

FY 2002 ANNUAL REPORT OF ACCOMPLISHMENTS AND RESULTS

West Virginia Agricultural and Forestry Experiment Station
Davis College of Agriculture, Forestry and Consumer Sciences
West Virginia University

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A. Planned Programs

Program 1 (National Goal 1): Develop and support globally competitive agricultural and forestry production systems.

Overview

Lacking the efficiencies of large scale, most businesses of agriculture and forestry in West Virginia must rely on specific advantages other than size to be competitive. Consequently, the focus of research programs in the West Virginia Agricultural and Forestry Experiment Station is on economic activities for which West Virginia conditions provide some degree of competitive advantage for state producers. Examples include an expanse of exceptional hardwood forests; a topography, soil and climate well suited to the production of forages and/or pasture-reared livestock; a rich history, scenic beauty, abundant wildlife, and varied recreational opportunities which are highly attractive to tourists; extensive water resources well suited to the production of cool and cold water fish for food or recreational use; and a proximity to large urban population centers of potential demand for the goods and services produced by state industries of agriculture and forestry.

West Virginia's forests and grasslands are among the state's most unique and valuable natural resources. Critical to effective management of the former are methods to accurately assess and efficiently respond to natural or human mediated attacks by diseases, insects or invasive plant species. Recent research conducted in the West Virginia Agricultural and Forestry Experiment Station has defined potentially effective biological treatments for Chestnut blight which may at least partially restore this species which once dominated Appalachian hardwood forests. Additional research has determined parameters defining the transmission of oak wilt, confirmed continued oak wilt resistance for North American white and chestnut oaks, and begun to document control methods for the invasive species, *Ailanthus altissima*. Finally, computer models are being developed to more accurately predict orthotropic elasticity and strength of manufactured hardwood composites and to estimate product volume of harvested timber from measures made on standing Appalachian hardwoods.

Hatch supported research to enhance profitability of low input, pasture-raised beef cattle and sheep has produced a genetically modified endophyte fungus which successfully colonizes fescue and other grasses symbiotically but does not produce the ergopeptines

toxic to livestock. Additionally, cultivars of tall fescue are being developed which are higher in late season (late summer and fall) total nonstructural carbohydrates for more productive late season grazing of beef and sheep.

West Virginia has sufficient natural and human resources to support economically strong recreational and food aquaculture industries. Research supported by Hatch and special research grant funding has devised water treatment systems which allow trout to be reared in abandoned coal mine sites with high volume water flows of constant cool temperature but with high mineral content and low pH. Research also has provided information to enable the development of alternative business plans for fee fishing enterprises – plans which meet preferences of potential customers and collaborate with businesses providing lodging and other recreational activities.

Research to support West Virginia’s fresh fruit industry (primarily apples and peaches) has focused on breeding disease and insect resistant cultivars to reduce the high costs of pesticide treatment while conforming to demands of an emerging organic fruit market, and on assuring adequate pollination by natural populations of honey bees threatened by Varroa and tracheal mites.

Assessment of Progress

Excellent progress has been made toward achieving the objectives of Program 1 (National Goal 1). We are particularly encouraged by the recent 35% growth in the state aquaculture industry. Additionally as a result of collaborative efforts with ARS, NRCS, WVU Extension, West Virginia State Conservation Agency and the West Virginia Department of Agriculture, we have considerable anecdotal evidence of improving economic health of state industries producing pasture raised beef and sheep.

Expenditures and SY for Program 1 (Goal 1)

| Source | \$ or SY |
|----------------------|------------------|
| Formula | 1,203,858 |
| State Funding | 2,590,998 |
| SY’s (FTE) | 15.5 |

Key Theme – Forest Management and Wood Products

- a) Description – Research to enhance sustainable logging, value added wood product manufacture and tourism.
- b) Impacts – A hypovirus of European origin has shown some ability to control blight in the American Chestnut. Reduced growth of blight cankers inoculated with hypovirus has occurred in successive years. The hypoviruses examined spread readily from inoculated to non-inoculated cankers on the same tree but less readily from tree to tree. The hypovirus was most effective when inoculations were made in

Spring. Periodic removal of competing vegetation reduced tree mortality due to blight but only after practiced for extended periods.

