Appendix II: Cross Cutting Issues

Pesticide Resistance

Plasticity of Weeds

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Integrated Weed Management

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Appendix II: Cross-Cutting Issues

There exist several important research areas and issues that relate to the goals, objectives, and future of invasive species control, but that do not fit specifically into any individual component in this Action Plan. These cross-cutting issues include the emerging research needs to overcome weed plasticity and pesticide resistance; overarching programs, such as the IR-4 program (pesticides for minor crop use) and Areawide pest management; overarching research areas, such as integrated weed management and biological control at our Overseas Biological Control Laboratories; and, research tools and resources, such as scientific collections and microbial control; and, emerging issues, including biofuels and climate change, that may impact the future of pest and weed management.

Emerging Problems/Research Needs

Pesticide Resistance

Pesticide resistance of insects and weeds is a widely-recognized barrier to controlling the detrimental impact of many species in agriculture; it has been estimated that pesticide resistance management, including the rotation of pesticides with differing modes of action, contributes as much as 25 percent to U.S. annual pest control expenditures. Frequently-arising issues needing attention and additional resources from industry and government include cross-resistance; cross-breeding of introduced resistance factors into native plants, especially in centers of crop origin or genetic diversity; the potential for decreased use of broad-spectrum chemical pesticides that are used in conjunction with biotech crops; and the acquisition of novel traits by pathogens that disrupt plant genetic resistance, increase virulence, or expand host range.

In the case of insects, complex management schemes are being developed and implemented to provide sanctuaries or refuges for susceptible insects to prevent the rapid selection of genetically resistant insects. New insect resistance management strategies may be possible with emerging plants that produce two or more insecticidal toxins. As for weeds, the alternating use of genetically engineered (GE) crops with tolerances to different types of herbicides and the inclusion of alternative management tools, such as “non-GE” herbicides and cultural management, will likewise reduce the likelihood and impact of selecting for plants that are resistant to particular herbicides.

Looking to the future, gaining recognition is the need to manage the *rate* at which insects and weeds develop resistance to all forms of intervention, ranging from chemical and biological controls to traditional plant breeding and GE plants. Another major challenge for both biotechnology and crop pest and weed management science will be the needed shift from focusing on pest population reduction to that of emphasizing profitability, both in industry and on-farm, through novel integrated and sustainable management alternatives.

Plasticity of Weeds
Weed management ranks among the most costly aspects of most cropping systems, with some individual weed species being serious pests in multiple ecosystems. In part, this is because the opportunistic plants that colonize new areas or persist in managed systems tend to exhibit a high degree of phenotypic plasticity, or environmental adaptability, that facilitates the plants' invasiveness through enhanced survival and reproductive success over a range of environments. Unfortunately, limited information is available as to this phenotypic plasticity of weeds. Predicting weed behavior will be useful for management of weeds in agricultural and natural ecosystems.

Opportunity exists to develop a greater understanding of phenotypic plasticity through cooperation among units in different regions and ecosystems. By observing the natural variation of weed and environmental parameters in the field across several regions and environments, it would be possible for distributed networks of ARS facilities to collectively obtain the robust data needed to characterize the response of weed species to changing environments. Such data would be used to produce response surfaces as to the behavior of important weed species across environments, including those where weed fitness may be compromised. This information could be used to predict critical features such as weed seed production and timing of weed emergence and the various stages of growth.

Overarching Programs

IR-4 Program: Pesticides for Minor Crop Use
Effective pest and weed control methods are essential to reducing the impact of small acreage crops, historically known as "minor crops" and more recently "specialty crops," as well as of major crops such as corn, cotton, small grains, and soybeans. However, pesticides registered on major food crops are not generally available to growers of small acreage crops because of the economic disincentives of pesticide registrants to register pesticides on these crops. Registrants are reluctant to add pests to their product label without data on efficacy, and it is often not cost-effective to obtain this data for small acreage crops.

To respond to the pest control needs of minor crop growers, the ARS IR-4 program coordinates research at 11 ARS locations impacting the control of plant pathogens and insect and pest weeds on about 600 specialty crops. The program has four specific goals: 1) provide growers with safer pesticide chemicals needed to maintain crop quality and productivity; 2) maintain a viable ARS Minor Use Pesticide Program to cooperate with the IR-4 program and assist in the registration of new crop protection tools for specialty crops; 3) generate sufficient, high quality residue data to support tolerances for specialty food crops and expand existing label registrations; and 4) develop crop safety and efficacy data to add new uses to existing pesticide labels for growers of nursery and floral crops. As a result of these efforts, adequate pest and pathogen control measures will be available for continued growth and marketing of high quality, high yielding commodities, as well as plants for landscapes, homes, and gardens. Further, this work will result in an expanded store of safe, effective pest control materials for conventional and organic, large and small farm and greenhouse production systems, replacing higher risk, less environmentally-friendly products. As an added benefit, the expanded technologies will improve resistance management schemes due to reduced reliance on a few pesticides.

