FY 2005

Introduction

The Crop Protection and Quarantine National Program (NP 304) addresses high-priority insect, mite and weed pest problems of crops, forests, urban trees, rangelands, postharvest systems (e.g. stored grains) and natural areas. The goals of NP 304 are to understand the biology, ecology and impact these pests on agricultural production and natural systems, and to develop, improve, and integrate environmentally safe technologies to exclude, eradicate, or manage pest populations. A priority is placed on sustainable and integrated practices that enhance the productivity, quality and safety of U.S. agriculture while protecting natural resources, native ecosystems, human health, and the overall environment.

To accomplish its goals, the Crop Protection and Quarantine National Program is divided into two research mission areas: 1) insects and mites; and 2) weeds. Each mission area is comprised of several components. There are six research components for insects and mites.

I. Identification and Classification of Insects and Mites
II. Biology of Pests and Natural Enemies (includes microbes)
III. Plant, Pest, and Natural Enemy Interactions and Ecology
IV. Postharvest, Pest Exclusion, and Quarantine Treatment
V. Pest Control Technologies
VI. Integrated Pest Management Systems and Areawide Suppression Programs

There are four research components for weeds.

VII. Weed Biology and Ecology
VIII. Chemical Control of Weeds
IX. Biological Control of Weeds
X. Weed Management Systems

Because the Plant Diseases National Program (NP 303) addresses plant pathogens and nematodes, they are excluded from NP 304. However, the IR-4 Minor Use Pesticide Program (which falls under the direction of NP 304) deals with all pests including plant pathogens and nematodes. Some research projects in NP 304 expired during 2005 and new projects were initiated. These new projects began after being approved via a peer review process under the auspices of the ARS Office of Scientific Quality Review (OSQR).

National Program 304 not only addresses research on insect, mites and weeds that have been established for a long time, but also on more recently introduced and invasive pests. All invasive species (insects, weeds, plant pathogens and nematodes) cost the U.S. over $137 billion per year, which is equal to about $500 per U.S. citizen each year. Their impact on production agriculture is staggering, and is second only to habitat loss in causing negative effects on the natural environment and biological diversity. Currently, there are more than 30,000 invasive species in the U.S. and the number of new species introduced increases each year. Many of these newly introduced and invasive species have yet to be described and are unknown to science and therefore there is no information on what their impact may be or how to deal with them. The growing threat of introduced organisms prompted the formation of the Invasive Species Council in 1999, which provides guidance for agencies to increase their efforts to exclude, detect, and eradicate incipient populations and to manage established species.

Invasive insects such as the glassy-winged sharpshooter, emerald ash borer, silverleaf whitefly and other whiteflies, Asian longhorned beetle, Russian wheat aphid, pink hibiscus mealybug, cereal leaf beetle, Chinese soybean aphid, numerous fruit flies, and many others are high priority targets of NP 304. The ultimate goal of NP 304 is to develop area-wide and integrated pest management strategies to mitigate these problems. On average, insect and mite pests destroy 13% of crop production each year, which amounts to about a $36 billion loss. Invasive arthropods are responsible for about $14 billion of this total. Just the loss to lawn and garden pests from insects such as Japanese beetle is $1.5 billion annually. Invasive insects and mites are a frightening threat to the U.S. with new species appearing each year.

Invasive weeds threaten U.S. agriculture and its environment, and are also a great concern of the Crop Protection and Quarantine National Program. Over 100 million acres are currently infested by invasive weeds such as leafy spurge, melaleuca, Old World climbing fern, giant salvinia, salt cedar, hydrilla, waterhyacinth, yellow starthistle, downy brome, Brazilian pepper, jointed goat grass, and purple loosestrife. Total weed populations increase 8% to 20% annually. As aggressive, destructive pests, they are extremely difficult to control. In addition to being hard to kill, weeds are difficult to control over wide areas because land is owned and managed in a discontinuous manner. Land ownership and use is like a checkerboard pattern, therefore control actions are not coordinated across boundaries. Challenges to manage weeds safely and economically occur in production agriculture, grazing lands and natural areas. Each year, weeds reduce crop yields by about 12% (about $36 billion in losses) and 20% of forage yields (about $2 billion in losses). Aquatic weeds also are a major problem with $100 million spent annually on their control. Besides losses to the agricultural economy, invasive weeds also damage the environment. About half of the threatened and endangered plant species in the United States are primarily at risk because of invasive weeds.

