

**THE NATIONAL STRATEGY
FOR MANAGEMENT OF INVASIVE SPECIES**

NATIONAL WILDLIFE REFUGE SYSTEM

Fulfilling the Promise
National Invasive Species Management Strategy Team
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Executive Summary

This document sets forth a comprehensive strategy for dealing with the critical problem of invasive species in the United States. Developed within the context of the *National Invasive Species Management Plan* (as called for by *Presidential Executive Order 13112*), and with the support of regional chiefs and representatives of the *Fulfilling the Promise* team, this National Strategy will provide clear guidance to regional and field offices as they conduct invasive species management efforts. It will also make us better neighbors to our external partners at the local, state, and federal level.

The National Strategy provides specific action items to achieve the following four invasive species management goals: 1. Increase awareness; 2. Reduce the impacts to refuge habitats; 3. Reduce impacts to neighboring lands; and 4. Use and develop new integrated pest management approaches. This document consists of two interrelated parts: Current Status and Tools and Recommendations.

Part I: Current Status

This section reviews current invasive species management practices in the Refuge System. It identifies deficiencies, chiefly limited staff, infrastructure, and support. It then recommends that dedicated staff positions be increased at all levels, that information technology processes be updated and implemented across the Refuge System, and that support be increased at both the regional and national levels. Additional staff in the field would support early detection/rapid response, prevention and control, and sustained management activities; additional regional and national staff would improve internal communication and coordination, raise awareness, provide technical support, and strengthen the financial base.

Part II: Tools and Recommendations

This section presents plans and processes to achieve the goal of long-term, sustained management of invasive species. It provides guidance on assessment, monitoring, and standard operating procedures (SOPs). It also includes specific information on employing integrated approaches to control, such as prevention, early detection/rapid response, mechanical removal, as well as cultural (e.g., restoration), physical (e.g., prescribed burning), biological, and chemical techniques. Additionally, it presents a suite of SOPs directed at such topics as habitat management, recreation, land acquisition, and the design and operation of facilities, roads, and waterways. This section emphasizes ways to integrate invasive species management with refuge planning activities, especially comprehensive conservation planning. It also recommends survey, mapping, and inventory protocols, as well as procedures for monitoring and evaluation.

Part I: Current Status

The Invasive Species Threat to the National Wildlife Refuge System: Background and Scope

Invasive species are widespread and extremely damaging to native ecosystems.

An Invasive species is defined by the Executive Order as a species that is 1) non-native (alien or exotic) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species are, collectively, the single greatest threat to native plants, fish, and wildlife with the potential to degrade entire ecosystems. Based on national interagency estimates, more than six million acres of the Refuge System are infested with exotic plants. Nearly 50% of all refuges report that such infestations interfere significantly with their wildlife management objectives. Aquatic invasive species are particularly damaging to refuge habitat management efforts since most refuges have significant wetland components.

Examples of invasive species

Some important examples of plant invaders include salt cedar, leafy spurge, perennial pepperweed, exotic thistles, cogon grass, Brazilian pepper, purple loosestrife, Australian pine, Chinese tallow tree, Old World climbing fern, and melaleuca. Animal invaders are also a problem throughout the Refuge System. Examples include the brown tree snake, tilapia, Norway rat, Asian carp, nutria, Asian swamp eel, feral goat, and wild pig.

Pathogens, parasites, and diseases may themselves be invasive or may be introduced by invasive species. The recently introduced West Nile virus, which is transmitted to humans by mosquitoes that feed on the blood of infected animals, now threatens people and animals, including wildlife.

The cost of dealing with this problem is staggering and increases each year.

In 1998, combined invasive plant and animal control cost the Refuge System 94 full-time employees/equivalents (FTEs) and an estimated \$12.7 million. And these efforts addressed only a small fraction of the invasive species problem. Like an out-of-control wildfire, the cost of fighting invasive species increases each year. Among those who work with invasive species, the consensus is that for every year control is delayed, the costs of control increase two- to three-fold.

A review of Refuge Operations Needs System (RONS) projects shows the rapidly increasing challenge presented by invasive species. In February 2000, refuges identified approximately \$44 million in invasive species management projects. By July 2000 those problems grew to almost \$120 million. One year later the database identified nearly \$150 million in invasive species projects, the fastest growing component of RONS.

The invasive species problem has assumed top priority for refuge staff.

