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Forest Service National Strategic Framework for Invasive Species Management

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Executive Summary

Invasive species pose some of the greatest environmental and economic threats to the Nation's forests, grasslands, and waterways. To ensure the continued production of needed goods, services, and values from our Nation's terrestrial and aquatic ecosystems, the Forest Service, an agency of the U.S. Department of Agriculture (USDA), must implement a strategic systems approach for managing invasive species.

This *Forest Service National Strategic Framework for Invasive Species Management* (Framework) prioritizes and guides the prevention, detection, and control of invasive insects, pathogens, plants, wildlife, and fish that threaten our Nation's terrestrial and aquatic ecosystems. The Framework incorporates the Invasive Species Systems Approach (ISSA) (appendix B) developed by the Forest Service to respond to these threats over the next 5 to 10 years and supersedes the Invasive Species Strategy and Implementation Plan (2004). This Framework is intended to provide broad and consistent strategic direction across all Forest Service Deputy Areas and agency programs. The Forest Service developed the Framework in response to the USDA Office of the Inspector General audit (2010) and a review by the Forest Service's Washington Office invasive species program. This Framework describes how National and Regional Invasive Species Issue Teams (NISIT and RISITs, respectively) will coordinate activities within the Forest Service and with Federal, State, and local partners. National priorities will be reviewed at least once every 5 years and adjusted as needed. RISITs will assess and adjust their regional invasive species priorities for their respective ecosystems at least once every 5 years.

The ISSA identifies four key invasive species program elements: (1) prevention, (2) detection, (3) control and management, and (4) restoration and rehabilitation. The ISSA elements are dynamic in application; inclusive, not mutually exclusive; and integrated through management actions. Within each element, four themes are evident:

- Scientific basis—conducting research to provide a sound scientific foundation for all program activities and to establish program priorities based on science-based risk assessments and other relevant information.
- Communication and education—rapidly and effectively disseminating research results, new detection information, management practices, technology, and other relevant information to land managers and stakeholders.
- Organization—improving capacity, streamlining procedures, and providing funding flexibility with long-term commitment.
- Partnerships and collaboration—actively seeking and engaging external and internal partners.

The following are key actions to be implemented:

- Administer NISIT and RISITs to facilitate coordinated, efficient, and effective invasive species management and research programs.
- Build new and strengthen current collaborations within the agency and with its external partners.
- Communicate effectively with the public, stakeholder communities, and partners.
- Enhance capabilities of managers, scientists, and forest health specialists to rapidly respond to threats; provide managers with tools needed to prevent, detect, and control invasive species and to rehabilitate affected ecosystems; and identify internal barriers to rapid and effective response.
- Inventory priority invasive species across the National Forest System and, as appropriate, non-Forest Service lands.
- Implement standard operational procedures and databases across the agency when such implementation will improve effectiveness in managing invasive species.
- Report agency accomplishments, expenditures, and efficacy of actions.
- Conduct a national oversight review by NISIT once every 5 years.
- Review NISIT and RISIT (regions, stations, area) accomplishments and reassess their priorities every 5 years.

Successful implementation across the agency of the preceding elements and actions should increase the effectiveness of Forest Service management of invasive species and improve the health and productivity of forests and grasslands.

Introduction

Invasive species are among the most significant environmental and economic threats facing our Nation's forest, grassland, and aquatic ecosystems. They endanger native species and threaten ecosystem services and resources, including clean water, recreational opportunities, sustained production of wood products, wildlife and grazing habitat, and human health and safety. Property values are also adversely affected, and cities, counties, and small landowners are often disproportionally impacted. Adverse effects from invasive species can be exacerbated by interactions with fire, native pests, weather events, human actions, and environmental change. Invasive species cause billions of dollars in damage each year (Aukema et al. 2011, Holmes et al. 2009, Kovacs et al. 2010, Pimentel et al. 2005). Pimentel et al. (2001) estimated damage from invasive species worldwide totaled more than $1.4 trillion per year—5 percent of the global economy.

Burgeoning global trade and transportation have facilitated the distribution of many species among continents well beyond their native range. Species introductions have enhanced the probability of exotic establishment. The spread and persistence of invasive species result in high levels of environmental damage, significant control and other economic costs, and social impacts including harm to human health and well-being. Because the number of people living in, accessing, and using forests, grasslands, and water resources is continually increasing, the likelihood of invasive species being spread through transportation and recreational activities is also rising. As a result, many species of invasive plants, insects, pathogens, terrestrial animals, and aquatic organisms are already established in forest, grassland, and aquatic ecosystems. The harm currently caused by the numerous invasive species in the United States, combined with the likelihood of new introductions, necessitates that the Forest Service, an agency of the U.S. Department of Agriculture (USDA), develop a more comprehensive approach to guide current and future activities related to invasive species management to reduce undesirable impacts.

Strategically investing in programs and projects to address invasive species threats will help reduce the economic and environmental impacts of invasive species on all lands.

Responsibilities and Capabilities of the Forest Service

The mission of the Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. The agency is a leader in forest and grassland management and research in the United States and is recognized internationally for its land management and scientific expertise. The Forest Service directly manages 193 million acres of forests and grasslands within the National Forest System (NFS), which includes forests, grasslands, and waterways. The Forest Service also provides a wide range of assistance to others to better manage private and other public natural resources. With regard to forest insects, and pathogens, the Forest Service is specifically authorized to provide technical and financial assistance to State natural resource and agricultural agencies, tribal governments, and other Federal land management agencies to respond to and manage forest pests that threaten the Nation's 731 million acres of rural and urban forests of all ownerships. The Forest Service routinely conducts research, scientific collaboration, and reviews that address priority information gaps necessary for forest, watershed, and grassland management. The technology and development centers of the Forest Service provide a wide array of scientific information and assessments and specialize in developing and applying new management technologies for forests and grasslands. On an international level, the Forest Service also delivers scientific information and technical and financial support to overseas partners and nations to address global conservation issues.

The agency workforce includes scientists in forest entomology; forest pathology; botany; wildlife and fisheries biology; aquatics; rangeland ecology, forestry, fire and wildlife management; cultural science; and economics. Experts in public communication, legislative affairs, technology transfer, and education also provide important support in effectively addressing invasive species issues.

Vision

The Forest Service will use the best available science-based methods to prevent and reduce the unacceptable impacts caused by invasive species and thereby sustain the integrity and resilience of the Nation's forest and grassland ecosystems. To achieve this vision, the Forest Service has established an improved comprehensive, integrated

approach that highlights the agency's commitment to a timely response to the threat of invasive species by using resources effectively, efficiently, and safely and by engaging, communicating, and coordinating actions at all levels and across all deputy areas of the Forest Service and with its partners.

Purpose of the Framework

This *Forest Service National Strategic Framework for Invasive Species Management* (Framework) is intended to provide broad strategic direction for the Forest Service's programs, spanning the NFS, Research and Development (R&D), and State and Private Forestry (S&PF) Deputy Areas, and International Programs. This document supersedes the National Strategy and Implementation Plan for Invasive Species Management (2004) and is intended to clarify the roles of the deputy areas of the Forest Service regarding invasive species and enhance internal coordination of agency invasive species programs. This Framework is a guide for the agency's full suite of invasive species research and management activities and is consistent with existing law, policy, and other direction at the field, regional, and national levels. The recently approved Forest Service Manuals (FSMs) 2020, 2070, 2900, and the development of an associated Forest Service Handbook (FSH) 2909.11 will provide more policy and directions on implementing this Framework within the NFS. The manuals and handbooks of the S&PF (FSM 2150, FSM 3400, FSH 2109.14) and R&D (FSM 4000) Deputy Areas also provide guidance and direction.

Framework Organization

This Framework outlines the vision, approaches, guiding principles, and actions the agency needs to follow for successful management of invasive species. It is divided into six sections: (1) Introduction, including the Vision, Purpose of the Framework, and Framework Organization; (2) Invasive Species Strategic Approach (3) Guiding Principles; (4) Summary; (5) Framework in Action; and (6) Appendixes. The Introduction section describes the responsibilities and capabilities of national and regional offices of the Forest Service. The Invasive Species Systems Approach (ISSA) section focuses on a new Forest Service approach to invasive species management and research and includes strategic elements, actions, and prioritization. The Guiding Principles section presents standards and actions that all Forest Service programs and activities follow to achieve success.

Executive Order 13112 and Forest Service Policy

The Forest Service is obligated by law, and regulations such as Executive Order 13112, to respond to invasive species that threaten terrestrial and aquatic resources of the National Forest System and to collaborate with Federal, State, and local partners to address invasive species that can spread from adjacent lands. Forest Service policy for invasive species management and research has recently been updated by direction provided in Forest Service Manual (FSM) 2900 and by directions provided in FSMs 3400 and 4000.

National and Regional Invasive Species Program Organization

In 2003, a multidisciplinary team of specialists, managers, and scientists developed a *National Strategy and Implementation Plan for Invasive Species Management (2004)*. That plan established a national Forest Service invasive species program under the leadership of the Washington Office National Invasive Species Issue Team (NISIT). The NISIT developed Forest Service policies consistent with agency mandates, and it fostered the development of Regional Invasive Species Issue Teams (RISITs). In 2006, the regional, Northeastern Area, and station directors established RISITs to coordinate management activities and research needs at the regional, station, and area levels and to interface with Regional Aquatic Nuisance Species Panels, Invasive Species Councils, State agencies, and other local and regional organizations. This Framework continues the NISIT and RISIT organization within the Forest Service. Key roles and responsibilities of the NISIT and RISITs are identified in appendix B.