Areawide Pest Management Program

A prominent focal point of the Agency's integrated pest management (IPM) program continues to be its Areawide IPM pest management projects, which have been developed in partnership with other Federal and State institutions and the private sector. The Areawide IPM program focuses on management of pests where existing technologies are needed over a multi-State or multi-regional area. Since 1995, Areawide IPM projects have targeted codling moth on tree fruits in the Pacific Northwest, corn rootworm, and noxious weeds such as leafy spurge in Montana, North and South Dakota, and Wyoming; melaleuca in the Florida Everglades; insects of stored grain in Kansas and Oklahoma; and fruit flies in the Hawaiian Islands, among others.

The goal is to transfer technology for on-the-ground implementation, hence the limited time frame for each project (generally 5 years), and provide low-input, permanent, environmentally compatible technology to partners and the general public. Importantly, the Areawide projects take technology that is proven on an IPM (*i.e.*, field-by-field, farm-by-farm) basis and develop the technology for larger areas (often many States; a region; or a specific habitat). Most recently, four new Areawide IPM projects were initiated on the management of weedy annual grasses on rangelands, such as cheatgrass and medusahead in the Great Basin ecosystem of the United States; the Asian tiger mosquito/West Nile virus, with initial demonstration sites located in New Jersey; the navel orangeworm attacking almonds, pistachios, and walnuts in California; and improved honey bee health, nutrition, survival and pollination availability across the United States through the control of *Varroa* mites as well as bacterial, fungal, and viral pathogens that attack honey bees. Individual projects frequently draw from the combined capacity of several Subcomponents addressed in this Action Plan.

Overarching Research Areas

Integrated Weed Management

Integrated weed management (IWM), involving both prevention and intervention, is essential to minimizing opportunities for weedy species to invade, establish, and multiply. Various preventive strategies can be designed into an ecosystem to minimize opportunities for weedy species to invade, establish, and multiply, including the use of components such as crop rotations, cover crops, competitive crop cultivars, soil fertility management, and rangeland grazing intensity that could be manipulated to deny weed populations a niche in the ecosystem. Critical to weed prevention is an understanding of weed biology and population dynamics and their response to crop and soil management, since a collective knowledge of weed biology and how various cultural practices can interrupt the life cycle at various stages provides the basis for developing weed suppressive cropping designs.

Since weed prevention is often not sufficient to achieve weed management objectives, some form of intervention must be also available. Possible strategies include the use of combinations of cropping design and site specific conditions to present different challenges for intervention.

Options available to managers will vary with the nature of their operations, ranging on a continuum from organic systems to herbicide-based row crop agriculture.

ARS scientists in different regions will investigate weed management under various environmental conditions to understand the adaptive mechanisms that allow weeds to succeed and facilitate development and assessment of integrated weed management systems. Underlying this work is the need for management objectives that target not only weed populations, but also factor in productivity, profitability, soil resource maintenance, environmental protection, and influences on local community welfare. Estimation of tradeoffs, particularly a consideration for long-term stability and sustainability, will be essential to balancing the benefits and liabilities of alternative systems.

Overseas Biological Control Laboratories

In response to the serious economic and ecological challenges to agriculture presented by invasive species, ARS established four Overseas Biological Control Laboratories (OBCLs) to discover, identify, and evaluate potential natural biological control agents to use against pests that are invasive to the United States. Biological control agents and techniques developed through the laboratories have been applied successfully to protect a variety of commodities and natural ecosystems from introduced weeds or pests. The laboratories, located in France, Argentina, Australia, and China, organize teams that perform exploratory work to find biological control agents for target pests, many of which are regulated or under some type of regional or national quarantine in the United States. Scientists then evaluate their effects against the pests within their home range, saving months or even years of expensive quarantine work in the United States.

The European Biological Control Laboratory (EBCL) in Montpellier-sur-Lez, France, provides the gateway for work throughout Europe, the Middle East, and Africa. EBCL provides the majority of all biological control agents imported into the United States and has made an important impact on biological control efforts directed toward invasive weeds and insects. Some of the priority programs include identification and evaluation of biological agents to manage the varroa mite, olive fruit fly, black pod of cocoa, Arundo-giant reed, Guineagrass, and teasel.

The South American Biological Control Laboratory (SABCL) is located in the Hurlingham neighborhood of Buenos Aires, Argentina. Major projects include identification and evaluation of parasites and pathogens of imported fire ant, tropical soda apple, corn root worm, water hyacinth, and cactus moth.

