FY 2003

Annual Report of Accomplishments and Results

West Virginia Agricultural and Forestry
Experiment Station

and

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

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Introduction

The West Virginia Agricultural and Forestry Experiment Station is administered within the Davis College of Agriculture, Forestry and Consumer Sciences at West Virginia University. The College is relatively broad in academic and research discipline areas, including within the College, Divisions (academic program units equivalent to departments) of Family and Consumer Sciences and Forestry in addition to the more typical Animal Sciences, Plant and Soil Sciences, and Resource Management (agricultural economics, agricultural education and, less typical, landscape architecture).

The College has about 95 full-time faculty to direct research and teaching programs in the College. West Virginia University Extension is administered independently of the Davis College, but Extension and the College have several jointly appointed faculty and conduct a number of integrated programs. The Davis College and WVU Extension have discussed joint accomplishments reporting and development of a joint plan of work for FY 2007-11, but this report covers only research and integrated, research-extension programs.

The West Virginia Experiment Station employs approximately 35 FTE research faculty distributed across about twice this number of individual scientists. The Station also supports approximately 25 FTE technical positions, 35 clerical and farm/forest worker positions and 40 professional support positions (mostly graduate students).

The West Virginia Station operates seven farms and two forests which support research. Four of the farms (Animal and Veterinary Sciences farms in Morgantown and Reidsville, Horticultural and Agronomy farms in Morgantown) and the University Forest are sufficiently close to the University to be used extensively to support academic programs in addition to research. Outlying farms include the Reymann Memorial Farm (beef, sheep, agronomic crops and bull testing station) and Kearneysville Tree Fruit Research Farm (primarily apples and peaches) in northeastern West Virginia; the Willow Bend Farm in the southeast (pasture raised and finished beef cooperative project with ARS); and the Tagart Valley Forest (mostly oak regeneration and disease control research) in east-central West Virginia. All but Tagart Valley Forest are extension as well as research centers and, in fact, approximately half the FTE faculty positions at the Kearneysville Farm are Extension appointments.

In addition to competitive, sponsored research, Station faculty participate in approximately 60 formula funded projects (Hatch or McIntire-Stennis), about 15 multi-state research projects, and an additional ten state supported projects. Federal formula funding of approximately $3 million is slightly more than matched by about $4 million in state support. Faculty also generate an additional $5.5-$6.0 million annually in externally supported research.

The focus of research programs in the West Virginia Station is on economic activities for which West Virginia conditions provide some degree of competitive advantage for state producers, or on problems having impact on rural families and communities in the state.

Examples of the former include proximity to large urban population centers of potential demand for specialty or niche market products; an expanse of exceptional hardwood forests; a topography, soil and climate well suited to the production or forages and/or pasture-reared livestock; a rich history, scenic beauty, abundant wildlife and varied recreational opportunities which are highly attractive to tourists; and extensive water resources well suited to the production of cool and cold water fish for food and recreation. Most common problems impacting rural communities in West Virginia include a state population which is decreasing in size and aging as well due to a disproportionate loss of younger citizens; a largely rural population with limited access to health and nutritional information and a consequent tendency towards poorly balanced, calorie-dense diets; and an extreme need for environmentally friendly and sustainable economic development which will provide jobs to replace the many which have been lost in coal and timber harvesting industries.

A. Planned Programs

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

Overview

Farmers in West Virginia, and in the Northeast US generally, are poorly positioned to compete in US commodity markets for fruits, vegetables, field crops and livestock products (due to small acreages, dense population, high land and labor prices, etc.). To remain viable, many West Virginia producers are seeking either to increase the value of what they produce or to produce their products at significantly lower cost.

Markets for organically produced food products have increased in volume approximately 20% annually for the last several years and generally are characterized by product prices which are substantially higher than corresponding commodity markets. At the same time, requirements for transitioning to certified organic production are stringent, potentially costly, and lacking sufficient research-based recommended management practices. The West Virginia University Organic Research Project, supported by Hatch funding and the USDA Sustainable Agriculture Research and Education program, was established to develop and test alternative, low cost systems for transitioning from conventional to organic production of vegetables, fruits, field crops and/or livestock. The primary objective is to define practices most environmentally sustainable and economically efficient during the period of transition and early certification.

A focus of the project is on a comparison of systems which transition from conventional to organic production using green manure and cover crops (low input) and those which rely on compost amendments from off-farm sources (high input). Systems are being assessed in market garden vegetable trials (cropped to beans, peas, tomato, pepper, squash, pumpkin, lettuce, and spinach) and in field crop trials (potato, wheat, soybean, Brussels sprouts, and red clover/orchard grass as forage), with and without livestock.

Comparisons between systems have involved crop yields; soil organic matter and mineral content; populations of earthworms and nematodes; insect and disease damage; weed infestation levels; and the use of companion crop plantings. Results of this project are being used extensively by producers in transitioning from conventional to organic production. The recent report, *State of the States 2nd Edition: Organic Farming Systems Research at Land Grant Institutions* ranks this project among the five best nationally.

