A National Road Map
For Integrated Pest Management
Revised September 21, 2018

INTRODUCTION

Integrated Pest Management (IPM) is a sustainable, science-based, decision-making process that combines biological, cultural, physical and chemical tools to identify, manage and reduce risk from pests and pest management tools and strategies in a way that minimizes overall economic, health and environmental risks. Pests are defined as any organism (microbes, plants or animals) that poses economic, health, aesthetic or environmental risk. Pests are context-specific, so an organism that is a pest in one environment may be benign or beneficial in others.

IPM uses knowledge of pest and host biology, as well as biological and environmental monitoring, to respond to pest problems with management tactics and technologies designed to:

- Prevent unacceptable levels of pest damage.
- Minimize the risk to people, property, infrastructure, natural resources and the environment.
- Reduce the evolution of pest resistance to pesticides and other pest management practices.

IPM provides effective, all-encompassing strategies for managing pests in all arenas, including all forms of agricultural production, military landscapes, public health settings, schools, public buildings, wildlife management, residential facilities and communities, as well as public lands including natural, wilderness and aquatic areas. This National IPM Road Map identifies strategic directions for building and maintaining research, education and extension programs that focus on IPM priorities for each of these arenas. Examples of programmatic IPM principles for several federal agencies can be found in Appendix 1.

The goal of the IPM Road Map is to increase adoption, implementation and efficiency of effective, economical and safe pest management practices, and to develop new practices where needed. This is accomplished through information exchange and coordination among federal and non-federal researchers, technology innovators, educators, IPM practitioners and service providers, including land and natural resource managers, agricultural producers, structural pest managers and public and wildlife health officials. The IPM Road Map will be updated periodically by the Federal IPM Coordinating Committee (see pp. 10-11) as the science and practice of IPM evolve, with continuous input from numerous IPM experts, practitioners and stakeholders.

EVOLVING IPM CHALLENGES

Pest management systems are subject to constant change, and must necessarily respond and adapt to a variety of pressures. Pests may become resistant to pesticides, whether they are conventional or

biologically-based, or adapt to crop rotation, trapping or other control methods. The evolution of weed, microbe, and arthropod pest resistance is a complex problem with consequential costs to food security and public health that requires innovative solutions. Coordination between federal agencies, universities, communities and other stakeholders is needed to address the ecological, genetic, economic and socio-political factors that affect development, communication and effective implementation of IPM strategies and technologies to manage pests effectively, slow the rate of resistance evolution, preserve existing control measures and create effective new approaches.

The United States Environmental Protection Agency (EPA) regularly reviews registered pesticides and may restrict or cancel labeled uses when risks outweigh benefits. Environmental concerns, consumer demands and public opinion can significantly influence pest management practices. New and invasive disease-causing pathogens, weeds, vertebrate and arthropod pests are introduced more frequently as global trade and travel increase. Changing environmental conditions pose new challenges for maintaining effective pest management systems. Pest species expand their geographic and temporal ranges, occurring in expanded areas and both earlier and/or later in seasons, in response to changes in climate. Pest species interactions within and among trophic levels, and across landscapes, must also be considered when IPM strategies are being developed. IPM practitioners must strive to implement best management practices, using tools and strategies that work in concert with each other, to achieve desired outcomes while minimizing risks. Current and evolving conditions necessitate increased development and adoption of IPM practices and technologies. The National IPM Road Map serves to make these transitions as efficient as possible.

IPM was originally developed to manage agricultural pests but expanded into new arenas as its success in agriculture became clear. Federal, state and local governments now use IPM in residential, recreational and institutional facilities, biosecurity and natural wildland areas. A successful IPM in Schools program was created through state and federal cooperation, and many states and local governments have adopted IPM policies.