Root graft transmission is a primary mechanism in the spread of oak wilt. European oaks, frequently planted as ornamentals in North America, are highly susceptible and represent sources of potential disease spread. In contrast, North American White and Chestnut oaks tend to be quite resistant.

A project has been initiated to assess the efficacy of herbicides for control of the invasive species of *Ailanthus*, in stands of hardwoods. The project will determine the rates and environmental impact of herbicide necessary to eliminate this exotic species.

Models to predict (1) mechanical properties of composite lumber, (2) weight and volume of standing timber, and (3) hardwood stand regeneration at different points in time (including stand visual impact and level of photosynthesis) are in various stages of development. These will assist in (1) predicting elasticity and strength of manufactured wood products, (2) estimating value of woodlots (locally) or area-wide quantity of product (more globally), and (3) developing BMP's for forest managers.

- c) Funding – Hatch, McIntire-Stennis, State
- d) Scope of Impact – Multi-state Research
CT, MA, MD, NJ, NY-G, NY-I, PA

Key Theme – Utilization of Grasslands

- a) Description – Utilize extensive state grassland resources for sustainable, cost efficient production of forages and livestock
- b) Impacts – The alkaloid, ergovaline, accumulates in forage grasses infected with certain endophytic species of *Neotyphodium*. Symbiotic colonization by *Neotyphodium* provides several benefits to the grass but ergovaline is toxic to grazing animals. Two knockout genes have been developed to eliminate the alkaloid, one of which interrupts the ergovaline pathway in its initial step such that no intermediates accumulate. The other represents an interruption much later in the pathway and allows production of several intermediates. The latter was equal to wildtype *Neotyphodium* in suppressing endoparasitic nematode populations on perennial ryegrass while the former was less effective. Ergovaline itself is not necessary for the fungus to provide resistance to this endoparasitic nematode and may not be essential for other beneficial effects. However, one or more intermediates in the ergovaline pathway apparently is required for suppression of endoparasitic nematodes.

Results have shown considerable variation among clones of tall fescue for an index including late season total nonstructural carbohydrates (a common weakness of fescue) along with disease resistance and dry matter yield. This suggests an opportunity to select successfully for a disease resistant, high yielding fescue with relatively high late season nonstructural carbohydrates. Such cultivars, infected with

a genetically altered endophyte, theoretically would significantly improve weight gains of grazing animals in late spring and summer.

Cost of gain for commercial calves reared on pasture-only was approximately one-half (\$.44 vs. \$.81/kg) that for calves fed a combination of pasture and limited concentrate. Additionally, rotational grazing produced 17% more calf gain/ha/year than continuous grazing. However, crossbred steers pastured on cool season grasses at a rate exceeding two animals per ha were found to require supplemental feed to attain acceptable gains and desirable carcass quality by conventional market age.

- c) Source of Funding – Hatch, State
- d) Scope of Impact – multi-state integrated research and extension
CA-B, CA-O, CO, CT-NH, FL, GA, IN, KS, MA, MD, MN, NV, NY-G, NY-I, OR, PA, RI, SD, UT, VA, WA, WI, USDA

Key Theme – Aquaculture

- a) Description – Assess potential and develop best aquaculture practices and provide support for the establishment of food and recreational fish production enterprises.
- b) Impacts – Working with cooperating coal companies, Rainbow Trout are being successfully reared in treated acid mine waters at three locations. No detectable accumulation of toxic metals (mercury, lead, cadmium, etc.) have been found in the fish. Raising cool water fish represents a potential way to at least partially recoup cost of mandated remediation of water quality in previous mine sites.

Surveys of in-state and out-of-state fishermen have indicated general interest in fee fishing activities as part of a larger overall recreational package including other recreational activities as well as lodging. Cooperative efforts can at once attract more recreational fishermen and enhance other sectors of the West Virginia travel and tourism industry.

