and goat breeding soundness exams were performed in 2008.

Research data from two tests in young rams were used to investigate relationships among production traits and behavior. Data included 37 Dorset, Suffolk or Khatadin rams in yr 1 (60 days) and 44 Dorset or Suffolk rams in yr 2 (64 days). Rams were fed a pelleted ration *ad libitum* and had access to one feed node per pen in yr 1 and two nodes per pen in yr 2. Feed intake, number of visits, feeding events, non-feeding events, feeding location, RFI, average daily gain, scrotal circumference, loin eye area and fat thickness were measured. Negative RFI animals consumed less feed ($P < 0.01$) than positive animals. In yr 1 but not yr 2, negative RFI rams had fewer visits ($P < 0.01$), feeding ($P < 0.01$) and non-feeding events ($P < 0.05$), and a faster eating rate ($P < 0.01$). In both years, single-born rams had greater initial and final weights ($P < 0.01$), and 70% of feeding events occurred during daylight ($P < 0.01$), with less than 113.5 g consumed per bout. In conclusion, RFI had limited relationships with feeding behavior.

In previous work with embryonic and fetal mortality of lambs, different breed groups had different rates of loss. That result indicated that loss or survival of individual lambs during the prenatal period had a genetic basis. A study was initiated to examine whether mortality varied with service sires to which the ewes were bred. Collection of data is complete on 923 ewes pregnant to 60 different rams. Analyses are underway, looking at location, breed, and season as well as individual rams that sire the embryos. Age of both ewe and service sire will be examined.

Another study, a collaboration between Dr. Gene Felton at WVU and Dr. Justin Luther at North Dakota State, is motivated by our earlier finding that low progesterone contributed to embryonic and early fetal losses and the finding that treatment with arginine, an amino acid that is a precursor of nitric oxide, which increases blood flow to the reproductive tract, increased litter sizes in pigs and rats by about two piglets or pups. Dr Luther obtained data that injected arginine increased blood flow to the ovaries and corpora lutea (source of progesterone) in ewes. Treatment for the first 15 days of gestation seemed to decrease losses in a small sample of pregnant ewes (11 to 12 per group). To test this concept, ewes have been treated on days 1 to 7 after mating, the period when cells in the embryo are dividing rapidly and the critical transformation from morula to blastocyst begins. That trial is underway in the Wardensville hair sheep flock. A second trial has been initiated during another critical period, maternal recognition of pregnancy during days 11 through 17, as an undergraduate research participation project with Edith Johnson in the WVU teaching flock.

An on-going project in the West Virginia Station is focused on 5 specific objectives that pertain to or can drastically impact forage based ruminant livestock production in the hill lands of the eastern United States. The objectives were to: 1. Investigate the effectiveness of incorporating legumes in pastures for cow-calf production, 2. Investigate the value of supplementation on pasture-finished beef produced from naturalized cool-season grass pastures, 3. Improve the cost and efficiency of nutrient utilization with supplementation on pasture, 4. Determine need and effectiveness of control of horse nettle and ironweed in pasture, and 5. Determine the effects of grazing management on grassland productivity in subsequent seasons.

Systems research with regards to ruminant production is a major focus of this project. Direct results generated from the project "NE 1024 Whole Farm Dairy & Beef Systems for Environmental Quality" are derived from experiments that are a part of the investigation of beef production systems. Specific to this report, the area of research described investigated progeny of bulls selected for high (POS; less efficient) and low (NEG; more efficient) residual feed intake and their performance on pasture and in reproductive development. POS heifers tended to have more carcass fat and reach puberty at a slightly younger age than did the NEG heifers with no difference in any other measures of description (frame, size, growth, body condition) or conception and pregnancy rates. In a pasture experiment, steers were allotted to 1 of 4 treatments, with treatment group being randomly assigned to 1 of 4, one-hectare plots (subdivided into 4 subplots for rotational grazing) located in 3 areas of differing terrain. Thus, steers were stocked at a rate of 4 hd per hectare with 4 treatments equally represented within each terrain classification. Treatments tested were 4 positive RFI steers per pasture (POS), 4 negative RFI steers per pasture (NEG), 2 positive RFI steers per pasture lead grazing with 2 negative RFI steers follow grazing (+/-), and 2 negative RFI steers per pasture lead grazing with 2 positive RFI steers follow grazing (-/+). Results from measurements taken from the beginning of the experiment to late June

(Period of excess forage) indicate that POS stocked pastures have more forage disappearance than NEG stocked pastures with no difference in animal performance. There was also no difference in pasture disappearance between +/- and -/+ stocked pastures. Although not significant, numerical differences in gain indicate that negative RFI sired steers are better able to utilize material left by forward grazed positive sired steers while no difference was seen in weight gain when positive RFI sired steers followed negative RFI sired steers. Results from late June to early August (Period of limiting forage indicate a 1.3 fold improvement in daily growth of NEG vs. POS steers. Raw means of the -/+ vs. +/- treatment showed similar better use of forage as seen in the earlier period with 1.6 fold greater ADG.