West Virginia has extensive supplies of rapidly flowing, constant temperature, cool waters which are well suited for the production of cool and cold water fish for food or recreational use. West Virginia also is blessed with numerous ideal settings for sport fishing. Aquaculture research at the West Virginia Station has emphasized the creation and testing of methods to use state water resources (which often flow from abandoned mine sites at heavy volume and near constant 60^{o}F temperature but many, more recently mined, with high mineral content and relatively acetic) in aquaculture production, and on developing a significant fee fishing industry in the state. Specific projects have examined survival, growth and tissue composition of fish reared in treated and untreated mine water; evaluated various rations with respect to rates of gain; compared different strains of fish for vigor, growth and ultimate size; constructed and tested alternative raceway rearing systems; and surveyed the health status of fish at production facilities throughout the state.

Beef production is among the largest agricultural enterprises in West Virginia, with approximately 13,000 producers statewide. Pasture-based systems to carry cattle from birth to market, as opposed to raising feeder cattle to be finished elsewhere, could significantly enhance the competitive position of state producers by using the abundant and inexpensive grassland resources available to most producers. Pasture raised beef research at the West Virginia Station is conducted cooperatively with scientists at Virginia Tech and at the ARS Appalachian Farming Systems Research Center. Research has centered on pasture plant species and management, optimum animal stocking rates, enhancing forage intake and digestibility, eliminating endophyte toxicity to grazing animals in various grasses, minimizing supplemental feeding, attaining market weight and condition at reasonable ages, and maintaining carcass quality characteristics of pasture finished beef.

Efficient reproduction is prerequisite to profitable production of all livestock species, on pasture or in confinement. Research at the West Virginia Station has focused on neuroendocrine control of ovarian function, role of the uterus in luteolysis, and follicular development, rupture and persistence in order to develop management programs which increase conception rates, reduce embryonic and fetal mortality, and maintain ideal birth weights in cattle and sheep.

Poultry production is West Virginia's most lucrative livestock industry with production of broilers doubling in the last ten years. Recent results from the West Virginia Station suggest that uric acid is a potent antioxidant in poultry with moderate reduction in concentrations of plasma uric acid leading to increased measures of oxidative stress.

Methods are being developed to increase plasma uric acid as a means of protecting against oxidative stress and promoting increased growth rate.

Farm production of cut flowers has increased rapidly in recent years among small-scale producers of vegetables and field crops, as a means of diversifying production, capitalizing on higher value crops, and better utilizing farm resources. The focus of ornamental horticulture research at the West Virginia Station is to understand the role of ethylene and its relationship to the process of flower senescence and to thereby control flower longevity. Primary interest would be in increasing longevity for greater cut flower value or increased time for fruit and/or seed set. However, a shortening of flower longevity and consequent reduced fruit and seed set, is equally valuable for many landscape plantings.

Assessment of Progress

All projects discussed have made, and are making, significant contributions toward enhancing competitiveness of state and regional industries of agriculture and forestry. We are particularly pleased with the growing interest in the organic production research on the part of producers as well as the recognition afforded the project by outside evaluators. Producer interest is likewise high in results of the pasture raised and finished beef project conducted jointly with USDA-ARS and Virginia Tech. The project has produced pasture-finished beef of excellent quality, indicating the possibility of future transition from producer sales of feeder cattle to sales of finished beef.

Expenditures and SY for Program 1 (Goal 1)

Source	$ or SY
Formula	**1,120,902**
State Funding	**2,732,977**
SY's (FTE)	**18.5**

Key Theme 1.1 – Organic Production Systems

a) Description: Compare alternative systems for conversion from conventional to organic production of vegetables, field crops and/or livestock products; determine practices most environmentally sustainable and economically efficient during periods of transition and early certification.

b) Impacts:

The high input transition method (cover crops + compost to supply 150 lbs/a/year nitrogen) had higher yields for most market garden crops (beans, peas, spinach, lettuce, tomato, pepper zucchini and pumpkins) and field crops (potato, soybeans, wheat, and Brussels sprouts) than did the low input transition method (cover crops only) during the first planting year, but not in year two.

Lambs grazing orchard grass and red clover gained 313 lb/a during 2002. Infestations of internal parasites were low without the use of anti-helminthics possibly due to the system of rotational grazing.

Soil organic matter increased from 4.5% to 5.0% in two years and was significantly greater in high, as compared to low input field crop plots, but not for high and low input market garden plots. High input market garden plot soils were significantly higher in K, Mg, and Na while field crop plots were higher in K, Mg, Ca, and P. Populations of earthworms were higher in high input treatments (compost added) but nematode populations were not. There was evidence of excessive build-up of P and K by the second year of the high input treatment.

Best weed suppression was from black plastic with hand weeding superior to wheat straw. Acetic acid spray and corn gluten as a soil amendment did not yield satisfactory weed control. Surround WP reduced potato leafhoppers but not aphids and generally showed about 10% higher yields than untreated plots. Companion crop plantings of the same or differing species generally had fewer pest problems and higher yields than monocultures (same species and variety).

Soil samples collected pre-planting and late season showed small populations of plant parasitic nematodes with no differences between compost and green manure treatments. Populations of the predatory nematode, *C. papillatus*, were higher in compost treatments during Spring of 2002 and 2003, but not at other times. Nematode trapping fungi did not differ for high or low input treatments or among crops.