Results have shown efficiency of gain to be both substantially higher and cost effective with higher energy feeds. A fish health survey indicated a rather modest level of pathogens in the state. Diseases such as bacterial gill disease, coldwater disease, protozoan diseases and bacterial diseases secondary to fin erosion were the most costly to producers.

NSS trout production report indicates total value of fish sold in West Virginia increased 35% from 2000 to 2001.

- c) Funding – Hatch, State and Special Research Grant.
- d) Scope of Impact – Integrated research and extension

Key Theme – Agricultural and Forestry Profitability

- a) Description – Support state economic development of agricultural and forest industries with focus on activities offering competitive advantage to state producers.

- b) Impacts – Susceptibility of 26 apple cultivars on two rootstocks (MARK and M.9 337) to 13 arthropod foliage and fruit pests was examined. Cultivars differed for relative susceptibility to forage and fruit pests but for all pests combined, susceptibility was lowest for Pristine and highest for Fortune, Fuji Red Sport #2, Golden Supreme and Golden Delicious. Additionally, susceptibility was lower on MARK than on M.9 337 rootstock. Results provide producers with cost effective controls alternative to chemical use.

A four-part protocol including a commercial product developed in this research was used to treat honey bee colonies infested with Varroa and tracheal mites. The final step of the protocol involves treatment in August-September with a special fumigator applying 50% formic acid combined with a 10% solution of the commercial product. A single 24-hour application killed all mites on bees and about 95% inside cells.

- c) Funding – Hatch, State
d) Scope of Impact – Multi-state research
CT-NH, MA, ME, NH, NJ, NT-G, NI-I, PA, VT

Program 2 (National Goals 2 & 3): Ensure a healthy, well-nourished population with access to a safe and secure food system.

Overview

Program 2 combines national goals 2 and 3 due to the strong relationship between the goals and the relatively small size of this program in West Virginia. The focus of research related to this goal is on food quality and safety, on concerns with potential accumulation of toxic substances in soils and water, with subsequent entry into the human food chain, and on the nutritional status of rural, low income families, especially young children and pregnant women.

Abundant supplies of cool water of nearly constant year-round temperature, as well as easy access to large urban markets, offer West Virginia cool water aquaculture producers potential competitive advantage. Capitalizing on these advantages requires products of consistent high quality even though fish are among the most difficult to adequately preserve. Recent research in the West Virginia station has shown vacuum tumble processing with sucrose to be an effective cryopreservation method for whole fish muscle.

Additionally, important results have been obtained regarding lead contamination in soils and the nutritional status of infants from rural West Virginia families participating in the Supplemental Nutrition program for Women, Infants, and Children. Continuing work will assess the impact of nutrient intake on child health and development in rural West Virginia communities.

Assessment of Progress

Program 2 (National Goals 2 and 3) represents a limited research area in West Virginia. One new faculty member has been hired and has initiated research on electron beam preservation of muscle foods. Interviews for an additional faculty member in the area of human nutrition are ongoing.

Expenditures and SY for Program 2 (Goal 2 & 3)

| Source | \$ or SY |
|---------------|----------|
| Formula | 435,284 |
| State Funding | 330,086 |
| SY's (FTE) | 1.5 |

Key Theme – Food Safety and Quality

- a) Description – Research to ensure food quality and safety for consumers.
- b) Impacts – Fish muscle is particularly susceptible to quality deterioration associated with changing balance in protein-water and protein-protein interactions. Quality preservation of whole muscle fish products through sucrose incorporation under vacuum tumbling was evaluated. Following six weeks frozen storage, all of a variety of vacuum tumble treatments examined had lower thaw loss and gel cook yield, as well as higher gel hardness and cohesiveness than control. Tumbling under 70-kPa vacuum at 7 rpm for 30minutes was found to yield the optimum quality of frozen chunks following storage.

