



**Research and Development National
Invasive Species Strategy**



COVER PHOTOS

Front cover top left: Beech bark disease (Nectria coccinea (Pers.) Fr.).

Credit: Mike Ostry, Forest Service

Front cover top right: Salt cedar/tamarisk (Tamarix ramosissima Ledeb.) flower.

Credit: Forest Service

Front cover bottom left: Salt cedar/tamarisk along snake river.

Credit: Forest Service

Front cover bottom right: Lady beetles feeding on Hemlock woolly adelgid (Adelges tsugae Annand).

Credit: Forest Service

Back cover top: Spotted knapweed (Centaurea stoebe ssp. micranthos (Gugler) Hayek).

Credit: Michael Shephard, Forest Service, <http://www.bugwood.org>

*Back cover bottom: American chestnut killed by chestnut blight (Cryphonectria parasitica (Murrill) M.E. Barr).
Picture taken in 1943.*

Credit: Forest Service—Northeastern Area Archive, Forest Service, <http://www.bugwood.org>

Inside front and back cover: Mediterranean pine engraver beetle (Orthotomicus erosus (Wollaston)).

Credit: William M. Ciesla, Forest Health Management International, <http://www.bugwood.org>

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Quagga mussels (New Zealand Mud Snail) (Dreissena bugensis Andrusov, 1897) at Lake Mead. Credit: Bryan Moore, National Park Service

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Executive Summary

Asian long-horned beetle (Anoplophora glabripennis (Motschulsky)). Credit: Larry R. Barber, Forest Service, <http://www.bugwood.org>

Vision: Science-based tools, techniques, and information are developed and transferred to stakeholders in a timely manner through enhanced and efficient public-private partnerships. Their adoption and use reduces the threat from invasive species and mitigates their impacts.

Mission: The Research and Development (R&D) Invasive Species Strategic Program Area (SPA) provides the scientific information, methods, and technology application services needed by regulators, managers, and the public to reduce, minimize, or eliminate the introduction, establishment, spread, and impact of invasive species.

CURRENT AND EMERGING ISSUES FOR INVASIVE SPECIES

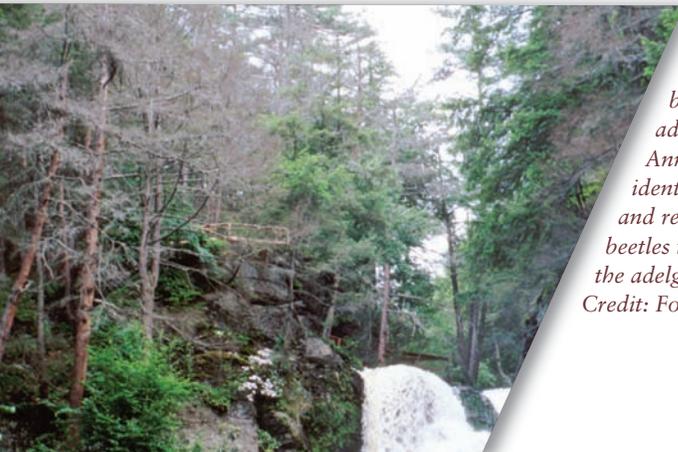
- Terrestrial and aquatic ecosystems in our Nation's forests and grasslands are threatened by invasive insects, pathogens, plants, wildlife, and fish.
- Accelerated global trade and transportation have increased invasive species movement across boundaries, causing harm to economies, environments, and human health.
- Increased human use of forests and rangelands leads to increased spread of invasive species through waterways, roadways, etc.
- Conflicts over invasive species prevention and treatment measures can lead to litigation on public lands and result in delayed or failed control efforts and increased associated costs.
- The Natural Resource Information System documents approximately 6 million National Forest System acres infested with invasive plants.
- About half the species currently on the endangered species list are at risk because of invasives.
- The ability to prevent and control infestations and to restore forest and rangeland health is compromised

by knowledge and technology gaps and complicated by unplanned reallocation of limited resources to address newly discovered aggressive invasives.

- Climate change, urbanization, and bioenergy production systems pose special challenges for invasive species management. Inventory and monitoring, conservation education, and international coordination are key tools that can help address these issues.

INVASIVE SPECIES RESEARCH EMPHASIS AREAS

- *Predict and prevent invasive species introductions* by understanding, identifying, and characterizing invasive species and pathways and by developing and providing tools for risk analysis, detection, monitoring, and interception for Federal and State agencies.
- *Detect, respond, and eradicate invasive species recently introduced* by developing and providing tools for detection, monitoring, enforcement, and eradication to Federal and State agencies so they can eliminate invasive species populations and prevent economic loss and ecological damage to the Nation's forests and rangelands. This includes developing



Hemlock at Dingman Falls, PA, were killed by hemlock woolly adelgid (Adelges tsugae Annand). Scientists have identified, evaluated, and released lady beetles to control the adelgid. Credit: Forest Service

Woolly adelgid. Credit: Forest Service



Lady beetle feeding on hemlock woolly adelgid. Credit: Forest Service

risk and cost/benefit analysis tools to determine when eradication efforts should be implemented or suspended.