Systems research with regards to ruminant production is a major focus of the researchers involved in an on-going project in the West Virginia Station. Results generated from the project "Forage Based Ruminant Production" are the direct result of and derived from experiments investigating a beef production system. The areas focused on in this systems work were: cow calf and summer forage production to carry retained animals through the winter, raising and finishing calves on pasture with appropriate supplementation when needed to allow animals to be harvest off of pasture under 2 years of age, improving production efficiency and, investigating animal/forage/soil interactions that occur. Two systems of cow calf production were compared over 8 years, with the last 6 being part of the current described project. Each system (6.5 ha) consisted of grassland managed as pasture (2.5 ha), hay (2 ha) and a buffer (2 ha) which was cut for hay and then grazed. Eight cow/calf pairs were utilized per each grazing system. Two levels of soil fertility were maintained in each system. One system used overseeding with red clover (OVERSEED) and the other used 56 kg/ha of N applied as urea (UREA) in early spring to areas used for first cut hay. Soil tests were made each fall and lime, triplesuperphosphate and KCl applied to maintain the two levels of soil fertility. The OVERSEED system had a pH of 6.0, with 100 kg available P, 330 kg K and 347 kg Mg/ha. The UREA system was lower in each of these tests (pH 5.9, 10 kg available P, 321 kg K and 247 kg Mg/ha). Grassland never harvested as hay was lower in pH and higher in available P and K than hayed areas. Average hay production (dry matter) over 7 years was 4751 kg/ha on the OVERSEED system and 5784 kg/ha on the UREA system. Percentage legume in hay from hay and buffer usages from the UREA was 4% compared to 10% for the OVERSEED. Weed percentage was also higher for OVERSEED (11 vs 8%). Soil fertility level had no effect on botanical composition, but DM accumulation was 4920 kg/ha on low soil fertility grassland compared to 5621 kg/ha on high soil fertility. First cut hay production was higher on the buffer usage (5482 kg ha⁻¹) than on the hay usage (5054 kg/ha. Weed percentage was lower on buffer usage. Over the last 6 years, neither cow body weight (BW) at the end of the grazing season nor pounds of calf weaned off of these systems differed. However, fluctuations in cow BW were greater for the system utilizing applied N. No reproductive differences were observed. Concurrently to the cow calf experiments, pasture finishing experiments took place on set stocked naturalized pastures. Optimal stocking rates, without any supplementation early season, were determined to be at 4 animals per ha from early May to mid to late July. Starting mid-summer without supplementation approximately 2 animals per ha were all that could be supported, still yielding acceptable carcasses. With supplementation at 1.25% of body weight of high energy fiber based supplement starting in mid-summer, optimal stocking rates were near 4 animals per ha.

A project was conducted to assess the legal/institutional framework supporting aquaculture in West Virginia. Investigators concluded the regulatory environment as it relates to aquaculture is supported by a convoluted statutory/regulatory structure. There is no centralized leadership from state regulators, resulting in poor flow of information to the public and to lawmakers; poor response to entrepreneurs seeking to invest in aquaculture, and uncertainty regarding natural resource rights and responsibilities. The state has no aquaculture plan/development act and is characterized by the absence of interagency communication / cooperation and limited state financial investment. A mechanism proposed to begin addressing these problems has been endorsed by the West Virginia Aquaculture Association and WV Farm Bureau.

Verification and application of a computer simulation model (RDSS) developed to assist fish management was based on data generated from brook trout production at a WVU production site. Observed and estimated average fish weights match closely for the first several months of growth, and then diverge as fish approach sexual maturity. RDSS underestimates fish length for approximately the first five months, then overestimates it.

Ten markers previously developed for use in genetic evaluation of bluegill sunfish have successfully amplified microsatellite sequences in a variety of sunfish species, including red ear sunfish, green sunfish and two types of hybrid bluegill that are likely products of a green sunfish mating. Differences in allele size between individual sunfish within each species have been identified.

Geospatial technologies can make significant contributions to spatially targeted pest management strategies. A total of 20 putative bacterial leaf scorch samples were taken from symptomatic maple trees in Monongalia County West Virginia. Enzyme-linked immunosorbent assay (ELISA) was used to detect the presence of causal bacteria, *Xylella fastidiosa*. Samples were tested early in the summer and samples were re-taken and tested in autumn. Results of Enzyme-linked immunosorbent assay (ELISA) to detect the presence of causal bacteria, *Xylella fastidiosa*, showed that the maple trees were slightly positive, indicating a chance of *X. fastidiosa* infection. More detailed experiment will be followed next year to confirm the presence of bacterial leaf scorch in Monongalia County where no bacterial leaf scorch has been reported in West Virginia.

Laboratory experiments were conducted to determine plants that attract Multi-colored Asian lady beetles using choice tests. Multi-colored Asian lady beetles were collected from the field and propagated in the entomology laboratory by feeding aphids. Ten plants that can attract and provide multi-colored Asian lady beetles with nectar and pollen were selected from the literature. These plants include dill (*Anethum graveolens*), tansy (*Tanacetum vulgare*), goldenrod (*Solidago* spp), sunflower (*Helianthus annuus*), yarrow (*Achillea* spp.), butterfly weed (*Asclepias tuberosa*), morning glory (*Ipomoea* spp.), dandelion

(*Taraxacum officinale*), bugleweed (*Ajuga reptans*) and marigold (*Tagetes tenuifolia*). The preference of multi-colored Asian lady beetles to different plants was investigated with a choice test by using a Y-tube olfactory meter. For each choice test, five females and five males were used. The data of each experiment was analyzed for significant preference differences by chi-square test. When bugleweed and dandelion were compared, lady beetles preferred bugleweed over dandelion. In addition, lady beetles showed preference to yarrow over marigold, dill over butterfly weed, morning glory over goldenrod, and sunflower over tansy. However, there was no significant difference between male and female lady beetles attracted to certain plants. Additional test results showed that the top two attractant plants out of ten were sunflower and dill. The findings of this study showed the potential of sunflower and dill as companion plants to help recruiting biological control agents for pest management in the field.