Many NP 304 research activities on invasive species are conducted in support of action agencies, such as the Animal and Plant Health Inspection Service (APHIS). The research has resulted in the exclusion of more potential invasive species, faster detection, and more effective eradication of new invading species. The research already is resulting in more efficient long-term management of established invasive species. These improvements result from emphasizing weed identification, systematics, biologically based areawide and integrated pest management, and ecosystem management.

In 1995, ARS implemented its first areawide integrated pest management (AWPM) partnership project against the codling moth on apples and pears in the Pacific Northwest. Three additional projects were initiated shortly thereafter with corn rootworms, stored wheat insects, and leafy spurge weed as targets. These four projects have been completed and now enjoy great success with adoption of the technologies by end-users. Between 2000 and 2002, ARS initiated five new areawide IPM projects aimed at both invasive and established species: 1) fruit flies in the Hawaiian Islands in multiple crops, especially fruits and vegetables, using field sanitation, male annihilation, protein bait applications, biological control, and sterile insect technology (Hilo, Hawaii, FY 2000); 2) fire ants in Florida, Texas, Oklahoma, Mississippi, and South Carolina, on pastures using natural enemies, microbial pesticides, attracticides and GIS/GPS tracking (Gainesville, Florida, FY 2001); 3) Russian wheat aphid and greenbug on wheat in the U.S. Great Plains using crop diversification, aphid-resistant varieties, biological control agents, and other biologically-based pest control technologies (Stillwater, Oklahoma, FY 2002); 4) the melaleuca tree in Florida using natural enemies and microbial biological control (fungus), judicious use of herbicides, mechanical (mowing) and physical (fire) control, and combinations of these tactics (Fort Lauderdale, Florida, FY 2002); and, 5) the tarnished plant bug on cotton in the delta of Mississippi and Louisiana using alternate/non-crop host destruction host-plant resistance, and remote sensing technology (Stoneville, Mississippi, FY 2002). Most of these projects have received one or more prestigious awards for their customer outreach and technology transfer successes.

ARS has made significant progress during Fiscal Year 2005 in crop protection and quarantine research. Some noteworthy examples are listed below, representing a few of the many accomplishments that have been reported from the numerous in-house and extramural projects assigned to National Program 304. Each project's annual progress report can be accessed at this site. The reader may obtain additional information on all of NP 304's programs and accomplishments by accessing the annual progress reports.

Insects and Mites

Component I: Identification and Classification of Insects and Mites

Insect identifications prevent introduction and spread of invasive species into the United States. Most U.S. pests have been introduced from other parts of the world and cause billions of dollars in damage annually. In fiscal year (FY) 2004, scientists in Beltsville, Maryland, provided 11,145 identifications (5,083 of urgent priority) to a broad array of organizations. The vast majority of identifications are provided to the USDA Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine division. APHIS reports that nine species identified by ARS scientists were new immigrants to the United States. In addition, a new species of fruit fly was described from Columbia. This will facilitate trade in mangos and other fruit between Columbia and the United States. Response to scale pests will now be facilitated by development of an online expert system, which has tools for accommodating a large amount of morphological variation in specimens. In addition, a comprehensive analysis was completed that describes and illustrates all members of the genus Diuraphis, including the destructive Russian wheat aphid.

Component II: Biology of Pests and Natural Enemies (includes microbes)

Red flower beetle genome sequenced. This is the first agronomic pest species to be sequenced and represents the joint efforts of the ARS Grain Marketing and Production Center, Biological Research Unit, Manhattan, Kansas; Kansas State University; and the Baylor College of Medicine's Human Genome Sequencing Center. The genome sequence scaffolds were merged with genetic and physical maps, resulting in map position assignment for 75 percent of the genome. Planning and coordination of genome analysis and annotation efforts were initiated at the International Tribolium Genomics Meeting in Gottingen, Germany, in August 2005. The analysis of this sequence will have far-reaching impact on understanding physiological adaptations of pest and beneficial beetle species, and the identification of novel targets for pest control exploitation.