- *Manage and mitigate established invasive species infestations* by developing, evaluating, and distributing management guidelines, tools, and alternatives, such as genetic protocols or resistant stocks. Assess long-term efficacy via direct and indirect effects on the ecosystem to minimize economic loss and ecological damage to the Nation's forests and rangelands. Develop risk and cost/benefit analysis tools to determine when control efforts should be implemented or suspended.
- *Restore and maintain ecosystems degraded by invasive species* by developing, evaluating, and distributing guidelines, tools, and solutions for rehabilitating and sustaining forest and rangeland ecosystems, preventing reinvasion, and regaining long-term multiple uses, including goods, services, and values.

OVERARCHING RESEARCH PRIORITIES

External peers reviewed the R&D Invasive Species SPA in October 2006. In response to this external peer review, the following overarching research priorities are being emphasized:

- *Elucidating invasive species' biology, ecology, interactions, and impacts* by studying genetic, ecological, and evolutionary relationships among priority invasive species and ecosystems where they occur and quantifying their ecological, social, and economic impacts.
- *Predicting and prioritizing invasive species* by developing methodology for predicting which species are likely to become invasive and developing science-based protocols to prioritize invasive species and help managers assess action thresholds.
- *Identifying and detecting invasive species* by improving invasive species detection and diagnostics technology and quantifying invasive patterns and processes across geographical and elevational gradients.
- *Managing invasive species and altered systems* by developing more effective treatments and control or management methods for high-priority species and predicting interactions between multiple invasives and multiple disturbances under varying climatic scenarios.



Saltcedar/Tamarix are considered highly invasive and among the most potentially detrimental exotic plants in the United States. Although largely associated with the arid southwest, tamarisk is becoming the dominant shrub along rivers and streams in the interior Pacific Northwest. Credit: Forest Service

SOME PLANNED MAJOR ACCOMPLISHMENTS FOR 2008 TO 2012

- Use native species seed mixes to rehabilitate grasslands after cheatgrass-fueled wildfires. Field-scale trials found that native species mixes seeded as effectively as traditional introduced species.
- Develop DNA-based techniques to detect and identify over 2,000 isolates related to invasive forest fungi, including root-disease pathogens (*Armillaria* spp. and *Fusarium* spp.), associates of wood decomposers, woody root endophytes, potential biological control agents, and historical herbarium specimens of forest pathogens.
- Evaluate and develop new attractants and trapping techniques for emerald ash borer.
- Field test new strains of Gypchek exhibiting five-fold greater potency than the current Gypchek product.
- Develop nanocarrier delivery systems for organic biocides to protect wood and wood products from Formosan subterranean termites and nanobiocides to prevent their spread.
- Convert juniper bark to biodegradable polyurethane foams for use in controlled-release antifouling coatings against zebra mussels and related marine invasive species.
- Establish regional seed orchards of American beech trees with resistance to beech bark disease.
- Generate novel ash hybrids with resistance to emerald ash borer.

Introduction

Redbay ambrosia beetle damage. Credit: Michael Thomas, Florida Department of Agriculture and Consumer Services, <http://bugwood.org>



*Rebay mortality caused by laurel wilt, a disease transmitted by the invasive redbay ambrosia beetle (*Xyleborus glabratus*) and caused by its associated fungus (*Raffaelea lauricola* Harrington and Fraedrich). The percentage of dead redbays in this section of forest increased from 10 to 81 percent in the course of 1 year. The disease also threatens avocado and other native trees.*

Credit: Albert (Bud) Mayfield, Florida Department of Agriculture and Consumer Services, <http://www.bugwood.org>

The Research and Development (R&D) Deputy Area of the Forest Service, U.S. Department of Agriculture (USDA) has developed this document to address threats to the Nation's forests and grasslands from invasive insects, pathogens, plants, wildlife, and fish.

This R&D National Invasive Species Strategy outlines how R&D will provide—over the next 10 to 15 years—the tools needed to prevent, detect, and control invasive species and to restore, rehabilitate, and manage ecosystems to continue to provide needed goods, services, and values. This national strategy has a direct link through the USDA strategy to the 2008 National Invasive Species Management Plan released by the interdepartmental National Invasive Species Council. The Forest Service R&D strategy identifies national invasive species research priorities and performance expectations. The strategy describes how R&D coordinates activities within research, with other deputy areas, and with other agencies.