An emphasis of the National IPM Road Map is to prioritize responses that mitigate the adverse impacts of invasive species: non-native organisms whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal or plant health (Executive Order 13751). The arrival of invasive species often disrupts established IPM programs in the short-term, as emergency responses are undertaken to limit potential damage caused by the species of concern until scientists and practitioners become well-informed of the invasive pest's biology and ecology and management practices are developed and delivered. Invasive species are currently estimated to cause $140 billion in economic losses annually. Some species act as vectors of parasites**,** viruses and bacteria, potentially leading to the spread of human illnesses, such as Zika.

The impact of invasive species in natural and human-created environments received national attention and federal support when Executive Order 13112 on Invasive Species was signed by President Clinton in 1999 and updated in December 2016 by Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species. This Executive Order established the National Invasive Species Council to ensure that federal programs and activities to prevent and control invasive species are coordinated, effective and cost-efficient (www.invasivespecies.gov). Federal and state agencies are coordinating efforts and developing programs and policies in this effort. IPM programs are continually under

development at all levels to minimize the impact of invasive pest organisms, which can disrupt established and effective IPM practices.

IPM FOCUS AREAS

A primary goal of the National IPM Road Map is to increase adoption and efficiency of effective, economical and safe pest management practices through information exchange and coordination among federal and non-federal researchers, educators, technology innovators and IPM practitioners, including pesticide applicators and other service providers. Pesticide safety education that teaches pesticide applicators sound safety and stewardship practices in the safe and efficacious use of pesticides is an important component of IPM programming across focus areas.

Production Agriculture

The priority in this focus area is the development and delivery of diverse and effective pest management strategies and technologies that fortify our nation's food security and are economical to deploy, while also protecting public health, agricultural workers and the environment.

IPM experts, educators, practitioners and stakeholders expect pest management innovations will continue to evolve for food, fiber and ornamental crop production systems that improve their efficiency and effectiveness. IPM practices that prevent, avoid or mitigate pest damage have reduced negative impacts of agricultural production and associated environments by minimizing impairments to wildlife, water, air quality and other natural resources. Fruits, vegetables and other specialty crops make up a major portion of the human diet and require high labor input for production. Agricultural IPM programs help maintain high-quality agricultural food and fiber products, and coupled with pesticide safety and stewardship practices, help protect agricultural workers, consumers and the environment by keeping pesticide exposures within acceptable safety standards. Agricultural IPM programs also extend to and consider pest management in areas beyond production field borders, to places that can harbor or serve as a source of agricultural pests such as adjacent roadsides, rights-of-way, ditches, irrigation canals, storage and processing areas, compost and mulch piles and gravel pits.

Natural Resources

Our nation's forests, parks, wildlife refuges, military landscapes and other natural areas, as well as our public land and water resources, are under constant pressure from endemic pests and aggressive invasive species. Invasive pests diminish habitat quality by out-competing native species for resources, reducing biological diversity, richness and abundance; impairing grazing lands for livestock and foraging habitats for wildlife; and degrading or impairing many other uses of public lands, waters and natural areas. Americans value, and spend large amounts of time, in natural and recreational environments like lakes, streams, parks and other open spaces. Protecting the ecosystem functions, aesthetic standards and values of natural resources and recreational environments is as important as protecting public health and safety. IPM practices help minimize the adverse environmental effects of pest species on our natural areas. As we move into the future, commonly used and accepted metrics are needed to quantify the impact of IPM programs and practices in these environments.

Residential, Structural and Public Areas

For the general public, the greatest exposure to pests and control tactics occurs where people live, work, learn and recreate. IPM programs for schools and public buildings are excellent examples of successful education and implementation programs designed for institutional facilities. Priorities in this area include enhanced collaboration and coordination to expand these programs to other public institutions and infrastructure. Residential and commercial environments require different tools and educational materials than schools, and multifamily public housing structures present particular challenges, including addressing pest issues for people who are unable or unauthorized to manage pests themselves. Expanding IPM programs in these areas would reduce human health risks posed by pests and mitigate the adverse environmental effects of potentially harmful pest management practices. Preventing and controlling bed bug and cockroach infestations in multifamily and public housing and other built environments is a high priority.