Radio Transmitters Prove Key to Understanding Mormon Cricket Swarms and Migrations. Radio transmitters have been used to track everything from antelope to zebra; but insects? You bet! Scientists from the ARS Northern Plains Area, University of North Carolina-Chapel Hill, and University of Toronto-Mississauga placed miniature radio transmitters on Mormon Crickets to study their behavior and movement. Mormon Crickets are notorious for the huge and devastating swarms (or bands) they occur in and their ability to migrate hundreds of miles in the Western States. Why and how these swarms are formed and maintained has been a mystery until now. The above researchers demonstrated that Mormon crickets form migratory swarms to avoid being eaten by their predators. Once the swarms are formed, the movement of individual crickets within these groups is induced simply by contact with other crickets, thereby providing a mechanism to explain the constant long-term movement of these insect groups across the landscape. This work helps explain why insects around the world such as the infamous desert locust in Africa form migratory bands, and provides important information on the movement of individuals within these groups. This knowledge will form the basis for predictive movement models that will aid management efforts for Mormon crickets and desert locusts.

Scientists find that selenium, hydrogen peroxide, and Vitamin C provide resistance to baculoviruses. ARS scientists in Columbia, Missouri, were able to show that the budworm requires selenium for optimal resistance to baculovirus infection. As levels of selenium rise after feeding with a selenium-supplemented diet, virucidal activity against baculoviruses also increases. These results indicate that viral ecology may be directly influenced by micronutrients available to leaf eating insect pests both in the soils below and in the species of plants they consume. In addition, the scientists found that the generation of hydrogen peroxide appears to be the mechanism to kill viruses in budworm larvae. Supplements of Vitamin C given to the larvae also abolish virucidal activity.

Genetic structuring of corn rootworm populations. The corn rootworm causes over $1 billion in losses each year in the United States. The western corn rootworm has developed a resistance to crop rotation, many insecticides, and may have become resistant to Bt corn as well. ARS scientists in Ames, Iowa, have determined the genetic variation across 10 widely separated populations. The results show that the populations have not had time to drift apart genetically. This knowledge will be used to determine migration rate and population size of these insects. This information is critical to successful insect resistance management. The related northern corn rootworm has been show to have genetically distinct populations by ARS scientists in Fargo, North Dakota. This dramatic delineation of populations could possibly be accompanied by extended diapause or increased resistance to Bt corn. This could cause the populations to react differently to control methods.

Component III: Plant, Pest, and Natural Enemy Interactions and Ecology

New Russian Wheat Aphid Biotype Discovered. The Russian wheat aphid is a serious pest of wheat and barley in the Western States. Resistant wheat varieties served as the cornerstone for managing Russian wheat aphid until 2003, when a biotype (AKA strain) of the aphid appeared that was able to feed on, injure and kill the resistant wheat. The aphid-resistance in these wheat varieties was based on one and the same wheat gene. In 2005, ARS scientists at the Wheat, Peanut and Other Field Crops Research Unit in Stillwater, Oklahoma discovered three new Russian wheat aphid biotypes differing in their ability to injure wheat with unique resistance genes. One of the new biotypes is especially troublesome, because it damages all commercially available sources of plant resistance. While the new biotypes still occur in low numbers in the field, they may become numerous in the near future. This information was quickly disseminated to wheat breeding programs in the U. S. Due to these population monitoring activities by the ARS, scientists in the U. S. have a head start in finding and developing new sources of Russian wheat aphid resistance before the new biotypes become abundant.

Epidemiology of Pierce's Disease in Grapevine is Linked to Age of the Disease Vector, the Glassy-Winged Sharpshooter. Pierce's disease is a lethal disease of grapevine caused by the bacterium *Xylella fastidiosa* (*Xf*). Before Pierce's disease (or any plant disease for that matter) can be adequately managed, the epidemiology and rate of transmission of *Xf* by the glassy-winged sharpshooter needs to be defined. ARS scientists in Riverside, California were able to determine the proportion of glassy-winged sharpshooters which were harboring *Xf* and able to transmit *Xf* over the growing season. Using a combination of PCR and ELISA techniques, they determined that an increasing proportion of the adult glassy-winged sharpshooter population becomes positive for *Xf* as it ages following emergence from mid-June through early August. In addition, the mean titer of *Xf* also increases through time, suggesting that glassy-winged sharpshooter adults become a greater threat as vectors of *Xf* as they grow older.

Weak Link in Population Ecology Identified for Sweet Potato Whitefly Becoming Problematic on Cotton. The Sweet potato whitefly is a severe pest of cotton. This is partly due to its wide host range of other crops and weeds which it uses a bridge between cotton crops. However, ARS scientists at the Western Cotton Research Laboratory in Weslaco, Texas have discovered that while predation and dislodgement from host plants are major sources of mortality for sweet potato whitefly on all host plants, how well they do on spring-planted cantaloupes largely determines if they will be pests on summer cotton. This new information on sweet potato whitefly ecology can be used to predict outbreaks and designing control strategies that take advantage of this weak link in whitefly's population dynamics.