Laboratory cultures of *C. papillatus* were prepared and fed weekly with either M. incognita or an unidentified Cephalobid. Reproduction was greatest at 20C and significantly reduced below 20C or above 28C. Reproduction was more rapid with 3-6 adults as initial inoculum and juveniles rarely survived, or reproduced poorly, in the absence of adults. Cannibalism appeared to restrict population increase making estimation of generation interval difficult. However, new adults typically appeared in 3-8 weeks after plates were inoculated.

At locations other than the organic farm, poultry litter compost was examined as a means to inhibit weeds, 26 apple cultivars were examined for natural resistance to arthropod pests, an entirely organic treatment for honey bees infested with varroa mites was successfully tested, and an unusual effect of mycorrhizal fungi which was inhibitory to plant (sugar cane) growth was investigated.

Poultry litter compost extracts mixed 1:8, 1;5 and 1:2 with water were applied to 25 seeds of 13 weed species on moist filter paper in petri-dishes maintained at 25C with 12 hours of daylight. The highest concentration of compost extract completely prevented germination of seven species and reduced germination of five other species by 60-80%.

An evaluation of 26 apple cultivars for susceptibility to damage by nine insect pests showed highest percentage of clean fruit from Pristine and Sunrise cultivars while Ginger Gold, Braeburn, Sansam Arket and Creston had the lowest. Percentage of clean fruit generally was higher for cultivars (3) tested on MARK rootstock than for cultivars (23) tested on M.9 337 rootstock. Three cultivars tested on both rootstocks also showed higher (but non-significant) susceptibility to arthropod pests on M.9.337 rootstock.

A four-part protocol for managing honey bee mites using organic acids and essential oils has been developed which allows beekeepers to maintain strong colonies for pollination and honey production without reliance on synthetic acaricides. Large scale beekeepers (>1000 colonies) have adopted the protocol in five states and Canada. Fluvalinate-resistant and coumaphos-resistant varroa mites can be successfully treated with formic acid fumigation.

Mycorrhizal fungi, generally symbionts beneficial to plant growth, were shown to cause early growth depression in sugar cane when stem pieces were used to start new plants, but not when new plants were started from seed. Data collected to date suggests fungal colonization of roots emerging from stem pieces diverts excessive carbon from stored reserves and consequently slows subsequent shoot growth.

c) Funding: Hatch, State
d) Scope of Impact: Integrated research and extension

Key Theme 1.2 – Aquaculture

a) Description: Assess potential and develop optimum economic and environmental practices and provide support for the establishment and success of food and recreational aquaculture enterprises.

b) Impacts:

Two strains of hybrid bluegill were characterized for production potential using five commercially available feeds. Fingerlings (34g) were stocked at 5, 10, and 20 thousand/a in earthen ponds and fed 42% protein diets for approximately 400 days. Net production levels for the three stocking rates were 672, 1488 and 2151 lb/a, with a 16% fat diet producing the most growth. The Georgia Giant Hybrid grew more rapidly, but not more efficiently, that the other strain.

A survey of 220 responding customers (65% of the initial sample), first identified at three fee fishing enterprises, examined consumer opinions regarding fee structure and other variables affecting customer satisfaction with a fee fishing experience. Site cleanliness and availability of parking and rest rooms were variables not directly related to sport fishing which were most important to

customer satisfaction. Of those responding, 43% expressed a willingness to pay $30 for a successful "catch and keep" fishing experience. Hybrid bluegill could be a profitable species for fee fishing enterprises, especially for those enterprises catering to families and children.

Rainbow Trout grew well in effluent from an acid mine drainage treatment plant. Differences in inlet and outlet water quality were not significant except for dissolved oxygen. Fish showed no detectable levels of heavy metals.

A health survey (by veterinarian visit) of 15 West Virginia trout production facilities found pathogens endemic to the northeastern US at low prevalence. Infectious hematopoietic necrosis virus and viral hemorrhagic septicemia virus were not detected at any of the facilities. Cost for the health certification resulting from the survey would have been $3,000 - $5,000 with testing for *Myxobolus cerebralis* accounting for approximately 25% of the cost.

Raceways constructed of Honeycomb Fiber Reinforced Polymer (HFRP) have several advantages over those constructed from concrete. A study was conducted to develop and test an HFRP tank which can be field assembled from flat panels. Flat panels and prototype connectors were developed and the system was field assembled in approximately two weeks. The unit was stocked with 8000 Rainbow Trout and operated for 9 months in effluent from an acid mine drainage treatment plant. Fish showed a 98.6% survival rate and a 1.4 feed conversion ratio. Average stocking density at harvest was 52.6 kg/m^3 with a total net production of 3756 kg. Dissolved ion concentrations (in water) of Fe, Al, Mg. Ca, and SO_4 frequently exceeded recommendations but, accounting for ionic strength and dissolved ligand complexes, concentrations of free metal ions were within recommended limits. Fish grown in treated acid mine drainage were not different from those grown in spring water for plasma lactate levels or for tissue concentrations of Cd, Se, Al, Mn or Mg.

