Action Plan: National Program 104 – Veterinary, Medical, and Urban Entomology (2009-2013)

Goal: National Program (NP) 104: Veterinary, Medical, and Urban Entomology, ultimately aims to develop more effective methods of preventing or suppressing insects, ticks, and mites that affect animal and human well being. This Action Plan presents the proposed activities of NP 104 for 2009-2013 required to achieve this goal.

The Stakeholders' Workshop held in October 2007 identified four areas of research that need special attention: sensory ecology, problems associated with higher flies (*i.e.*, the suborder Cyclorrhapha of the order Diptera), geographic information systems and spatial analysis, and invasive species. Each of these research areas represents a group of interests that cut across the efforts of multiple Research Management Units (RMUs). Better focus in these areas will improve the ability of NP 104 to solve agricultural problems associated with many kinds of pests.

Sensory Ecology
Sensory ecology is the study of inputs, including chemicals, that affect arthropod behavior, and includes a spectrum of research from the most basic to the most applied. NP 104 has considerable capability for determining these effects, and this effort will require the organized efforts of multiple RMUs.

Discussions at the Stakeholders' Workshop identified the development of attractants and repellents as two of the major goals of this area of research. In the past, a good means of developing attractants for baits and traps, as well as repellents for protection, has been through the identification of molecules that affect specific aspects of arthropod behavior. Workshop participants also recognized that many important behaviors are only partially described, or even completely unrecognized. More detailed behavioral studies of certain activities (*e.g.*, blood sucking) will result in the association of chemical and other stimuli with these behaviors. A new understanding will also present the possibility of entirely new tools being developed to alter arthropod behavior in such a way that their damage is prevented.

Beyond the research needed to understand the nature of these behaviors, bioassays that accurately measure them will be necessary to find out what chemical or physical factors affect them. Before integrating bioassays into an evaluation scheme, they should be validated independently to be sure that they are measuring what is intended. Electrophysiology is another essential part of development, representing a range of activities and measurements. Among the organizational products required for maximum impact are a standard vocabulary for influences on hematophagous arthropods and a standard concept of how to develop useful products.

Higher Flies
Higher flies damage livestock and poultry in several ways. First, some species (stable flies, face flies, horn flies) suck blood. Second, other species carry pathogens from place

to place (mechanical vectors) and probably have a major role in food contamination (e.g., *Staphylococcus, Salmonella*, echo viruses), as well as transmission of pathogens (e.g., *Streptococcus*) that cause diseases (*e.g.*, mastitis). Finally, some species of flies infest wounds as larvae (a condition called myiasis), causing injury or even death. Among the problems identified were house flies (including military situations overseas), stable flies, and horn flies; the potential threat of *Chrysomyia* introduction; habitats for stable flies created by the use of round bales, as well as the potential for transport of the stable fly larvae in round bales; need for a better stable fly trap; high labor expenses associated with existing management strategies; appearance of insecticide resistance; need for attractants as well as toxicants; need to increase effectiveness of biocontrol (pathogens and parasitoids); movement of flies from agricultural to urban communities; and determination of the focal distribution of larvae.

Geographic Information Systems

The Stakeholder's Workshop also identified geographic information systems (GIS) and spatial analysis as important tools for examining the distribution of organisms and environmental parameters for their habitats. Stakeholders recommended continued work on finding effective ways to use these rapidly developing tools.

Almost every project within NP 104 uses GIS for some of its work, ranging from simple mapping efforts to complex spatial models distributed monthly to customers. NP 104 currently applies GIS and spatial analysis to the following problems areas: Rift Valley fever virus (RVFV) risk assessment, West Nile virus risk assessment, fire ant habitat analysis, fire ant risk assessment and surveillance, distribution of vesicular stomatitis virus, distribution of the New World screwworm fly, distribution of *Rhipicephalus* (*Boophilus*) ticks, and local distribution of termites and their swarms. In addition, proposals were made for work on epidemic hemorrhagic disease virus in relation to farmed cervid populations and also for analysis of large-scale stable fly distributions. Meanwhile, the Animal and Plant Health Inspection Service's Center for Epidemiology and Animal Health does extensive work on tick distributions, RVFV, Venezuelan equine encephalitis virus (VEE), and other relevant topics.

Invasive Species

Invasive species are the subject of much organized effort by the National Invasive Species Council (http://www.csrees.usda.gov/nea/plants/part/hort_part_invasive.html) and its subcommittees. The following needs have been identified: better traps at ports and airports; organization of operational entomology assets (*e.g.*, mosquito abatement, forensic entomologists, and pest control operators) for early detection of invasive species; capabilities to intercept invasive species before they become established; ARS involvement in eXtension, the National Invasive Ant Reporting System, and other organized efforts to prevent invasion; integration of efforts of separate RMUs; maintenance and expansion of systematics and taxonomy assets; prioritization of potentially invasive species into a "watch list," making use of efforts of other organizations; and examination of whether potentially invasive rodents (e.g., *Rattus losea, Rattus exulans*) *are* part of the NP 104 mission. There is also a need to prioritize actual and potential invasive species, as well as the pathogens they might transmit.

Background: To achieve its goals, research within NP 104 uses a framework of components within the idealized structure of applied entomology known as Integrated Pest Management (IPM), which provides the basic organization for the program's research. Developed during the 1960s and 1970s, IPM drew on the previous hundred years of accumulated entomological wisdom to produce a methodology that would guide research, education, and application toward solutions that were effective, economical, sustainable, and safe. IPM can be divided into four elements: *risk assessment/biology*, *surveillance*, *control*, and *monitoring/sustainability*.

Risk Assessment and Biology

Risk assessment/biology is the first necessary step for any IPM program. Background information on the identification (systematics and taxonomy), distribution (spatial and temporal), behavior (particularly potential for causing damage), and bionomics of the pest defines the problem and suggests strategies for its control. Research on almost any aspect of the pest's biology can contribute toward the practical goals of risk assessment. In a sense, biological studies contribute toward risk assessment by improving our ability to "know thy enemy." Further, when the damage is caused by a pathogen transmitted by the pest (*i.e.*, vector), an understanding of the pathogenesis and epidemiology is also important. This knowledge of the relationship between the vector and the pathogen can lead to a much better understanding of the problem. Particularly useful tools for risk assessment include geographic information systems and spatial analysis, especially when they are applied at a sufficiently local level to direct the next steps in IPM.