An experiment was conducted in a grower's peach orchard to evaluate DuPont's Avaunt and Altacor insecticides for insect (including stink bug) control. The study site consisted of a 21 acre block of 8-yr-old Bounty, PF5, Sentry, and Redskin trees on Lovell rootstock planted at a spacing of 18 x 24 ft. The western 10 acre portion of the block was designated for the Avaunt/Altacor program, with the eastern 11 acre portion designated for a standard insecticide program. All insecticides were applied as alternate-row-middle sprays with a Durand-Wayland airblast sprayer, which traveled at 2.7 mph and delivered a spray volume of 100 gal/acre. Six applications of Avaunt (3 oz/acre) were applied from May 7 to June 10, followed by six applications of Altacor (1.5 oz/acre) from June 14 to July 21. In both Avaunt/Altacor and standard treatments, stink bugs were monitored weekly with three yellow pyramid/plastic jar traps suspended from horizontal branches of trees. Traps were baited with a *Euschistus* spp. aggregation pheromone lure that was changed every four weeks. Data were taken on 10 randomly-selected single trees of the Bounty cultivar in each treatment. Fruit injury from stink bugs was determined by evaluating 50 fruit from each single-tree replicate. Capture of stink bugs was generally low and similar in both treatments through early July, but then became increasingly higher for the remainder of the season (ending in early August) in the Avaunt/Altacor treatment. Stink bug catfacing/scarring injury was low and similar in both treatments in June, whereas this and gummosis/watersoaked injuries were higher in the Avaunt/Altacor treatment at harvest.

An experiment also was conducted to evaluate various insecticide treatments for stink bug control in a peach orchard at the WVU Tree Fruit Research and Education Center. The study site consisted a 2.1 acre portion of a 5.2 acre block of 6-yr-old Bounty trees on Lovell rootstock planted at a spacing of 20 x 23 ft. The experimental design consisted of 5 single-tree replications per treatment in a randomized block design, with each replicate surrounded by at least one unsprayed tree on each side. Insecticides were applied as complete sprays to both sides of the trees with a Durand-Wayland DA500A airblast sprayer, which traveled at 2.6 mph and delivered a spray volume of 100 gal/acre. Fruit injury from stink bugs was determined by evaluating 50 fruit from each single-tree replicate. DPX-HGW86/Imidan and the high rate of BAS 32000I resulted in a significantly lower level of catfacing/scarring injury from stink bugs than in the untreated check in July. In the harvest evaluation, there were no significant differences among treatments in this injury. All treatments reduced the incidence of gummosis injury, caused by late season stink bug feeding, below that in the untreated check in the harvest evaluation.

A project was conducted at the WVU-KTFREC to evaluate the performance of a botanical insecticide (ARY-0504-015) derived from an herb for insect control on apple. The experimental design consisted of 4 single-tree replications of 30-yr-old Rome trees that received seven applications of this product, applied at 100 gal per acre with a Durand-Wayland airblast sprayer. The full rate of ARY-0504-015 provided good activity against codling moth (CM) and oriental fruit moth (OFM), however the level of injury was numerically higher than in other treatments in July. One quarter rate of this product did not contribute to any control of CM & OFM when used in combination with other standard insecticides. ARY-0504-015 had no activity against spirea aphids. At harvest, fruit treated with the full rate of this product had a higher incidence of CM & OFM entries than fruit treated with other standard products. The one quarter rate of this product in combination with other materials did not contribute any control of CM & OFM, as control was not significantly better than that provided by the other materials used alone. The full rate of ARY-0504-015 had the lowest injury from San Jose scale. The full rate of this product, and one quarter rate in combination with other materials, provided a comparable level of clean fruit. Of the spray treatments, the greatest incidence of worms in harvested fruit (19) occurred in the full rate treatment of ARY-0504-015, with 74 percent being codling moth. A second experiment was conducted to evaluate recently registered insecticides for insect control on apple. The experimental design consisted of 4 single-tree replications of 25-yr-old Delicious trees that received two to three applications of each product in a season-long program with other standard insecticides. All sprays were applied with a Durand-Wayland airblast sprayer. Movento and Voliam flexi provided excellent control of spirea aphids. There were no significant differences in spirea aphid control between the two application rates of Movento (6 and 9 oz per acre). Treatments of Voliam flexi/Proclaim/Assail/Delegate and Delegate/Intrepid/Altacor resulted in less than 1 percent injury from codling moth and oriental fruit moth. A pink application of Assail provided more effective control of tarnished plant bug than pink applications of Calypso and the low rate of Movento. The high rate of Movento was very effective against San Jose scale.

The grower peach trial demonstrated that the early season use of Avaunt was comparable to the standard insecticide program (Imidan) in the control of stink bugs, since the level of fruit injury in June was similar in both treatments. However, the use of Altacor in the second half of the season resulted in a 9 and 3 percent greater incidence of catfacing/scarring and gummosis/watersoaked injuries, respectively than the standard insecticide program at harvest. Other materials will need to be tank-mixed or substituted for Altacor in the peach pest management program in order to maintain effective control of stink bugs. The evaluation of new candidate insecticides and control timing strategies has the potential to increase fruit quality and economic return, and result in more effective use of insecticides for stink bug management.