A cross-sectional analysis of infants from rural West Virginia families who were participating in the Supplemental Nutrition Program for Women, Infants, and Children (WIC) did not find iron deficiency to be a significant problem in this population. Blood lead levels were detectable but was not observed at toxic levels. Data from 75 infants, aged six-months to two years of age, will be used to quantify relationships among nutrient intake, iron status and blood lead levels as they affect child health and development.

- c) Funding – Hatch, State.
- d) Scope of Impact – State specific.

Program 3 (National Goal 4): Greater harmony between agriculture and forestry practices and the environment.

Overview

West Virginia's economic future depends in large measure on preserving the rich natural resources of the state. Promoting a symbiotic coexistence between our farms, forests and natural environment, with policy decisions based on reliable, scientific information, is therefore an important area of research in the West Virginia Station.

Station research centers on developing environmentally friendly practices for managing farms and forests to protect state wildlife, water and soil for future generations. An evaluation of the impact of gypsy moth infestations on cavity dwelling birds and effects on non-target organisms of attempts to control gypsy moth infestation revealed increases in songbird habitat and minimal effects on non-target Lepidoptera. In contrast, work to define the parameters of impact on brook trout populations from logging and farming practices has shown significant effects of small sediment particles and suggested remedial actions.

Substantial resources are devoted to developing and evaluating holistic, organic methods of plant and animal production and toward defining economically viable methods of transitioning – wholly or partially – from conventional to organic production methods. The work has centered on managing disease and insect pests for a large variety of food crops with minimum or no chemical intervention.

Protection of soil and water is a national concern. Research from the West Virginia Station during the past year has evaluated programs to transport poultry litter from high- to low-density livestock production areas, developed procedures for producing liquid fuels from animal manure, defined phosphorus retention capacity of various soils, assessed the consequences of highway construction on previously mined soils, evaluated the impact of aggressive ectomycorrhizal fungi on young plant growth and subsequent productivity, measured the removal of biochemical oxygen demand in constructed wetlands and developed a low-cost split-flow wastewater management system with significant environmental advantages relative to conventional detention systems.

Assessment of Progress

Progress toward achieving the objective of Program 3 (National Goal 4) is extremely encouraging. Of particular note are results documenting abilities of constructed wetlands to remediate environmental pollution, development of a process for producing liquid fuel from animal manure, and devising potentially substantial improvements in methods of stormwater management.

Expenditures and SY for Program 3 (Goal 4)

| Source | \$ or SY |
|----------------------|------------------|
| Formula | 1,040,662 |
| State Funding | 809,442 |
| SY's (FTE) | 9.9 |

Key Themes – Wildlife Science and Management

- a) Description – Research to identify, and remediate as necessary, negative impacts of agriculture and forestry on wildlife populations.

- b) Impacts – The effect of *Bacillus thuringiensis* (Bt) on non-target Lepidoptera, their predators and parasitoids in central Appalachian hardwood forests was determined. Selected species of Lepidoptera were significantly reduced on Bt treated plots but most were unaffected. Population dynamics of spring defoliating, non-target caterpillars were minimally affected. Only subtle effects on behavior and productivity of selected songbirds were observed.

Cavity nesting birds may be negatively impacted by a lack of proper nesting sites. Cavity tree abundance differed significantly among central hardwood (most abundant), northern hardwood, and boreal forest (least abundant) cover types. Black locust and American beech were most likely to have tree cavities although results for beech likely were influenced by increased mortality from recent outbreaks of beech bark disease. Evaluation of the impact of gypsy moth infestation on cavity nesting bird populations show dramatic increases (>10x) in numbers of cavity nesting birds approximately two years following defoliation and concomitant tree mortality. Forest management must focus on monitoring wildlife populations to maintain species diversity.

Very small quantities (<1% of substrate by weight) of small (<.063 mm) sediment particles from land use practices (e.g., logging, agriculture, road construction, etc.) were shown to have a significant negative impact on brook trout reproduction. Adding large woody debris to create pools and sediment storage areas appear to mediate the problem to a large extent. Results will be useful in defining BMP's and TMDL standards for streams.