POTENTIAL APPROACHES/STRATEGIES FOR STRENGTHENING IPM

Improve economic and social analyses of adopting and implementing IPM practices, including assessing the benefits of practice adoption

Improving the overall benefits resulting from the adoption of IPM practices is a critical component of the National IPM Road Map. Cost-benefit analyses of proposed IPM strategies should not be based solely on the monetary costs, but also includes consideration of the efficacy of managing the target pest, environmental and ecological health and function, aesthetic benefits, human-health protection and pest resistance-management benefits. Additionally, the personal costs of adoption to end users in terms of time management and other social costs must be considered.

Economics must be considered for IPM practices to be widely adopted and their benefits realized. Risks and benefits need to be defined and determined. A major factor in the adoption of IPM programs is whether the benefit to humans and the broader natural systems outweighs the cost of implementing an IPM practice. Evaluation of short- and long-term risks and benefits is needed. Attention should also be paid to understanding the social and cultural characteristics of pest management, because in some systems risks and benefits cannot be monetized and in others the costs and risks of pest management practices are primarily borne by one party and the benefits realized by other parties.

Reduce potential human health and safety risks from pests and related pest management strategies

IPM plays a major role in protecting human health. Public health is dependent upon a continual supply of safe, affordable, high quality food and fiber, often referred to as food security. IPM also protects human health through its contribution to food safety by reducing potential health risks from food-borne pathogens and reduced pesticide exposure, and further protects human health by reducing populations of insect vectors that transmit diseases to humans. Mosquito and vector-abatement districts across the country use integrated pest management practices to control potentially dangerous

disease vectors, while minimizing human and environmental pesticide exposure. Pesticide safety training and certification programs also help limit the public's exposure to pesticides.

Historically, the success of IPM adoption and implementation, and resulting benefits to the health of humans and the environment, was measured by tracking annual changes in the amount of pesticides used in the United States, measured in pounds of "active ingredient." For many reasons, pesticide usage reduction is an inadequate measure of IPM successes when used alone. Pounds of active ingredient used per acre does not address the evolving nature of pesticide chemistries (differences in frequency and rate of application, toxicity, modes of action or human exposure), nor does it consider changes in the pest complex being managed, including the introduction of invasive species or resurgence of native pests. Also, in many cases, routine usage data are not available.

IPM practices, technologies and innovations have helped pest managers have move away from calendar-based spray programs to more informed use of integrated management combining pesticides, biological, mechanical and cultural controls in a way that minimizes economic, health and environmental risks. These innovations include advances in pest monitoring, use of predictive models to target vulnerable pest life stages, new spray technologies to reduce off-target drift, new planting systems, population-suppression strategies such as mating disruption, use of disease resistant cultivars or weed seed bank management, advances in scientific knowledge of pest and host biology and ecology, and use of biological controls, biopesticides and biotechnology.

Minimize adverse environmental effects from pests and related management practices

IPM programs are designed to protect agricultural, urban, and natural environments from the damage incurred from native and non-native pest species while minimizing adverse effects on soil, water, air and non-target organisms. IPM practices in agriculture promote healthy crop environments while conserving organisms that are beneficial to those agricultural systems, including pollinators, natural enemies and soil flora and fauna. By reducing non-target impacts, IPM helps maximize the positive contributions that agricultural land use can make to watershed health and function and minimize the impacts pest control can have on non-pest organisms. IPM practices, tools and technologies enable land managers to target pest species while minimizing environmental risks to natural ecosystems. Examples include using trained dogs for detecting marsh-destroying nutria or brown tree snakes in cargo. Other examples include releases of *Wolbachia*-inserted mosquitoes to reduce risk of mosquito-vectored avian diseases in the Hawaiian Islands and management of additional species on lands and structures managed by many federal agencies.

RESEARCH, TECHNICAL DEVELOPMENT, EDUCATION, COMMUNICATION AND IMPLEMENTATION

In order to continue IPM development and adoption, and increase the benefits it provides nationally, it is critical to enhance investment in:

- New strategies and tactics for pest management.
- Public and private education infrastructure, including existing land-grant university IPM and pesticide safety education programs.
- Communication about the importance and effectiveness of IPM.
- Adoption and implementation of IPM plans and programs.