Component IV: Postharvest, Pest Exclusion, and Quarantine Treatment

Near-Infrared Spectroscopy Helps Keep Flour Safe and Clean for Consumers. The U.S. has the safest and cleanest commercially milled flour in the world. Because stored grain insects are a fact of life in the milling industry, it is impossible to completely rid flour of insect part contaminants. However, the Food and Drug Administration (FDA) sets a high standard of cleanliness for milled flour. Any flour that has 75 insect parts per 50 grams of flour is unfit for human consumption and cannot be sold or used. Milled flour is rigorously checked by the FDA. ARS scientists are helping to ensure flour meets the FDA standards by improving on the methods to detect contaminant insect parts. Near-infrared spectroscopy is proving to be an improvement over the older chemical extraction method for testing flour. ARS scientists have shown that near-infrared spectroscopy is a faster and less costly method, but still as effective. In addition, ARS has found that the number of fragments of insect parts found in flour depends on the life stage the insect was in when the wheat was milled. For example, wheat kernels infested with adult lesser grain borers contribute 10 to 28 times more fragments than kernels infested with larvae or pupae. This means that more heavily infested grain can be milled and still pass the FDA test if the insects are in the larvae or pupae stage. This information will allow for a refinement in the testing process and improve the quality of milled flours for consumers.

Aerated Wheat Stored in Bins to Control Insect Pests. Once wheat is harvested and placed in grain bins on the farm, it is still not safe from insect attack. Stored grain insects feed on wheat in bins thus reducing the quantity and quality of the harvested grain. ARS scientists at the Grain Marketing and Production Research Center in Manhattan, Kansas have found that cooling bins by aerating with low-volume rates of ambient temperature air reduces insect populations. This is true for the autumn and warmer summer months as well. Research is continuing to refine aeration technology for optimization of stored grain pest management.

Component V: Pest Control Technologies

Biological control at the ARS overseas laboratories. Invasive weeds and insect pests of foreign origin cause major economic losses (greater than $100 billion per annum) and ecological problems in the United States. Olive fruit fly was first reported in California in 1998 and is now established in olive growing regions in the central part of the state. The fly is capable of infesting 100 percent of the fruit on a tree, rendering the harvest unmarketable. In 2004, a project was initiated at the European Biological Control Laboratory (France), and explorations for natural enemies were immediately conducted in southern Africa. Olive fly parasitoids (small wasps) were identified and sent to University of California-Berkeley and California Department of Food and Agriculture cooperators, who first released the biocontrol agent in 2005. This represents a rapid response to a serious agriculture problem.

Genetic transformations stabilized. A system was tested that stabilizes certain forms of genetic transformations by ARS scientists at the Center for Medical, Agricultural, and Veterinary Entomology, Insect Behavior, and Biocontrol Research Unit, Gainesville, Florida. The danger of genes from modified organisms being transferred to other plants or animals has hindered or prevented the application of transformation technology in insect control programs. A new technique was successfully tested in an insect that immobilizes the integrated DNA once it has been transferred. By limiting risk, the “suicide” system has the potential to make new and improved forms of control – such as sexual-sorting strains for sterile insect technique and temperature-sensitive strains that cause the offspring of released insects to die at certain temperatures – available for area-wide management of pest fruit flies and moths.

Experimental attractant for cactus moth males. A synthetic lure has been developed for cactus moth males based on chemicals produced by virgin female cactus moths by scientists at the ARS Subtropical Horticulture Research, Miami, Florida, in collaboration with ARS scientists in Gainesville and Tallahassee, Florida and APHIS in Raleigh, North Carolina. A lure for this invasive pest is needed to delimit movement into areas that are currently uninfested and to evaluate implementation of control measures such as mechanical control or use of sterile insect technique. A chemical blend based on chemicals found in the glands and/or released from sexually mature virgin female cactus moths has been formulated into a lure. Laboratory and field tests were conducted to determine release rates and rations of the chemicals, and experimental lures were produced by a CRADA partner for field tests by APHIS.