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

Key Theme 1.3 – Pasture Raised and Finished Beef

a) Description: Cooperative project with USDA ARS Appalachian Farming Systems Research Center and College of Agriculture and Life Sciences, Virginia Tech, to develop and implement beef cattle, birth-to-market production systems capitalizing on low-cost, Appalachian grasslands as a major production input.

b) Impacts:

Evaluation of variable stocking rate systems to maximize pasture availability utilized an initial stocking rate of four steers per hectare in 12 one-hectare groups,

without supplemental feeding, from early spring until mid-summer. When pasture height averaged 9.9cm, half the groups were reduced to a stocking rate of two steers per hectare, and half maintained at 4/ha. Half of both groups were given supplemental feed at 1.25% of body weight while half received no supplement. Both stocking rate and supplemental feeding affected final body weight and average daily gain with the latter having the larger affect on both. The lower stocking rate and supplemental feeding also increased carcass quality, hot carcass weight, rib eye area and dressing percentage, with supplementation also increasing yield grade. Results suggested a variable stocking rate system with limited supplemental feeding can be used to pasture finish steers by two years of age.

The ability of sodium bicarbonate to counter previously observed negative effects of concentrate supplementation on forage intake and fiber digestion was examined using growing steers receiving orchard grass hay, with or without either corn or wheat supplementation. Forage intake was greatest with the hay-only diet with no difference between supplement types. Total dry matter intake was greatest with the corn supplemented diet and was increased with the addition of sodium bicarbonate. Digestibility of both dry matter and fiber also were increased with the addition of sodium bicarbonate.

Two distinct knockout mutant endophytes, which are symbiotic with perennial ryegrass but fail to produce the ergot alkaloids toxic to grazing animals, were evaluated for ability to colonize and be transmitted through seeds of its host and to suppress the plant parasitic nematode, *P scribneri*. Results showed both knockout mutants to be essentially equivalent to the wild type endophyte in suppressing nematodes in perennial ryegrass (approximately 16% of the infection rate of endophyte-free controls). These results suggest ergot alkaloids do not contribute significantly to the nematode suppression observed in wild type, endophyte-infected ryegrass. Data also showed knockout mutant types to readily colonize their hosts and to be normally transmitted across generations in seeds of their host.

Significant progress has been made in identifying additional genes encoding enzymes involved in the ergot alkaloid synthetic pathway. Computer analysis highlighted a clustering of candidate genes tightly linked to known ergot biosynthetic genes in each of the previously investigated ergot alkaloid producing fungi. Additionally, investigation of alkaloid production in vitro led to the discovery of some rapidly growing fungal strains that produce significant quantities of ergot alkaloids under routine laboratory culture conditions. These fungal strains will greatly facilitate genetic analyses of newly discovered putative ergot alkaloid biosynthetic genes.

c) Funding: Hatch, State and special research grant.

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 1.4 – Agricultural and Forest Profitability

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

b) Impacts:

Analysis of embryonic and fetal mortality in sheep led to development of a model predicting events during the course of a typical pregnancy. Typical ewes which become pregnant are expected to have about a .97 chance to successfully complete while the probability an individual embryo will produce a live birth is .81. Pregnant ewes also are predicted to lose about 3% of their potential lambs during each 20-day period of pregnancy. Embryo or fetal mortality is predicted to occur equally with in-season and out-of-season breeding, from farm to farm and year to year within farm. Ewes carrying twin lambs are more likely to loose one of the pair than they are to loose both. Twin losses (complete) were associated with lower concentrations of progesterone at day 25-30 of pregnancy but partial losses showed no consistent relationship with serum concentrations of ovarian hormones. Additionally, GnRH injections were shown to increase percentage of ewes lambing to first service (32 vs. 27%) when given seven days after ram introduction, and also to increase percentage of ewes ovulating (53 vs. 48%) and ovulation rate (1.6 vs. 1.5) when given as an ovulatory dose.

Low birth weight lambs experience slower neonatal growth rate, reduced average daily gains, higher feed intake, reduced feed efficiency, lower accretion of fat and nitrogen, and have decreased bone development compared to higher birth weight lambs. Ewes injected with 500 mg of growth hormone at breeding and evaluated at 80 days of pregnancy had smaller chorioallantoic weight, higher percentage of placental cotyledons, and more efficient placentae (fetal weight/chorioallantoic weight) than non-injected controls. Growth hormone treatment modified placental development and may impact lamb birth weight and neonatal losses.

Previous work in the West Virginia Station has established the critical role of uric acid as a protection against oxidative stress in poultry as measured by accumulation of markers of reactive species mediated tissue damage. Supplementation of poultry diets with uricogenic compounds resulted in a dose-dependent decrease in oxidative stress. In vitro studies showed uric acid able to protect DNA and cellular membranes from damage by specific reactive oxygen species. The activity of hydroxyl and superoxide radicals detected by electron spin resonance was inhibited by addition of uric acid in a concentration dependent manner. Lipid peroxidation, a marker of cellular injury by reactive oxygen

species, was induced in cell culture by exposure to a silica-based stimulant of reactive oxygen species. Peroxidation of cellular membranes was reduced with addition of uric acid to the cell incubation mixture. Results suggest uric acid scavenges hydroxyl and superoxide radicals and protects against DNA damage and lipid peroxidation.