Local Networking and Organization

Staffs from NFS, R&D, and S&PF network with local, county, and State governments; Cooperative Weed Management Areas; Cooperative Invasive Species Management Areas; and other organizations in the public and private sectors to promote a collaborative approach to mitigate, manage, and adapt to invasive species threats across the landscape, while improving and sharing information. Improved knowledge development, communication, coordination, and information sharing enables the Forest Service to stay apprised of local issues and advances, while remaining relevant and connected with local expertise that is valuable in planning, prioritizing, and implementing invasive species management activities.

What Is an Invasive Species?

A species is considered to be invasive if it meets two criteria: (1) it is nonnative to the ecosystem under consideration, and (2) its introduction causes, or is likely to cause, economic or environmental harm or harm to human health (Executive Order 13112, 1999). This definition can be confusing. Consider the following examples to better understand the meaning of the term invasive. Not all "exotic" species (i.e., species living outside their native range) are invasive. In fact, many exotic species provide environmental and economic benefits to society. Potatoes *(Solanum tuberosum)*, honey bees (Apis spp.), and cattle *(Bos primigenius taurus)* descended from ancient European livestock are exotic species in the United States that have been domesticated and are considered beneficial. Feral swine *(Sus scrofa)* and emerald ash borer *(Agrilus planipennis)* are invasive pests because of their introduction into the United States and their ability to cause environmental and economic harm. Although Canada geese *(Branta canadensis)* might be serious pests for Maryland property owners, they are historically migratory to this region. Mute swans *(Cygnus olor)* in the same area would be considered invasive, however, because they are a nonnative pest species.

Some North American species are native to certain areas of the continent but are considered invasive when they move to new ecosystems. For example, mountain pine beetles *(Dendroctonus ponderosea)* are considered native in western pine ecosystems and invasive in the mixed jack pine forests east of the Canadian Continental Divide. Similarly, walnut twig beetle *(Pityophthorus juglandis)*, the vector of the invasive thousand cankers disease *(Geosmithia morbida)*, is a native insect in southwestern ecosystems but is behaving like an invasive species in other North American ecosystems.

An integrated systems approach relies on multiple risk management measures that independently reduce risk. The Framework describes a new tool to assess program effectiveness in addressing invasive species. The ISSA applies particular criteria for prioritizing Forest Service management and research priorities (see appendix B) and performance measures for evaluating success. The 4 elements and their 18 components included in the ISSA are needed for an effective invasive species program. Use of the ISSA across the Forest Service will promote high standards and consistently high levels of effectiveness for the activities of its invasive species program. The Framework and the ISSA complement directions in Forest Service manuals and handbooks that set forth policies, responsibilities, and requirements for invasive species management and research. Likewise, the ISSA integrates an adaptive framework for managing the Nation's forests and grasslands consistent with the Forest Service Planning Rule, which guides development, amendment, and revision of land management plans for all units of the NFS, consisting of 155 national forests and 21 grasslands.

Invasive Species Systems Approach Elements

The Forest Service will focus on four key elements for invasive species research and management.

1. Prevention
2. Detection
3. Control and Management
4. Restoration and Rehabilitation

Forest Service employees record survey results.
Photo by Bob Nichols, USDA Photography

Cost of Responding to New Pest Introductions

The cost of responding to new pest introductions can be huge. Successful eradication might be possible, if an infestation is detected early, but it can take many years of concerted effort and millions of dollars. For example, before 2006, USDA spent more than $420 million for containment, control, and eradication of only three invasive forest pests: Asian longhorned beetle (ALB) *(Anoplophora glabripennis)*; emerald ash borer (EAB) *(Agrilus planipennis)*; and *Phytophthora ramorum*, the fungal pathogen that causes Sudden Oak Death (SOD) (GAO 2006). Since 2006, USDA has spent many more millions of dollars on these species with mixed results. After nearly 15 years of effort, ALB has been eradicated in Illinois and New Jersey. In 2009 and 2011, however, large infestations of ALB were detected in Worcester, MA, and Cincinnati, OH, respectively. It will likely take decades and many millions of dollars to contain and eradicate these infested areas. SOD has not yet been established in the Eastern United States, in part, because USDA and State efforts appear to suppress the spread of the pathogen from the West Coast. On the other hand, EAB has become widely established in much of the Eastern United States. The focus has shifted from prevention and eradication to minimizing the spread of EAB through a variety of management tactics, including detection, eradication of small populations on the leading edge of the infestation, biological control, and insecticides.

These four elements are not separate and distinct from one another; they overlap and form an integrated adaptive approach for addressing invasive species. Furthermore, this strategy facilitates integrated funding for all four elements; none can stand alone. For example, Early Detection and Rapid Response (EDRR) is a commonly used approach that combines two of the elements. Early detection of a species is paired with control actions, such as physically removing the invader or applying pesticides to eliminate it.

Element 1.—Prevention. **Keep invasive species out of the Nation's forests and grasslands and identify potential introduction pathways for known threats**. The most effective strategy to protect forests, waterways, and grasslands from invasive species is to prevent invasive species introduction and establishment. Containing known infestations is also important for blocking the spread of invasive species from infested lands to surrounding areas. Coordination with Federal and State regulatory agencies is important in understanding pathways for introductions, implementing quarantine regulations, and educating the public about invasive pest threats and how to prevent the spread of invasive species.

The Forest Service will actively prevent the introduction and spread of invasive species that adversely affect the health and sustainability of U.S. forests, watersheds, and grasslands. The Forest Service will coordinate and cooperate with USDA Animal and Plant Health Inspection Service (APHIS) and other State and Federal agencies, as necessary, and will identify and inform the public about invasive species threats and their management. The Forest Service supports this element through research, resource stewardship, active collaborative efforts, education and outreach activities, and the development of new technology.

Forest Service prevention efforts include the following actions.

- *P1—Identify, forecast, and prioritize invasive species threats*. Many invasive species are already established in the United States but are not yet widespread. Knowledge of which species are already present in a region, State, forest, or district, or are likely to be introduced into these areas, can guide prevention efforts.
- *P2—Identify high-risk pathways of movement and introduction.* Numerous pathways (or vectors) introduce exotic species, some of which might become invasive, to the United States. Identifying pathways that pose the greatest risk for the introduction of invasive species and, if appropriate, following up with focused actions will help prevent introduction and spread.
- *P3—Identify vulnerable ecosystems.* Knowing which resources are the most threatened by a particular invasive species and what the impacts are on an ecosystem will help prioritize detection and management efforts.
- *P4—Improve cooperative efforts.* Invasive species

Early Detection and Rapid Response

Early detection and rapid response (EDRR) is a commonly used approach that combines two of the elements of the *Forest Service National Strategic Framework for Invasive Species Management*. Early discovery and identification of newly arrived invasive species before they become widespread is critical to their eradication, management, and control. Distinguishing an invasive species from similar species in the ecosystem is essential to assessing its risk to the environment. When coupled with rapid responses, such as immediately eradicating the organisms or implementing control measures to reduce their abundance and slow their spread, it is one of the most effective methods for managing a newly arrived species. For example, on a national scale, the Forest Service and the Animal and Plant Health Inspection Service jointly implement EDRR to detect and eradicate the Asian gypsy moth when and wherever it is found in the United States, thereby thwarting its successful establishment.

prevention requires the efforts of multiple agencies, organizations, communities, and individuals. Crucial steps for establishing effective cooperative efforts include identifying local and regional partners, actively participating in cooperative efforts, and helping to identify and obtain sufficient and appropriate funding to support prevention activities.

- *P5—Recommend, program, and implement appropriate actions to prevent introduction and establishment of target invasive species.* Local, State, regional, and Federal actions are important in preventing the movement of invasive species. Once high-risk invasive species and their pathways are identified, actions should be taken to prevent their establishment.

Element 2.—Detection. **Survey to detect new invasive species and monitor existing priority species.** Detection and monitoring are critical components of an effective management program. They provide the basis for control and management including rapid response. Using risk assessments and pathway analysis, detection efforts for priority species can be directed towards high-risk areas. When early detection is combined with other management tools, such as rapid response, it leads to a more effective invasive species management approach.

The Forest Service will develop and implement efficient survey and monitoring tools and technologies as needed to facilitate earlier detection of invasive species and rapidly assess their potential impact on forest and grassland health. As necessary and appropriate, the Forest Service will coordinate with Federal and non-Federal cooperators across all lands.

Forest Service detection actions include the following:

- D1—*Survey effectively to detect new invasive species and monitor priority species.* Discovery and correct rapid identification of newly arrived species is critical for their eradication. Early detection and continued monitoring of established species are critical to slowing their spread.
- D2—*Evaluate the extent and severity of invasive species infestations and assess their potential impacts.* Delimiting the extent of an infestation is important for selecting appropriate control actions. Invasive species infestations that are widespread might need to be treated differently than small or isolated infestations that can be eradicated.
- D3—*Report invasive species detection findings in standardized databases.* Access to information on invasive species distribution is important when determining management actions. Information from detection and delimiting surveys should be entered into standardized databases, and Natural Resource Manager—Natural Resource Information System, so that information can be shared quickly and widely. All invasive species inventories and infestation maps will be shared among land management and regulatory agencies, States, and

Forest Service employee conducting invasive species survey.
Photo by Katrina Krause, USDA Forest Service

other partners to monitor population trends and treatment effectiveness.