Refuge staff members find that much of their biological and habitat management efforts are spent on battling exotic species, not enhancing the quality of native wildlife habitats. Refuge staff have limited ability to conduct preventive measures because their attention is focused on controlling established and expanding infestations. A recent test run of the new Refuge System Threats and Conflicts Database indicated that invasive species problems ranked highest of all threats or conflicts affecting the Refuge System, scoring almost double that of the next highest threat ranked by refuge managers.

Mission, Goals, and Objectives of the Refuge System Invasive Species Program

Mission

Through partnerships, prevent, eliminate, or significantly reduce populations of aquatic and terrestrial invasive species throughout the Refuge System in order to protect, restore, and enhance native fish and wildlife species and associated healthy ecosystems.

Four goals have been adopted for the development of the National Strategy and are given here, along with specific objectives.

Goal 1: Increase the awareness of the invasive species issue internally and externally.

Objectives:

- §Initiate or expand invasive species training for Service personnel.
- §Develop and distribute public outreach and education materials.
- §Conduct and/or participate in invasive species public education programs.
- §Increase networking and information exchange throughout the Refuge System and with external partners.
- §Increase congressional outreach activities and programs.

Goal 2: Reduce impacts of invasive species to allow the Refuge System to more effectively meet its fish and wildlife conservation mission and purpose.

Objectives:

- §Emphasize and increase invasive species prevention efforts throughout the Refuge System.
- §Initiate an early detection and rapid response program in the Refuge System.
- §Implement more effective control and eradication measures

for all invasive species.

§Integrate restoration and rehabilitation efforts into control programs.

§Incorporate invasive species management recommendations into planning efforts at all levels.

Goal 3: Reduce impacts of invasive species on Refuge System neighbors and communities.

Objectives:

§Expand outreach programs to include discussion of invasive species threats and issues.

§Work closely with external stakeholders to accomplish landscape- or ecosystem-based invasive species management efforts.

§Increase cooperation with neighboring landowners and coordinate with local and state agencies on invasive species management efforts.

§Promote and expand invasive species assistance program efforts, such as grant programs or other partnerships.

Goal 4: Promote and support the development and use of safe and effective integrated management techniques to combat invasive species.

Objectives:

§Complete the Refuge System Invasive Species and Pest Management Policy.

§Provide training and guidance to implement the integrated pest management approach.

§Increase and focus invasive species research, surveys, mapping, and monitoring efforts to identify and fill information gaps.

§Promote and implement adaptive management philosophies throughout the Refuge System.

§Expand and encourage internal participation of cross-program biological review teams.

§Develop and implement Standard Operating Procedures to combat invasive species.

§Adopt and implement standard inventory, data recording, analysis, mapping protocols, and reporting procedures.

Current Status of Invasive Species Management Activities and Their Effects: 5 Key Aspects

Refuge staff are currently forced to deal with invasive species reactively, rather than proactively.

Current management actions to combat invasive species throughout the Refuge System are primarily focused on control and eradication, with lesser degrees of effort on prevention, education, research, and monitoring. Project accountability and follow-up reporting and monitoring is limited for Refuge System invasive species management activities. Field stations and regional offices use a variety of mechanisms to determine priorities for action and justification for funding their management needs. Projects are often prioritized and funded based on the severity of the invasive species= impacts on human or natural resources, legal or political considerations, and internal and external economic factors. Refuge control programs inadequately address invasion on an area-wide basis to prevent reinfestation.

1. Invasive Species Control and Eradication

Refuges are currently using a variety of methods to control invasive species populations.

The Refuge System is replete with established invasive species populations; therefore, control and eradication efforts tend to be the focus of the invasive species initiatives. These types of activities consumed more than 95% of funds specifically appropriated by Congress in FY2001 for refuge invasive species management. Control efforts include removal of plants and animals through mechanical means (such as trapping, pulling, cutting, or mowing), cultural methods (such as revegetation with native species, prescribed burning, or water management), biological controls (such as introducing phytophagous insects and pathogenic micro-organisms, or grazing), and chemical treatments (such as herbicides, insecticides, rodenticides, avicides, or piscicides). Refuges attempt to use a combination of those methods that are most effective in controlling invasive species while minimizing impacts on native species or their ecosystems, an approach known as integrated pest management.

These control methods are limited and frequently subjected to outside prioritizing.

The selection of control options is dependent on individual refuge perspectives, staff biases, and perceived Ared-tape@ associated with approval processes. Control options are further limited by target species, legal and scientific criteria, the availability of control techniques information, budget constraints, and economic and environmental considerations. Once refuges choose to take action against an invasive species, they most often choose the chemical control option over other techniques available. In some cases, political pressures to control or eradicate certain invasive species may complicate or circumvent agency processes used to determine priority actions and control methodology.