Surveillance

Surveillance is the measurement of factors that inform the IPM program about where to concentrate control measures. Examples include detection and enumeration of the pest species, its damage, and occurrence of infection. Surveillance also includes measurement of correlates such as soil moisture or canopy density that are related to pest population. In addition, trap development and interpretation of trapping results are important aspects of research on surveillance.

Control

Control includes all measures that might be taken to prevent damage from a pest. Common classifications of techniques include cultural control, mechanical control, physical control, and chemical control. In practice, each method is applied individually and locally, so that projection of research results from the laboratory to the farm is especially challenging. Development of new methods often requires coordination with industry and extension to translate results into action. The other major developmental challenge is the consideration of biology in order to integrate control methods efficiently. Careful timing of each kind of treatment can make a big difference in effectiveness, efficiency, and safety of an IPM program. Each control program must balance risk and benefit, but the admonition to "do no harm" to the environment, applicator, and consumer should be at the foundation of all research on this aspect of IPM.

Monitoring and Sustainability
Monitoring a pest to ensure continuous, successful IPM has proven very difficult for the field of entomology. Farmers or other applicators may lose interest in the problem once it has disappeared. Monitoring for sustainability requires systems that can accurately detect the reappearance of the pest, its damage, or disease caused by a transmitted pathogen. In general, entomological research has concentrated its efforts more on surveillance for control rather than monitoring for sustainability, with the result that many successful IPM programs have eventually failed as operational resources were diverted to other problems. In many cases, the technical tools of surveillance will be the same as those for monitoring, but the deployment of those tools will be different.

All of the research and development in NP 104 supports one of the four elements of IPM. Fundamental research, even that which aims to discover the unknown, can eventually lead to advances in IPM; in fact, such work is the only way to find truly new solutions to agricultural problems. Applied research is more closely related to the actual application of IPM.

Relationship of This National Program to the ARS Strategic Plan: This Action Plan addresses the high level goals and objectives of the 2006-2011 Strategic Plan: (http://www.ars.usda.gov/SP2UserFiles/Place/00000000/ARSStrategicPlan2006-2011.pdf) as part of ARS Strategic Goal 4: Enhance Protection and Safety of the Nation's Agriculture and Food Supply. Within that Strategic Goal, Objective 4.2 (Reduce the number, severity and distribution of agricultural pest and disease outbreaks) includes the purposes of NP 104. Two performance measures set the targets for NP 104 research within the USDA ARS Strategic Plan:

> **Performance Measure 4.2.1:** Provide scientific information to protect animals, humans, and property from the negative effects of pests, infectious diseases, and other disease-causing entities. **Target:** Cumulatively, complete 10 research studies that have significant impact on the scientific community, leading to development of technologies for the integration of prevention and treatment strategies to manage top priority endemic and exotic threats to livestock, humans, and property.
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> **Performance Measure 4.2.2:** Develop and transfer tools to the agricultural community, commercial partners, and government agencies to control or eradicate domestic and exotic diseases and pests that affect animal and human health. **Target:** Cumulatively, transfer five technologies to the commercial and government sectors.

Research Component Overview:
The NP 104 Action Plan contains general strategies and specific actions within the following organizational hierarchy: 1) Components, which are general categories of agriculturally useful research areas identified with the help of stakeholders; 2) Problem Statements, indicating the specific nature and scope of problems to be solved by ARS;

and 3) Research Needs, which are the kinds of research to be performed by ARS in order to achieve a successful resolution of the problem. The components of the program are:

Component 1: Medical Entomology for the Public
Component 2: Medical Entomology for the Military
Component 3: Veterinary Entomology of Livestock and Poultry
Component 4: Pests that Damage Structures
Component 5: Fire Ants, other Invasive Ants, and Household Pests

These components were chosen in order to organize the action plan according to disciplinary areas that would match prospective reviewers. The components were also discussed in detail at the NP 104 Stakeholders' Workshop and in subsequent discussions with stakeholders. Therefore, the components as stated should facilitate the retrospective review process and they should reflect the interests of our principle stakeholders.

Component 1: Medical Entomology for the Public
Compared to people in many other parts of the world, U.S. residents suffer much less from diseases caused by arthropod-borne pathogens. Effective interventions based on sound medical entomology have had tremendous success in America against scourges like malaria, filariasis, typhus, yellow fever, and dengue. However, the epidemic of West Nile virus disease that began in 1999 was a strong reminder that our country remains susceptible to these kinds of threats. Lyme disease, transmitted by certain species of ticks, is another persistent problem and appears to be getting worse over time. In addition, the public naturally dislikes the discomfort caused by all kinds of arthropod bites and actively seeks solutions on product shelves and from community governments. Therefore, improving the effectiveness, personal safety, and environmental safety of entomological interventions continues to be a priority outcome for research.

Problem Statement 1A: Priority species of mosquito (*e.g.*, *Aedes aegypti* and *Aedes albopictus*, floodwater mosquitoes, *Culex* vectors of viruses, and *Anopheles*) are often controlled inefficiently because appropriate tools either do not exist or are not used in the most effective manner.

Research Needs:
Research in all four areas of IPM is needed to address problems for people associated with mosquitoes: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products
Risk Assessment and Biology

- Assess landscape correlates as predictors of distribution.
- Assess the potential redistribution of insecticide resistance genes.
- Determine the effect of arboviral infection on population parameters.
- Use genetic markers to assess movement of adults.
- Evaluate the taxonomy of *Culex tarsalis* nationally.

- Discover critical features of life histories and physiology by investigating parasite and pathogen interactions with immature and adult flies using genomics and molecular biology.
- Determine components of behavior leading to resource location (*e.g.*, hosts, oviposition sites, sugar sources, and mates).

Surveillance

- Develop traps and strategies designed to detect pest species in a manner that is practical for operational vector control.
- Explore the possibility of new methods for larval detection and surveillance such as infrared surveillance, acoustics, etc.
- Determine benefit to human health of mosquito abatement.

Control

- Develop new ULV and residual toxicants that are environmentally and occupationally safe.
- Develop new formulations for egg, larval, and pupal control, emphasizing duration and environmental suitability
- Develop new formulations that facilitate penetration of hydrophilic toxicants through the adult cuticle.
- Explore the possibilities of managing populations through the use of behavior-altering chemicals, including repellents.
- Develop standard methods to be used by industry for Environmental Protection Agency (EPA) labeling data to compare repellent products. In particular, it would be beneficial to EPA in developing assessment tools if the following research issues were to be addressed:
  -Develop standardized test methodology to reduce variability associated with field testing.
  -Continue research in standardizing test methods for cage testing.
  -Evaluate non-human models for replacing human subjects (comparison between humans with non-human mode).
  -Compare test methods, cage and field, to determine the best method to determine repellent performance.
  -Establish procedures for testing pests that affect human health outside the United States.
  -Develop methodologies for statistical analysis of field data for accurate determination of performance.
  -Assess the relationship between use of repellents and pathogen transmission.
- Develop attract-and-kill products.
- Determine whether microbial control agents, including bacteria, viruses, and fungi, could be useful for practical mosquito abatement.