- c) Funding – McIntire-Stennis and State.
d) Scope of Impact – State specific.

Key Theme – Alternative Agricultural and Forestry Practices

- a) Description – Research to devise and evaluate alternative, sustainable agricultural and forestry practices.

Impacts – The efficacy of systems to manage arthropod and disease pests of apples using IPM and organic pest control methods (oils and pheromone mating disruption for insects; copper and sulfur fungicides for disease) were evaluated. During the first two years of the project, organic plots showed lower levels of aphids, leafhoppers and mites and increased numbers of arthropod predators, but significantly more injury to harvested fruit (from codling moth, oriental fruit moth, plum curculio and apple maggot). In 2002, a combination codling moth and oriental fruit moth mating disruptions dispenser resulted in complete elimination of oriental fruit moth and a mean codling moth capture of only six moths per trap compared with 482 and 158 oriental fruit and codling moths per trap in an adjacent orchard treated with conventional insecticides. A severe hail storm in May 2002, prevented collection of fruit data for this year.

A cooperative project with USDA-ARS compared baited (*Euschistus* spp. aggregation pheromone) and unbaited pyramid and jar traps for capture of stink

bugs in apple and peach orchards. Baited pyramid traps were by far most successful (3.5X or more captures than other treatments) and were effective throughout the season.

A “Reduced-risk and Mitigation Program” (RAMP) which uses soft, selective chemicals (no organophosphates) and mating disruption, was compared to a conventional insecticide program in six orchards (five apple, one peach). RAMP procedures provided pest control that was comparable to or better than conventional programs in all but one orchard. However, RAMP programs were 2 to 2.5 times as expensive as conventional programs primarily due to the greater cost of mating disruption compared with insecticides.

An evaluation was conducted of a program to transport poultry litter from high- to low density livestock production areas. Mail and phone surveys indicated that first time users of poultry litter purchased 62% of the litter and that litter was moved further from the five-county production region than prior to the program. Farmers using litter were highly pleased with its performance and demonstrated levels of compliance with nutrient management plans comparable to poultry producers supplying the litter. Subsidies were found to be effective in reducing the financial risk of trying litter for the first time and achieved environmental objectives.

Results of laboratory bench-scale reactions of hog manure with water under conditions of high temperature and pressure indicate that hog manure can be converted to a liquid fuel with almost no waste stream being generated. Reacting 30 g hog manure dry matter with 30 g water resulted in 6 g of material not soluble in diesel fuel or acetone and 3 g of aqueous phase. Sawdust also was tested but found to be much less reactive. A pilot-scale reaction system has been constructed as a prototype for waste streams of a size typically generated by family-owned livestock farms.

- b) Funding – Hatch, McIntire-Stennis and State.
- c) Scope of Impact – Multi-state integrated research and extension
CT-NH, MA, ME, NH, NJ, NY-G, NY-I, PA, VT

Key Theme – Soil and Water Quality

- a) Description – Research to evaluate soil and water quality, prevent soil and water contamination, and, where required, develop remediation programs.
- b) Impacts – Multivariate regression and principle component analysis were used to determine the ability to predict soil P retention capability from the soil physical and chemical properties provided with many soil tests. For samples from a given soil series, there was a linear increase in P retention capacity with increasing concentrations of amorphous oxides of Fe and Al. When multicollinearity of data was accounted for, P sorption capacity of soils could be predicted quite accurately from basic soil properties.

A study was conducted to evaluate properties of wetland soils and soils from previously mined land and to assess the impact of proposed highway construction over these areas. Analysis indicated that highway construction would increase the potential for exposing pyritic materials to accelerated weathering with the expectation of increased acid mine drainage production. Results prompted the decision to relocate the highway.

Eleven species of mycorrhizal fungi were isolated from sugar cane growing in muck soils as examples plant-fungi relationships more parasitic than symbiotic. The purpose was to determine if the fungi cause a widely observed decline in sugarcane yield when the crop is grown in successive years without fallow. Three of the most aggressive fungal species were used in greenhouse studies which showed an inverse correlation between crop growth and rate of mycorrhizal colonization. Rapid colonization of young plants appears inhibit early growth and that translates to a larger yield loss by the end of the growing season.