2. Invasive Species Prevention, Early Detection and Response, and Education Activities

Refuges are implementing some preventive measures, but they are few and far between.

Although prevention is the key to a successful invasive species program, little emphasis is placed on prevention activities in the Refuge System. Indeed, many refuges tend to give low priority to invasive species until they become a major problem. The relatively few examples of proactive preventive measures include regularly sanitizing maintenance equipment, requiring certified seed for farming programs, requiring the use of certified weed-free hay, developing and distributing educational materials about invasive species, holding various public awareness meetings, and training staff and volunteers to identify invasive species.

Some refuges have achieved success.

Refuges which have increased their efforts to institute prevention and early detection/rapid response measures have experienced greater success battling invasive species and minimizing costs as well as ecological and economic impacts. Sevilleta NWR has significantly reduced infestations of perennial pepperweed and other invasives through a cooperative mapping and control partnership with the local Soil and Water Conservation District and others. An early detection and response program established on Klamath Basin NWR prevented the spread of yellow starthistle and spotted knapweed. In addition, establishment of the National Bison Range/Northwest Montana Wetland Management District Joint Control Program prevented the spread of purple loosestrife on the refuge.

3. Invasive Species Research and Monitoring

Research and monitoring are critical tools for managing the invasive species problem proactively.

Reliable information about an invasive species= presence, distribution, rate and direction of dispersal (as well as its reproductive status), is crucial for setting priorities for control, developing management strategies, estimating likely impacts, and evaluating progress.

Research, surveys, inventory, mapping, and monitoring provide information critical to determining the characteristics and magnitude of invasive species problems, designing control programs, and evaluating effectiveness. Research, surveys, and monitoring can also increase the likelihood of early detection, measure the spread or reduction of invasive species infestations, determine their effect on native species and ecosystems, and provide justification for management actions.

Currently, these tools are limited in their use and the information they

Throughout the Refuge System invasive species research and monitoring efforts are limited, particularly long-term studies. Furthermore, many of the invasive species inventory and monitoring efforts are primarily site or species specific and lack coordination

gather is not shared among other concerned parties.

with adjacent landowners, other refuges, regions, and other outside partners. Since adequate surveys and reliable monitoring data for invasive species are not always available from other sources, refuges must frequently rely on their own limited funding, skills, and technical abilities to acquire information about invasive species problems impacting their habitats. Consequently, unless a refuge or region has the resources to conduct adequate invasive species inventory and monitoring efforts, management decisions are often made with limited scientific information

4. Mechanisms to Prioritize Invasive Species Management Actions and Funding

Funding and activities to deal with this problem are subject to a variety of pressures, both internal and external.

Invasive species management and funding are prioritized in the context of other refuge operations needs and legal mandates. In most cases, refuges consider invasive species management critical to meeting their wildlife conservation goals and objectives. However, once an infestation is considered important enough to be listed along with all other refuge operations needs, the ranking and funding of invasive species projects vary. This situation is further complicated by the external factors that pressure decision makers to change priority rankings or modify project lists.

Quantitative information is more useful to refuges, but available resources currently favor qualitative studies.

Prioritization of activities to battle invasive species within the Refuge System is variable and based primarily on qualitative information. Qualitative information may include field observations, perceived impacts to natural or human resources, or ease of control and restoration. In some cases, projects are prioritized based on quantitative information such as magnitude of the infestation (population density, number of acres) or rate of spread (as when an infestation has doubled its size over a short period). However, quantitative information, as a whole, is limited, especially regarding ecological impacts (such as documented losses of ecosystem function, or quantitative changes in survival of native fish or wildlife) because most refuges do not have the resources to conduct the necessary research and monitoring activities. Furthermore, invasive species research and monitoring activities are rarely ranked as priorities. Research and monitoring needs to be integrated with control and eradication projects.

5. Invasive Species Project Accountability and Follow-up Reporting/Monitoring

Until FY 2002 there was no consistent reporting or accountability for

The fastest growing component of the RONS database includes invasive species-related projects. However, until FY 2002, these projects were reported in numerous activity categories and invasive species management accomplishments were not included in the Refuge Comprehensive Accomplishment Report (RCAR).

invasive species management.