CURRENT AND EMERGING SCIENCE AND SOCIAL ISSUES

Invasive species have become one of the most significant environmental and economic threats facing the Nation's natural resources. Accelerated global trade and transportation have increased the movement of invasive species across continental boundaries, causing economic and environmental damage and harm to human health. Increased human populations living in, accessing, and using forests and rangelands has led to an increased risk of the spread of invasive species through waterways, roadways, etc., and increased conflicts over invasive species management strategies, owing to different social and economic

values. These conflicts over prevention and treatment measures can lead to litigation on public lands and result in delayed or failed control efforts and increased associated costs. An example of a conflict is when members of the public disagree about whether an invasive is a problem that should be removed or an aesthetic or recreational enhancement of the native habitat.

Invasive species concerns have reached global proportions. Within the United States, there have been significant Federal and State responses to address the issue. The Forest Service has recognized the dangers posed by invasive species to ecosystem health and the economy. The Forest Service has also identified invasive species as one of the most significant issues affecting National Forest System lands (forest, rangelands, and waterways), as well as neighboring private, State, and tribal lands across all ecosystems. Invasive species cost the public more than \$138 billion per year in damage, loss, and control costs. The Natural Resource Information System estimates that approximately 6 million National Forest System acres are infested with invasive plants. Expanding numbers and ranges of invasive species have an increasingly negative impact on products and the recreational and aesthetic value of forest and range ecosystems. About half the species currently on the endangered species list are at risk because of competition and loss of habitat traceable to invasive species. Some endangered species, however, have adapted to the presence of invasive species, and removal of the invasive may create a conflict with management of the threatened and endangered species.

Severe gaps in our current science and technological capacity threaten the Nation's ability to prevent and

control infestations and to restore forest and rangeland health. Unplanned reallocation of limited resources to address newly discovered invasives without risk/benefit analyses compromises the ability to appropriately identify and address invasive species research priorities.

For this strategy, invasive species are defined (per Executive Order 13112) as species nonnative to the ecosystem under consideration, and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. This includes species native to North America that are spreading outside their normal range owing to changes in climate or to human introductions.

BACKGROUND

In 2004, the Forest Service developed a National Strategy and Implementation Plan for Invasive Species Management to address the invasive species problem. This strategy and implementation plan identifies the following invasive species goal for the agency:

Reduce, minimize, or eliminate the potential for introduction, establishment, spread, and impact of invasive species across all landscapes and ownerships.

The strategy and implementation plan is divided into four program elements/activities: Prevention, Detection and Rapid Response, Control and Management, and Rehabilitation and Restoration. The plan identifies proactive prevention, rapid response, and partnerships as keys to agency success in addressing invasive species issues.

The strategy and implementation plan also clarifies the role of the R&D Deputy Area in addressing invasive species issues. Invasive species research will provide the information, knowledge, and tools needed to reduce, minimize, or eliminate the introduction, establishment, spread, and impact of selected priority invasive species and to develop integrated pest-management systems. To accomplish this, the strategy recognizes that invasive species research must have the resources and flexibility to address today's issues effectively and the foresight to predict tomorrow's needs. The R&D staffs also must be effective communicators—transforming scientific discovery into usable knowledge.

*Sudden Oak Death zone lines on coast live oak.
Credit: Joseph O'Brien,
Forest Service,
<http://www.bugwood.org>*



*Coast live oaks and tanoaks killed by sudden oak death (Phytophthora ramorum).
Credit: Joseph O'Brien, Forest Service,
<http://www.bugwood.org>*



Invasive Species Research Program Mission

Chinese privet (Ligustrum sinense Lour). Credit: Chris Evans, River to River CWMA, <http://www.bugwood.org>

Vision: Science-based tools, techniques, and information are developed and transferred to stakeholders in a timely manner through enhanced and efficient public-private partnerships. Their adoption and use reduces the threat from invasive species and mitigates their impacts.

Mission: The R&D Invasive Species SPA provides the scientific information, methods, and technology application services needed by regulators, managers, and the public to reduce, minimize, or eliminate the introduction, establishment, spread, and impact of invasive species.

Where technology or knowledge gaps occur, R&D serves a vital role in developing new techniques and providing up-to-date information needed to develop integrated pest-management systems, to inform policy decisions, and to implement regulatory and management goals. Enhanced collaborative partnerships with universities, States, other agencies, and the private sector reduce costs, enhance effectiveness, and form the foundation of the invasive species science and technology development programs.

GOAL

Develop and deliver to customers, in a timely manner, the knowledge and tools needed to reduce, minimize, or eliminate the potential for introduction, establishment, spread, and impact of priority invasive species across all landscapes and ownerships.