Monitoring and Sustainability

- Develop strategies designed to detect the earliest stages of invasion or re-invasion at the lowest possible cost.

Potential Benefits

New methods of mosquito abatement in the United States will be developed to increase the number of people who benefit, at lower costs, and with a wider margin of safety for the environment.

Problem 1A Resources

The following locations have research projects addressing the problem statement identified under Problem 1A:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Arthropod Borne Animal Diseases Research Laboratory, Laramie, WY
- Invasive Insect Bio-control and Behavior Laboratory, Beltsville, MD
- Biological Control of Pests Research Unit, National Biological Control Center, Stoneville, MS

Problem Statement 1B: Tick pests of humans (*e.g.*, *Ixodes scapularis* and *Ixodes pacificus* [Lyme disease]; *Dermacentor variabilis* and *andersoni* [Rocky Mountain Spotted Fever]; *Amblyomma americanum* [Human Monocytic Ehrlichiosis]) are often controlled inefficiently because appropriate tools either do not exist or are not used in the most effective manner.

Research Needs:

Research in all four areas of IPM is needed to address tick pests: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Assess landscape correlates as predictors of distribution.
- Determine components of host-finding and other essential behavioral functions.

Control

- Systematically assess efficacy of topical repellents.
- Develop standard methods to be used by industry for EPA labeling data for comparison of repellent products. In particular, it would be beneficial to EPA in creating assessment tools if any of the following research issues were to be addressed:
  - -Develop standardized test methodology for the cage and field.
  - -Evaluate non-human models for replacing human subjects (comparison between humans with non-human mode).
  - -Compare test methods, cage and field (if available), to identify the best method for determining repellent performance against ticks.
  - -Assess the relationship between the use of repellents and pathogen transmission.
- Develop anti-tick vaccine for administration to wild populations of deer.

- Develop deer-collaring and vaccination device for applications to wild populations.
- Develop attract-and-kill products.
- Explore the practical application of bio-control agents, including bacterial toxins, fungi, or other sources.

Monitoring and Sustainability

- Establish correlates of eco-epidemiology of Lyme disease for eventual distribution to the public. This effort would be useful for EPA in its efforts to improve labeling of consumer products.

Potential Benefits

Methods will be developed that are capable of reducing the risk of tick-borne pathogens in the United States

Problem 1B Resources

The following locations have research projects addressing the problem statement identified under Problem 1B:

- Knipling-Bushland U.S. Livestock Insects Research Laboratory, Kerrville, TX
- Animal Parasitic Diseases Laboratory, Beltsville, MD
- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD
- Yale University School of Medicine, New Haven, CT (headquarters cooperative agreement)

Problem Statement 1C: Flies, as mechanical vectors of pathogens to humans and food, are generally controlled poorly, resulting in standing populations capable of inoculating food and wounds with pathogens.

Research Needs

Research in all four areas of IPM is needed to address flies: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Determine the role of flies in distributing priority food safety pathogens with special attention to less-studied species.
- Develop a better understanding of house fly feeding behavior, resource location, and nutrition under field conditions.

Surveillance

- Develop methods for evaluation of vector and non-vector flies.

- Determine evidence-based economic thresholds.

Control

- Determine optimal integration of existing methods to take advantage of weaknesses in life cycle.
- Explore the practical application of bacterial toxins.
- Study the value of viral and fungal pathogens for management of adult house flies.
- Develop chemical device to control pathogens on flies.

Monitoring and Sustainability

- Develop monitoring devices for homes to indicate local disease threat from flies.

Potential Benefits

Methods will be established for focused management of flies that maximize the effects of IPM for disease prevention.

Problem 1C Resources

The following location has research projects addressing the problem statement identified under Problem 1C: Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL.

Problem Statement 1D: Bed bugs have become much more abundant in the United States during the last five years, presenting the need for better surveillance and control technology.

Research Needs:

Research in two areas of IPM, surveillance and control, is needed to address to key challenges to bed bug control.

Anticipated Products

Surveillance

- Develop highly sensitive traps and devices for detection.

Control

- Assess the extent of insecticide resistance in the United States.
- Develop new products to prevent movement of bed bugs between locations.
- Explore the practical application of bacterial toxins.

Potential Benefits

Key tools will be provided to reverse the current outbreak of bed bugs in the United States, as measured by sale of products and pest control operator visits.

Problem 1D Resources

The following locations have research projects addressing the problem statement identified under Problem 1D:

- Imported Fire Ant and Household Insect Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD
- Arthropod Borne Animal Diseases Research Laboratory, Laramie, WY

Problem Statement 1E: Invasive vectors of human pathogens should be detected early, stopped before they can establish themselves, or eradicated if they become established.

Research Needs:

Research in all four areas of IPM is needed to address invasive vectors of human pathogens: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Determine if there are "hallmark" issues that need to be addressed by EPA with respect to controlling the various species of mosquitoes with pesticides.

Surveillance

- Develop new and improved methods and techniques to accurately assess mosquito population density.
- Develop new and improved systems and strategies for the deployment of adult mosquito traps.

Control

- Develop response plans to high priority invasive mosquito species.
- Develop methods for integrated aircraft disinsection.

Monitoring and Sustainability

- Develop trapping systems and strategies to detect, monitor, and control mosquito vectors for use by APHIS personnel at ports and airports.
- Develop highly sensitive trapping technologies to evaluate aircraft disinsection.

Potential Benefits

This work will provide tools helpful in the prevention, introduction, and establishment of key public health pests in the United States.

Problem 1E Resources

The following location has research projects addressing the problem statement identified under Problem 1E: Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL.

Component 2: Military Medical Entomology

The U.S. military is one of the few armed forces in the world that is able to deploy large numbers of forces and keep them healthy in challenging environments. However, one of the major threats to health consists of vector-borne pathogens, particularly those that cause diarrheal disease, malaria, dengue, and leishmaniasis.