Previous work has cloned three genes from carnation petals shown to be related to ethylene associated flower senescence (all have associated mRNA's who's levels change significantly during flower development and senescence, during sucrose treatment, upon ethylene exposure, and with wounding of leaves, or after pollination). Wild-type and transgenic plants, the latter showing increased flower longevity, are being used to determine plant hormones involved in nutrient remobilization in age related senescence and also senescence following pollination. Petunia corollas loose essential nutrients in a very distinct pattern of remobilization during age-related flower senescence. Comparisons of age-related and pollination-induced senescence show similar patterns of remobilization but the time frame is significantly shorter in the latter.

A four-part protocol for managing varroa mites infecting honey bees using organic acids and essential oils has been developed. This protocol allows beekeepers to maintain strong colonies for pollination and honey production without reliance on synthetic acaricides. Large scale beekeepers (>1000 colonies) have adopted the protocol in five states and Canada. Fluvalinate-resistant and coumaphos-resistant varroa mites were successfully treated with a formic acid fumigator.

Efficacy of a hypovirus for the natural control of chestnut blight has been evaluated for approximately 14 years. Results show 90% of blight cankers originally inoculated with hypovirus still contain hypovirus. Additionally, 80% of non-inoculated cankers contain hypovirus if they were on a tree with an inoculated canker. Non-inoculated cankers on trees not having inoculated cankers, showed very infrequent infection with hypovirus. Invasive (scratch and puncture wounding of cankers) and non-invasive methods (simple application of hypovirus to cankers) of inoculation were compared both with and without application of an absorbent pad to protect the treatment inoculum and maintain a moist condition. Invasive treatments were approximately twice as likely to establish a hypovirus infection as was the non-invasive treatment. Covering cankers after treatment had no effect on hypovirus infection rate.

c) Funding: Hatch, State

d) Scope of Impact: Multi-state research
CTH, GA, KY, MA, ME, MI, MN, NH, NJ, NYC, NYG, PA, TN, TX, VA, VT, WA, USDA

Program 2 (National Goal 2 and 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 relationships between these goals and the small size of both programs in West Virginia. The small program size is partly due to loss of faculty and an inability to hire suitable replacements. We have recently hired two food scientists and are conducting searches for two human nutritionists. We therefore expect to make a considerably greater contribution to these national goals in our 2007-11 Plan of Work

The scope of Program 2 research efforts has included research in food quality and safety in support of state poultry and aquaculture industries. Because fish proteins are especially susceptible to freeze and freeze-thaw cycle induced denaturation, one research focus has been on developing superior (measured by product quality and safety) methods of cryopreservation for fish fillet and restructured fish products. A recently instituted and related area or research involves developing improved methods for protein and lipid recovery from trout processing by-products. Finally, research is being instituted to evaluate and develop non-thermal electron beam treatment as a critical control point to minimize microbial contamination, particularly in ground meat products.

A need to describe and understand dietary patterns among rural, relatively non-affluent families has been a primary motivation for studies to determine iron status of WIC infants, possible lead toxicity in mothers and infants, and levels of obesity in pre-school children in rural West Virginia.

Assessment of Progress

Program 2 (National Goals 2 and 3) currently represents a very limited area of research in the West Virginia Station. Our expectation is that efforts in this area will increase considerably in the next 5-year Plan of Work. Given the limited personnel and operating support afforded these goals, progress has been acceptable.

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

Source	$ or SY
Formula	**150,632**
State Funding	**221,417**
SY's (FTE)	**1.0**

Key Theme 2.1 – Enhancing Safety and Quality of Aquaculture Food Products

a) Description: Research to increase food safety and product quality, focused on poultry and aquaculture industries

b) Impacts:

Vacuum tumbling and alternative cryoprotection treatments (8% sugar/sorbitol; 8% trehalose/sorbitol and 2% sodium lactate) were examined for protection against product loss and protein denaturation during freeze-thaw cycling. Vacuum tumbling reduced thaw loss, all cryoprotectants reduced thaw loss and toughening after 1, 5, 10 and 15 freeze-thaw cycles, and sodium lactate reduced lipid oxidation and bacterial growth in trout fillets without adversely affecting product color.

A simulated 5.5 hour transport of live Artic Char in water, ice slurry, CO_2 or anesthetic solution was used to measure differences in indicators of fish stress (plasma cortisol, glucose, lactate, etc.) from transport in the alternative media. Plasma cortisol and lactate increased during the first hour of simulated transport in all treatments. Use of anesthetics during transport provided no clear advantage and, relative to ice slurry and CO_2, may have resulted in additional loss of product quality due to a more severe stress response.

Supplementation of trout diets with vitamin E (5000 mg/kg alpha-tocopherol) increased vitamin E content of trout fillets approximately three-fold following a seven week feeding period. Neither refrigerated storage nor fish fasting affected fillet vitamin E content.