RESEARCH ACTIVITIES

Invasive species research provides the knowledge and tools for use across all landscapes and ownerships to reduce, minimize, or eliminate invasive species. This research focuses on four activities directly related to the goals, objectives, and priorities identified in the Forest Service's 2004 National Strategy and Implementation Plan for Invasive Species Management. These activities are:

- Predict and prevent
- Detect, respond, and eradicate
- Manage and mitigate
- Provide long-term rehabilitation/restoration and maintenance of ecosystems degraded by invasive species

Activity 1: Predict and Prevent Invasive Species Introductions (Risk Assessments and Risk Management)

Objective: Develop and provide the scientific information, tools, and application services needed by Federal and State agencies for risk analysis, prevention, detection, monitoring, and interception so they can eliminate the potential for the introduction of invasive species.

Kudzu (Pueraria montana var. lobata (Willd.) Maesen & S. Almeida) kills trees by shading them and spreads inexorably, mostly through soil movement and vegetative growth.

Credit: Kerry Britton, Forest Service, <http://www.bugwood.org>

This is the most cost-effective approach to dealing with invasive species. Elements of predicting and preventing include:

- Identify and characterize species of concern.
- Identify and characterize pathways and potential mitigation tools.
- Develop or evaluate risk analysis tools and methodologies.
- Develop or evaluate tools for detection, monitoring, and interception of invasives.
- Understand how a particular species becomes invasive and how we can use this information to prevent this threat.

Activity 2: *Detect, Respond, and Eradicate Invasive Species Recently Introduced*

Objective: To develop and provide the scientific information, tools, and technology application services for detection, monitoring, enforcement, and eradication of invasive species to Federal and State agencies so they can eliminate invasive species populations and prevent economic loss and ecological damage to the Nation's forests and rangelands.

Quick eradication of recent infestations is much more effective and less expensive than dealing with a widely established invasive species. Elements of detection, response, and eradication include:

- Develop or evaluate tools for detection, monitoring, and interception of invasives.
- Develop or evaluate eradication treatment guidelines, tools, or solutions.
- Develop risk and cost/benefit analysis tools to determine when eradication efforts should be implemented or suspended.

Activity 3: *Manage and Mitigate Established Invasive Species Infestations*

Objective: Provide scientific information, methods, and technology application services to Federal and State agencies and private landowners so they can reduce the extent and/or spread of established invasive species, minimizing economic loss and ecological damage to the Nation's forests and rangelands.

OVERARCHING RESEARCH PRIORITIES

A recent peer review recommended increased funding for two areas: prevention and prediction and early detection and rapid response. Quantitative risk analysis and pathway assessments will be key components of the research program. The R&D future strategy also recognizes the importance of maintaining research in two other areas: control and management and restoration and rehabilitation. A holistic national strategy will improve sharing of expertise across research stations and encourage actions that prevent regional threats from expanding into national ones. Increased coordination with other agencies will help identify regulatory and research gaps and improve the complementary use of resources.

In response to the external peer review, the R&D National Invasive Species Strategy will emphasize the following overarching research priorities:

Quantify Invasive Species' Biology, Ecology, Interactions, and Impacts

- Quantify genetic, ecological, and evolutionary relationships among priority invasive species and ecosystems where they occur.
- Quantify ecological, social, and economic impacts of invasive species.

Predicting and Prioritizing Invasive Species

- Develop methodology for predicting which species are likely to become invasive.
- Develop science-based protocols to prioritize invasive species to help managers assess action thresholds.

Identifying and Detecting Invasive Species

- Improve invasive species detection and diagnostics technology.
- Quantify invasive patterns and processes across geographical and elevational gradients.

Managing Invasive Species and Altered Systems

- Develop more effective treatments and control or management methods for high-priority species.
- Predict interactions between multiple invasives and multiple disturbances under varying climatic scenarios.

The anticipated products, outcomes, and skills needed to address these priorities are discussed in the paper "USDA Forest Service Research and Development Invasive Species Overarching Research Priorities."



*Forest Service scientists are developing techniques for detecting and monitoring invasive bark beetles using traps baited with attractants. These traps are used around ports to detect newly arrived beetles.
Credit: Forest Service*

Several established invasive species are causing great ecological and economic damage to the Nation's forest and grasslands. Providing controls for these species results in a good return on investment in spite of the expense of developing them. Elements of management and mitigation activities include:

- Develop or evaluate management and mitigation treatment guidelines, tools, or solutions (includes genetics protocols or resistant stocks).
- Assess management and mitigation tools for long-term efficacy and secondary effects.
- Assess direct and indirect effects of invasive species on the ecosystem.
- Assess direct and indirect effects of control of invasive species on the ecosystem.
- Develop risk and cost/benefit analysis systems to help determine when managing a changed system is a reasonable option.
- Develop risk and cost/benefit analysis tools to determine when control efforts should be implemented or suspended.
- Develop tools for prioritizing control activities.