The U.S. military has responded by deploying significant assets to address the problem, with a focus on preventive medicine and a capability for entomological intervention. The Department of Defense has provided significant funding to facilitate the use of ARS resources and expertise for the purpose of developing new tools for the control portion of IPM. This effort is organized under the Armed Forces Pest Management Board's Deployed Warfighter Protection program, which manages the research jointly with ARS. It specifically targets the development of new pesticides, new personal protection systems (*e.g.*, bed nets, repellents), and new application equipment.

Problem Statement 2A: Toxicants currently available for controlling arthropod vectors are not adequate to protect deployed military personnel. The development of public health pesticides does not receive as much attention from industry as the development of agricultural pesticides. As a result, the number of active ingredients is limited and important pests are not listed on the labels of existing products. The situation is dangerous because loss of any of the current active ingredients to resistance or environmental concern could lead to an inability to control some vectors. Recent failure by the military to control sand-fly transmitted leishmaniasis in Iraq was a consequence of the absence of a suitable toxicant.

Research Needs

Research in the control aspect of IPM is needed to address arthropod vectors.

Anticipated Products

- Discover new chemistries, particularly with new modes of action.
- Explore natural products and compounds inferred from their structures.
- Discover new chemicals based on modeling of known products.
- Evaluate new and existing toxicants against target pests.
- Develop formulations for bacterial toxins and toxicants against larval and adult pests.
- Work with industry to develop new products for use by the military.
- Facilitate registration of new products and addition of relevant pests to the labels of existing products.
- Develop a better understanding of the modes of action of existing and new toxicants (*i.e.*, behavioral effects).

Potential Benefits

This research will help protect deployed American military personnel assembled in encampments or garrisons from vector-borne pathogens.

Problem 2A Resources

The following locations have research projects addressing the problem statement identified under Problem 2A:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD
- Natural Products Utilization Research Unit, Oxford, MS
- Biological Control of Pests Research Unit, National Biological Control Center, Stoneville, MS

Problem Statement 2B: Personal protection products against arthropod vectors are not capable of providing optimal protection for military personnel. The current military system for personal protection consists of the Extended Duration Topical Insect and Arthropod Repellent (EDTIAR), permethrin treatment of uniforms, and permethrin treatment of bed nets. Each component of this system has serious problems. The EDTIAR is thick and difficult to apply, in part because the 8-12 hour efficacy required necessitates a high percentage of the active ingredient (deet). Permethrin treatment of uniforms only protects the skin it covers, offering little protection by itself against flying vectors like mosquitoes. Also, permethrin treatment continues to present logistical challenges despite almost 20 years of experience with this technology. Finally, it has been difficult to develop a rugged design for bed nets that is compact, easy to use, and pre-treated with a chemical to prevent biting through the mesh.

Research Needs

Research in the control aspect of IPM is needed to address arthropod vectors.

Anticipated Products

- Develop new repellent active ingredients and combinations that can be formulated to give protection for at least 8 hours with excellent user acceptability and low percentage active ingredient. Coordinate with EPA as needed to determine which registered products already meet these criteria.
- Develop new methods for treating bed nets with repellents and insecticide.
- Develop new and more effective insecticide products for application by individuals.
- Develop new spatial repellent products that can either be used indoors or used as a barrier to prevent entry. Coordinate with EPA as needed to determine which registered products already meet these criteria.
- Work with the military and industry to develop new and improved insect repellent-treated clothing.

Potential Benefits

Products will be developed that help protect deployed American military personnel from vector-borne pathogens when troops are operating in small groups or community vector control is not practical.

Problem 2B Resources

The following locations have research projects addressing the problem statement identified under Problem 2B:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Insect Bio-control and Behavior Laboratory, Beltsville, MD
- Natural Products Utilization Research Unit, Oxford, MS

Problem Statement 2C: Application techniques and equipment for dispersal of pesticides are not adequate to protect deployed military personnel from pathogens transmitted by arthropods. Identification of an effective active ingredient is only part of what is needed for a good insecticidal treatment. Formulation of the active ingredient imparts characteristics necessary for a particular use. For example, good spreading characteristics and long residual would be desirable for a barrier treatment applied to vegetation. The equipment dispensing the pesticide is also important, since it controls many factors that affect final distribution of the toxicant.

Research Needs

Research in the control aspect of IPM is needed to protect the U.S. military from arthropod disease vectors.

Anticipated Products

- Determine the most effective spray systems for aerosol application of adulticides.
- Determine the most effective spray systems for efficient application of residual insecticides to surfaces.
- Determine the most effective application characteristics of new formulation technologies and toxicants.

Potential Benefits

Research will provide tool to apply pesticides for the protection of deployed American military personnel.

Problem 2C Resources

The following locations have research projects addressing the problem statement identified under Problem 2C:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Areawide Pest Management Research Unit, College Station, TX

Component 3: Veterinary Entomology of Livestock and Poultry

Biting arthropods cause three different problems for livestock and poultry. First, they can transmit a wide range of pathogens, many of which are specific to certain species of domestic animals. Examples include bovine babesiosis transmitted by *Rhipicephalus* (*Boophilus*) one-host ticks, equine piroplasmosis transmitted by ticks, and vesicular stomatitis virus transmitted by biting flies. Second, the bites or infestations of the arthropods can be directly damaging to the animal. Stable flies as pests of cattle are a

prime example. Finally, insects can spread organisms, such as *Salmonella enteriditis* in poultry, that threaten food safety.

Problem Statement 3A: The *Rhipicephalus* (*Boophilus)* one-host tick transmits bovine babesiosis (Texas cattle fever) among cattle. An extensive effort started in the early 1900s culminated in eradication of this tick from the entire U.S. in 1943, eliminating the threat of Texas cattle fever to the beef industry. In recent years, the cattle fever tick has been expanding its range into the southern counties of Texas despite the continuing efforts by APHIS (Cattle Fever Tick Eradication Program) to maintain the control area. The expansion in range is probably the result of the increase in numbers of an alternative host, the white-tailed deer. In addition, feral exotic ungulates (e.g., axis deer) may contribute to the tick infestations. At the current time, the dollar value of the ungulate hunting business is greater than the value of cattle in parts of this region, making landowners reluctant to limit the ungulate herds. Although laboratory tests indicate that introduced ticks are usually susceptible to acaricides, dipping treatments of infested cattle herds seem to be failing more often. Unless this situation is understood and controlled, the cattle industry throughout the southern United States could be threatened with a disease that has been controlled for over 60 years.