The fire blight management tool, Maryblyt, predicted the onset of shoot blight symptoms within 48 hours of their appearance in 3 of the 4 years studied, and this report is the first to validate the shoot blight portion of the Maryblyt model. In the third year of the study, the first occurrence of shoot blight was observed 6 days later than the predicted date. The basis for shoot blight predictions in the Maryblyt model is the presence of blossom blight or canker blight and 375 accumulated degree days (base 4.4 C) after bud break (i.e., green tip). The required degree day accumulation is based on the appearance of adults of the putative vector white apple leaf hopper. No variations in insect occurrence or development rate were noted, therefore the delay in shoot blight appearance in year 3 could not be explained by differences in vector populations or their rate of development. Additional research is needed to gain a better understanding of the role of insects and weather in the development of shoot blight epidemics. Our observations of blossom blight development in relation to Maryblyt predictions are in agreement with previous studies. Of the four cultivars examined, disease incidence and rate of disease increase was greatest in York. This observation agrees with previous reports of high susceptibility of the cultivar York to *E. amylovora*. However, Fuji has been reported to be as highly susceptible as York, and our results do not support this ranking. The mathematical description of these fire blight epidemics by the logistic model has been associated with a polycyclic disease cycle, which is typified by the secondary spread of inoculum. For the cultivar York, the apparent infection rate for shoot blight ranged from 0.053 to 0.20/day in the year in which shoot blight was most severe. These values show that disease incidence can increase dramatically, easily doubling in 3 to 5 days when environmental conditions and host susceptibility are highly favorable. It should be noted that these infection rates were observed under a disease management strategy that was considered optimum at the time (i.e. copper applied at the 1-cm stage of leaf development, applications of streptomycin during the bloom period, as determined with the Maryblyt model, and removal and destruction of infected plant tissues on a weekly basis).

2. Brief description of the target audience

Producers, extension specialists, consultants, regulators, policy makers, researchers

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	4	
2008	0	6	6

V(F). State Defined Outputs

Output Target

Output #1**Output Measure**

- Research manuscripts

Year	Target	Actual
2008	4	4

Output #2**Output Measure**

- Scientific presentations

Year	Target	Actual
2008	8	4

Output #3**Output Measure**

- Popular articles

Year	Target	Actual
2008	2	2

Output #4**Output Measure**

- Producer presentations, workshops, etc.

Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Growth in state production of beef and lamb %
2	Increase in production/consumption of pasture finished beef %
3	Increase in state aquaculture industry %
4	Increase state production and sales of organically produced vegetables %
5	Growth in state's ornamental horticulture industry %
6	Develop and market organic control for honey bee mites - adoption %

Outcome #1**1. Outcome Measures**

Growth in state production of beef and lamb %

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	2	9

3c. Qualitative Outcome or Impact Statement**Issue (Who cares and Why)****What has been done****Results****4. Associated Knowledge Areas**

KA Code	Knowledge Area
205	Plant Management Systems
303	Genetic Improvement of Animals
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
307	Animal Management Systems

Outcome #2**1. Outcome Measures**

Increase in production/consumption of pasture finished beef %

*Not reporting on this Outcome for this Annual Report***Outcome #3****1. Outcome Measures**

Increase in state aquaculture industry %

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	8

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
303	Genetic Improvement of Animals
133	Pollution Prevention and Mitigation
307	Animal Management Systems
302	Nutrient Utilization in Animals

Outcome #4

1. Outcome Measures

Increase state production and sales of organically produced vegetables %

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
212	Pathogens and Nematodes Affecting Plants
211	Insects, Mites, and Other Arthropods Affecting Plants
205	Plant Management Systems
133	Pollution Prevention and Mitigation
202	Plant Genetic Resources

Outcome #5

1. Outcome Measures

Growth in state's ornamental horticulture industry %

Not reporting on this Outcome for this Annual Report

Outcome #6

1. Outcome Measures

Develop and market organic control for honey bee mites - adoption %

Not reporting on this Outcome for this Annual Report

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

Neither adoption of the honey bee mite control which was developed nor growth in the state ornamental horticultural industry is not measured in a routine or reliable way and will be replaced as a program outcome in future plans of work.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Before-After (before and after program)
- During (during program)

Evaluation Results

The number of trout and other cool water fish producers in West Virginia has been highly variable from year to year. We likely will use changes in two or multiple-year averages as an outcome measure in the future

Key Items of Evaluation

Program #6

V(A). Planned Program (Summary)

1. Name of the Planned Program

Production Forestry - Timber Management and Wood Utilization

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
123	Management and Sustainability of Forest Resources			80%	
511	New and Improved Non-Food Products and Processes			20%	
Total				100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	6.0	0.0
Actual	0.0	0.0	8.3	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	471919	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	868025	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	740213	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct research, report results, assist with technology transfer

This program includes research to develop optimum procedures for hardwood timber management and harvest, to increase the efficiency of wood utilization while developing new uses for hardwoods, and, increasingly in the future, to devise new processes to efficiently utilize wood and timber resources in the production of renewable bio-energy and bio-products. Timber management research includes specifically the development of models to predict yields, systems to protect forest resources from insect pests, disease, and invasive species; harvest management protocols for optimum regeneration and re-growth; methods to use harvest and processing wastes to efficiently produce bio-energy; programs that respond to research needs and concerns of corporate and private owners and provide economic comparisons among alternative management and harvest methods.

Wood utilization research likewise is focused on hardwoods with a goal of maximizing hardwood timber to lumber throughput, reducing the impact of brown rot fungi; development of non-destructive methods to determine lumber strength and stiffness, expanding uses for Appalachian hardwoods; and devising sawmill systems for moderate sized to small operations. Additional research will develop systems for use at harvest to optimize bucking; develop new uses for low quality hardwoods, use ground penetrating radar to develop non-destructive scanning methods to identify subsurface defects in hardwood logs and incorporate cellulose nanocrystals into biopolymer composites to determine the effect on mechanical properties.