- D4—*Develop tools and techniques to detect and monitor invasive species.* Improving the availability and effectiveness of detection tools will help achieve earlier detection of new infestations and lower eradication and management costs. Less costly and more effective monitoring tools will facilitate improved efficiencies in invasive species management.

Forest Service employees discuss invasive species management.
Photo by Bob Nichols, USDA Photography

Element 3.—Control and management. **Directly eradicate (if possible), control, or manage priority invasive species on priority acres to minimize their spread and adverse effects.** Based on integrated pest management (IPM) principles, such as using risk assessments, identifying thresholds for actions, and identifying expected outcomes, management activities can aim to eradicate an infestation, to contain its spread, or to mitigate its impacts.

The Forest Service will directly intervene, when cost-effective, to manage populations of invasive species that threaten forest and grassland health and sustainability. Rapid response following early detection will be used to eradicate new infestations. If eradication is not feasible, IPM and adaptive management techniques will be implemented to help maintain ecosystem function. This will include research and management to increase the resilience of threatened ecosystems to mitigate the impacts of pests invading. In cooperation with external stakeholders, the Forest Service will conduct research to characterize infestations, identify factors conducive to infestations, and develop tools and techniques to cost-effectively eradicate or manage priority invasive species. The Forest Service will optimize efficacy and cost effectiveness of treatment by timing interventions to maximize forest health benefits (Schoettle and Sniezko 2007). Following impact assessment and response plan development, the Forest Service will implement and monitor management actions. When and where possible, the Forest Service will eliminate barriers to rapid response via process improvements. Subsequent management actions will be adapted based on outcome and cost monitoring.

Forest Service control and management actions include the following actions:

- *CM1—Coordinate as needed with partners*. Coordination and collaboration with key partners and other stakeholders will help to identify common objectives and gain efficiencies, resulting in more effective treatment programs against terrestrial and aquatic invasive species. Partners include adjacent private landowners, nongovernmental organizations, and governmental partners (e.g., State departments of agriculture, State fish and game agencies, county governments, Federal regulatory agencies, and other Federal partners).
- *CM2—Prioritize and implement treatments.* Prioritizing which species to treat and when and where to treat them might be influenced by management objectives for the landscape as well as by conditions in the surrounding area. Effective control of invasive species depends on understanding the species' biology, its interactions within the landscape, the availability of effective tools, costs, anticipated impacts, and land management ownership and objectives. Mechanical, biological, chemical, and cultural techniques may be used in an integrated approach to reach the desired outcome. Treatments will follow standardized, science-based procedures to maximize efficiency and effectiveness. Strategies, systems, and practices for managing changed ecosystems to continue to deliver needed goods and services will be developed.
- *CM3— Implement rapid response for new infestation in response to new invasions.* Consistent long-term commitment of resources and budgets is essential for successful control and management. Effective "rapid response" to new infestations requires streamlining or removal of time-consuming and expensive procedures. When coupled with early detection, rapid response is the last opportunity to eradicate new invasions at low costs. Current Council on Environmental Quality Regulations and Guidance for

Implementing the National Environmental Policy Act (2007), the Forest Service manuals (2900, 3400) and Forest Service handbooks (2109.44, 2909.11) are helpful for facilitating the timely response to new infestations consistent with invasive species prevention and control requirements of Executive Order 13112. As procedural barriers are identified, they should be addressed and quickly mitigated if possible. Successes in rapid response efforts and methods for reducing barriers should be shared with the widest audiences possible.

- *CM4—Monitor and report accomplishments in standardized databases.* Standardized databases enable the integration and leveraging of data from multiple sources in order to more effectively manage information about treatments that are accomplished. Entering the treatment records into standardized databases (such as Natural Resource Management—Forest Service Activity Tracking System) enable the linking of data sets and ease comparisons between datasets. Ensure data comparability by using standardized guidelines to facilitate consistent species or activity reporting and long-term treatment efficacy reporting. All accomplishments should be verified before initial entry into corporate application databases. These databases must be compliant with agency and interagency agreements.
- *CM5—Develop the tools, technologies, methods, and budgetary processes necessary to prioritize and eradicate or manage invasive species.* Eradication might require a long-term commitment of resources to be effective. Although initially expensive, eradication costs are typically far less than the cost of management activities subsequent to spread into surrounding areas and States. Improving the availability and effectiveness of treatment tools will help achieve eradication of new infestations and lower costs. Likewise, proactive management to increase the resilience of threatened ecosystems to impacts by pending invasions might also be more cost effective than later restoration of degraded ecosystems (Schoettle and Sniezko 2007). Less costly and more effective tools to manage existing infestations will prevent degradation of additional ecosystems and facilitate restoration.

Element 4.—Restoration and rehabilitation. **Minimize or reverse adverse ecosystem effects caused by invasive species.**

Restoring landscapes that have been impacted by invasive species or associated management activities is necessary for improving ecosystem integrity and function and might reduce vulnerability to invasive species establishment in the future. Restoring and maintaining the health, functions, and productivity of areas affected by invasive species is consistent with management guidance on restoring national forests (FSM Chapter 2000, National Forest Resource Management and FSM Chapter 2020, Ecological Restoration and Resilience) and the effective use of native species (FSM Chapter 2000, National Forest Resource Management and FSM Chapter 2070, Vegetation Ecology).

Forest Service restoration and rehabilitation actions include the following actions:

- *RR1—Identify and prioritize restoration and rehabilitation needs*. Prioritizing restoration actions can help the Forest Service meet the most critical management needs for a forest or grassland. These needs are based on management objectives, feasibility, and cost-effectiveness. Landscapes that have been impacted by invasive species and are a threat to human health and safety would be of highest priority. Areas that might also receive priority attention include those that are rendered more susceptible to fire; those that provide critical water resources, wildlife habitat, or recreation opportunities; those that contain rare resources; or research natural areas, special botanical areas, or other areas containing high-quality natural resources. The impacts of invasive species control and subsequent restoration efforts on the native species and ecosystems must be considered when selecting the most appropriate options.
- *RR2—Take actions to restore, monitor, and maintain affected areas.* Identification, prioritization, and implementation of the most effective science-based actions are essential for successful restoration and rehabilitation. Using the best available science will enable the Forest Service to apply the most effective actions to restore or rehabilitate areas affected by invasive species. The intervention should be timed to optimize efficacy and cost effectiveness of treatment for long-term sustained ecosystem health (Schoettle and Sniezko 2007). When the invasive threat cannot be contained or eradicated, prioritizing when and

where to increase the resilience of threatened high-value ecosystems helps to mitigate later degradation upon invasion. Success will be improved by pooling the expertise of partners in restoration, rehabilitation, and technology development and transfer and by using genetically appropriate material in a timely manner.

- *RR3—Assess effectiveness of rehabilitation and restoration activities.* Monitoring and managing restored areas reduces vulnerability to future invasions and allows for the achievement of land management goals and objectives. Recording assessment of restoration effectiveness and efficacy data will inform Forest Service decisions about future restoration activities.
- *RR4—Develop, synthesize, and evaluate effective rehabilitation and restoration tools, technologies, and methods.* Rehabilitation and restoration of forests and grasslands takes a long-term commitment of resources to be effective. Developing, evaluating, and improving the availability and effectiveness of methods, tools, and technologies will benefit this process and reduce costs. These tools should include adaptive learning techniques and advance knowledge of best practices.

The Forest Service will emphasize the four key elements at all levels of the organization, while ensuring activities are conducted in a manner that strongly incorporates partnership and collaboration and that promotes using communication and education, organizing for success, and having a solid foundation in applicable science. Paramount to success is management's ability to prioritize activities; establish and implement performance measures; and assign roles, execute responsibilities, and hold people accountable across staffs. Across the agency, the following common actions will assist in this process:

- Administer NISIT and RISITs to facilitate coordinated, efficient, and effective invasive species management and research programs.
- Conduct a national oversight review by NISIT once every 5 years.
- Review RISIT (Northeastern Area, regions, and stations) accomplishments and reassess their priorities every 5 years.
- Implement standard operational procedures and databases across the agency to improve effectiveness in managing affected systems.
- Report accurate agency accomplishments, expenditures, and efficacy of actions.
- Build effective collaborations within the agency and with partners.
- Communicate more effectively with the public, user communities, and partners.
- Enhance capabilities of managers, scientists, and forest health specialists to rapidly respond to threats; provide managers with tools needed to prevent, detect, and control invasive species; monitor and understand vegetation succession following different types of treatment to rehabilitate and manage affected ecosystems; and identify internal barriers to rapid and effective responses.
- Inventory priority invasive species across the NFS and, as appropriate, other cooperators' lands and all lands in partnership with the Forest Service Forest Inventory and Analysis and State, Federal, and local agencies.

Successful implementation of the above elements and actions will increase the effectiveness of Forest Service management of invasive species and improve the health and productivity of both forests and grasslands.