Studies of the usefulness of small subsurface flow wetlands as a means of treating domestic wastes for individuals in rural areas showed reduced functional diversity in communities of heterotrophic bacteria during months of active plant growth (April to October). Analysis also suggested the functional community of bacteria differed in planted versus unplanted wetlands during the growing season. However, treatment efficiency with respect to removal of biochemical oxygen demand or reduction in fecal indicator organisms generally was not a function of growing season or plant treatment. Constructed wetlands designed in this project appear to function reasonably well under local climatic conditions.

A study to examine the feasibility of a split-flow stormwater management system suggests substantial advantages relative to conventional detention systems. Preliminary results indicate that in addition to costing substantially less to construct, split-flow systems will not substantially increase downstream flow rates, will reduce non-point source water pollution, and will result in reduced groundwater pollution.

- c) Funding – Hatch and State.
- d) Scope of Impact – Multi-state research
CA-B, CA-D, CO, CT, GA, IA, MD, ME, MI, MN, MT, NH, NM, NV, NY-I,
OH, OR, TN, VT

Program 4 (National Goal 5): Enhance economic opportunity and quality of life for citizens and communities

Overview

Declining per capita income and population outflow are chronic problems in West Virginia. Research to develop technologies and management systems which support economic development consequently represents a high priority in the West Virginia

Station. Research which supports improvements in quality of life may be equally important in stemming outflows of human capital.

The extensive rural areas of West Virginia have dictated that Station research will focus on economic development in rural communities having agricultural or forest based economies. Small farms unable to compete successfully in agricultural commodities markets are turning to niche markets and value added products to remain viable. Examples in West Virginia supported by station research include cut flower production, pasture-finished beef, organic fruit and vegetable production and cold water aquaculture. Outdoor recreational activities and youth development represent issues of economic opportunity and quality of life in West Virginia. Both are supported with modest research programs in the West Virginia Station.

Assessment of Progress

Results contributing to the objectives of Program 4 (National Goal 5) were limited by the modest resources allocated to this program. We are well pleased, however, with results – and stakeholder interest in and application of those results – generated by research related to aquaculture, livestock grazing, organic fruit and vegetable production and floriculture.

Expenditures and SY for Program 4 (Goal 5)

| Source | \$ or SY |
|----------------------|-----------------|
| Formula | 357,228 |
| State Funding | 358,766 |
| SY's (FTE) | 5.1 |

Key Theme – Community Economic Development

- a) Description – Research to assist communities in developing profitable and sustainable local industries and to improve quality of life.
- b) Impacts – Diversification to include cut flower production is contributing to economic success and sustainability of small farms in West Virginia. Research to support this effort has cloned, sequenced and characterized three genes from carnation petals thought to be involved in the ethylene signal transduction which regulates flower development and senescence. Genes Dc-EIL2 and Dc-EIL3 have been characterized. DcEIL2, which is nearly identical to DcEIL1, showed no changes in steady state levels of its mRNA during development, upon ethylene exposure or after wounding. In contrast, steady state levels of DcEIL3 increase during development of petals and styles, making it a potentially important part of the mechanism for controlling flower development and senescence.

Economic analysis of niche markets and value added products has focused on pasture-finished beef, organic vegetables and cool water aquaculture. Results for the latter indicate a doubling of recreational fishing within the state would increase annual industry income by \$2.5 million and create 70 new jobs. A

similar increase in output of food fish would generate \$2 million annually with more than 100 new jobs created.

Research in forensic entomology is supporting the development of forensic science in West Virginia. A computer database of arthropod specimens has been constructed which facilitates identification of forensic specimens, improves interpretation of information from crime scenes and allows the use of additional species to more accurately determine post mortem interval (time of death until time of discovery).