Mechanisms were in place to track expenditure of invasive species appropriations, but there was no mechanism to track expenditures of other funds (1261, etc.), such as a specific sub-activity code for invasive species. Categories in RCAR were established in FY 2002 for Invasive Plant Management (3.h.), and Invasive Animal and other Invasive Taxa Management (4.h.). RONS database modules allow refuges to list and rank projects for refuge invasive species operations in various activity categories. The two main RONS activity categories for invasive species related projects are Pest Plant Control (3.g.), and Pest, Predator, and Exotic Animal Control (4.e.).

Funding is not adequately tracked at the regional and field levels.

Regions are required to provide accountability for invasive species management activities and expenditures through annual business plans provided to the Service budget offices and Congress. However, these business plans do not provide detailed examinations of individual project successes or failures and rarely provide recommendations for follow-up activities to improve or adapt management strategies. Typically, funding for invasive species management activities is supplemented with other base funding sources at the regional and field levels; this funding cannot be adequately tracked or reported.

To the limited extent that the Refuge System prepares reports on invasive species projects, accountability and follow-up reporting/monitoring is associated primarily with research, control, and eradication efforts.

Written documentation is neither standardized nor distributed adequately.

Although technical reports are sometimes available for research, reporting and accountability for control and eradication efforts are limited and variable. In most cases there is no standardized reporting process for control and eradication projects, and regions collect information about invasive species impacts inconsistently. Granted, quarterly or annual reports are required for some invasive species control grant programs currently providing funding support to the Refuge System, but these are not widely disseminated.

Invasive Species Management Roles and Responsibilities of the Refuge System: 3 Recommendations

The Refuge System must have staff positions dedicated exclusively to invasive species management.

Currently, each region organizes positions and duties related to invasive species management in different ways. Personnel working on invasive species related issues are found in at least five different Service programs, but the Refuge System lacks positions dedicated exclusively to invasive species management. Collateral duty invasive species work tends to be the norm across all levels (field, regional, and national).

1. Improve the National, Regional, and Field Infrastructure

At least one national position should be dedicated exclusively.

At the national level, refuge program invasive species coordination involves five efforts:

1. budget formulation and legislative efforts;
2. national coordination of invasive species work among regions;
3. tracking of funding allocations;
4. linking of agency invasive species efforts with external partners and other state and local agencies; and
5. monitoring implementation of the National Strategy and other policies.

To be most effective, at least one national position should be dedicated exclusively to invasive species projects. This position will require additional supporting staff, such as data management, and outreach and education specialists.

Full-time regional invasive species specialists should be hired.

The lack of national consistency and focus on invasive species issues in the Refuge System has resulted in an inefficient and cumbersome program. Full-time regional invasive species specialists are needed to carry out at least five major efforts:

1. support the field with technical training and policy guidance;
2. be the direct contact for regional invasive species issues;
3. guide regional decision makers in prioritizing invasive species problems;
4. direct the implementation of the National Strategy in each region;
5. network with partners to accomplish invasive species work on refuges throughout their respective region; and
6. coordinate with the regional ANS coordinator.

Field level invasive species specialists are also needed.

Some field stations will need full-time, field -level invasive species specialists to address serious invasive species infestations. (Seasonal or part-time invasive species personnel should also be considered, as appropriate.) Furthermore, managers should consider incorporating or expanding invasive species management activities into their volunteer programs, youth programs, Americorps, or other labor programs.

2. Improve Internal Coordination

A diversity of roles and lack of consistency exist between Service programs.

Internally, the Service=s approach to the invasive species problem has been fragmented, with each region operating differently. Inconsistent management recommendations and policies have also been developed by the different Service programs. At a minimum, the Division of Environmental Quality (DEQ), Refuges, Endangered Species, Fisheries, and Law Enforcement have invasive species responsibilities, but there is no guiding facilitator of policy/philosophy differences between the different programs. Examples of the differing roles and approaches include the following:

A difference in pest management perspectives exists between DEQ and Refuges.

§Regional Office and Washington Office review of pest management on refuges is largely driven by the Division of Environmental Quality. Their focus is on contaminants and toxicology issues related to pesticide control techniques, while refuges should focus on the broader topic of developing integrated pest management programs. In addition, refuge leadership should play an important role in facilitating cross-programmatic cooperation for bio-control agent development review.

Regulatory tension exists between the Endangered Species Program and the Technical Advisory Group for Bio-control of Weeds.