Prioritization of ISSA Elements and Actions

Prioritizing programmatic and invasive species-specific activities is necessary to effectively use the resources available. Setting priorities will be an iterative process using the best available science and information to facilitate decisionmaking. A suite of factors, including availability of effective prevention, detection, monitoring, and control methods; availability of funds; resources at risk; potential for invasive species spread; and likelihood of success will be considered in assessing risk and setting priorities. Of these factors, prevention and EDRR are, in general, recognized as the most efficient and cost-effective strategies for addressing invasive species. Ordering invasive species management priorities will occur at all levels of the Forest Service. NISIT will establish national priorities for Forest Service. RISITs will work with the NISIT and regional and station leadership to identify complementary focus areas, issues, scales, and priority species. The Forest Service emphasizes the use of highly effective and efficient methods when available, based on prevention, impact assessments (e.g., economic, ecological, landscape, and social impacts), and species characterization (e.g., life history and spread).

Guiding Principles

All Forest Service programs and activities conducted or implemented under this Framework will use the following guiding principles for success.

- **Emphasize safety as a core value in all actions.** Chief Tom Tidwell (Forest Service letter dated February 18, 2011) directed the Forest Service to incorporate safety into all agency programs. This incorporation requires an examination of ingrained habits, expectations, and "ways of doing business, or culture" that contribute to death or injury, as well as changing the agency's processes to address these concerns.
- **Use a systems approach for invasive species management.** Integrated management is a cost-effective system of actions that reduces pest presence, distribution, or reproductive success. The advantage of an integrated approach is that it addresses uncertainty and variability better than any single approach and includes a structured decision process that adapts to current conditions and allows for flexibility in funding, staffing, and program direction as needed. A commitment to both short- and long-term funding support for a systems approach to the program is required both internally and externally. This commitment might require budget process changes that allow for and secure multiyear and continuing funding for long-term management activities.
- **Use standardized, science-based methodologies and strategies.** Methodologies need to be (1) science-based, (2) standardized, and (3) comparable across time and scales to facilitate consolidation and analyses at multiple organizational levels. Scientific information is critical in guiding management activities, estimating actual and potential impacts caused by invasive species, planning for future research and management programs, and improving intervention efforts and prioritization analysis. The Forest Service will participate in appropriate research, technology development, and methods improvement activities to ensure that management programs are effective, science-based, and feasible. This strategy relies on substantial contributions to invasive species science, technology, and management and an improved ability to understand and predict management outcomes of single approaches or treatments by universities; other Federal, State, and local agencies; nongovernmental organizations; tribal governments; industry; and others.
- **Identify and address gaps in procedures necessary for an effective integrated invasive species management program.** All employees are responsible for identifying gaps and barriers to successful and timely program implementation. Inclusion of personnel from all deputy areas in RISITs ensures awareness of information needs, facilitates technology development, and expedites science and technology exchange. Research and technology developed by the Forest Service and others will serve a vital role in designing new techniques to achieve comprehensive invasive species management goals. Managers will familiarize themselves with available techniques and apply the most effective strategies necessary for program success.
- **Incorporate invasive species assessment results into ongoing monitoring efforts during all project and activity phases according to mutually agreed standards, protocols, and criteria**. Under law and policy, the Forest Service is responsible for properly managing, planning, and implementing monitoring efforts, and subsequently analyzing potential impacts and treatment efficacy. Agency employees will monitor priority species using the best available standardized techniques and assess changes in species presence, behavior, and distribution to inform management decisions and actions.
- **Ensure internal Forest Service communication and coordination.** Invasive species management activities will be coordinated at all levels and across all program areas of the Forest Service. Clear communication regarding all components of invasive species management between and among Forest Service units at all levels and across multiple geographic scales is critical to success. Key factors to enhance the success of invasive species programs within the agency include new policy, guidance, and direction in manuals, handbooks, and technical guides that establish invasive species management as a routinely practiced agency activity; appropriate forest plan direction; best management practices; contract and permit language; and terms and conditions for

issued authorizations. Increased internal communication will raise awareness among Forest Service employees and facilitate incorporation of invasive species management practices into day-to-day activities, such as removing weeds from all-terrain vehicles when leaving an infested area, ensuring footwear and clothes are invasive free and reporting observations of unusual pests or pest-caused damage.

- **Collaborate and coordinate with external partners.** Collaboration is a critical overarching component across all the national strategy elements. Collaboration extends outside the agency and across ownerships and political jurisdictions to the other Federal, State, and local government agencies; tribal groups; nongovernmental organizations; the private sector; and international stakeholders. The Forest Service will also expand partnership development with nontraditional partners and increase national cooperation and coordination with environmental groups, recreational groups, and industry. The agency will facilitate the establishment of cooperative invasive species management areas, participate in research activities, operate all Forest Service programs to incorporate invasive species management and share infestation information with partners across collaborative databases, and links to Web sites such as EDDMapS. Communication with other agencies and groups will foster relationships and partnerships that increase the likelihood of management and research success and limit duplicative efforts and expenditures. Key groups for coordination include tribes, Federal, State forestry and regulatory agencies, native plant conservation groups or invasive plant coalitions, aquatic nuisance species organizations, pest advisory groups, international agencies, and invasive insect and pathogen coalitions.
- **Conduct outreach and public education.** Communication, education, and interpretive programs are needed to help the public gain an understanding of the magnitude and urgency of invasive species impacts. An educated public can help prevent, identify, detect, and control invasive species; provide input into program plans; and promote partnerships in plan implementation. The Forest Service cooperates with other agencies and organizations to conduct outreach and education activities for pests of common interest and where common messages are identified.

Blackfoot Challenge members learn, from Forest Service scientists and managers, the protocols for monitoring biocontrol releases, such as the toadflax stem mining weevil (*Mecinus janthinus*) on yellow toadflax (*Linaria vulgaris*) near Ovando, MT. The Blackfoot Challenge coordinates efforts to conserve and enhance natural resources and a rural way of life throughout the Blackfoot River Watershed among various stakeholders, both public and private.
Photo by Sharlene Sing, USDA Forest Service

Summary

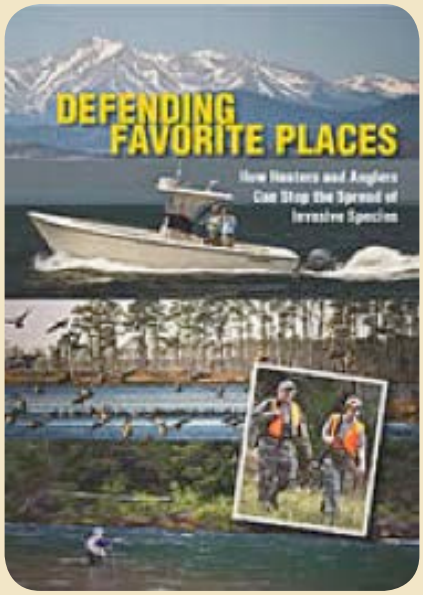
The Framework for the Forest Service's management of invasive species emphasizes four elements: (1) prevention, (2) detection, (3) control and management, and (4) restoration and rehabilitation. Fostering partnerships and collaboration; developing and implementing science-based actions; improving communication, outreach, and public education; and organizing for success are critical components that span all elements. The ISSA identifies broad targets and outlines the agency approach to attaining these elements. More specific regional targets will be developed and programmed at the regional scale, as appropriate. The ISSA guiding principles and the roles and responsibilities sections clarify the roles of the national office, Northeastern Area, International Institute of Tropical Forestry, and regions, stations, and forests (appendix A). Successful implementation of the ISSA involves coordination and communication among all parts of the agency and effective outreach and collaboration with local, regional, national, and international partners.

Purple Loosestrife (*Lythrum salicaria L.*) on the Sawtooth National Forest, Idaho.
Photo by Bob Nichols, USDA Photography

Preventing Aquatic Introductions Through Partnerships and Education

The Forest Service is working with Wildlife Forever, a nonprofit group, and others to reach the outdoor recreation community about invasive species issues. Joint outreach projects between the Forest Service and Wildlife Forever educate the outdoor recreation community and enlist their combined efforts to report invasive species, prevent their spread, and help eradicate these insidious invaders of fish and wildlife habitat. For example, aquatic invasive species, such as zebra and quagga mussels *(Dreissena polymorpha* and *Dreissena rostriformis bugensis)* and Eurasian watermilfoil *(Myriophyllum spicatum)*, have already infested some lakes and rivers and threaten many other waterways nationally. The Forest Service and Wildlife Forever developed a billboard and public service announcement campaign to remind hunters, anglers, and recreational boaters to clean, drain, and dry their boats and gear before moving from one waterway to another. This partnership also developed a seven-episode conservation education television program about aquatic invasive species issues in the Great Lakes region. These outreach and education efforts have already reached tens of millions of people. Also part of this invasive species prevention campaign, the Forest Service, in association with local partners, has deployed portable high-pressure, high-temperature washstations at key water access sites. The employees at these washstations teach boaters about aquatic invasive species, answer questions, share printed materials, and inspect and clean boats and trailers.