Research Needs

The IPM toolbox is in a continuous state of evolution. Introduction of new pesticides, changes to existing pesticide labels resulting from EPA registration review, the influx of invasive species, development of new technologies, and federal, state and local fiscal constraints on funding all influence the furtherance of IPM research. Research needs in IPM range from basic investigations of pest and host biology to the development of new pest management strategies and tools, and their integration into decision support systems.

Technical Development

While there have been dramatic improvements in pest management practices during the last four decades, there continues to be a critical need for new options that provide effective, economical and environmentally sound management of pests. Rapidly evolving molecular genetic approaches, including genetic engineering, gene silencing, gene editing, gene-drive systems and other genetic-based IPM practices are being developed. Geographic Information Systems that analyze layers of data from computers, satellites, aerial photography, drones, soil sensors, crop sensors or handheld GPS units are enabling new mapping capabilities and spatial analyses of soils, crop health and pest and weed infestations to allow farmers to better predict pest outbreaks and identify problem areas within their fields. Variable-rate technology tools provide growers with abilities to vary the application rate of crop inputs, enabling more spatially and temporally targeted management of pests. Drift-reduction technologies that enable more precise deposition of pesticides and reduce pesticide drift to non-target areas are being developed and adopted. As these and other technologies are delivered, they are likely to significantly impact IPM moving forward.

National research and technology development goals and objectives identified by the Federal IPM Coordinating Committee include (non-prioritized list):

- Investigate local and regional climatic effects on all aspects of IPM.
- Determine pest biology and biotic/abiotic interactions to develop and deliver tools and tactics to manage pests across all IPM arenas and localities.
- Develop management tactics for specific settings (including crops, parks, homes, forests, natural landscapes, wetlands, infrastructure and workplaces) to prevent or minimize pest damage.
- Develop diagnostic tools for identifying pathogens, arthropods, vertebrates and weed pest species, and how they may differ in certain geographic areas and crops.
- Develop and deliver more rapid diagnostic tools for detection and management of pests and pesticide resistance in pest populations, including aquatic pests, plant diseases, arthropods, vertebrates and weeds.
- Develop low-risk suppression tactics, including use of biopesticides, biological control and products of both traditional breeding and molecular genetic technology.
- Develop monitoring tools, action thresholds and suppression tactics and tools for existing and emerging pests that vector human diseases.
- Develop efficacious suppression strategies that are cost-effective to implement.

- Develop a more thorough understanding of adverse non-target impacts of pest management tactics and means of mitigating those impacts, including impacts on society and culture.
- Develop a more-thorough understanding of beneficial impacts of pest management strategies, including impacts on society and culture.
- Expand web-based resources for IPM systems.
- Integrate postharvest pest management approaches for food and fiber products in both field and storage.
- Develop and implement new pesticide chemistries and application technologies.
- Encourage and support the development of areawide IPM projects to more effectively manage pests on regional or landscape scales.
- Encourage and support research that addresses barriers to the adoption of promising IPM technologies like agricultural uses of Unmanned Aerial Vehicles, social acceptance of molecular genetic approaches, etc.
- Develop economic models for IPM that inform research on new pest management strategies, as well as decision tools for growers to implement management.
- Develop research-based educational strategies for delivering IPM to practitioners.
- Investigate economic and risk-management models that consider the costs, benefits and risks of IPM adoption.
- Encourage and support research to assess economic, environmental, health and social barriers to, and impacts of, adoption of IPM.
- Evaluate and demonstrate the utility of precision agriculture technology to more accurately monitor and evaluate pest presence and the evolution and spread of resistant pests.
- Evaluate and demonstrate the efficacy of precision agriculture IPM tactics deployed within or across growing seasons and landscapes, including GPS-guided aerial or ground-based sensing or imagery systems, alone or integrated with tillage; or precision delivery systems to apply the right pesticide or microbial agent at the right dose, in the right place, at the right time.