More than 100 scientists at *Research and Development's* five research stations, the International Institute of Tropical Forestry, and the Forestry Products Laboratory are conducting research on invasive plants, insects, pathogens, terrestrial animals, and aquatic species. The research stations are Northern Research Station, Pacific Northwest Research Station, Pacific Southwest Research Station, Rocky Mountain Research Station, and Southern Research Station.

Chartered by the Ecosystem Sustainability Corporate Team in 1998, the Invasive Species Issues Team (ISIT) is a cross-deputy team with representatives from Research and Development, State and Private Forestry, National Forest System, and International Forestry. The team provides a forum for developing corporate agency policies and strategies, sharing information, and coordinating priority setting, briefing papers, and presentations for the Department and agency.

Regional Invasive Species Issue Teams are multidisciplinary invasive species management coordination teams established in each region/ station with representatives of management and research to implement the Forest Service National Strategy and Implementation Plan.

The National Invasive Species Council (NISC) is an interdepartmental council that helps to coordinate and ensure complementary, cost-efficient, and effective Federal activities regarding invasive species. Established February 3, 1999, by Executive Order 13112, NISC members include three co-chairs—the Secretaries of Agriculture, Commerce, and the Interior—and the Secretaries of State, Defense, Homeland Security, Treasury, Transportation, and Health and Human Services, as well as the Administrators of the U.S. Environmental Protection Agency, the U.S. Agency for International Development, the Office of the U.S. Trade Representative, and the National Aeronautics and Space Administration.

The Federal Invasive Species Advisory Committee (ISAC) was created by Executive Order 13112 to provide information and advice for consideration by NISC. The ISAC is composed of approximately 30 stakeholders from State organizations, industry, conservation groups, scientists, academia, and other interests.

Activity 4: Restore, Rehabilitate, and Maintain Ecosystems Degraded by Invasive Species

Objective: Develop, evaluate, and distribute scientific information, guidelines, tools, technology application services, and solutions to Federal and State agencies and private landowners for restoring, rehabilitating, and sustaining forest and rangeland ecosystems by preventing reinvasion and regaining long-term multiple uses and values.

When controlling an established invasive species, if rehabilitation is not planned, the controlled invasive species will reinvade, or another invasive species will occupy the opening. Rehabilitation with native species is a vital step in an invasive species control program. Elements of long-term restoration, rehabilitation, and maintenance of ecosystem research include:

- Develop or evaluate ecosystem analysis tools for describing successful restoration.
- Develop guidelines, tools, or solutions for restoring and sustaining the ecosystem (includes genetic protocols or resistant stocks, etc.).
- Assess the direct and indirect effects of invasives on the ecosystem.
- Assess the direct and indirect effects of rehabilitation and maintenance activities on the invasive species and ecosystem.

Prioritization: The Invasive Species SPA team will meet annually with the Forest Service's National Invasive

Species Issue Team (ISIT) to select priority species and ecosystems needing research, to identify key knowledge and tools needed by landowners and managers, and to identify national priorities. Input solicited from customers and partners in the National Invasive Species Council and the Federal Invasive Species Advisory Council will inform this process. A similar process will be used to identify regional priority species and research foci. The Forest Service research stations, the International Institute of Tropical Forestry, and the Forest Products Laboratory will work with the Forest Service's regional ISITs to identify regional priorities in invasive species strategic plans/charters and business plans. Input from non-Forest Service regional customers and partners is always welcomed.

Cheatgrass
(*Bromus tectorum L.*).
Credit: Chris Evans,
River to River CWMA,
<http://www.bugwood.org>



Sulfur cinquefoil.
Credit: Ken Chamberlain,
The Ohio State University,
<http://www.bugwood.org>

Forest Service scientists are evaluating the effect of fire on the introduction of invasive plants. The scientists are examining the type and extent of invasive weed growth on burned areas in Montana.
Credit: Forest Service



Performance Measures

Russian knapweed (Acroptilon repens (L.) DC.). Credit: Dave Dewey, Utah State University, <http://bugwood.org>

The following performance measures are used for the invasive species SPA:

Outcome Measure: Score of R&D customers reporting satisfaction with accessibility, relevance, outcome, and cost-effectiveness of tools developed, delivered, and used.

Explanation: R&D seeks to provide quality products and services as assessed through evaluations from their customers. Customer satisfaction is assessed every 3 years.

Year	Target	Actual
2006	72 Baseline	72
2009	74	75
2012	76	NA

Output Measure: R&D tools developed, delivered, and used.

Explanation: One critical role of research is to translate scientific developments into useful tools to resolve management problems. A tool—in this context—is defined as any method, technique, technology application service, model system, science synthesis, database, evaluation or monitoring protocol, prototype, operational application, and decision-support system that is developed, maintained, or revised to address current and emerging invasive species issues. This measure is a 5-year running average, beginning with numbers reported for 2007.