Propeller clogged with an invasive weed.
Photo by John Rothlisberger, USDA Forest Service



National invasive species threat campaign video.
Photo by USDA Forest Service

Inspecting and cleaning a boat to remove invasive plants and mollusks.
Photo by John Rothlisberger, USDA Forest Service

Don't Move Firewood Campaign

When the Gold Spotted Oak Borer (GSOB) *(Agrilus auroguttatus)* arrived in San Diego County in 2008 and began killing native oaks, forest health protection specialists developed a campaign to prevent the spread of invasive insects and diseases that move in firewood in California. They led the creation of the California Firewood Task Force with other Federal, State, and local partners. The task force established a Web site (complete with interactive cartoons), developed and distributed education and outreach materials to each of the 18 national forests in California, and developed a Firewood Pest Passport Activity to educate youth and their families about the risk that moving firewood poses to forests. Efforts are ongoing with multiple private and public landowners to halt the movement of GSOB-infested oak firewood; 39 million acres of oak forests are at risk in California alone. A multipartner effort is also working on improved methods for GSOB detection, appropriate use/disposal of infested material, and individual tree protection.

To address the potential for artificially spreading emerald ash borer *(Agrilus planipennis)*, national forests in the East coordinated with State agencies to implement consistent statewide regulations regarding the movement and use of firewood in State and federally managed forests, parks, and recreation areas.

Nationally, the Forest Service continues to collaborate with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service; the National Association of State Foresters; the National Plant Board; and others to develop and implement national standards for "pest-free" firewood. In addition, Forest Service scientists at the National Threat Centers and their partners focused on pathways for human-assisted spread of forest pest species. This research helps to craft strategies that help land managers prepare for and respond to the spread of multiple pests across very large regions in North America.

Don't move firewood,use local firewood—on Northeastern Area's don't move firewood poster (NA-PR-02-06).
Photo by *Tom Denhom, USDA-APHIS*

Emerald ash borers and other borers move with firewood.
Photo by David Cappaert, Michigan State University, http://www.bugwood.org

Integrated Weed Management in Hawaii Requires Feral Swine Management

Feral pigs *(Sus scrofa)* are formerly domestic swine hybrids that are free-roaming. Their rooting in the ground for food creates large areas of disturbance, which causes soil erosion, degrades water quality in streams, and damages property. More importantly, ground disturbance promotes the introduction and establishment of many invasive plants. In addition, feral pigs are very effective at dispersing the seeds of the many invasive plants with edible fruits, further exacerbating the spread and abundance of invasive plants. In Hawaii, invasive plants are replacing native species in native forests across whole watersheds and landscapes. In most instances, invasive plant management and restoration cannot be successful until the feral pigs are removed and excluded from the area. The Forest Service is partnering with the State of Hawaii and other organizations to fence large areas (2,000 to 5,000 acres) to enable the removal of feral pigs as a first step toward the restoration of native plant species and communities and the myriad of ecosystem services they provide.

Feral swine.
Photo by http://www.thinkstockphotos.com

Addressing the Threat of White-Nose Syndrome

Hibernating bats species are threatened by a rapidly spreading, lethal disease called white-nose syndrome (WNS). The disease is caused by a new fungal pathogen, presumed to be exotic, called *Geomyces destructans*. It was first discovered in 2007 in upstate New York and has already killed more than a million bats, including rare and endangered species. The pathogen is spreading rapidly south and west. The Forest Service is very concerned about the spread of WNS, an unprecedented wildlife health crisis, and has joined with other agencies and conservation organizations in restricting access to caves and mines to help slow the spread of WNS. Forest Service scientists worked with partners to develop a sensitive test to detect the fungus in cave soils. Now they are evaluating the genetic viability of the Indiana bat based on current population losses, to look for resistance to the disease among hibernating bat species, and to characterize the distribution of the pathogen in cave sediment samples from bat hibernation sites in the Eastern United States. Bat biologists working on WNS are using this research to devise strategies to save these animals from extinction.

Little brown bat; close-up of nose with fungus, New York, October 2008.
Photo by Ryan von Linden/New York Department of Environmental Conservation

Identifying Potentially Invasive Plants in the United States

Forest Service scientists and managers at the National Threat Centers are working closely with domestic and international partners to develop a comprehensive database that will aid in prediction, prevention, and proactive management of invasive plants. This tool will advance understanding about the more than 4,300 plants introduced in the United States through accidental and intentional releases. Some of these species have become invasive by outcompeting native species for resources, resulting in threats to native communities and reducing species diversity. Researchers are developing methods to identify potentially invasive species from these introduced plants to help predict and prevent future invasions.

The database compiles key life history and genetic traits for all currently known introduced plant species, including structure and form traits, pollination and dispersal mechanisms, chromosome number, habitat preferences, and geographical distribution in both native and invaded regions. Researchers and collaborators are populating the database using a variety of sources, such as relevant existing databases, scientific literature, Web sites, and dried plant specimens. These data will allow for continental scale analyses of biological traits that influence species invasiveness and distribution (e.g., species rankings) and will aid in developing early warning systems, predictive models, risk assessments, and management plans for invasive plant species. The database will be made available on the Internet for the public, land managers, scientists, and policymakers to use as a comprehensive resource of introduced invasive plants in the United States.

Scientists also are developing a tool to prioritize treatment of invasive plants in the Intermountain West by identifying key environment and species attributes to focus on, community and ecosystem tipping points, and the most effective treatments. Eventually this tool will be scaled up and generalized to the Western United States.

Eastern Threat Center scientists are populating a comprehensive database, useful when developing early warning systems, risk assessments, and management plans for invasive plant species such as kudzu (*Pueraria lobata*).
Photo by Kerry Britton, USDA Forest Service, http://www.bugwood.org

Detection of a Disease Vector

Dieback and mortality of eastern black walnut trees *(Juglans nigra)* in the Western States has become more common and severe during the last decade. Walnut twig beetles *(Pityophthorus juglandis)* initiate this mortality, by creating numerous galleries beneath the bark of affected branches. The walnut twig beetle carries the fungus (*Geosmithia morbida*) that causes large numbers of cankers under the bark, hence the name "thousand canker disease." The beetle and the disease have now been confirmed in several Eastern States.

Walnut twig beetle.
Photo by Steven Valley, Oregon Department of Agriculture, http://www.bugwood.org

The potential loss of black walnut is of great concern to the walnut industry and nursery stock producers. The disease could also adversely affect wildlife that depends upon the tree for food, recreation quality, and trees in urban areas. The Forest Service developed a Thousand Canker Disease (TCD) Framework with concurrence from the USDA Animal and Plant Health Inspection Service, the National Association of State Foresters, and the National Plant Board to address the issue. This framework identifies management and research priorities, provides stakeholders with current TCD information, and forms a National TCD steering committee for research and management. Forest Health Protection developed and leads a national survey to detect the beetle and disease. Forest Service scientists, working with university and industry partners, patented an attractant and repellent for the beetle and developed the trapping technique used in this survey.

Collaborative Development of an Early Detection and Rapid Response Program for Invasive Plants on the Francis Marion and Sumter National Forests

The Francis Marion and Sumter National Forests in South Carolina work closely with State agencies, the Southeastern Exotic Pest Plant Council, and other stakeholders to develop, prioritize, and coordinate invasive plant management activities on the forests and adjacent lands. The teams developed a joint list of the 50 high-risk invasive plants and prioritized prevention and control efforts based on threat distribution, threat to forest resources, and the geographic area threatened. The Forest Service eradicates high-risk species not known to occur on Forest Service lands and detects and manages invasive species that threaten priority habitats.

Cogongrass (priority 2 weed) invading pine stand on Francis Marion National Forest.
Photo by Jean Everett, USDA Forest Service

Bridger-Teton National Forest Early Detection and Rapid Response (EDRR) Program for Invasive Plants

The Jackson and Buffalo Ranger Districts of the Bridger-Teton National Forest make up 52 percent of the land within the Jackson Hole Weed Management Association. In the past, weed invasions tended to enter the forest near the boundaries of lands of other jurisdictions and at the periphery of the Jackson Valley, typically along roads, trails, and river corridors, and spread into the forest from there. In 2006, using this geographic information and a list of 15 priority "new invader" plant species, the Forest Service initiated an Early Detection and Rapid Response (EDRR) program in priority (emphasis) areas, with the objective of eradicating those high-risk invasive plants before they could get a foothold and spread. By adapting the geospatial and tabular capability of the Natural Resource Information System-Terra invasive species application, the Forest Service identified almost 7,000 priority acres for detection and immediate eradication efforts. In total, the Forest Service successfully eradicated 15 priority species from those 7,000 acres. One emphasis area was the Teton Wilderness. The forest hired a packhorse contractor with extensive experience to detect, map, and treat all listed species of priority invasive weeds within the Teton Wilderness. This jointly funded Forest Service and Rocky Mountain Elk Foundation effort was the first broad effort to proactively confront and successfully address the invasive-weed problem within the Teton Wilderness using the EDRR approach.