Education and Communication

A diverse and evolving pest complex requires a cadre of trained individuals with enhanced skills that ensure human health, food security and environmental protection. It is important for practitioners to have sound knowledge of pest and host biology, soil and ecosystems functioning, and to acquire new skills to conduct research and implement IPM strategies using new technologies, including biotechnology, reduced-risk pesticides, cultural practices, resistance management and biocontrols. It is also important to have an interdisciplinary cadre of researchers and educators that includes natural and social scientists and educators to engage practitioners in the process – this cannot be a top down process. To be successful, effective IPM communication and education must be both ground up (end-user led initiatives and communication of issues to the researchers and educators) as well as top down. The end-user input is critical to identify problems as well as to develop innovative solutions. Collaboration with pesticide safety education programs will ensure a significant number of applicators are trained each year on topics critical to the safe use of pesticides. Additional training programs should be implemented to educate and equip IPM practitioners with up-to-date information ranging from basic IPM principles to advanced skills in various technical categories.

Significant effort and support is needed for IPM education programs at U.S. universities to ensure training for the next generation of IPM scientists and practitioners. This effort should include outreach to the public so that the challenges of pest management and the benefits IPM delivers across multiple systems is better understood. Goals of this effort include:

- Create public awareness and understanding of IPM programs and their economic, health and environmental benefits through education programs in schools, colleges and the workplace; through organizations for education, mentoring and technical assistance initiatives for beginning farmers and ranchers and similar programs; and through creative use of media, with attention to underserved and disadvantaged populations.
- Ensure a multi-directional flow of pest management information by expanding existing and developing new collaborative relationships with public- and private-sector cooperators, including end-users.
- Spotlight successful IPM programs and practices at the local, regional and national level to engender support and promote informed discussion and involvement from stakeholders and consumers who understand the benefits of public investment in IPM.

Adoption and Implementation of IPM

IPM research, education and outreach must continue to be conducted and communicated between federal, state and local partners to ensure widespread adoption and implementation of evolving IPM practices. Outreach and education with the public is also critical. Promoting IPM practices and technology, and communicating relevant information about the value of IPM to producers, homeowners, land managers and the public, continues to be a major need. The following activities will contribute to the adoption of IPM:

- Engage with user groups to understand the value and challenges of incentive programs, both those existing and proposed, to adopt IPM practices. Develop user incentives for IPM adoption reflecting the value of IPM to society and reduced risks to users. Work with existing risk-management programs, including federal crop insurance, and incentive programs such as the Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) and other farm conservation programs to fully incorporate IPM tactics as rewarded practices.
- Research how best to provide educational opportunities for IPM practitioners to learn new communication skills that improve their extension and outreach practices, and enable them to engage new and unique audiences in ways that help overcome potential barriers such as language, cultural sensitivities, lack of internet access, disabilities, etc.
- Improve public awareness and understanding of IPM programs and their economic, health and environmental benefits.
- Leverage federal and state resources to enable on-site research, extension, education and training for end users to ensure long-term adoption and implementation of IPM practices including the safe use of pesticides.
- Develop ways to spotlight successful IPM programs, including areawide management efforts.

MEASURING IPM PERFORMANCE

Through policies, directives, rules, regulations and laws, federal, state and local governments place high priority on accountability systems. Such systems are based on performance measurements, including setting goals and objectives and measuring achievement. Federally-funded IPM program activity performance can also be evaluated.

The establishment of measurable IPM goals and the development of methods to measure progress should be appropriate to the specific IPM activity undertaken. Performance measures may be conducted on a pilot scale or on a geographic scale and scope that corresponds to an IPM program or activity. Examples of potential performance measures are:

Outcome: Effective IPM practices that are economical and lessen environmental risk are adopted.