Methods for protein and lipid recovery from trout processing by-products found solubility of myofibrillar and sarcoplasmic proteins to be highest at pH 2.5 and 12.5, with maximum precipitation at pH 5.5. Protein recovery was approximately 90% at pH 2.5 and near 80% at pH 12.5. Concentrations of omega-3 and omega-6 fatty acids in recovered lipids were approximately three time higher than in trout muscle, while concentrations of linolenic, EPA, DHA , linoleic and arachidonic were three to five times higher. Protein gels developed from recovered trout muscle protein exhibited superior gel strength but were more yellow than gels from Alaska Pollack surimi.

c) Source of Funding: Hatch, State

d) Scope of Impact: Integrated research and extension

Key Theme 2.2 – Promoting Healthy Nutrition for Rural Families

a) Description: Research to document and improve nutritional and dietary practices of rural families.

b) Impacts:

A study to describe dietary and non-dietary factors related to iron status of rural WIC infants (6-24 mos) found 75% of 57 subjects were normal for blood iron levels, 21% were iron deficient, and 4% were iron deficient anemic. Iron status was negatively affected by ounces of cow's milk per day, grams of calcium, and grams of phosphorus, and positively affected by number of daily servings of meat, fish or poultry. Breastfeeding for longer than six months had a larger negative effect on iron status than did not breastfeeding at all. Results indicate that breastfed infants need an additional source of iron at around six months of age.

c) Funding Source: Hatch, State

d) Scope of Impact: State specific

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

Overview

Research to support preservation of West Virginia's soil, water, forest and wildlife resources is an increasingly high priority in the West Virginia Station. Key research themes include protecting soil and water quality and developing economically effective and environmentally sustainable management practices for agriculture and forestry.

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.

Most acid mine drainage sites involve complex mixtures of contaminants. Efforts to define the nature and scope of the contamination have used both actual mine drainage sites and simulated drainage situations. Examples of the former inclued comparing wetlands impacted by the release of metal-laden sediments from acid mine drainage and those not so impacted. Research with simulated mine drainage is measuring, under laboratory conditions, impacts of sulfate, neutralizing cation action and endpoint pH on acid mine drainage neutralization with the goal of designing more efficient acid mine drainage treatment systems.

Research to develop 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. Examples include the development of soft chemical and mating disruption programs to minimize insect damage to tree fruit orchards, efforts to document and correct as necessary, impacts on non-target species from efforts to control gypsy moth defoliation of state forest lands, and developing methods to objectively assess value of environmentally sustainable practices.

Assessment of Progress

Progress toward achieving the objectives of Program 3 (National Goal 4) is acceptable. Of particular note are results documenting impacts on wetlands from surface and acid mine drainage and improving remediation methods as well as the successful simulation of acid mine drainage remediation under laboratory conditions.

Expenditures and SY for Program 3 (Goal 4)

Source	$ or SY
Formula	**443,191**
State Funding	**464,824**
SY's (FTE)	**4.3**

Key Theme 3.1 – Protecting Soil and Water Quality

a) Description: Research to evaluate soil and water quality, develop methods to prevent soil and water contamination and, where necessary, develop effective and cost efficient remediation programs

b) Impacts:

Selenium contamination of ground water from surface mining is a growing concern. Investigations were conducted to determine the effect of three levels of oxide coatings of kaolinite on Se and Mo retention capacity. Adsorption of selenite and molybdate occurred on hydrous oxide coated kaolinite above pHo. However, significant adsorption of selinate occurred only at pH values lower than pHo of the concerned solid phase. Coating of kaolinite with Fe as well as Al hydrous oxide increased the anion retention capacity of the minerals but the effect was greater with Fe than with Al hydrous oxide.

Wetlands impacted by the release of metal-laden sediments of acid mine drainage and those so not impacted, were compared. Wetlands receiving acid mine drainage generally contained higher levels of total sulfur and more often in the form of acid volatile sulfides and/or chromium reducible sulfides (generally >90% of sulfur is organic in non-impacted wetlands). Total iron was 4-5 times higher in

impacted than in non-impacted wetlands. Total nitrogen, total carbon and cation exchange in wetlands receiving acid mine drainage generally were lower than in non-impacted wetlands due to the influx of sediments from mine spoils and decreased plant productivity. Redox potential in wetlands receiving mine drainage indicated conditions that favor iron and sulfate reduction. The presence of acid volatile sulfide, coupled with high total sulfur and low sulfate, indicated sulfur is reduced and retained or never completely oxidized in at least some acid mine drainage impacted wetlands.

Floc properties are important considerations in the design of AMD treatment systems. Two common AMD neutralizing bases, NaOH and NH_4OH were used to treat synthetic AMD at three initial sulfate to iron molar ratios (0:1, 2.5:1 and 5:1) to endpoint pH values of either 7, 8 or 9. Neutralizing cation, sulfate content and endpoint pH had significant effects on floc mass and volume but sulfate ratio was most important. Settled floc volumes were slightly larger in the sodium system. Floc mass and volume decreased with increasing pH. Floc generated in the presence of sulfate required significantly more time to reach a total suspended solids discharge limit of 70 mg/l, had slower initial settling rates and smaller settled volumes than floc generated without sulfate.

A previously described persistence of the waterborne pathogen *Arcobacter butzleri*, was examined in laboratory microcosms to determine effects of temperature and antecedent oxygen growth conditions on survival following prolonged stress in groundwater. *A. butzleri* was very stable at lower temperatures but more sensitive to 25^{o}C, with survivors reduced from two to five orders of magnitude within two days. Aerobically grown cells were most persistent (two-log reduction), while those previously growing anaerobically were considerably more sensitive (three- to five-log reduction).