Outdoor recreational opportunities generally are viewed as contributing to quality of life but they may contribute to the enhancement of population health as well. Spatial analysis of West Virginia and the Appalachian region has shown a positive relationship between the availability of outdoor recreational activities and rates of physical activity, which in turn are inversely correlated with regional health care expenditures. Additionally, preservation of land as wilderness areas (e.g., to support outdoor recreational activities) was not associated with reductions in employment in extractive industries and, in fact, contributed to employment growth in service industries.

A group of 77 high school students engaged in the 4-H Charting curriculum were compared with non-4-H students for measures of identity, coping skills, ego strength, social competency, decision making and communication skills. Testing prior to and following completing the Charting curriculum showed high levels of achievement for participants in the 4-H program. However, participants in 4-H also tended to be involved in multiple extracurricular and volunteer activities in addition to 4-H, making the isolation of impact difficult. Results will be reanalyzed by levels of “involvement” expressed as *none, extracurricular only, 4H and extracurricular, and extracurricular and volunteerism*. Data also showed that socioeconomically disadvantaged adolescents, who arguably have the greatest need, were least likely to be involved in adult sponsored, group learning activities.

- c) Source of Funding – Hatch and State
- d) Scope of Impact – Multi-state research
AL, AR, FL, GA, KY, LA, MS, OR, TX, NC(A&T), ND

B. Stakeholder Input Process

Stakeholder input has been collected in conjunction with West Virginia Extension (which is administratively distinct from the College of Agriculture, Forestry and Consumer Sciences at West Virginia University) since we share the vast majority of our stakeholders. Previously, stakeholder input has been obtained at dedicated public meetings having no other purpose than to receive input. This procedure has been augmented by collecting input at the annual meetings of major state associations of stakeholders including the West Virginia Farm Bureau, West Virginia Forestry

Association, West Virginia Grasslands Steering Committee and the state Aquaculture Forum. Our intention is to continue using a combination of dedicated and annual association meetings to gather input.

Valuable input also is obtained from the West Virginia Agriculture and Forestry Advisory Board, which meets twice annually and deals mostly with research issues, and from our College Visiting Committee which considers academic as well as research programs. Both groups are intentionally balanced to represent the diversity of agricultural and forestry enterprises in West Virginia as well as consumers of products and services from those industries.

Stakeholder input is considered for implementation annually during program planning and periodically in strategic or special planning sessions. The most frequently made suggestion during the past two years, from a wide range of constituents, is to increase the level of interaction and cooperation between the West Virginia Experiment Station and West Virginia Extension. In response, the Station and Extension Service have been, and continue to be involved in a series of discussions to develop agreements for:

- Increasing numbers of faculty with joint College-Extension appointment
- Developing procedures for joint hiring, administration and evaluation of faculty
- Enacting policies to increase joint programmatic use of faculty (Extension faculty teach and conduct research supported by College and Station resources; College / Station faculty conduct extension programs supported by Extension resources)
- Establishing joint expectations for promotion and tenure
- Devising methods to more efficiently and effectively share resources

Agreements for four of the above six are either completed or nearing completion. Details regarding the extent to which and exactly how resources are shared await a final decision on joint housing for College and Extension administration and faculty. We expect the model to come from the numerous ad hoc arrangements which evolved to accommodate the growing number of jointly appointed faculty currently housed together. Joint programming as a concept is in place. The specifics are developed (or confirmed) at least annually considering available personnel, resources and clientele needs.

C. Program Review Process

There have been no changes in the merit review process from that indicated in the Plan of Work.

D. Evaluation of the Success of Multi and Joint Activities

Personnel from the West Virginia Station participated in 11 Northeastern, three Southern, one Western and one Northcentral regional projects. Multi-state cooperation allows researchers to address numerous questions which could not be addressed by any state alone. Additionally, opportunities to share ideas, resources and expertise is especially beneficial to the West Virginia Station where resources are limited.

Northeast regional project, NE-185, represents an especially important project for the West Virginia Station research effort due to its focus on economic development of local food systems. The rural and oftentimes isolated nature of many communities in the state, as well as their dependence on farm and forest economies, has made stakeholders in West Virginia extremely concerned with community economic development. Many of these stakeholders, additionally are from rural, low income families, typically underserved by governmental programs.