Year	Target	Actual
2003	106 Baseline	106
2004	106	135
2005	106	157
2006	133	170
2007	142	170
2008	152	180
2009	155	177
2010	163	NA
2011	179	NA
2012	NA	NA



*Researchers are evaluating herbicides for control of sulfur cinquefoil, an invasive weed in the Pacific Northwest.
Credit: Forest Service*



Western mosquitofish Gambusia affinis (Baird & Girard, 1853). Credit: Duane Raver, U.S. Fish and Wildlife Service, <http://bugwood.org>

The Office of Management and Budget and USDA are requiring that all parts of the Forest Service, including R&D, explicitly consider performance in their budget formulation and allocation decisions.

A budget decisionmaking process will be developed based on the R&D investment criteria: relevance, quality, and performance. This process will use the peer review process scores and other performance indicators to make invasive species budget and other program management decisions.

Performance-Based Budgeting

Partners, Collaborators, Users, and Customers

Mediterranean pine engraver beetle (Orthotomicus erosus (Wollaston)) brood gallery.
Credit: Francis Maugard, Département de la Santé des Forêts, <http://bugwood.org>

INTERNAL PARTNERS

Forest Service internal partners include State and Private Forestry, especially Forest Health Protection; National Forest System, including Technology Development Centers; International Programs; Threat Assessment Centers; other R&D units; and Forest Service quarantine and international facilities.

EXTERNAL PARTNERS

External partners include other Federal agencies, such as USDA Animal and Plant Health Inspection Service, Agricultural Research Service, Economic Research Service, and National Institute of Food and Agriculture; U.S. Department of the Interior, including U.S. Geological Survey; and U.S. Department of Defense. External partners also include public and private landowners, State Departments of Agriculture and Natural Resources, universities, private R&D organizations, nongovernmental organizations, local and tribal governments, private industry, and international governments and organizations.

Alignment With Other Interagency and Other Agency Initiatives

Sulfur cinquefoil (Potentilla recta L.). Credit: Richard Old, XID Services, Inc., <http://bugwood.org>

2008 National Invasive Species Management Plan Goals

- *Goal 1:* Prevention
- *Goal 2:* Early detection and rapid response
- *Goal 3:* Control and management
- *Goal 4:* Restoration
- *Goal 5:* Organizational collaboration

2004 Forest Service Invasive Species Strategy and Implementation Plan Elements

- *Element 1:* Prevention
- *Element 2:* Early detection and rapid response
- *Element 3:* Control and management
- *Element 4:* Rehabilitation and restoration

USDA Forest Service Strategic Plan, FY 2007–2012 Goals and 2008–2012 R&D Strategic Plan Goals

- *Goal 1:* Restore, sustain, and enhance the Nation's forests and grasslands
- *Goal 2:* Provide and sustain benefits to the American people
- *Goal 3:* Conserve open space
- *Goal 4:* Sustain and enhance outdoor recreation opportunities
- *Goal 5:* Maintain basic management capabilities of the Forest Service
- *Goal 6:* Engage urban America with Forest Service programs
- *Goal 7:* Provide science-based applications and tools for sustainable natural resources management

USDA Forest Service R&D Growth Platforms: Climate change, biomass and bioenergy, urban natural resources stewardship, water and air management, and restoration.

USDA Forest Service R&D Foundation Elements: Forest Inventory and Analysis, Experimental Forests and Rangelands, and Urban Long-Term Research Areas.

Strategic Program Area Intersects/Overlaps

White pine blister rust damage (Cronartium ribicola J. C. Fisch.). Credit: Ogden Archive, Forest Service, <http://www.bugwood.org>

The following SPAs intersect/overlap with the Invasive Species SPA:

- **Fire prevention:** Management and restoration activities for wildland fire and fuel treatments and for invasive species affect each other.
- **Recreation:** Human health issues and recreation management activities and invasive species management and restoration activities affect each other. Conservation education and interpretive services programs are mechanisms for transferring invasive species knowledge to recreationists.
- **Wildlife and fish:** Management and restoration activities for wildlife and fish and for invasive species impact each other. Some wildlife and fish are invasive.
- **Resource management and use:** Human mobility and activity affect invasive species introduction, distribution, abundance, and management. The presence of invasive species can alter community economic and social health, ecosystem function, and product/output options. Their presence may also require new management strategies and systems. This includes the ability of land to provide goods and services and potential management systems shifts and options.
- **Water and air:** Invasive species can adversely affect ecosystem health.
- **Resource data and analysis:** The Forest Inventory and Analysis and Forest Health Monitoring programs survey and monitor for the presence and abundance of select invasive species.