Numbers, distribution and diversity of coliform and heterotrophic bacteria were examined in wastewater treated by a subsurface flow wetland servicing a large multi-user facility. Passage through the wetland resulted in a minimum two-log reduction of coliforms and heterotrophic bacteria, even during colder months when surface of the wetland was frozen. Differential survival of heterotrophs occurred as a function of cell size with smaller cells less likely to maintain influent proportions to the wetland effluent.

c) Funding: Hatch, McIntire-Stennis and State

d) Scope of Impact: Multi-state, integrated research and extension
CT-NH, NA, ME, NH, NJ, NY-G, OA, VT

Key Theme 3.2 – Sustainable Agricultural and Forestry Practices

a) Description: Research to devise, evaluate, and implement alternative, sustainable agricultural and forestry practices.

b) Impacts:

A soft-chemical / mating disruption program (Reduced-risk and Mitigation Program or RAMP) was compared to a conventional chemical spray system for controlling apple and peach insect pest. The RAMP system experienced less apple damage than conventional spray from codling moth, oriental fruit moth and leafrollers; greater damage from tarnished plant bug and San Jose scale; and similar damage from plum curculio, European apple sawfly and apple maggot. Clean fruit averaged 95 and 90% for RAMP and conventional systems, respectively. Insect injury in peaches was similar between RAMP and conventional spray systems with near 99% clean fruit for both systems. Stinkbug traps placed between apple trees were found to be more effective than those placed in the tree canopy. Traps baited with Euschistus spp. aggregation pheromone were more effective than unbaited traps.

The monitoring of impacts on non-target species from spraying of *Bacillus thuringiensis kurstaki* (Btk) to control gypsy moth continues. Significant declines were found in selected spring feeding Lepidoptera. Tachinid parasitic flies declined on Btk plots but not significantly, and to this point, neither sawfly adults nor predators, carabid beetle or spiders show any clear decline on treatment plots. There are no significant treatment effects for songbirds but a tendency for fewer birds has been noted for 19 of 27 species, presumably due to fewer caterpillars on which to feed.

The economic value of three attributes of stream restoration (aquatic life, swimming and scenic quality) was determined from survey responses using multi-attribute, choice experiments with analysis of nested logit models. Results showed relative economic value to full stream restoration to be: aquatic life > scenic quality = swimming. Consumer surplus estimates for full restoration for all three attributes ranged between $10 and $19 per month per household, or about 20-40% of the average monthly charges for water and sewer in the area surveyed. Aggregating consumer surplus estimates for the entire watershed gave an estimated benefit of restoration for this stream of just under $2 million. The procedure used here should be of value as part of a cost-benefit analysis for stream or other environmental restoration projects. The procedure should be equally useful for economic evaluation of alternative management systems which avoid the need for subsequent restoration.

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

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

Overview

Stagnant or declining per capita income, population outflow and unemployment are chronic problems in large areas of West Virginia. Research to develop technologies and management systems which support economic development consequently represent a high priority in the West Virginia Station. Research which supports improvements in factors, independent of income, which affect quality of life may be equally important in stemming outflows of human capital.

The predominantly rural character of West Virginia dictates that Station research will focus on economic development and quality of life issues primarily in rural communities having agricultural and/or forest based economies.

Assessment of Progress

Progress toward achieving objectives of Program 4 (National Goal 5) were modest but acceptable given the limited resources allocated to this program. Results relating to the potential for substantially increasing the fee fishing industry in West Virginia and to package this activity with accommodations, meals and other activities, is especially encouraging as is the ability to utilize treated mine drainage in aquaculture production. Obtaining premium prices for hardwood products produced by sustainable methods also may offer potential for small, niche markets.

Expenditures and SY for Program 4 (Goal 5)

Source	$ or SY
Formula	**647,761**
State Funding	**721,660**
SY's (FTE)	**8.7**

Key Theme 4.1 – Enhancing Community Economic Development

a) Description: Research to assist rural communities in developing profitable and sustainable local industries and improve local quality of life

b) Impacts:

Surveys were sent to 5000 (received by 4,628) individuals previously contacting the West Virginia Bureau of Tourism for travel information and not having a then

current West Virginia fishing license. The intended, out-of-state resident target audience was achieved with respondents from 47 states and the District of Columbia. Respondents (691 = 14%) indicated fee fishing would be attractive to them as a potential visitor to the state and favored the activity to be bundled in a lodging/multi-activity package.

Rearing rainbow trout in treated mine water was found to be profitable under the conditions investigated and can be a potent strategy for economic development in West Virginia. Fish grow essentially as well in treated mine waters as in other waters and treated mine water aquaculture frequently has the additional advantage of being allowed as a modification / alternative to legally required water quality remediation programs which are more costly. Like other forms of aquaculture, however, the level of risk is relatively high with fish production in treated mine waters. Raising a combination of fish species and establishing a variety of sales outlets were found to be effective risk management strategies.

A survey designed using a modified Dillman approach was sent to 265 nationwide exporters of hardwood products. The survey addressed their assessment of demand for hardwood products "certified" as produced using sustainable practices. Responses were received from 111 exporters (42%) and of those, 29 (26%) indicated they receive requests for certified products. Highest levels of demand were indicated as coming from European and Chinese markets. Results show demand for certified hardwood products may be a valuable niche market for some hardwood product producers and exporters.