An optimal tree-stem bucking system was developed for central Appalachian hardwood species using 3D modeling techniques to generate log bucking decisions and increase the value of the tree stem. The 3D optimal bucking system for Appalachian hardwood species could increase values from 26-43% per tree stem. The bucking comparison will provide results to analyze how to optimize log bucking.

Stranding variables were adjusted to produce an acceptable strand for OSB production while reducing the fines content, hence improving the yield from logs used to make OSB. Through this research "Increased Use of Low-quality Wood in the Upland Hardwood Region of North America" we have determined that a geometrically desirable strand could be produced from oak species for OSB production. Panels containing various percentages of oak were produced and tested for mechanical properties. Results indicate that oak may be used for OSB production in moderation.

Approximately 100 tons of pulpwood was produced from traditional supply chains in cooperation with five wood products companies in West Virginia to investigate the feasibility of an improved merchandizing program. Currently, over 400 sawlogs have been merchandized from the pulpwood procured from industry cooperators, and resulting lumber yields have been documented. Results from this research showed what characteristics need to be addressed when maximizing returns from pulpwood inventories. The research on improved pulpwood merchandizing has found definite trends in economic feasibility related to the species and characteristics of pulpwood that is merchandized and has shown improved yields during the production of value-added products from merchandized pulp.

Ground Penetrating Radar (GPR) has shown the ability to detect embedded defects in wooden logs and provide information that can be used to develop automated algorithms for orienting the cutting blade for optimal sawing, thus minimizing defects in finished products and increasing their market value tremendously. Significant increase in productivity can be achieved by regulating and coordinating the sawing process through the active control of saw blade's orientation and or the log orientation based on prior knowledge of the interior defects. These yield improvements are in addition to the reduction in waste from conversion of presently discarded logs into lumber.

Cellulose nanocrystals were produced from Avicel, recycled pulp, hardwood dissolving pulp and pine dissolving pulp using three "Green" technologies, sono-chemical-assisted and microwave assisted hydrolysis. Four solvent systems, deionized water, maleic acid, oxalic acid, and endoglucanase enzymes were evaluated. In deionized water, Avicel produced cellulose nanocrystals with average diameter of 21, plus or minus 5 nm (minimum 15 nm and maximum 32 nm). Cellulose nanocrystals from recycled pulp were not distinctively spherical and had an average diameter of 23, plus or minus 4 nm (minimum 14 nm and maximum 32 nm). Only one treatment of maleic acid produced cellulose nanocrystals and only from Avicel. These were cylindrical in shape and were of greater dimensions, length of 65, plus or minus 19 nm and width 15 nm. Cellulose nanocrystals from microwave-assisted hydrolysis of hardwood dissolving pulp and Pine dissolving pulp are currently undergoing characterization. Current commercial nanofillers such as nanoclay are all produced from non-renewable finite resources. A potential alternate nanofiller is cellulose nanocrystals from wood residues. It has the potential of creating a high value product from wood residues.

A regional sawmill support program was developed to help sawmills define their profitability in terms of their standard log grades and to help them benchmark their productivity against their competitors. The regional log and lumber yield initiative has conducted 12 visits in 2007 to 3 hardwood sawmills. Log and lumber characteristics were collected on >750 logs representing 7 hardwood species during these visits. A total of 30 visits have been made through the course of this study and over 2000 logs have been followed through the production process.

Preliminary research demonstrated that veneer clippings can be successfully transformed into composite materials using traditional consolidation and gluing technologies. Furthermore, it was confirmed that mechanical properties of the composites can be engineered by statistical methods. Different matrix materials were used as binders in order to select the best viable combinations. Among them we find the polyurethane foams (PU) as a potential component of the new clipping-based products. In the reported period various PU-veneer prototypes were produced and their mechanical properties analyzed. The successful

completion of the project will lead to well defined technological steps for manufacturing novel composite materials both for interior and exterior applications. The obtained results could provide motivation to initiate pilot-manufacture of the proposed products. Additionally, the scheduled analytical works may provide useful information to the composite industry in future development processes. Furthermore, the raw material source for the wood based composite industry will be extended without increasing logging.

Understanding the underlying factors influencing forest management decisions of a diverse group of private forest landowners could form the basis for developing, modifying and targeting policy instruments to motivate non-industrial landowners in forest management. The main objective of this research is to conduct a comprehensive survey of private landowners in West Virginia to provide information on the different aspects of their behavior related to the management, production and utilization of forest resources and implications on the hardwood resources of the State.

Two sets of surveys have been conducted to date. The first was conducted in 2005 and examined four categories of decisions related to forest management: timber harvest, silvicultural activities (i.e., tree planting, herbicide application, fertilization, thinning, grapevine control, and timber stand improvement), property management activities (i.e., road construction, road maintenance, surveying/boundary maintenance, and access control), and wildlife habitat management and recreation improvement activities. Four models were developed to examine factors affecting each category of forest management activity. The results showed that landowner, ownership, and management characteristics of private landowners are associated with their forest management decisions. Specifically, age, education, profession, income, ownership size, period of forestland acquisition, distance of the forestland to the place of residence, whether the forestland was purchased or acquired through inheritance or as a gift, primary objective of forestland ownership, and presence of a written forest management plan were found to be significant determinants for at least one of the categories of forest management activities. The models explained 25%, 27%, 31%, and 24% of the variation in timber harvesting, silvicultural activities, property management activities, and wildlife habitat management and recreation improvement activities, respectively. The second survey conducted in Fall of 2008 examined landowners participation in West Virginia's Managed Timberland Tax Program. Data entry and analysis is currently on-going.