Performance Measures:

- *Adoption of IPM Practices* - Design and conduct surveys that document the adoption of IPM practices specific to regional production concerns in specific crops or in the management of specific pests.
- *Impacts and Outcomes of IPM Adoption* - Document and demonstrate the impacts and outcomes of IPM adoption, including short- medium- and long-term changes.
- *Economic, Environmental or Health Benefits* - Evaluate IPM programs based on their ability to improve economic, environmental or health benefits, and to project these economic results to a regional or national basis that predicts large-scale impacts.
- *Public Awareness* - Develop measures of public awareness and acceptance of IPM.
- *Training and Technology* - Document educational training and technology adoption in IPM programming that mitigates pesticide exposures and reduces the evolution of pesticide resistance.

Outcome: Potential human health risks from pests and the use of pest management practices are reduced.

Performance Measures:

- *Pesticide Exposure* - Relate dietary exposure to pesticides to IPM practice adoption using U.S. Department of Agriculture Agricultural Marketing Service Pesticide Data Program and any other available data.
- *Human Health Impacts* - Document changes in human health impacts caused by pests (such as asthma cases related to cockroach infestations, insect-vectored diseases, allergic reactions to plants, etc.) relative to changes in IPM adoption.

Outcome: Adverse environmental effects from pests and the use of pest management practices are mitigated.

Performance Measures:

- *Endemic Pest Control* - Document the changes in endemic pest levels and damage following adoption and implementation of IPM practices.

- *Invasive Species Damage and Invasion* - Document the increasing or decreasing rates of incursion and damage of selected invasive species following adoption and implementation of IPM practices.
- *Contaminants* - Document reduction in the movement and accumulation of contaminants used to manage pests and relate those to specific IPM tools and practices.
- *Environmental Health Improvements* - Document long-term improvements in environmental health in local landscapes following adoption and implementation of IPM practices.

IPM LEADERSHIP AND COORDINATION

The Federal IPM Coordinating Committee (FIPMCC):

The FIPMCC was established in 2001 by USDA Secretary Ann Veneman. It is composed of representatives of all federal agencies with IPM research, implementation or education programs, and may include other public and private sector participants as appropriate. The function of the FIPMCC is to provide interagency guidance on IPM policies, programs and budgets. A key responsibility of the FIPMCC is to provide strategic direction for IPM by:

(1) Clearly defining, prioritizing, and articulating the goals of the federal IPM effort.
(2) Making sure IPM efforts and resources are focused on the goals.
(3) Ensuring that appropriate measurements toward progress in attaining the goals are in place.

The FIPMCC reports to the Secretary of Agriculture through the USDA Office of Pest Management Policy. The national IPM effort stems from a partnership of federal governmental institutions working with stakeholders on diverse pest management issues. Leadership, management and coordination of these IPM efforts occur at many levels to more completely address the needs of stakeholders. The role of the committee is to provide guidance in the establishment of goals and priorities for IPM programs across all IPM focus areas. To achieve this, the FIPMCC regularly communicates with stakeholders, including the Regional Integrated Pest Management Centers, land-grant universities and other public and private entities.

The USDA-funded Regional IPM Centers play a major role in gathering information concerning the practice and status of IPM, and in the development and implementation of an adaptable and responsive National IPM Road Map. The Regional IPM Centers have a broad, coordinating role in the communication and regional coordination of IPM.

Federal Membership of FIPMCC:

- United States Department of Agriculture
  - Office of Pest Management Policy
  - Agricultural Research Service
  - National Institute of Food and Agriculture
  - Animal & Plant Health Inspection Service

    - Natural Resources Conservation Service
    - National Agricultural Statistics Service
    - Economic Research Service
    - Forest Service
- Environmental Protection Agency
- Department of the Interior
    - National Park Service
    - Bureau of Land Management
    - Fish & Wildlife Service
- Department of Defense
- Centers for Disease Control
- Department of Housing and Urban Development
- General Services Administration
- Agency for International Development
- Smithsonian Gardens
- By Invitation of FIPMCC
    - Western Integrated Pest Management Center
    - Southern Integrated Pest Management Center
    - North Central Integrated Pest Management Center
    - Northeastern Integrated Pest Management Center
    - IR-4 Project
    - National IPM Coordinating Committee