White pine blister rust (Cronartium ribicola J.C. Fisch.) Uredia stage on alternate host Ribes. Credit: Robert L. Anderson, Forest Service, <http://www.bugwood.org>



White pine blister rust aecia. Credit: Forest Service



Crosscutting Issues for Invasive Species

Asian long-horned beetle larvae (*Anoplophora glabripennis* (Motschulsky)). Credit: Michael Boone, <http://www.bugwood.org>

- **Climate change and variability:** Invasive species interact with climate change and variability to affect ecosystem health, fire conditions, wildlife habitat, water quality and yield, and other ecosystem functions. Climate change also influences the range and distribution of native species with some potential for species becoming invasive and moving into other ecosystems. Research on this topic will improve our ability to predict and manage insect and disease outbreaks, manage fire risk through earlier prediction of severe wildfire conditions, and improve our understanding of the complex interactions among landscape change, climate change, and water and air quality. A better understanding of invasive and native species responses to climate change and extreme events is critical to being able to continue to manage a changing landscape to deliver needed goods and services.
- **Ecosystem health:** Invasive species interact with disturbances to alter forest and range health, wildlife habitat, water quality and quantity, and other ecosystem characteristics. Management and rehabilitation activities across these sectors can conflict with each other and, in some cases, can increase the problem (e.g., restocking with invasive wildlife or fish and road construction as a conduit for invasive plants).
- **Conservation education:** Education and interpretive programs can provide information for use by managers, recreationists, and other public parties about invasive species and their management.
- **Urbanization:** Resource use affects invasive species distribution, abundance, and management and can affect community economic and social health. Invasive species can move from developed areas to forest and rangeland ecosystems or from forest and rangeland ecosystems to developed areas.
- **International dimensions:** Invasive species research requires global cooperation and coordination on measures to prevent, reduce, and/or mitigate to prevent entry or export.
- **Sustainable forest bioenergy production systems:** Development of bioenergy systems can introduce invasive biofuel species into forest ecosystems, and biofuel forest species can serve as hosts for nonnative invasive species. New varieties of perennial woody bioenergy crops are resistant to invasive insects and diseases, fast growing, and nutrient and water efficient.



Emerald ash borer larvae.
Credit: David Cappaert, Michigan State University, <http://www.bugwood.org>

- Describing and communicating a national invasive species program that is developed and managed regionally.
- Marketing the invasive species program so that research's contribution to management of invasive species is maximized.
- Emphasizing impacts of urbanization and other human activities on invasive species prevention, detection, and spread.
- Maintaining program vitality under shrinking budgets and conflicting priorities.

Challenges and Influences



Adult emerald ash borer (*Agrilus planipennis* Fairmaire).
Credit: David Cappaert, Michigan State University, <http://www.bugwood.org>

Invasive bullfrog (Rana catesbeiana Shaw, 1802) from the east coast. Credit: Marcia Erlich

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Forest and Rangeland Renewable Resources Research Act of 1978

This act is the USDA's primary authority to conduct research activities, including research about invasive species that relate to vegetation management and protection; wildlife, fish, water, and air sciences; resource valuation and use; and inventory and monitoring. The act contains expansive authority to conduct research and technology development on, and with applications for, all U.S. lands related to the protection, conservation, and sustainable use of natural resources. The act also authorizes competitive grants to conduct research and authorizes cooperative agreements with university, industry, and other partners, as needed, to complement national program needs.

International Forestry Cooperation Act of 1990

Under section 602(b) of the International Forestry Cooperation Act of 1990 (16 U.S.C. 4501(b)), the Secretary [of Agriculture] may, in support of forestry and related natural resource activities outside the United States and its territories and possessions, provide assistance for the prevention and control of insects, diseases, and other damaging agents.

Invasive Species Executive Order 13112 of February 3, 1999

Directs Federal agencies to use relevant programs and authorities to:

- a. Prevent the introduction of invasive species.
- b. Detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner.
- c. Monitor invasive species populations accurately and reliably.
- d. Provide for restoration of native species and habitat conditions in ecosystems that have been invaded.
- e. Conduct research on invasive species and develop technologies to prevent introduction and provide for

environmentally sound control of invasive species.

- f. Promote public education on invasive species and the means to address them.
- g. Not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species, and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.

The Executive Order 13112 further requires Federal agencies to work in consultation with the National Invasive Species Council, consistent with the National Invasive Species Management Plan, and in cooperation with stakeholders, as appropriate, and, as approved by the U.S. Department of State, with international organizations and foreign nations.

GLOSSARY

Characterized: Species for which knowledge on host and geographical range, biology, spread, damage potential, etc., is documented.

Infestation: An area where a population of invasive species exists.

Interception: An invasive species detected at the point of arrival.

Integrated pest management (IPM): A process that determines the economic or environmental threshold for pest populations and prescribes the management techniques to reach desired conditions. IPM includes four broad

categories: biological, cultural, mechanical, and chemical techniques.