Atmospheric deposition is thought to impact forest productivity through, among other things, depletion of soil calcium, and deterioration of water quality through increased nitrate leaching to streams. A greater understanding of nutrient release dynamics from organic matter such as leaf litter in the forest floor under conditions of atmospheric deposition and liming with calcium will help determine actual impacts and effectiveness of remediation methods.

A research trial investigating effects of atmospheric deposition and forest management effects on sustainable forest productivity showed that high levels of atmospheric nitrogen deposition decreased nitrogen retention in foliar litter and probably contributes to nitrogen leaching in forests. This study, done in collaboration with the USDA Forest Service, also has implications for phosphorus nutrition in forest trees.

Additionally, this work gave rise to a new approach to determine whether foliar litter can act as a nitrogen-retention mechanism in forests. Results of this study have practical implications in mitigating the effects of atmospheric deposition on forest productivity. A new study begun in August 2007, is analyzing tree biomass changes under nitrogen deposition. Root samples will be collected to determine effects of nitrogen deposition on tree root biomass. This work builds on previous work and will culminate in the development of nutrient budgets for young forests impacted by deposition and treated with lime. An extension of this project was an analysis of stream water chemistry in another forest impacted by atmospheric deposition - in Adirondack Mountains of NY to determine spatial and temporal variation in water-dissolved elements.

In another effort, the pilot study started in fall, 2004 to determine the fate of nitrogen released from leaves decomposing with small woody pieces as a carbon source, has ended. Samples were analyzed with and research results shared in a major forest soils conference, as well, as submitted as a research note to a scientific journal. Through this study, I was able to provide preliminary evidence for the fate of N mineralized from leaf litter. The importance of this finding is in increased understanding of nitrogen cycling in forests.

Maximizing profits during the conversion of hardwood logs into hardwood lumber is a primary concern for sawmill owners. Recently there has been an increase in the competition for hardwood logs in order to meet increasing demands for timber products. It is also critical to use timber resources efficiently because of the trends of increased log costs and limited availability. An optimal sawing system is needed to provide the most efficient method of maximizing the grade and yield of hardwood lumber from saw logs, which is a start to solving these problems. Once information about the shape of a log, and number and position of internal and external defects is obtained by scanning, a suitable sawing strategy is needed to combine the information and determine the optimal sawing pattern. The first cut determines the remaining cuts which must be either parallel or perpendicular to the first cut in the grade sawing method. The key to the sawyer is the ability to combine scanning information and an optimal sawing algorithm to maximize the lumber value and yield. During the production of lumber, the best *open face algorithm* developed can help the sawmill operators to correctly select the first opening face, which is critical to receiving the highest yield lumber from a log. At the same time, the *heuristics log grade sawing algorithm* can determine the greatest lumber value from a given log. An algorithm to determine the best opening face on a hardwood log, using log shape and surface defect data has been developed, which is suitable to grade sawing method. Log grading is obtained by a computer algorithm which is based on grading rules developed by the US Forest Service. A second algorithm based on NHLA grading rules, is nearly complete to grade the sawn lumber.

Additionally, we have developed a software system to implement the algorithms in a 3-D visual simulation environment. When a sawyer selects a log from the database, a 3-D visual log will be generated and displayed in the screen. By clicking the

"live sawing" button, the log can be sawn from the best open face. So far, only the live sawing has been simulated. The user can change the sawing factor, such as lumber sizing and kerf width to reproduce lumber at the same log. The generated sawing patterns will be displayed in the 3-D environment. Users can view the lumber either from the small end or the large end of the log by rotating it. The detailed information about all the lumber including lumber dimension, surface measure area, volume, value, and grade is displayed in the designated area of the screen. A hardwood grade sawing algorithm is being developed considering that most sawmills use grade sawing method to produce lumber to date. The program is expected to be uploaded to a website and accessible to the general public for ease of use and convenience. The system can be used as a decision-making system for hardwood lumber production and training tool for novice sawyers.

A survey of methods employed by university wood science and technology (or related) programs to improve public awareness and understanding of their programs has been developed and is expected to be administered in January. The survey is being conducted in collaboration with the Society of Wood Science and Technology as a project of the Society's Committee on Education. In addition, proposals have been submitted to obtain supplementary funding from external sources to support this line of research. Participation in a National Research Needs Workshop and the 51st Annual Convention of the Society of Wood Science and Technology as the Society's President was part of a larger effort to advance the profession through better articulation of research and educational needs in wood utilization and in advancing better international cooperation within the profession. It is expected that this project will identify positive messages concerning the wood products industry and forest management and test the effectiveness of those messages in improving public perceptions about the industry and its related professions. Promotion of wood science and technology on an international level through the vehicle of the Society of Wood Science and Technology resulted in the Society's first annual convention held outside North America and led to the initial accreditation by SWST of a program outside the United States.

Celastrus orbiculatus (bittersweet) is a deciduous, dioecious round-leaved vine that establishes under closed canopy forest conditions and persists indefinitely until it is released by a disturbance that creates conditions optimal for rapid growth. It invades forested land but has also been known to persist on coasts and may possibly disrupt dune formations. *C. orbiculatus* can overtop and girdle native trees and shrubs along roads, in clearings and in forest gaps. Identifying and eradicating populations before they are released by an opening in the canopy is the easiest method of control. A study of control methods was conducted in Marion County, West Virginia. The study site is on a property that is approximately eighty eight acres and has an elevation of fifteen hundred feet. The slopes are generally north facing. There are two types of forest covers; cove hardwoods and yellow poplar-red maple.