Concluding Remarks

The goal of the National Road Map for Integrated Pest Management is to increase the adoption and efficiency of effective, economical and safe IPM practices. This is facilitated through information exchange and coordination among federal and non-federal researchers, educators, technology innovators, IPM practitioners and service providers, including land and natural resource managers, agricultural producers, structural pest managers, and public and wildlife health officials. The IPM Road Map is intended to be a living document that will be updated periodically by the Federal IPM Coordinating Committee as the science and practice of IPM evolves, with continuous input from numerous IPM experts, practitioners, and stakeholders. We hope that the information in the Road Map is meaningful and timely, and will help inform the development and implementation of IPM programs in the future.

Appendix 1. Principles of an Integrated Pest Management Program

Examples:

A. U.S. Fish and Wildlife Service, Department of the Interior

B. National Park Service, Department of the Interior

C. U.S. Environmental Protection Agency

D. U.S. Air Force

Appendix 1A.

PRINCIPLES OF INTEGRATED PEST MANAGEMENT (IPM) - U.S. Fish and Wildlife Service, Department of Interior

These IPM principles are the foundation for pest management planning and implementation.

- **Understand the site management objectives; establish short- and long-term priorities.** Decide on your site objectives for pest management; use Specific, Measurable, Achievable, Realistic, and Time-based (SMART) objectives when choosing tools.

- **Prevent species from becoming a pest at your site.**
  Prevention is the first line of defense against any pest species.

- **Identify and monitor the pest species.**
  Know the life history and the conditions that support the pest(s).

- **Understand the physical (air, water, food, shelter, temperature, and light) and biological factors that affect the number and distribution of pests and any natural enemies.** Conserve natural enemies when implementing any strategy.

- **Build partnerships and consensus with stakeholders, such as communities and decision-makers.**

- **Review available tools and best management practices (BMP) for pest management.**
  Tools and strategies can include: 1) no action, 2) physical (manual and mechanical), 3) cultural, 4) biological, and 5) chemicals.

- **Establish the "action thresholds."**
  Decide at the level of pests/damage you will implement a management action to control the pest population.

- **Obtain approval, define responsibilities, and implement preventive, BMPs and control treatments in accordance with applicable laws, regulations, policies and an Integrated Pest Management Plan.**

- **Practice adaptive management.**
  Evaluate results of implemented management strategies through authorized monitoring; determine if objectives have been achieved, and modify strategies, if necessary.

- **Maintain written records**.
  Document decisions and the treatments implemented, and record monitoring results.

- **Outreach and education.**
  Inform staff of the pest management issues in and around the site, and prepare informative materials for outreach to visitors and others, if appropriate.

Appendix 1B.

National Park Service, U.S. Department of the Interior

11-Step Integrated Pest management Process

The Process

We use the following 11-step process to develop and implement an effective IPM strategy:

1. Describe your site management objectives and establish short and long term priorities.
2. Build consensus with stakeholders-occupants, decision makers and technical experts (ongoing).
3. Document decisions and maintain records.
4. Know your resource (site description and ecology).
5. Know your pest. Identify potential pest species, understand their biology, and conditions conducive to support the pest(s) (air, water, food, shelter, temperature, and light).
6. Monitor pests, pathways, and human and environmental factors, including population levels and phenological data.
7. Establish "action thresholds," the point at which no additional damage or pest presence can be tolerated.
8. Review available tools and best management practices. Develop a management strategy specific to your site and the identified pest(s). Tools can include: 1) no action, 2) physical, 3) mechanical, 4) cultural, 5) biological, and 6) chemical management strategies.
9. Define responsibilities and implement the lowest risk, most effective pest management strategy, in accordance with applicable laws, regulations, and policies.
10. Evaluate results; determine if objectives have been achieved; modify strategy if necessary (adaptive management).
11. Education and outreach. Continue the learning cycle, return to Step 1.