Introduction: The occurrence of an invasive species in an area where it was not previously established.

Invasive species: A nonnative species that is likely to cause or has the potential to cause economic or environmental harm to the ecosystem under consideration or harm to human health.

Nonnative species: Any species that is not native to the ecosystem in question.

Pathways: The means by which an invasive species enters a new ecosystem.

Priority species: The invasive species that pose the highest consequences of impact as a result of a risk assessment.

Reclamation: Restabilization of land denuded by land management activities.

Rehabilitation and restoration: Active or passive management of an ecosystem or habitat following disturbance, or management action to minimize subsequent effects.

Risk analysis: The process of collecting data and estimating the potential for and consequences of introduction, establishment, and spread of invasive species.

Risk assessment: A published document detailing the likelihood of an invasive species introduction and the potential consequences of its establishment and spread.

Targeted species: An invasive species identified for some specified research and development action.

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

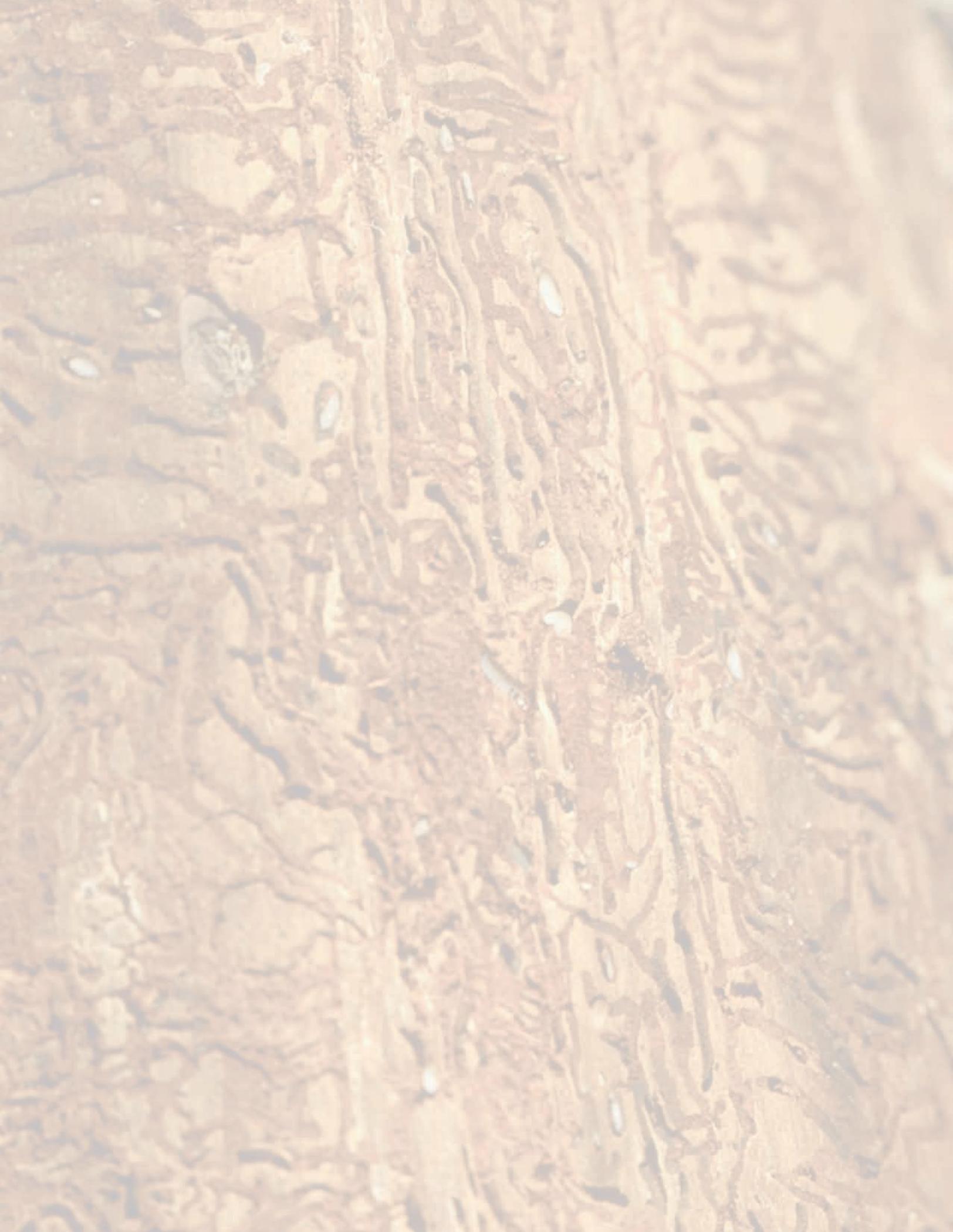
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