Horse-mounted pesticide application equipment used for backcountry weed eradication on national forests.
Photo by High Country Sprayers, LLC

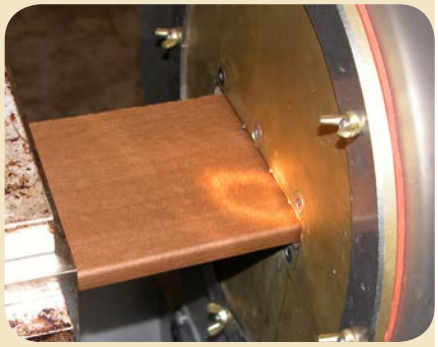
Early Detection and Eradication of White Sweetclover on the Chugach National Forest

White sweetclover (*Melilotus albus*) and other invasive plants on the Chugach National Forest in Alaska occur in areas of human disturbance and adjacent river systems, but they are generally absent in backcountry areas. In 2006, a large patch of clover was found at the Girdwood Airport, an entryway to a salmon stream. The Forest Service immediately partnered with the town on a weed-pulling campaign by local students. During the first couple of years, a 10-person crew annually pulled weeds and filled dozens of bags during a 1-week-long period. After 5 years, a 2-person crew was able to complete the job in 1 day. This white sweetclover infestation is a priority because the sweetclover has the potential to disburse its seed via the adjacent creek and via aircraft into much larger areas of roadless land throughout the Chugach National Forest and interior Alaska.

Eradication of white sweetclover (*M. albus*) in Alaska.
Photo by USDA Forest Service

Putting Invasive Species To Work by Using Them in Wood Composite Materials

Another strategy for managing invasive woody plant species is to identify value-added uses for the invasive species. For example, the Forest Products Laboratory partnered with the National Forest System and a small business owner to demonstrate that wood fibers chipped from the entire tree of the invasive juniper *(Juniperus osteosperma)* in the Southwest can be used to manufacture wood composites for road signs and other non-load-bearing outdoor applications. In another research project in partnership with the National Forest System and the Bureau of Land Management, Forest Products Laboratory scientists have shown that invasive saltcedar *(Tamarisk ramosissima)* and juniper *(J. osteosperma* and *J. monosperma)* from Arizona and Utah can be used to manufacture wood plastic composites. The aim is to expand the research to optimize durability and processability of invasive species wood plastic composites for exterior applications such as siding, decking, and roofing. The long-term goal of this strategy is to provide the basis for commercial, job-producing materials while offsetting the costs associated with removal of invasive trees and shrubs from the Nation's forests and grasslands.



A composite board containing 50-percent saltcedar *(Tamarix spp.)* and additives exiting extrusion die (right) and entering cooling tank.
Photo by Steve Schmieding, USDA Forest Service

Salt Cedar *(Tamarix spp.)* on Snake River.
Photo by C. Parks, USDA Forest Service

Saltcedar composite boards.
Photo by Steve Schmieding, USDA Forest Service

Gypsy Moth Slow-The-Spread Program

Gypsy moth *(Lymantria dispar)* is a destructive, exotic forest pest that was accidentally released into the United States in the late 1860s. It is a permanent resident in all or parts of 19 States and the District of Columbia. The insect feeds on more than 300 species of trees—oaks are the most preferred. Since 1970, the insect has defoliated more than 80 million acres. Defoliation often causes extensive tree mortality, reduces property values, adversely affects commerce, and causes allergic reactions in sensitive individuals that come in contact with the caterpillars. Almost 70 percent of the susceptible hardwood forests in the United States have not been infested by gypsy moth and are at risk.

Since 2000, the Forest Service, working with States and other Federal agencies located along the leading edge of gypsy moth populations, has implemented a national Slow-the-Spread Program, with a strategy to minimize the rate at which gypsy moth spreads into uninfested areas. This program is possible because of (1) the existence of a strong science foundation; (2) a process of continuous reviews by the scientific community and management that relies heavily on development of new methods and (3) the implementation of the program across all jurisdictional boundaries, including the participation of national forests. As a direct result of this program, spread of the insect has been dramatically reduced by more than 60 percent from the historical level of 13 miles per year. In only 12 years, this program has prevented impacts that would have occurred on more than 100 million newly infested acres across multiple jurisdictions.

A key lesson to learn from the success of the gypsy moth Slow-the-Spread Program is the importance of working with partners to promote and implement a coordinated, regionwide program based upon the biological parameters of the pest. Gypsy moth Slow-the-Spread exemplifies a well-coordinated, broad landscape response that is often necessary to effectively respond to invasive pests.

Gypsy Moth Larvae.
Photo by E. Bradford Walker, Vermont Department of Forests, Parks and Recreation, http://www.bugwood.org

Integrated Control of Toadflax in the West

Dalmatian toadflax *(Linaria dalmatica)* and yellow toadflax *(L. vulgaris)* are invasive perennial plants of rangeland, forests, and cropland that were introduced to North America from Eurasia during the 1800s as ornamental plants for use in fabric dye and folk remedies. Both species thrive particularly well in disturbed, open habitats and can out-compete and easily dominate native or desirable plant communities in areas characterized by dry summers. They propagate by seeds and by shoots growing from vegetative root buds. One plant can produce up to 500,000 seeds and have lateral roots extending as far as 10 feet from the parent plant. The fast growth, extensive root system, and high reproductive capacity of this plant requires long-term, cooperative, integrated management programs and planning to contain and reduce Dalmatian toadflax populations.

The Forest Service's work with local, State, and Federal research and management partners has developed an integrated treatment program for controlling this aggressive and adaptable invasive species that focuses on preventing toadflax seedling establishment through the maintenance of a vigorous, competitive plant community.

Effective control often requires an integrated approach such as mechanical control combined with herbicide treatment, herbicide treatment followed by seeding with competitive grasses, and the treatment of large infestations with herbicides in combination with biological control with insects. One example of this technique would be to release biological control agents near the center of the infestation, and then spray the edges to reduce or prevent the spread of the infestation. The greatest impact is obtained by repeated treatments over multiple years.

Dalmatian toadflax.
Photo by Susan Turner, British Columbia Ministry of Forests, http://www.bugwood.org

Left: Yellow toadflax.
Photo by Linda Wilson, University of Idaho, http://www.bugwood.org

Below: Adult toadflax stem mining weevils *(Mecinus janthinus)* established on yellow toadflax near Ovando, MT.
Photo by USDA Forest Service

Sudden Oak Death Held at Bay by Coordinated Response

The Forest Service Research and Development, Forest Health Protection (FHP), and National Forest System (NFS) personnel in the Pacific Southwest Region worked with numerous partners to reduce the human-assisted spread of Sudden Oak Death (*Phytophthora ramorum*) and helped communities in 14 infested coastal counties in California and Oregon.

When oak trees started dying in the San Francisco Bay Region, the Pacific Southwest Station developed a collaborative research response that helped identify the cause—a water mold new to science. Starting from scratch, the station along with the University of California (UC) Davis, UC Berkeley, and FHP initiated a coordinated program to learn about the pathogen's biology and how to control and manage it. The diagnostic methods, treatments, and information on spread rates, supported by the Forest Service, serve as the scientific basis for regulations and best management practices for the United States and more than 60 other countries. FHP staff joined forces with researchers, State forestry and agriculture agencies, and others to form the California Oak Mortality Taskforce (see http://www.suddenoakdeath.org). The taskforce developed consensus on research priorities and developed support for appropriate regulations to prevent pest spread. They also developed and hosted numerous education and outreach programs for the nursery industry, land managers, and the general public to help prevent pathogen spread.

As scientists determined that the pathogen had a wide host range and could be spread on infected plant material, NFS and other land managers issued closure orders to prevent moving the pathogen on Christmas trees, firewood, or cut branches of host trees. The cohesive approach taken by the Forest Service and its partners has helped slow the geographic spread of the pathogen.

Although the impact of Sudden Oak Death, to date, has mainly been seen in coastal areas of Western States, the Forest Service's National Early Detection Survey for *P. ramorum* has surveyed more than 500 streams in the Eastern United States in an effort to protect valuable oak resources in the East.

Sudden Oak Death is costly and difficult to manage when infected trees occur in residential settings such as this San Francisco Bay Area neighborhood.
Photo released by Marin County, CA, Fire Department

Knapweed Responses To Interactions Among Drought, Biological Controls, and Plant Competition

Exotic species invasions and variations in climate patterns represent two of the greatest challenges to maintaining the ecosystem services provided by natural systems. These forces can have dramatic impacts on native systems independently, but they are also expected to interact in ways that are poorly understood. Currently, much speculation is made, but little empirical data exists regarding how weather patterns affect exotic species invasions.

In the early 2000s, Forest Service researchers documented regional declines in the aggressive range weed, spotted knapweed *(Centaurea stoebe),* that were thought to be correlated with regional drought. But, the declines could have been caused by a biocontrol agent called *Cyphocleonus achates* that was released in the 1980s to target spotted knapweed, or they could have been a combination of the two factors. To better understand these outcomes, Forest Service Research and Development, Forest Health Protection, and the Missoula Technology and Development Center evaluated the roles of the drought, biological control agent, and plant competition on knapweed decline.

After 3 years, the biocontrol agent and short-term drought each killed about 20 percent of adult knapweed plants. Together, they had the same impact—killing 20 percent together because the knapweed rapidly regenerated from the seed bank. The knapweed was able to recover from the individual mortality caused by the biocontrol agent and drought because overabundant young plants simply replaced dominant adults that died. When conditions were simulated to closely match those of the prolonged drought conditions observed in the early 2000s, preliminary results indicated that prolonged drought can strongly suppress knapweed populations, shifting communities back toward dominance by native grasses which are very drought resistant. These results suggest that some native plants might be better adapted to long-term drought stress than invaders like spotted knapweed, providing some of the first indications of how weather patterns might affect exotic plant invasions in this system.