Questions to Consider:

Some important questions to consider while determining an effective IPM strategy include the following:

- ♣ Is it a pest? (Is it interfering with your management objectives?)
- ♣ Is it a native or non-native organism?
- ♣ What conditions foster the pest?
- ♣ What management zone is it in?
- ♣ What are the chances of successful management?

https://www.nature.nps.gov/biology/ipm/Documents/11step_IPM_Process.pdf

Appendix 1C.

U.S. Environmental Protection Agency Principles of IPM

Traditional pest control involves the *routine* application of pesticides. IPM, in contrast:

- Focuses on pest prevention.
- Uses pesticides only as needed.

This provides a more effective, environmentally sensitive approach. IPM programs take advantage of all appropriate pest management strategies, including the judicious use of pesticides. Preventive pesticide application is limited because the risk of pesticide exposure may outweigh the benefits of control, especially when non-chemical methods provide the same results. IPM is not a single pest control method but rather involves integrating multiple control methods based on site information obtained through:

- inspection;
- monitoring; and
- reports

Consequently, every IPM program is designed based on the pest prevention goals and eradication needs of the situation. Successful IPM programs use this four-tiered implementation approach:

- Identify pests and monitor progress
- Set action threshholds
- Prevent
- Control

Identify Pests and Monitor Progress - Correct pest identification is required to:

- Determine the best preventive measures.
- Reduce the unnecessary use of pesticides.

Additionally, correct identification will prevent the elimination of beneficial organisms. When monitoring for pests:

- Maintain records for each building detailing:
    - monitoring techniques;
    - location; and
    - inspection schedule.
- Record monitoring results and inspection findings, including recommendations.

Many monitoring techniques are available and often vary according to the pest. Successful IPM programs routinely monitor:

- pest populations;
- areas vulnerable to pests; and

- the efficacy of prevention and control methods.

IPM plans should be updated in response to monitoring results.

Set Action Thresholds - An action threshold is the pest population level at which the pest's presence is a:

- nuisance;
- health hazard; or
- economic threat.

Setting an action threshold is critical to guiding pest control decisions. A defined threshold will focus the size, scope, and intensity of an IPM plan.

Prevent Pests - IPM focuses on prevention by removing conditions that attract pests, such as food, water, and shelter. Preventive actions include:

- Reducing clutter.
- Sealing areas where pests enter the building (weatherization).
- Removing trash and overgrown vegetation.
- Maintaining clean dining and food storage areas.
- Installing pest barriers.
- Removing standing water.
- Educating building occupants on IPM.

Control Pests - Pest control is required if action thresholds are exceeded. IPM programs use the most effective, lowest risk options considering the risks to the applicator, building occupants, and environment. Control methods include:

- Pest trapping.
- Heat/cold treatment.
- Physical removal.
- Pesticide application.

Documenting pest control actions is critical in evaluating success and should include:

- An on-site record of each pest control service, including all pesticide applications, in a searchable, organized system.
- Evidence that non-chemical control methods were considered and implemented.
- Recommendations for preventing future pest problems.

https://www.epa.gov/managing-pests-schools/introduction-integrated-pest-management#Principles

Appendix 1D. U.S. Air Force

From the 2017 U.S. Air Force Pollinator Conservation Reference Guide providing information to supplement the U.S. Air Force Pollinator Conservation Strategy (Strategy) developed jointly by Air Force Civil Engineer Center and U.S. Fish and Wildlife Service.

HIGHLIGHTS

- The elements of integrated pest management (IPM) are:
  - Describe the pest problem
  - Identify and describe the site and its ecology and management goals for the habitat and the pest
  - Know the pests and their natural enemies
  - Prevent pests at your site
  - Monitor the pest
  - Establish an action threshold (the level of damage or number of pests at which a pest control measures will be implemented)
  - Decide what methods, strategies, or tools will be used to control the pest
  - Notify neighbors, such as beekeepers, who may be affected by onsite pest management actions
  - Implement the lowest risk, most effective methods and tools. Conserve natural enemies of the pest
  - Evaluate the results and adapting and modifying the strategy, as needed.
  - Keep records

RELEVANT SECTION OF AFI

- AFI 32-1053, Integrated Pest Management Program