Research Needs

Research in all four areas of IPM is needed to address the reinvasion of the cattle fever tick: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Explore landscape and other geographic correlates of distribution with the ultimate objective of producing spatial models of risk.
- Create spatial models of the economic impacts of reinvasion.

Surveillance

- Develop systematic methods for detection and quantification of populations.
- Explore the possibility of remote detection of ticks on animals.

Control

- Develop anti-tick vaccine candidates, taking advantage of genomic information.
- Develop new acaricides based on genomic information.
- Determine whether new toxicants could be useful as acaricides.
- Develop operational plans for resistance management.

Monitoring and Sustainability

- Document the importance of the problem to stakeholders through historical accounts, popular articles, and communication with ranchers.

Potential Benefits

This research will provide key techniques to reverse the current reinvasion of the cattle fever tick into the United States.

Problem 3A Resources

The following location has research projects addressing the problem statement identified under Problem 3A: Knipling-Bushland U.S. Livestock Insects Research Laboratory, Kerrville, TX.

Problem Statement 3B: Stable flies **(***Stomoxys species*) are not adequately controlled on most farms and there is a threat of importation of other, related species of flies.

Research Needs

Research in all four areas of IPM is needed to address stable flies: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Create an EST library and begin annotation as a part of overall study of dipteran genomics.
- Initiate complete genome sequencing project.
- Explore determinants of oviposition site selection to understand larvae distribution.
- Explore larval behavior to understand distribution of larvae and their nutrition.
- Determine the risk of introduction of *Stomoxys* species other than *calcitrans.*
- Develop new surveillance tools using specific attractant chemicals.

Surveillance

- Develop traps that sample across the entire population of adults and produce results with quantifiable error terms.
- Develop devices for determining the presence of larvae.
- Establish economic thresholds based on damage.

Control

- Develop new biocontrol agents (pathogens and parasitoids).
- Develop more effective means of using existing biocontrol agents.
- Explore biological, chemical, and physical determinants of behaviors that could be disrupted for IPM purposes. This work may include physiological studies related to key behaviors.
- Determine the extent of insecticide resistance throughout the United States.

- Seek practical applications for behavior-altering chemicals and larval requirements.
- Develop tools for managing adult flies.

Monitoring and Sustainability

- Develop devices for individual farm use that determine whether or not the economic threshold has been exceeded.
- Develop systems for fly management.

Potential Benefits

New methods will be developed to reduce the impact of stable fly on livestock and people, and evaluations will determine whether research on potentially invasive stable fly species is necessary.

Problem 3B Resources

The following locations have research projects addressing the problem statement identified under Problem 3B:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Knipling-Bushland U.S. Livestock Insects Research Laboratory, Kerrville, TX
- Agroecosystem Management Research Unit, Lincoln, NE
- Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD

Problem Statement 3C: The housefly (*Musca domestica*) is not adequately controlled on most farms.

Research Needs

Research in all four areas of IPM is needed to address houseflies: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Use existing genome project to inform genomics efforts on other flies.

Surveillance

- Establish economic thresholds based on damage.

Control

- Develop new bio-control agents (pathogens and parasitoids).
- Develop more effective means of using existing biocontrol agents.
- Seek practical applications for behavior-altering chemicals and larval requirements.
- Explore the practical application of bacterial toxins.
- Assess novel parasitoids for management of filth flies.

- Develop and evaluate repellents for livestock.

Monitoring and Sustainability

- Develop devices for individual farm use that determine whether or not the economic threshold has been exceeded.

Potential Benefits

This research will reduce the negative impact of fly populations on farms.

Problem 3C Resources

The following locations have research projects addressing the problem statement identified under Problem 3C:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Agroecosystem Management Research Unit, Lincoln, NE
- Knipling-Bushland U. S. Livestock Insects Research Laboratory, Kerrville, TX

Problem Statement 3D: The horn fly (*Haematobia irritans*) can be a damaging pest of cattle in the United States.

Research Needs

Research in all four areas of IPM is needed to address the horn fly: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Create EST library and begin annotation as a part of an overall dipteran genomics study.
- Initiate complete genome sequencing project.
- Explore determinants of oviposition site selection to understand selection of manure pats.

Surveillance

- Establish economic thresholds based on damage.
- Develop new surveillance tools using specific attractant chemicals.

Control

- Develop new biocontrol agents (pathogens and parasitoids).
- Develop more effective means of using existing biocontrol agents.
- Explore biological, chemical, and physical determinants of behaviors that could be disrupted, for IPM purposes. This work may include physiological studies related to key behaviors.
- Explore the practical application of bacterial toxins.

Monitoring and Sustainability

- Develop devices for individual farm use that maximize sensitivity to the need for control.

Potential Benefits
Tools will be developed to reduce the impact of horn flies on cattle.

Problem 3D Resources
The following locations have research projects addressing the problem statement identified under Problem 3D:

- Knipling-Bushland U.S. Livestock Insects Research Laboratory, Kerrville, TX
- Agroecosystem Management Research Unit, Lincoln, NE
- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD

Problem Statement 3E: The screwworm fly (*Cochliomyia hominivorax*) has been eliminated from North America thanks to a program of detection, animal treatment, and mass release of sterile male flies. The current status of APHIS' Screwworm Eradication Program is maintenance of a barrier zone in eastern Panama, protecting the entire continent to the north. This program involves a continuous obligation of funding in order to maintain the barrier and protect the U.S. from this devastating pest of mammals. Expansion of the program to the Caribbean and South America is a possibility, but not currently planned or funded by the U.S. government. Various governments and NGOs discuss such expansion and have funded several efforts. ARS continues to perform research that improves the efficiency of the rearing, release, and control of screwworm flies.

Research Needs
Research in all four areas of IPM is needed to improve the efficiency of the screwworm fly eradication program: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products
Risk Assessment and Biology

- Determine the ability of screwworm flies to cross major geographic barriers.
- Annotate the EST library as a part of an overall dipteran genomics study.

Surveillance

- Develop new surveillance methods based on oviposition attractants.

Control

- Develop a strain of screwworm fly that produces only males.
- Identify chemical oviposition attractants that can be used in attract-and-kill baits and for improved rearing.
- Evaluate requirement for regional strain specificity.
- Facilitate establishment of cryopreservation as a routine tool for preservation of strains.
- Advise APHIS on development of new production strains.

Monitoring and Sustainability

- Publish semi-annual updates in major commodity trade journals.
- Document the importance of the problem to stakeholders through historical accounts, popular articles, and communication with ranchers.