Component VI: Integrated Pest Management Systems and Areawide Suppression Programs

Cooperative area-wide integrated pest management (IPM) tarnished plant bug project shows cotton growers how to manage a serious pest. The tarnished plant bug is a serious pest of cotton that is becoming more resistant to insecticides, requiring growers to use higher and higher levels of chemicals to achieve the same level of control. Within a few years, insecticides may no longer be effective against this pest. The tarnished plant bug is being thwarted thanks to a program that includes use of alternative host destruction, host-plant resistance, fungal pathogens, and remote sensing technology by ARS scientists based in Stoneville, Mississippi, in cooperation with cotton growers and university scientists in Mississippi, Louisiana, Tennessee, and Arkansas. Grower adoption of the technology is 86 percent in the Mississippi Delta and 33 percent in Arkansas, a state where the technology was demonstrated for the first time in 2004. Adoption of the technology is approximately 33 percent in Louisiana and Tennessee. Across the four states, the technology is applied to approximately 1.47 million acres of cotton. A cost/benefit analysis of the program on over 21,000 acres demonstrated benefits of $10.28 for every $1 applied to using the technology. Economists have determined the technology produced a $5.48 savings per acre in reduced insecticide costs. The savings in reduced insecticide costs for the technology was $8.1 million.

Integrated Pest Management Approach Adopted by Hawaiian Farmers to Suppress Fruit Flies. In past years, a complex of four fruit fly species was a major limiting factor to fruit production on the Hawaiian Islands. Farmers relied on organophosphate insecticides for control, but the sprays were costly, harmful to the environment, and generally not very effective. Today farmers are adopting an effective Integrated Pest Management Approach to deal with fruit flies and have greatly reduced the use of insecticides. The program utilizes four approaches: 1) Mass-trapping/male annihilation, 2) bait sprays/bait stations, 3) augmentative parasite releases, and 4) sterile fly releases. This success is a direct result of an ARS Areawide Pest Management Program, which was designed to transfer new fruit fly suppression technologies to Hawaiian farmers. The program began in 2001 with three demonstration sites at: 1) Waimea, Island of Hawaii; 2) Kula, Island of Maui; and 3) Central Oahu Island. On Hawaii Island, growers and cooperators increased to 378 with 2,600 acres under suppression; on Maui Island, grower and community cooperators doubled to 175 with 550 acres under suppression; and on Oahu Island, grower and community cooperators increased five fold to 287 with 4,500 acres under suppression, proving that the technology techniques are effective for fruit fly suppression and acceptable to Hawaii's farmers.

Aphid Infestations in Wheat Are Monitored by Remote Sensing Technology in the Areawide Pest Management Program for Russian Wheat Aphid and Greenbug. Accurate and inexpensive methods are needed for monitoring wheat fields to determine the presence of Russian wheat aphid or greenbug infestations. Wheat farmers and scientist cannot always easily detect aphid infestations or do not have the time to closely monitor their fields. ARS Scientists from the Wheat, Peanut and Other Field Crops Research Unit, Stillwater, OK, in collaboration with the cooperators at the Texas Agricultural Experiment Station, developed remote sensing technology for identifying greenbug and Russian wheat aphid-infested fields. Images obtained from aircraft allow the detection of Russian wheat aphid and greenbug infestations. Fields with high aphid infestations can be differentiated from fields with low infestations by unique "spatial signatures". Ultimately this technology could be applied for broad scale monitoring of wheat fields for greenbug and Russian wheat aphid infestations using existing satellites in the earth's orbit.

Weed Science

Component VII: Weed Biology and Ecology

Genetic identification of red rice ecotypes, rice cultivars and their crosses. Intercrossing between rice and ecotypes of weedy red rice, a dominant weed in the southern United States, may reduce yield when herbicide-resistant rice systems are used. DNA/PCR microsatellite fingerprinting analyses were conducted to quantify rates of outcrossing between rice x red rice crosses (including imidasolinone-resistant rice cultivars), foreign rice cultivars, and red-seeded rice relatives from throughout the world at the ARS Dale Bumpers National Rice Research Center, Stuttgart, Arkansas. A method was developed enabling distinguishing crosses using DNA marker analysis. These analyses may allow the rice industry to identify (or rule out) the parental lines that are responsible for development of an unwanted population of herbicide-resistant rice x red rice hybrids, a key management consideration in herbicide-resistant rice systems.