Four treatments were applied to each of ten individual bittersweet stems. Treatments were randomly applied to selected vines. These treatments were: -Cut/No fence. The cut treatments were applied by cutting bittersweet stems 10cm from the ground using a lopper. -Cut/Deer Fence. Mechanical cut treatment with small fence of four feet tall and four feet in diameter around the individual vines. Each vine was cut at 10cm from the ground. -Basal Bark herbicide. Basal bark application with the lower proportion of the trunk sprayed with Garlon 4 herbicide (Triclopyr). -Cut Stump treated with herbicide. Cut stump application was applied to ten vines 10 cm above the ground with a mixture of 50 percent Round-up (Glyphosate). In addition, six transects were established to illuminate the change in *C. orbiculatus* abundance from edge to interior forest perpendicular to a powerline right-of-way. The transects started at the ROW forest edge and extended into the forest for fifty meters. At each 5m interval along transect, a variable width strip plot was established to quantify woody stem density of *C. orbiculatus*. Also at each 5m interval, a light meter was used to determine the percent of light reaching the forest floor. A line intercept sample was used to estimate shrub cover along the transect. Lengths of shrub crowns were recorded along a tape that ran along the transect. A visual estimate of crown spread was taken. Shrub heights were measured with a height pole. Light measurements were made with a light meter attached to the height pole.

Oak wilt (causative agent, *Phytophthora* species) is an aggressive disease that affects many species of oak (*Quercus* spp.). It is one of the most serious tree diseases in the eastern United States, killing thousands of oaks each year in forests, woodlots, and home landscapes. Most significant from on-going research trials was the discovery of the variety of *Phytophthora* species that were present in oak forest soil. Their role now has been better defined because of a series of pathogenicity tests conducted to test the susceptibility of various plant parts (leaves, stems, roots) to infection. Very few of the *Phytophthora* species were pathogenic. The major exception was with the species *P. cinnamomi*. This species was able to cause damage to numerous oak species, American chestnut and some understory shrubs. An extensive soil survey of sites throughout the east and Midwest demonstrated the presence of *P. cinnamomi* below 40N latitude. This finding is significant for growers of Christmas trees and woody ornamentals.

P. cinnamomi also was found associated with sites in Ohio where white oak mortality had been observed. Periods of prolonged drought may have contributed to the damaging role of *P. cinnamomi* at the Ohio sites. These studies have demonstrated that temperature and other yet undefined factors may contribute significantly to the pathogenic role *P. cinnamomi* can play in southern climates but not in the more northern ones. Incidental to much of this research has been the discovery of several new species of *Phytophthora*. One of the most common novel species now formally described is *P. quercetorum*. The research has revealed how limited our knowledge is about forest soil microbes like *Phytophthora* species and the role they play relative to forest tree health.

Outcomes of a research project to restore the American Chestnut have focused on three field-oriented topics. The first is a long-term study designed to initiate biological control of chestnut blight at an American chestnut stand near West Salem, Wisconsin. The study has been in place of 20 years and involves the release of hypoviruses (viruses that reduce the virulence

of the chestnut blight fungus) by introducing them into the resident population of *Cryphonectria parasitica*, the fungus that causes chestnut blight. Annual evaluations of the disease have demonstrated that biological control is possible especially on trees that have been treated with strains that contain hypoviruses. Although some trees in the stand have died, others now display remission from the disease and should survive. Transition from high levels of blight to adequate levels of biological control requires significant time; in this case, more than 20 years. As biological control is achieved, seed production should be restored so that the American chestnut component of the stand can perpetuate itself.

A second topic has involved field testing of transgenic (genetically modified) strains of *Cryphonectria parasitica* to assess whether they can enhance the biological control potential of hypoviruses. The advantage the modified strains bring is their ability to transmit hypoviruses at high levels to asexual spores and also to sexual spores that result when mating occurs. The experimentation has demonstrated that the transgenic strains can function in the forest by increasing the production of hypovirus-infected inoculum. While this condition should allow for better biological control, additional time will be required to confirm their effectiveness.

A third series of studies is designed to evaluate whether increased disease resistance that has resulted from the American Chestnut Foundation's breeding program can be combined with biological control afforded by utilizing hypoviruses. To this end, numerous chestnut species (American, Chinese, European) and a variety of Chinese X American backcrosses are growing in an orchard setting and will be used to test whether the two approaches to disease control can be combined effectively to manage chestnut blight.

Extracellular production of organic acids such as oxalic acid negatively impacts the inclusion of copper as a biocide in wood preservatives. Copper tolerant fungi such as *Antrodia vaillantii* and *Aureobasidium pullulans* produce extracellular proteins in the presence and absence of copper sulfate. However, concentration of extracellular fungal proteins was very low and could not be characterized at the molecular level. Both fungi produced only one type of organic acid – oxalic acid. Production and concentration of oxalic acid varied between the two fungal species. Oxalic acid also precipitated as copper oxalate on fungal mycelia. The copper biocide is sequestered as copper sulfate and is therefore unable to diffuse through wood decay fungal cell wall and unable to inhibit/stop or kill the decay fungi.