Left: Microcosm experiment plots. An inter-deputy area team created 150 microcosm communities with electronically automated drought covers that could be used for long-term, multifactorial, community-level experiments. The microcosms allowed for the manipulation of precipitation inputs, biocontrol attacks, and plant competition to determine how these factors affect spotted knapweed invasion and its control.
Center: Testing automated drought covers.
Right: *Cyphocleonus achates* on spotted knapweed.
Photos by USDA Forest Service

Biological Control Efforts To Manage the Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA), *Adelges tsugae*, is a pest native to Asia and western North America. It was first discovered in eastern North America in 1951 near Richmond, VA, and molecular diagnostics has since pinpointed the origin of the infestation to southern Japan. In the late 1980s, HWA began to rapidly spread in hemlock forests from its point of introduction. It has since been detected in 18 Eastern States, threatening two species of hemlock-—the eastern hemlock, *Tsuga canadensis* (L.) Carr., and Carolina hemlock, *Tsuga caroliniana Engelm*. The insect has caused extensive mortality and decline of hemlock trees in the Eastern United States, particularly in the southern Appalachians. HWA is a serious threat to the survival of hemlocks throughout the region.

At the request of a broad range of stakeholders including the National Association of State Foresters, and the National Plant Board, the Forest Service (State and Private Forestry and Research and Development) prepared an HWA research and technology development needs assessment to address HWA and, particularly, the lack of management tools. In 2001, the Forest Health Protection program (State and Private Forestry) led development of an integrated pest management strategy implemented through the HWA Initiative. This Forest Health Protection-funded initiative is a broadscale, combined effort led by the Northeastern Area and the Southern Region to manage the adverse effects of HWA across its range in the Eastern United States. Early on in the HWA Initiative, forest health specialists and scientists recognized that focusing significant resources to develop a classical biological control program would provide the best chance for successful long-term management of HWA.

Of the nine species of hemlock worldwide, only eastern and Carolina hemlock evolved in the absence of an adelgid herbivore. Foreign exploration revealed that a number of adelgid specialist predators played an important role in regulating HWA populations in its native range. Several of these predators (there are no known parasites of adelgids) proved to be good candidates for establishment in the Eastern United States, including several coccinellid and derodontid beetles from China, Japan, and the Pacific Northwest. Although establishment efforts are still underway for most of the selected predators, a lady beetle from Japan, *Sasajiscymnus tsugae*, and the derodontid beetle *Laricobius nigrinus* from the Pacific Northwest are now confirmed established in a number of Eastern States. The establishment of *L. nigrinus* has been so successful in some areas that in the 8 years following its initial release, thousands of predatory beetles can now be collected in the field and redistributed annually to other infested areas.

Cottony masses on the underside hemlock branches are characteristic of the presence of hemlock woolly adelgid. These ovisacs contain mature hemlock woolly adelgid and eggs and are conspicuous from the late fall to early summer.
Photo by Mark McClure, Connecticut Agricultural Experiment Station (retired), http://www.bugwood.org

The beetle, *Laricobius nigrinus*, is a predator of hemlock woolly adelgid adults and eggs.
Photo by Ashley Lamb, Virginia Polytechnic Institute and State University, http://www.bugwood.org

Protecting High-Elevation White Pine Resources

Five-needle white pines are considered keystone species in fragile high-elevation ecosystems throughout western North America and protect soils from erosion, improve snow retention, and provide valuable habitat and food for wildlife species. Management in these white pine forests can be challenging because of poor access, steep terrain, and land management designations, such as wilderness and parks. White pines, including those at high elevation, face threats from bark beetles and white pine blister rust (*Cronartium ribicola*). Blister rust was introduced in the early 1900s on imported nursery stock and has since spread through much of the white pine ranges. The U.S. Fish and Wildlife Service has identified whitebark pine as warranting protection under the Endangered Species Act.

Since the 1950s, resistance screening has identified sources of resistance and genetic diversity in commercial white pine species. Recently, Forest Service scientists addressed questions about resistance in noncommercial, high-elevation species as well. Collaborations across all three deputy areas identified resistant individuals (called "plus trees") for further testing and have identified seed transfer zones to ensure that new plantings are adapted to local conditions. Forest Service scientists are developing and using genetically resistant populations for the long-term control of blister rust. Working together, these groups are collecting seed for gene conservation, as well as examining white pine population structure and the role of natural regeneration in stand recovery. The Forest Service's rust resistance program is one of the most developed/advanced conifer resistance programs in conifers for introduced pathogens.

Proactive management strategies are being tested that encourage regeneration in advance of the pathogens arrival so that a larger pool of genotypes is present (Schoettle and Sniezko 2007). Then natural selection will allow the survivors with more resistance to the rust pathogen to reproduce. In addition, preparation for early deployment of genetic resistance through plantings into threatened ecosystems is underway to sustain ecosystem health and function as blister rust continues to spread. Collaboration across Forest Service deputy areas and with cooperators/partners in other Federal and State agencies and tribes is essential to making progress in protecting, sustaining, and restoring key white pine ecosystems, including high-elevation ecosystems.

High-elevation western pines are threatened by invasive white pine blister rust, native bark beetles, and weather patterns.
Photo by Julie Kray, USDA Forest Service

White pine blister rust *(Cronartium ribicola)*.
Photo by Deems Burton, USDA Forest Service

Public-Private Partnership To Restore Westslope Cutthroat Trout to Cherry Creek, MT

Invasions of nonnative fish, such as brook, brown, and rainbow trout have relegated westslope cutthroat trout to a vestige of its historically occupied habitat in Montana's Missouri River basin and across much of its range. For example, habitat occupied by genetically pure westslope cutthroat has declined from 1,200 miles to approximately 5 miles of stream in the Madison River subbasin of the Missouri River. Restoring cutthroat trout populations requires removing nonnative trout, replacing them with genetically pure cutthroat populations, and preventing reinvasion.

Cherry Creek, with more than 70 miles of stream above a natural waterfall that provides a natural barrier to invasive trout, was identified as an important area for cutthroat restoration. After a decade of initial planning, a partnership between Montana Fish, Wildlife, and Parks; Turner Enterprise; and the Gallatin National Forest undertook 7 years of nonnative fish removal. Members of the partnership removed nonnative trout with piscicide application and installed temporary migration barriers to prevent reinvasion. They followed this activity with 5 years of westslope cutthroat introductions. After a decade of restoration efforts, Cherry Creek now contains the largest genetically pure population of this cutthroat trout subspecies in the upper Missouri River drainage area.

Although many restoration efforts focus solely on fish habitat, this effort illustrates the importance of restoring genetically pure fish populations. Forest Service scientists are supporting native trout restoration in Cherry Creek and other areas by assessing the effectiveness of restoration efforts, assessing and monitoring the extent of hybridization across the Interior Mountain West, and identifying areas for restoration that will be most resilient to changing weather patterns.

Cutthroat trout (*Oncorhynchus clarkii*) and brook trout *(Salvelinus fontinalis)*.
Photo by Michael K. Young, USDA Forest Service

The faces of success. The interagency 2007 Cherry Creek crew typifies the crews who walked many miles restoring the stream and the number of workers required annually for a successful treatment.
Photo by USDA Forest Service

APPENDIXES

Appendix A: Invasive Species Systems Approach (ISSA), ISSA Guiding Principles, and ISSA Roles and Responsibilities

The Invasive Species Systems Approach (ISSA) identifies the 4 elements and 18 actions of the *Forest Service National Strategic Framework for Invasive Species Management* (Framework) that all programs and units within the National Forest System (NFS), Research and Development (R&D), and State and Private Forestry (S&PF) should take, as appropriate, in addressing invasive species.

Prevention

- Identify, forecast, and prioritize invasive species threats (P1).
- Identify high-risk pathways of movement and introduction (P2).
- Identify vulnerable ecosystems (P3).
- Improve cooperative efforts (P4).
- Recommend, program, and implement appropriate actions to prevent introductions and establishment (P5).

Detection

- Survey aggressively to detect new invasive species and monitor priority species (D1).
- Evaluate the extent and severity of invasive species infestations and assess their potential impacts (D2).
- Report invasive species detection findings in standardized databases (D3).
- Develop tools and technologies to detect and monitor invasive species (D4).

Control and management

- Coordinate as needed with partners (CM1).
- Prioritize and implement treatments (CM2).
- Implement rapid response for new infestation (CM3).
- Monitor and report accomplishments in standardized databases (CM4).
- Develop the tools, technologies, methods, and budgetary processes necessary to prioritize and implement effective invasive species management or eradication activities (CM5).

Restoration and rehabilitation

- Identify and prioritize restoration and rehabilitation needs (RR1).
- Take actions to restore, monitor, and maintain affected areas (RR2).
- Assess effectiveness of rehabilitation and restoration activities (RR3).
- Develop, synthesize, and evaluate effective rehabilitation and restoration methods, tools, and technologies (RR4).

ISSA Guiding Principles

- Emphasize safety as a core value in all actions.
- Use a systems approach for invasive species management.
- Use standardized, science-based methodologies and strategies.
- Identify and address gaps in procedures necessary for an effective integrated invasive species management approach.
- Incorporate invasive species assessment results into ongoing monitoring efforts during all project and activity phases according to mutually agreed standards, protocols, and criteria.
- Ensure internal Forest Service communication and coordination.
- Collaborate and coordinate with external partners.
- Conduct outreach and public education.