Quality of life perceptions by rural West Virginia citizens were measured by survey and related to various economic and non-economic variables. Approximately 57% of respondents rated their quality of life as good. Perceived quality of life was lowest by age for individuals in their mid-thirties and between 45 and 64. Lower quality of life assessments were associated with men as opposed to women, single as opposed to married individuals, unemployed as opposed to employed, lower as opposed to higher levels of income and education.

Contact with wildlife populations generally is seen as enhancing quality of life but, increasingly, there are concerns with excessive human-wildlife interactions. Scientists in the West Virginia Station participate in a multi-state project to define the scope of this problem involving deer, black bear and other species, and to develop strategies for remedial action. Work in 2003, cooperative with the West Virginia Division of Natural Resources, analyzed data on 157 nuisance and 118 non-nuisance black bears captured between 1996 and 2002. When compared to their non-nuisance counterparts, nuisance bears tended to be male, older and more likely to survive fall hunting season. Nuisance bears translocated > 5 km from their capture site were less likely to repeat nuisance behaviors than those translocated a lesser distance. Sufficient translocation from capture sites and policies to increase hunting mortality rates of nuisance bears during hunting season were suggested as strategies for reducing problems

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c) Source of Funding: Hatch, State

d) Scope of Impact: Multi-state research
CT-NH, MD, NJ, NY-C, PA, VA

B. Stakeholder Input Process

Most stakeholder input has been collected in conjunction with West Virginia University Extension (administratively distinct from the College of Agriculture, Forestry and Life Sciences) since we share a large majority of stakeholders. We this year discontinued special meetings having the gathering of stakeholder input as their sole purpose, and instead, relied on 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, etc.). We find the new procedure to be 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 will be acted upon beginning in the coming growing season, is to develop and distribute cost-of-production and income budgets for individual vegetables in addition to those for the entire “market garden” as has been the past 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 quickly broadens to include many academic and outreach concerns which are linked to research. Examples of suggestions from the Advisory Board acted upon or currently being considered by College administration include, strong encouragement to work with 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 for 2007 – 2011 on clearly defined and uniformly understood vision and mission statements from the College/Station and from each Division in the College.

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 9 Northeastern, four Southern, one Western and one Northcentral regional projects during 2003. Subject matter addressed ranged from breeding improved forage crops (for feed and/or biomass), to developing TMDL assessment tools, to management of wildlife damage, to determining impacts of out-of-school experiences on youth development.

West Virginia scientists participate in two Southern regional projects designed to identify, remediate and protect water resources. S-1004 is testing the reliability of various models to develop TMDL standards in agricultural watersheds as well as methods to evaluate existing situations and provide remediation where necessary, considering both biologic and economic variables. Project S-297 is investigating a variety of techniques to distinguish human vs. livestock vs. wildlife fecal contamination to more quickly identify and eliminate sources of contamination. The latter project also is identifying microbial agents which either biodegrade or enable plant uptake of chemical contaminants. Both of these projects are extremely important for economic development and quality of life in West Virginia.

Multi-state projects relevant to specific, economically important plant commodities in West Virginia include projects to evaluate new apple cultivars, to 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 product quality.

The abundant wildlife in West Virginia is both an asset and potential liability. Property and personal damage from deer, bear, geese and other species are increasing rapidly in frequency and cost. West Virginia participates in NE-1005, *Management of Wildlife Damage in Suburban and Rural Landscapes*, which seeks to document and minimize damage to individuals and property from excessive contact with wildlife. Cooperation among researchers from seven northeastern states recently has assessed the impact of Sunday hunting on annual deer kill, developed and tested methods for dispersing Canada geese, significantly reduced repeat offending nuisance bears, and studied feasibility of controlling fertility in white-tailed deer.

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 while reducing pesticide exposure risks.

Multi-state research projects involving pasture-based production systems for beef, sheep and dairy; projects related to animal waste management and those developing methods for more efficient reproduction in pasture maintained livestock, are of key importance in enabling West Virginia producers to capitalize on 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 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 examples being the aquaculture and organic farming projects 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. Similarly, the organic farming project involves both Davis College and WVU Extension faculty in horticulture, agronomy, plant physiology, soil science, entomology, plant pathology, and economics in a holistic, user

centric approach to sustainable production. 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.

E. 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 the production, processing, and marketing of value-added products, as well as the 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.

Appendix C

U.S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Multistate Extension Activities and Integrated Activities
(Attach Brief Summaries)

Institution West Virginia University
State West Virginia

Check one:
_____ **Multistate Extension Activities**
__X__ **Integrated Activities (Hatch Act Funds)**
_____ **Integrated Activities (Smith-Lever Act Funds)**

	Actual Expenditures				
Title of Planned Program/Activity	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
1. Pasture Production of Livestock	**280,135**	**325,127**	**571,673**	**703,207**	
2. Competitive Poultry Industry	**279,656**	**140,078**	**265,064**	**310,876**	
3. Develop/Support Aquaculture	**160,762**	**244,047**	**429,663**	**480,105**	
4. Improved Water Quality	**169,940**	**162,058**	**257,827**	**660,445**	
Total	**890,493**	**871,310**	**1,524,259**	**2,154,636**	

_____ **4/1/04**

Form CSREES-REPT (2/00) **Director** **Date**