Potential Benefits

This work will improves the efficiency and effectiveness of the screwworm eradication program.

Problem 3E Resources

The following locations have research projects addressing the problem statement identified under Problem 3E:

SRU Screwworm Research Unit, Pacora, Panama (based out of the Knipling-Bushland U.S Livestock Insects Research Laboratory)
Knipling-Bushland U.S. Livestock Insects Research Laboratory, Kerrville, TX

Problem Statement 3F: Mosquitoes bite domestic animals, but little is known about their potential to cause decreases in yield; control is difficult in rural settings.

Research Needs

Research in two areas of IPM (surveillance and control) is needed to address mosquitoes in agriculture.

Anticipated Products

Surveillance

- Determine importance and economic thresholds based on damage, including the potential for local species to serve as vectors of dangerous exotic viruses like Rift Valley Fever virus.

Control

- Evaluate efficacy of aerosol control and spatial repellency tools for controlling mosquitoes and protecting livestock.

Potential Benefits

Research will objectively determine the agricultural importance of mosquitoes and provide new tools for protection of livestock.

Problem 3F Resources

The following locations have research projects addressing the problem statement identified under Problem 3F:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Arthropod Borne Animal Diseases Research Laboratory, Laramie, WY

Problem Statement 3G: Biting midges transmit viruses to cattle, sheep, and deer; the midges are often numerous enough to create a significant annoyance.

Research Needs

Research in all four areas of IPM is needed to address biting midges on farms: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Develop regional tools for identification of midge species.
- Assess vector competence of American species that regularly feed on livestock and poultry.
- Determine landscape correlates of larval distribution at fine scale.

Surveillance

- Evaluate the effectiveness of standard trapping techniques.
- Establish economic thresholds based on damage to cervids, other livestock, and poultry.
- Determine the seasonality of *Culicoides sonorensis* to support the designation of quarantines.

Control

- Evaluate available methods for protecting cervids and other livestock.
- Develop methods for larval control.
- Evaluate insecticide resistance of at least one species that regularly feeds on livestock and poultry.

Monitoring and Sustainability

- Develop methods for evaluating transmission risk at a regional level.

Potential Benefits

Research will provide practical IPM methods for biting midges on farms.

Problem 3G Resources

The following locations have research projects addressing the problem statement identified under Problem 3G:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Arthropod Borne Animal Diseases Research Laboratory, Laramie, WY

Problem Statement 3H: Phlebotomine sand flies transmit leishmaniasis and sand fly fever virus; current methods for control are not uniformly effective.

Research Needs

Research in the risk assessment and biology aspect of IPM is needed to study phlebotomine sand flies.

Anticipated Products

Risk Assessment and Biology

- Determine whether phlebotomines are a veterinary risk in the United States, including examination of their potential to transmit viruses like Rift Valley fever virus and vesicular stomatitis virus.
- Determine components of behavior (*e.g.*, hosts, oviposition sites, sugar sources and mates) leading to resource location.

Potential Benefits

This research will provide tools for evaluating sand flies as agricultural pests in the United States.

Problem 3H Resources

The following locations have research projects addressing the problem statement identified under Problem 3H:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Arthropod Borne Animal Diseases Research Laboratory, Laramie, WY

Problem Statement 3I: Imported and established in the United States, invasive vectors of livestock pathogens could threaten the industry by transmitting new pathogens.

Research Needs

Research in three areas of IPM (risk assessment and biology, surveillance, and control) is needed to find solutions to this general problem.

Anticipated Products

Risk Assessment and Biology

- Prioritize the risk of potentially invasive vector species with due consideration of the severity of pathogens they might potentially transmit.

Surveillance

- Develop an evidence-based plan for national surveillance.

Control

- Determine what products would be useful as pre-registered for emergency use to contain and eliminate infestations.

Potential Benefits

Research will evaluate the potential for the introduction and establishment of agricultural veterinary pests and provide tools to respond.

Problem 3I Resources

The following locations have research projects addressing the problem statement identified under Problem 3I:

- Mosquito and Fly Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Arthropod Borne Animal Diseases Research Laboratory, Laramie, WY

Component 4: Pests that Damage Structures

The Formosan subterranean termite (FST), *Coptotermes formosanus* Shiraki, was introduced to the continental United States after World War II in infested materials shipped from the Pacific Far East. Since then, it has spread to 11 States. The annual Nationwide cost for treatments and repair is an estimated $1 billion, excluding the value of trees lost to FST infestations. It is estimated that the population size of FST in the New Orleans area alone has expanded 35-fold in the previous decade. Other termites, such as the *Reticulitermes* native subterranean termite, are also damaging where they occur. The Nation should be mindful of the possible importation of additional damaging termite species.

Problem Statement 4A: Following the development of effective tools, the challenge to controlling FST is organization, creative technique, and application.

Research Needs

Research in all four areas of IPM is needed to address FST: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Determine current distribution, including the biotic and abiotic factors that contribute to the spread and potential range expansion of the FST.
- Compare and contrast factors that contribute to the establishment and growth of FST populations in urban and rural forested areas and the potential threat of infestation from one to the other.
- Examine the impact of FST on the native termite fauna and consequences of controlling the FST on the native fauna.
- Apply genomics to infer the distribution and track the global spread of the FST.
- Determine intrinsic and extrinsic factors that regulate termite growth, metabolism, caste development, social behavior, and foraging.

Surveillance

- Develop practical tools for detection in infested structures and trees
- Develop more precise and accurate methods and survey protocols for assessing the size, density, and distribution of FST populations.

Control

- Develop additional control technology suitable for use in an Areawide strategy.
- Develop low cost and effective termite control methods that take advantage of novel delivery systems.
- Discover new chemistries as toxicants against termites by examining natural products and compounds inferred from natural products.
- Identify, characterize, and isolate chemicals that affect termite behavior. Apply these findings to the development of biologically-based control techniques.
- Identify vulnerable genes involved in critical biological functions (*e.g.*, apoptotic, metabolic, chemoreception, pheromone production, sexual reproduction, and sex determination) to develop gene-targeted methods for species.

Work with urban planners, engineers, and the construction industry to develop evidence-based guidelines for building code-specific, biologically-based control of termites.

Monitoring and Sustainability

- Develop guidelines for adopting an Areawide strategy by communities, regulatory agencies, and the pest control industry.

Potential Benefits

This research will ultimately provides cheaper, more efficient, and environmentally safer IPM methods for the FST.