ISSA Roles and Responsibilities

- The Washington Office National Invasive Species Issue Team (NFS, R&D, S&PF, and International Programs) will develop national policies and monitor and coordinate Regional Invasive Species Issue Team (RISIT) activities, including compiling a comprehensive report on ISSA results every 5 years and helping the regions and stations overcome barriers to success. National priorities will be reviewed every 5 years and adjusted as needed.
- Region, station, and the Northeastern Area offices will administer and support ongoing RISITs to coordinate management activities, research needs, and projects. Region, station, and the Northeastern Area offices will also coordinate with national forests within their region or station area, helping them develop effective strategies to include in forest plans.
- Region, station, and the Northeastern Area offices will provide the Washington Office with an up-to-date report on their ISSA progress every 5 years and summarize their progress across respective units and adjust their priorities. This includes prioritizing species and verifying accuracy of invasive species accomplishments.
- National forests will incorporate invasive species prevention, detection, and control, including rapid response activities and restoration considerations, in forest plans and will coordinate with their district and regional offices (at a minimum) to ensure standards are followed and to provide a report on their ISSA progress every 5 years.

Appendix B: Invasive Species Issue Teams

National Invasive Species Issue Team (ISIT)

The National Invasive Species Issue Team (NISIT) is composed of the three invasive species program coordinators from the three branches of the Forest Service (National Forest System, Research and Development, and State and Private Forestry). In addition to this core group, the members of the NISIT will include a multidisciplinary set of national-level staff representing a wide range of Forest Service programs. The NISIT performs the following functions:

- Coordinates across all Forest Service offices and programs to identify and evaluate nationally significant invasive species issues and problems affecting the mission of the Forest Service.
- Provides coordinated policy direction to Regional Invasive Species Issue Teams.
- Identifies and evaluates Forest Service capabilities and limitations to manage and research invasive species issues and problems.
- Develops strategic recommendations and solutions to address nationally significant invasive species issues and problems.
- Collaborates with external national organizations or agencies, as might be needed, to address invasive species issues and problems.
- Formulates and directs priority actions associated with Forest Service invasive species research and management activities, as directed by Forest Service leadership through the sponsoring NISIT deputy area directors.

Regional Invasive Species Issue Team (RISIT)

Regional Invasive Species Issue Teams (RISITs) ensure frequent information sharing, collaboration, and communication—necessary aspects in integrating invasive species management activities across program areas. The regional, Northeastern Area, and station directors collaboratively established RISITs to address invasive species issues affecting their regional area. RISITs are established in a manner consistent with Forest Service Manual 2900 and other applicable direction. RISIT members can include staff from multiple disciplines and program areas, such as Forest Health Protection, Invasive Species Management, Research and Development, Fisheries and Aquatic Ecology, Wildlife Ecology and Management, and Rangeland Management, as appropriate. Each RISIT is empowered to accomplish the following actions:

- Collaborate, coordinate, and communicate across all Forest Service offices and programs.
- Cooperate and partner with external local organizations or agencies, as needed.
- Identify and evaluate regional activities and capabilities to effectively address invasive species threats.
- Make recommendations to leadership on strategic approaches and integrated activities to address invasive species threats.

Appendix C: Glossary

adaptive management—Reviewing practices and adjusting them as needed to achieve the desired resource objectives while incorporating the best available science and information, including protocols and standards, regular monitoring, and a scientific peer review process.

biological control— Intentional actions to foster the reduction of pest populations by natural competitors, predators, or parasites, thereby providing a sustainable and highly selective solution to many widely spread infestations. Release of natural competitors might enhance control and reduce the rate of expansion of large existing infestations. While most often involving the use of insect agents, fungi, and other microbes, such as the bacterial insecticide *Bacillus thuringiensis var. kurstaki* (*Btk*) can also provide biological control.

control—Any activity or action taken to minimize, contain, limit the spread, or reduce the effects of an invasive species. Control activities are generally directed at established infestations and are not, in all cases, implemented to eradicate the targeted infestation.

detection—Discovery and identification of invasive species.

early detection and rapid response—A prompt and coordinated response to reduce invasive species' environmental and economic impacts and spread, which might result in a lower cost and less resource damage than implementing a long-term control program.

- **early detection**—The process of finding, identifying, and quantifying invasive species infestations prior to, or in the initial stages of, its establishment as a free-living and expanding population. Early detection of an invasive species is typically coupled with integrated activities to rapidly assess and respond with quick and immediate actions to eradicate, control, or contain it.
- **rapid response**—Immediate actions taken to eradicate, control, or contain infestations that must be completed within a relatively short time to maximize the biological and economic effectiveness against the targeted invasive species. Depending on the risk of the targeted invasive species, rapid response actions on National Forest Systems lands may be supported by an emergency situation determination. Emergency considerations would include the geographic extent of the infestation, distance from other known infestations, mobility and rate of spread of the invasive species, threat level and potential impacts, and available treatments.

early warning system—A comprehensive monitoring framework for timely detection and quick response to environmental threats to forest lands in the United States that is based on four key steps necessary to detect and respond to environmental threats: (1) identify potential threats, (2) detect actual threats, (3) assess impacts, and (4) respond (Forest Service 2004).

ecological integrity—An ecosystem that maintains through time its health, self-organizing complexity, and capacity for self-organization and sufficient diversity within its structures and functions.

ecosystem—A community of living organisms (plants, animals, and microbes) in conjunction with the nonliving components of their environment (i.e., air, water, and mineral soil), interacting as a system. These components are regarded as linked together through nutrient cycles and energy flows.

ecosystem services—"The conditions and processes through which natural ecosystems, and the species that make them, sustain and fulfill human life" (Daily 1997).

establishment—Initiation of a free-living, reproducing population of an invasive species.

infestation—An invasive species population within a specified area.

integrated pest management (IPM)—Sustainable approach to managing pests that combines biological, cultural, physical, and chemical tools in ways that minimize economic, health, and environmental risks.

introduction—The initial movement of a species to any location outside of its documented native geographical range.

invasive species—A nonnative species whose introduction is likely to cause or has the potential to cause economic or environmental harm to an ecosystem or harm to human health or commerce (Executive Order 13112).

management—Any activity that directly intervenes to minimize the spread and adverse effects of an invasive species, including preventing, controlling, containing, eradicating, surveying, detecting, identifying, inventorying, and monitoring invasive species; rehabilitating and restoring affected sites; and providing technical outreach and educational activities related to invasive species. Management actions in the National Forest System are based upon species-specific or site-specific plans (including forest plans, integrated pest

management plans, watershed restoration plans, and so forth), and support the accomplishment of plan goals and objectives and achieve successful restoration or protection of priority areas identified in the respective plan(s).

mechanical control—Physical removal of invasive species by hand-pulling small infestations before flowers have bloomed, tilling larger infestations for several years, removing infested trees, squashing insect pests, etc.

monitoring—Long-term observation and recording of information related to abundance, distribution, and treatment of invasive species infestations. Long-term monitoring of abundance and distribution provides information on infestation dynamics. By monitoring treatment results over time, a measure of overall programmatic treatment efficacy can be determined and an adaptive management process can be used in subsequent treatment activities. Evaluation of monitoring results helps measure performance and attainment of goals by linking past, present, and future action and results.

nonnative species—Any organism that is not native to the ecosystem being considered.

pathways—A route or means by which an invasive species enters a new ecosystem or environment.

pesticidal control—Using a chemical to eradicate or manage a pest. Pesticides are among the most commonly available, and effective tools. Pesticides include conventional chemicals and biopesticides, such as bacterial and microbial insecticides and pheromones.

prevention—Often, prevention is the most effective and least expensive response to threats associated with invasive species. Prevention includes prioritization, as well as a wide range of actions and management activities to reduce or eliminate the chance of an invasive species entering or becoming established in a U.S. forest, ecosystem, watershed, stream, or other area.

priority species—An invasive organism that has been targeted for management action and research based upon risk assessments, project objectives, economic, environmental, and social considerations, or other rank setting decision support tools.

prioritization—The act of ranking invasive species, activities, etc., according to importance or urgency.

rehabilitation and restoration— Following a disturbance, the active or passive management of an ecosystem or habitat to restore ecosystem structure and function and prevent re-invasion by improving site resilience and reducing or eliminating the conditions on a site that might facilitate or promote invasive species establishment.

resilience—Capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.

risk analysis—A three-stage process of threat identification, assessment, and management, which includes the identification of measures to reduce the threat to an acceptable level.

risk assessment—An estimation of the likelihood of an invasive species introduction and the potential consequences of its establishment and spread.

species characterization—Description of a species, including identification, life forms, life cycle, behavior, distribution, etc.

systems approach—The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection. This concept emphasizes the interdependence and interactive nature of invasive species to other environmental components of a landscape.

targeted species—An individual invasive species or population of invasive species, which has been prioritized for research or management action based upon environmental, economic, or human impacts, risk assessments, or other decision support tools.

tools—Any method, technique, technology application service, model system, science synthesis, database, evaluation or monitoring protocol, prototype, operational application, or decision-support system that is developed, maintained, or revised to address current and emerging invasive species issues.

Appendix D: References

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For more information, see the following Web sites.

http://www.fs.fed.us/research/invasive-species/

http://www.fs.fed.us/invasivespecies/

http://www.fs.fed.us/foresthealth/management/fhm-invasives.shtml