2. Brief description of the target audience

Private and corporate commercial producers, managers, consultants, extension educators, regulators, policy makers

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	4	
2008	0	8	8

V(F). State Defined Outputs**Output Target****Output #1****Output Measure**

- Refereed, scientific manuscripts

Year	Target	Actual
2008	4	9

Output #2**Output Measure**

- Scientific presentations

Year	Target	Actual
2008	6	6

Output #3**Output Measure**

- Producer workshops & technical assistance

Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Adoption of BMP management and harvesting procedures %
2	Ability to more accurately predict yields of OSB, Paralam and additional wood species from measures on standing timber - new models
3	Development and adoption of field based, computer assisted systems to aid optimal bucking - use %
4	Process for commercial production of a high quality, oak OSB panels
5	Increased use of timber harvest residue. - %

Outcome #1

1. Outcome Measures

Adoption of BMP management and harvesting procedures %
Not reporting on this Outcome for this Annual Report

Outcome #2

1. Outcome Measures

Ability to more accurately predict yields of OSB, Paralam and additional wood species from measures on standing timber - new models

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources

Outcome #3

1. Outcome Measures

Development and adoption of field based, computer assisted systems to aid optimal bucking - use %
Not reporting on this Outcome for this Annual Report

Outcome #4

1. Outcome Measures

Process for commercial production of a high quality, oak OSB panels

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources

Outcome #5

1. Outcome Measures

Increased use of timber harvest residue. - %

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	0	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

V(l). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Before-After (before and after program)
- During (during program)

Evaluation Results

Key Items of Evaluation

Program #7

V(A). Planned Program (Summary)

1. Name of the Planned Program

Wildlife Management

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
135	Aquatic and Terrestrial Wildlife			100%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	1.0	0.0
Actual	0.0	0.0	0.4	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	20864	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	36077	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	89986	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct research; publish results in refereed research journals and, as appropriate, in popular press. Make presentation at professional meetings and at end-user workshops and meetings

The expansive hardwood forests which cover much of West Virginia provide extensive habitat for a variety of wildlife species which are extremely important to the economy of the state. Research in this planned program is aimed primarily at better understanding habitat requirements for the wildlife important to West Virginia, and to determine the impacts of human activity on wildlife habitat, particularly habitat for fish and birds. A large majority of the research in this program represents cooperative research between West Virginia State University faculty and scientists with the West Virginia Division of Natural Resources, USGS, US Fish and Wildlife Service, and the Wildlife Management Institute, a group collectively known as the West Virginia Cooperative Fish and Wildlife Unit. While formula funding provides infrastructure for this program, the majority of research in wildlife management is supported by non-formula funds, with very few formula fund projects directly supported over the last several years (currently two projects). Wildlife management therefore will not be continued as a separate, formula funded research program area in future plans of work.

We have continued the long-term studies of brook trout populations on 25 streams in West Virginia. This work is co-funded by the WV DNR, USDA Forest Service, and MeadWestvaco Corporation. Significant progress has been made on all study objectives for these allied projects. As part of a streamside management zone manipulative study we have collected two years of post-treatment data for 8 streams receiving either a 50% or 90% canopy removal. Data analysis is currently underway but initial results indicate canopy removal, coupled with the addition of large woody debris, greatly enhanced production of young-of-year brook trout in these streams.

Nest site selection of the endangered Virginia northern flying squirrel (VNFS) is poorly understood. On the basis of variation in tree species used and differences among tree/nest characteristics, the VNFS may not be as specialized in nest tree selection as indicated by previous studies. VNFS have long been associated with boreal conifer forests. In West Virginia, VNFS were found to prefer spruce, cherry-yellow-poplar, and spruce-mixed hardwood forests at the landscape- and stand-level spatial scales. On the basis of a GIS habitat model for VNFS the following characteristics were significant in predicting presence / absence: (1) elevation over 1036 m, (2) northern aspects, and (3) spruce and mixed hardwood spruce stands. Collaborators on this project included: (1) U.S. Forest Service, (2) U. S. Fish and Wildlife Service, (3) West Virginia Department of Natural Resources, and (4) MeadWestvaco Corporation. Information gathered was shared among all collaborators for mutual benefits.

2. Brief description of the target audience

Wildlife managers, regulators, policy makers, researchers.

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	Target
Plan:	0
2008 :	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	Research	Total
Plan	0	2	
2008	0	5	5

V(F). State Defined Outputs**Output Target****Output #1****Output Measure**

- Refereed scientific manuscripts

Year	Target	Actual
2008	2	5

Output #2**Output Measure**

- End user presentations at meetings and workshops

Year	Target	Actual
2008	3	8

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O No.	OUTCOME NAME
1	Sufficient understanding (to allow development of effective management plans) of habitat and other requirements of additional state bird and fish species
2	Documentation of impacts on wildlife from major, recurring activities associated with farming, logging and mining
3	Increased populations of threatened species, decreased populations of nuisance species - %

Outcome #1**1. Outcome Measures**

Sufficient understanding (to allow development of effective management plans) of habitat and other requirements of additional state bird and fish species

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #2**1. Outcome Measures**

Documentation of impacts on wildlife from major, recurring activities associated with farming, logging and mining

2. Associated Institution Types

•1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2008	1	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife

Outcome #3

1. Outcome Measures

Increased populations of threatened species, decreased populations of nuisance species - %

Not reporting on this Outcome for this Annual Report

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes
- Public Policy changes

Brief Explanation

Our greatest problem was the selection of measures from which to develop output indicators, measures which seemed destined to be determined and published annually, only to have those measures not updated by late February, 2009. It is unclear if these measures will be published at all and, if so, when.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Before-After (before and after program)
- During (during program)

Evaluation Results

Key Items of Evaluation