Component VIII: Chemical Control of Weeds

Development of in-crop herbicidal options to control grass and broadleaf weeds in sugarcane. In-crop herbicidal options, especially herbicides that can be applied to control a broad-spectrum of grass and broadleaf weeds at the start of a growing season when weeds have their greatest impact on sugar yields, are limited. Scientists at the Sugarcane Research Unit in New Orleans, Louisiana, evaluated herbicides alone and in mixtures for control of bermudagrass, itchgrass, morningglory, and seedling johnsongrass when applied as single and sequential applications. They found that morningglory in particular could be controlled under sugarcane crop canopy. Results of this research was used to support manufacturer petitions to the Environmental Protection Agency for labels for two herbicides, which were received in time for the 2004 growing season.

Component IX: Biological Control of Weeds

Successful biological control of weeds using weed destroying beetles depends on being able to monitor beetle populations in the field. Scientists from ARS, the Illinois Natural History Survey and Pfizer Manufacturing (Kalamazoo, Michigan) made a significant contribution to further control the invasive weed purple loosestrife. They extracted, identified, synthesized, and field tested a pheromone from the leaf beetle *Galerucella calmariensis*, which is a biological control agent of the weed. Pheromones are natural chemicals produced by insects, which help males and females attract each other for the purpose of mating. This accomplishment contributed significantly to the basic understanding of the chemistry and biology of leaf beetle pheromones. The pheromone could be developed into a practical tool for monitoring and manipulating populations of this important biological control agent of purple loosestrife.

<u>Successful biological control of melaleuca in South Florida</u>. The Australian melaleuca tree (*Melaleuca quinquenervia*) is an extremely aggressive invasive plant that alters the drainage of South Florida, and affects natural areas, outcompeting valuable native species. Restricting the invasiveness of melaleuca requires reducing its ability to produce massive amounts of seeds. ARS scientists at the Invasive Plant Research Laboratory, Fort Lauderdale, Florida, in collaboration with Florida Department of Environmental Protection, U.S. Army Engineers, and South Florida Water Management District personnel and other partners, released two biological control agents: a tip-feeding weevil (*Oxyops vitiosa*; 1997) and a sap-sucking psyllid bug (*Boreioglycaspis melaleucae*, 2002). Both species are contributing to successful biological control of melaleuca. In particular, the psyllid has spread throughout the infestation of melaleuca, and is significantly affecting growth and survival of the weed; in fact, melaleuca is almost gone from public lands!

<u>Biological Control of Salt Cedar</u>. Invasive saltcedar (*Tamarix* spp.) shrubs from Eurasia infest many Western U.S. waterways where they cause significant economic and environmental losses. Detailed studies on foreign exploration and host-specificity testing for natural enemies of saltcedar were conducted by ARS scientists at the European Biological Control Laboratory, Montpellier, France, the Western Regional Research Center, Albany, California, the Grassland Protection Research Unit, Temple, Texas, and the Crop Bioprotection Research Unit, Peoria, Illinois. The first biological control agent for saltcedar, the beetle *Diorhabda elongata*, was released in 1999 at 10 sites in six States. The beetle continues to cause widespread defoliation and death of saltcedar. A pheromone trap was developed this year that enables detection of the leading edge of spread of the beetle. Additional populations of the beetle are being sought in its native range that are better adapted to areas where the beetle is not performing as well due to a climatic mismatch. Impact of the beetle continued on saltcedar and on native plant communities (cottonwoods and willows). This research is important as it interfaces with on-going investigations of biologically based saltcedar control, provides revegetation strategies for land managers that are interested in removing and replacing saltcedar, and assists in evaluation of the impact of the program on an endangered bird.

Component X: Weed Management Systems

<u>Development of a conservation cropping system for winter annual grass weeds</u>. Winter wheat-fallow is the most prevalent wheat production system in the Pacific Northwest. It is characterized by winter annual grass weeds such as jointed goatgrass, soil-borne diseases, poor soil quality and highly erosive fields. Erosion is high during the fallow year because of the tillage necessary to control weeds, and to establish a dust mulch in which to plant the subsequent

winter wheat crop. ARS scientists at the Land Management and Water Conservation Research Laboratory in Pullman, Washington, and Washington State University collaborators examined herbicide-resistant wheat as an integrated strategy to manage jointed goatgrass in wheat. This system produced excellent jointed goatgrass control without crop injury, but resulted in some herbicide-resistant hybrids. These results indicate the use of imidazolinone-resistant wheat varieties should not be planted consecutively, to reduce the possibility of producing herbicide-resistant weeds. Adoption of this alternative conservation cropping system would reduce the impact of weeds and erosion susceptibility, and increase air quality.