Problem 4A Resources

The following locations have research projects addressing the problem statement identified under Problem 4A:

- Formosan Subterranean Termite Research Unit, Southern Regional Research Center, New Orleans, LA
- FSTCRP Formosan Subterranean Termite Cooperative Research Program, Southern Regional Research Center, New Orleans, LA
- NPURU Natural Products Utilization Research Unit, Oxford, MS

Problem Statement 4B: Invasive and native termites are a threat to structures.

Research Needs

Research in one IPM area (risk assessment and biology) is needed to study invasive and native termites.

Anticipated Products

- Evaluate the potential impact and threat of other native and invasive termite species in the United States.

Potential Benefits

This research will evaluates the potential for foreign termites to be introduced and established in the United States, comparing potential damage to that which already exists.

Problem 4B Resources

The following location has research projects addressing the problem statement identified under Problem 4B: Formosan Subterranean Termite Research Unit, Southern Regional Research Center, New Orleans, LA.

Component 5: Fire Ants, other Invasive Ants, and Household Pests

Imported fire ants inhabit over 350 million acres in 12 Southern States from Texas to Virginia, in addition to Puerto Rico, and have recently become established in limited areas in California and New Mexico. U.S. economic and medical costs exceed $6 billion dollars annually and commercial chemical treatments for control is estimated to cost as much as $40 per acre. Chemical control is effective in limited geographic areas, but it is costly and provides only temporary fire ant suppression. Other ants, particularly imported pests, are also problematic. The risk that a damaging, invasive ant will become established is greatly influenced by its interactions with native species of ants.

Problem Statement 5A: Imported fire ants threaten the safety of people on their property, the well-being of farm animals, and the condition of pastures.

Research Needs

Research in all four areas of IPM is needed to address imported fire ants: risk assessment and biology, surveillance, control, and monitoring and sustainability.

Anticipated Products

Risk Assessment and Biology

- Determine the potential range expansion of the black and hybrid imported fire ants.
- Identify and expand current knowledge of basic fire ant biology, *e.g.* colony size, colony density /area, mound dynamics, dispersal potential, modes and rates of dispersal, relative fitness, and competitiveness.
- Develop rapid, reliable, and specific methods to identify imported fire ants in the field.
- Apply genomics to infer the number of introductions and the origin of those introductions.
- Develop methods to study gene function, expression, and evolution in fire ants.

Surveillance

- Develop more precise and accurate methods to survey the size, density, and distribution of fire ant populations on a local and regional basis.
- Develop methods to detect pathogens and parasites of imported fire ants.

Control

- Discover, characterize, and evaluate fire ant repellents and their formulation, as well as other barrier methodologies to exclude fire ants in urban and environmentally sensitive areas where insecticide use is limited.
- Identify, characterize, and isolate chemicals that affect fire ant behavior with the goal of developing environmentally-friendly control techniques for imported fire ants.
- Identify vulnerable genes involved in critical biological functions, with the goal of developing gene-targeted methodologies for species-specific, biologically-based control of imported fire ants.
- Increase the effectiveness of biocontrol by defining host preferences genetically, discovering and studying new parasites and pathogens; improving mass culture and field release systems; and applying functional genomics to understand the fire ant immune system.
- Develop an integrated fire ant control plan that effectively uses exclusion barriers, targeted baits, sustainable biocontrol agents, and novel biologically-based control methods, including local eradication, that can be adapted to specific stakeholder needs.

Monitoring and Sustainability

- Develop accurate, sensitive, low cost, and easy to use methods for detecting incipient populations of imported fire ants for population monitoring and quarantine purposes.
- Monitor the abundance, dispersal, and sustainability of fire ant natural enemies released to control them as fire ant populations decline.

Potential Benefits

Research will provide better IPM tools for imported fire ants and reduce their impact regionally.

Problem 5A Resources

The following locations have research projects addressing the problem statement identified under Problem 5A:

- Imported Fire Ant and Household Insect Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL
- Biological Control of Pests Research Unit, National Biological Control Center, Stoneville, MS

Problem Statement 5B: Other invasive ants in the United States (*e.g.*, Argentine ant, little fire ant, crazy ants, the tropical fire ant, white-footed ant, and carpenter ants) are either difficult to control or threaten to become established pests in the United States.

Research Needs
Research in two IPM areas (risk assessment and biology and control) is needed to study invasive ants.

Anticipated Products
Risk Assessment and Biology
- Develop risk assessment models of existing pest ant species.
- Identify and expand current knowledge of basic biology of selected invasive pest ants, *e.g.* colony size, density colonies/area, dispersal potential, modes of dispersal and rate of dispersal, and competitiveness with native and other invasive ant species.

Control
- Develop and evaluate novel means of formulating bait toxicants and repellents that target selective factors associated with invasive pest ants.
- Discover and develop potentially selective biological control agents of pest ants.

Potential Benefits
This work will provide improved IPM tools for invasive ants.

Problem 5B Resources
The following location has research projects addressing the problem statement identified under Problem 5B: Imported Fire Ant and Household Insect Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL.

Problem Statement 5C. Potentially invasive ants (*e.g.* leaf-cutting ants and other fire ant species) could be introduced to the country, complicating already difficult ant control.

Research Needs
Research in one IPM area (risk assessment and biology) is needed to study potentially invasive ants.

Anticipated Products
- Develop risk assessment models of potential invasive pest ant species.

Potential Benefits
Research will determine the risk posed by potentially invasive ants.

Problem 5C Resources
The following location has research projects addressing the problem statement identified under Problem 5C: Imported Fire Ant and Household Insect Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL.

Problem Statement 5D: Emerging household pest insects could become established as major problems in the United States.

Research Needs

Research in two IPM areas (risk assessment and biology and control) is needed to study emerging household pest insects.

Anticipated Products

- Review the research gaps in effective IPM of potential and current household insect pests as they affect people and agriculture.

Potential Benefits

This work will focus research plans to improve IPM of new household insect pests.

Problem 5D Resources

The following location has research projects addressing the problem statement identified under Problem 5D: Imported Fire Ant and Household Insect Research Unit, Center for Medical Agricultural and Veterinary Entomology, Gainesville, FL.

APPENDIX I

NP 104 Operational Strategy

The following presentation of NP 104 operational strategy is intended to suggest some ideal best management practices that will promote accomplishment of programmatic scientific and developmental goals. Accomplishment of these goals should make NP 104 more cohesive, more efficient, and better able to accomplish its mission. These goals are in no way intended to replace or compete with the authority of line management through the Area Offices.