Results of research conducted by the participants in NE-185 have developed and refined protocols to study food systems of individual counties or regions within the participating states. Most importantly, results are demonstrating how the structures and viabilities of local food systems are heavily affected by public policy. Several states, including West Virginia, have used results to educate state agencies and local government officials and to assist them in making informed policy decisions.

Multi-state projects relevant to specific, economically important plant commodities in West Virginia include projects to evaluate new apple cultivars, to genetically enhance cold tolerance and extend blooming period in horticultural plants, and to develop biologically based IPM systems for the management of plant parasitic nematodes as well as oak and chestnut pathogens. Production of horticultural crops, including tree fruits and especially apples, represent areas of potential economic growth for West Virginia stakeholders. Evaluation of yield and quality for apple cultivars relevant to specific geographic areas and conditions, and the selection of those best suited for specific micro-environments, has enabled regional and national producers to remain globally competitive, keeping prices low for consumers without sacrifice of quality.

Plant parasitic nematodes and Chestnut blight represent chronic and acute problems, respectively, having extreme economic consequences. Compounding these problems are growing stakeholder concerns with the use of synthetic pesticides to control plant pests and diseases. Alternative control options, such as breeding of resistant plant strains, improved cultural practices, mating disruption and the identification/introduction of pest predators, are ensuring more sustainable and environmentally friendly crop production systems and reducing pesticide exposure risks.

Multi-state research projects involving pasture-based production systems for beef, sheep and dairy; as well as projects related to animal waste management and developing methods for more efficient reproduction in pasture maintained livestock, are of key importance in enabling West Virginia producers to capitalize on the abundant state grasslands. Again many of the stakeholders in these projects represent low income, rural and often underserved citizens seeking to supplement family income with a relatively low-intensity agricultural operation. The low cost production and improved marketing systems being evaluated in these projects, as well as the reproductive and animal waste management programs which have been developed, have the potential to contribute markedly to the economic growth of our rural communities.

Joint, integrated research and extension activities have been a central focus at West Virginia University during the past several years. Integrated projects now span all divisions of the College (Animal and Veterinary Sciences, Family and Consumer Sciences, Forestry, Plant Sciences and Resource Management) with the most mature and extensive example being the aquaculture project discussed in Program 1. The aquaculture project is a multidisciplinary, multi-college, multi-institutional integrated project to develop food fish and recreational fishing industries in the state with continued research involvement by faculty at West Virginia State (West Virginia's 1890 Land Grant), and Bluefield State Colleges. The direction of focus for this project is from the ultimate user to the technology delivery to the technology development, with needs of the first defining the structure of latter two. Additional examples of integrated activities include joint programs to foster increased use of abundant, low cost grasslands for the pasture production of beef, sheep and dairy; research and extension programs to support an expanding poultry industry; and coordinated efforts with farmers, foresters and the general public to improve state water quality.

F. Integrated Research and Extension Activities

Program expenditures listed in Appendix C are described briefly as follows:

1. ***Pasture Production of Livestock*** involves research and technology transfer related to developing superior strains of grass; eliminating the toxic effect of the endophyte fungus; devising more profitable livestock management systems for beef, sheep and dairy; improving animal marketing systems; and producing economic data, budgets and forecasts which enable profitable enterprises.
2. ***Competitive Poultry Industry*** includes research and technology transfer to enhance poultry growth rate and efficiency, improve product quality and safety, anticipate market trends and changes, and responsibly dispose of animal waste.
3. ***Develop / Support Aquaculture*** is a comprehensive, integrated effort to develop sustainable, profitable food fish and recreational fishing industries with focus on production, processing, marketing, value-added products, and use of abandoned mine water sources.
4. ***Improve Water Quality*** is a state-wide, integrated effort to improve water quality actually or potentially compromised by acid mine drainage, improper animal waste management and poorly maintained septic systems.