The Sino-American Biological Control Laboratory (Sino-ABCL) in Beijing remains an extremely important legal conduit of biological agents from China. Operating via a specific cooperative agreement between ARS and the Chinese Academy of Agricultural Sciences, Sino-ABCL is regarded by the biocontrol community as an essential resource to explore for predators of weeds and insects of concern. Exploration activities focus on a number of important pests, including the Asian long-horned beetle, brown marmorated stink bug, and Emerald ash borer.

Studies at the Australian Biological Control Laboratory (ABCL), located near Brisbane, concentrate on weeds of Australian and Southeast Asian origin. Potential biological control agents are identified and evaluated for use against broad-leaved paperback tree (*Melaleuca*) and Old World climbing fern, invasive weeds found particularly in Florida. One important success resulting from these collaborative efforts is between U.S. and ABCL researchers on *Melaleuca* have resulted in the successful development and transfer of Areawide suppression technology in South Florida.

Research Tools/Resources

Scientific Collections

In the Agency's 53-year history, scientific collections have contributed to a number of groundbreaking discoveries and have had a significant economic impact on the agricultural communities served by ARS as well as this Action Plan. ARS collections not only support work in all areas of research, but they also represent an important historical record of the Agency, including collections that existed before the founding of ARS and that later came into Agency possession. In response to the Administration's Guidance on Research and Development Priorities for Federal agencies in fiscal years 2007 and 2008, ARS has recently prepared a scientific collections status report that identifies the stewardship of Federal scientific collections as a top research and development priority which represents an important benchmark for our collections in the future as well as the Agency's coordinated efforts to document the holdings and needs of its collections within a vast range of research areas. Using the evolving plan, ARS will carry out the Government's call to identify, maintain, and use Federal collections to promote agricultural production, public health and safety, homeland security, trade and economic development, and environmental monitoring.

Microbial Biological Control

To enable sustainable agriculture, new products and strategies must be added to the array of options currently available to growers for managing all varieties of pests and weeds. Although microbial control still represents a very small portion of pest management applications, approaches such as the use of plant pathogens for control of weeds, remain important, long-term thrusts that may provide very useful components in the arsenal of pest and weed control strategies. Moreover, the development of microbial control agents may offer pest management alternatives with different modes of action than chemical pesticides, and at reduced registration costs. However, while the potential of microorganisms for controlling economic pests has been touted for a long time, efforts to use these strategies have met with limited success. Research is needed to break through some of the barriers responsible for holding back these potentially important control options.

ARS maintains a significant investment in microbial control research in a variety of crops as well as postharvest citrus, rangeland, forestry, horticultural, and aquatic systems. Novel approaches, including PCR-based methods, stable isotope profiling, and molecular markers, have begun to shed light on the activity, identity, and spatiotemporal location of microorganisms in agricultural systems. Trends in research that offer considerable future potential include the increased use of biorational screening processes to identify microorganisms with potential as controls, increased testing under semi-commercial and commercial production conditions, increased emphasis on combining microbial control strains with each other and with other control methods, integrating microbial control into an overall system. Research in production, formulation, and delivery could also assist in the commercialization of microbial control agents. Further research is needed in integrating microbial control agents into production systems, such as in rotating microbial controls with chemical pesticides, as well as other biological, cultural, and host plant resistance methods. For example, the use of viruses to control insect pests in refugia corn could be an excellent example of a novel use. Additional work is greatly needed to develop new economic treatment thresholds to choose whether to apply a chemical pesticide or microbial control.

Emerging Topics that May Impact Integrated Pest/Weed Management

Bioenergy

Bioenergy alternatives offer great promise to improving national security and the U.S. trade balance by reducing America's dependence on imported petroleum. However, in the transition to significant new environmentally- and socially-sustainable economic opportunities for rural America, there will likely be emergent weed and insect pest management challenges resulting from novel and in many cases non-native or weedy bioenergy crops (for example, switchgrass). Furthermore, market-driven pressures may increase the likelihood for crop monocultures and rotations of limited sustainability in some agroecosystems (for example, corn-on-corn-on-corn in some parts of the upper Midwest). Novel solutions to these challenges will not only have implications in agroecosystems for which they were intended, but will also contribute to the changing face of a diversified and sustainable 21st century agricultural landscape.

Global Climate Change

Agricultural practices potentially impact climate change, which, in turn, impacts agriculture. While it is indeed possible, under the range of scenarios currently being considered, that individual agricultural and natural ecosystems may experience near-term productivity increases, it is also likely that some pests will benefit from these effects as well. The combined impact of increased pest and other ecosystem pressures will likely result in longer term decreases in new, and in many cases significant, changes to management. In turn, ARS, through existing programs within this Action Plan and other National Programs, will be a major participant and contributor to both expanding the needed scientific knowledge base and the development of modified or novel management systems that support America's agriculture. Specific research is needed to improve our understanding of the scope of the future rate of change in natural and agricultural ecosystems, including the complex interactions between climate change, land use patterns, and non-native species invasion, and subsequent ecosystems balances.