Newly hired scientists are the future of NP 104, as well as the sources of many of our most innovative ideas. Senior scientists and leaders should strive to create opportunities for junior scientists and encourage them to accomplishment and promotion. One way to take the best advantage of new ideas is to include junior scientists in decision-making processes like reporting and planning. They should learn administrative procedures rather than be insulated from them.

Almost all project plans include the efforts of multiple scientists and technicians. Project plans are carefully crafted to accomplish objectives directed at the solution of agricultural problems. Scientists assigned to a project are likely to achieve the most efficient execution of plans when they communicate with each other about the work within the laboratory and about advances in the field that they learn during conferences or other activities. Reports staffed to National Program Staff (NPS) will be more useful if they include the accomplishments of all scientists working on a project.

NP 104 research management units (RMU) develop capabilities that can be useful to other units, even when the research problems are very different from each other. Each laboratory needs its own technical capabilities, but it is often possible to collaborate in such a way that there is efficient use of both equipment and intellectual assets. Those opportunities for collaboration may originate as suggestions from individual scientists, research units, or NPS. Communication is the key to starting the process, whether as a conversation, an article, or a conference.

Communication between RMUs and NPS is important for a number of reasons. The National Program Leader (NPL) may find opportunities for collaboration, funding, coordinated scientific advance, or product development that are not as clear from the perspective of the RMU. The NPL has the responsibility of informing ARS about the activities and achievements of individual RMUs, though there are many other sources of this information. Finally, the NPL needs to be able to make informed decisions about scientific objectives that reflect the needs of stakeholders, the capabilities of the RMUs, and the state of the science. In order to foster this communication, the NPL will have an "open door" policy (willing to receive calls or visits from any staff), respect the administrative chain of command, inform RMUs of administrative actions requiring the NPL's signature, consider RMU input when writing objectives, use the project pre-proposal as the principal tool for discussion of quality of approach, communicate with the Area Office in accordance with ARS policies and practices, and visit RMUs as possible and appropriate. In turn, RMUs should submit full text electronic files of publications to the NPL; allow the NPL to communicate directly with individual scientists, disseminate information from NPS within their units; coordinate as appropriate Cooperative Research and Development Agreements, position descriptions, changes in personnel, requests for external funding, and Specific Cooperative Agreements; and use the Annual Report as the principal representation of accomplishments.

NP 104 scientists want to perform high quality science and advanced development. They can strive for quality by participating competently in the NPS cycle of planning, execution, and evaluation. Publication in peer-reviewed format is the major method for recording scientific achievement and NP 104 scientists should aggressively pursue opportunities to publish. Although objectives are written by the NPL, scientists and RMUs can encourage creativity in order to solve problems, potentially providing agriculture better answers than exist today. When research leads to a tangible product, scientists, RMUs, and NPS can take advantage of ARS infrastructure for technology transfer.

Communication at all levels is the foundation of science. NP 104 will strive to improve communication within the program, between programs in ARS, and between ARS and stakeholders. NP 104 will distribute a semi-annual newsletter within NP 104 and to stakeholders, maintain a database of scientific resources within NP 104, make the NP 104 brochure and slide sets available to RMUs, cultivate communication with stakeholders, write clear and accurate representational reports (National Program Annual Report, National Program Accomplishment Report, PDRAM introductory material, white papers,

etc.), accept the value of scholarly reviews as well as hypothesis-driven reports, and actively seek opportunities to move the center of relevance in key areas (*e.g.*, by having symposia at national meetings), and keep contact with USDA sister agencies.

APPENDIX II

Linkages with Other ARS National Programs

NP 104 works closely with several other national programs. At the management level, NP 104 works especially closely with NP 101 (Animal Health) and NP 304 (Crop Protection and Quarantine). Several of the NP 104 projects are embedded in laboratories that include projects in other national programs, including the Arthropod-Borne Animal Diseases Laboratory, Laramie, Wyoming (NP 103), the Invasive Insect Biocontrol and Behavior Laboratory in Beltsville, Maryland (NP 304), the Biological Control of Pests Research Unit in Stoneville, Mississippi (NP 304), the Natural Products Utilization Research Unit, Oxford, Mississippi (NP 304, NP 106, NP 302, and NP 306), and the Agroecosystem Management Research Unit, Lincoln, Nebraska (NP 201, NP 211, NP 202, NP 206, NP 216, NP 204, NP 108, NP 307, and NP 203).

Linkages with USDA-CSREES National Programs

The missions of NP 104 and CSREES have many parallels. Not only does CSREES organize and fund research, it also promotes the use of scientific knowledge for practical purposes. NP 104 participates in multi-state research projects on house flies and stable flies (S-1030) and mosquitoes (NE 507). CSREES co-sponsored the NP 104 stakeholders' workshop and jointly promotes the USDA-Department of Defense Memorandum of Understanding on Pest Management. Other opportunities for communication have been joint meetings on research priorities and on animal health.

Linkages with the Environmental Protection Agency

USDA has worked with EPA on pesticide issues since its inception, a logical transition since ARS used to have responsibility for pesticide registration. Recently, due to the increase in disease from vector-borne pathogens, and the interest of the public in controlling these diseases by using effective pest control methods (*i.e.*, skin applied insect repellents), EPA has expressed an interest in greater communication and support for various research issues from USDA. In 2007, EPA held a Federal Partners Meeting confirming other Federal partners' (USDA, CDC, DOD, and FDA) interests. Since then, EPA has met with USDA and determined that there is a need for new methodology to evaluate skin-applied insect repellents. In particular, it would be useful if USDA could develop techniques to standardize field and cage testing, evaluating the results to determine potential future data requirements.

Linkages with the Department of Defense

USDA has a long history of cooperation with the Department of Defense (DoD) to develop products useful for military personnel. Entomology has been a big part of that collaboration, especially research on the means to protect personnel from arthropod-transmitted pathogens. The medical entomological mission within NP 104 generally supports this purpose, but a great deal of focus was brought to the issue when DoD began funding ARS to perform specific research in 2004. Thanks to this funding and close coordination under the Deployed Warfighters Protection Program, NP 104 includes dedicated efforts to understand and solve military medical entomology problems. The program specifically targets three aspects of research and development: new systems for personal protection, new toxicants, and new application equipment and techniques. In addition, NP 104 is an active participant in the Armed Forces Pest Management Board, a tri-service body that recommends pest management products and policy.