§The Endangered Species program has, on occasion, identified concerns about potential plant bio-control agents in biological opinions after extensive research of those agents has already been completed. When Endangered Species and the Service are not involved early in the research process, and then they raise last-minute concerns, they are both subjected to criticism for obstructing approval and release of new biological control organisms by the U.S. Department of Agriculture (USDA). Due to time and staff limitations, Endangered Species has been reluctant to commit the resources needed to become involved early in the research review process or to fully participate in the Technical Advisory Group for Bio-control of Weeds (TAG-BCW). The TAG evaluates the safety of bio-control organisms and makes recommendations for release to USDA-APHIS. Recently Fisheries-Aquatic Nuisance Species (ANS) has been assigned responsibility for participation in TAG-BCW, but Endangered Species will still review proposals for potential risk to threatened and endangered (T&E) species.

Political pressures cause further inconsistencies.

§Political pressures related to management of non-plant invasive species (feral pigs, feral goats, burros, sika deer, sambar deer, nutria, mute swans, and other exotic taxa) have caused inconsistencies in policy and administrative guidance.

Improved coordination requires improved communication.

Some of the many ways communication can be improved are listed here:

§Establish a cross-programmatic invasive species team in each region. This team would extend coordination and support to refuges and ecosystem teams and would be involved in all aspects of invasive species management and budgeting in the Refuge System. The team members should consist of at least one employee from the Refuge Program, the Division of Environmental Quality, Endangered Species, Fisheries-ANS, a line officer or someone such as a regional Ecosystem Team coordinator, and a field staff person.

§Promote regular communication between regional invasive species specialists and the field, and with external partners.

§Increase intra-agency coordination between regional, field,

ecosystem, and national personnel through meetings.

§ Increase refuge and other regional staff participation in invasive species management areas and groups, such as county weed boards, exotic pest plant councils, aquatic nuisance species councils, and cooperative weed management areas.

Refuges should strive to share ideas and information and become involved in invasive species organizations at the local, regional, and national levels. Information exists in a variety of locations and can be accessed by field stations and regional staff. With internet access, Refuges can tap into invasive species management information through hundreds of Internet web sites. This information should be compiled and distributed as needed.

3. Promote Existing and Potential Partnerships

Many opportunities exist for establishing and maintaining partnerships to deal with this problem.

External coordination and partnerships vary from region to region and refuge to refuge, although there are examples of successful partnerships and coordination between refuges and their local communities and neighboring public land managers. One of the most important functions of the regional and national invasive species coordinators will be to facilitate coordination among the numerous partner organizations, grant programs, and new opportunities to gain support for refuge invasive species management needs.

Partnership opportunities for coordinated invasive species management exist in local or regional areas; and refuge managers should seek these opportunities and take advantage of them. In addition, managers should be encouraged to be creative in establishing partnerships to fight invasive species. A team approach has been proven to increase the effectiveness of invasive species management operations. Building local support for refuge invasive species management is essential, but will vary depending on the location and public awareness of the issue.

Part II: Tools and Recommendations

Part II contains the following documents:

- A. Standard Operating Procedures
- B. Integrated Pest Management Approach to Invasive Species
- C. Special Designation Areas Management

A: Standard Operating Procedures for Managing Invasive Species on National Wildlife Refuges

[Note: **References** notated in this section can be found on p. 52.]

This SOP includes specific action items, organized into 10 categories.

If the Refuge System is to fulfill its mission, each refuge needs to prevent the introduction and spread of invasive species. The following Standard Operating Procedures identify 10 categories that include action items for implementation on all wildlife refuges, including both those with existing infestations of any size and those with no known invasives.

Implementation requirements include additional funding and staffing, as well as using HAACP procedures.

Implementation will, in most cases, require refuge management and staff to rethink routine operations and, in some cases, to modify traditional management practices and reset funding priorities. Initially this may require considerable effort and some additional cost. However, the extra effort and cost required to prevent problems will be a small fraction of that which will be required to restore a habitat once it has been degraded by an invasive species.

To achieve these management actions, each refuge should have at least one person trained in identification and management of invasive species.

Additionally, Hazard Analysis and Critical Control Point (HACCP) procedures should be developed for each refuge activity to prevent the spread of invasive species. The HACCP model was originally developed by Pillsbury foods to insure food purity [21]. As applied to Refuges, the model uses a systematic pathway and vector analysis to identify critical control points or mechanisms of invasive species spread, establish countermeasures, monitor control points, and maintain records. It also includes standard flow charts and forms to document the process. Information provided in this section will be useful in developing refuge HACCP plans.

1. Facilities

Facilities include buildings, fences, signs, parking lots, storage sites, boat launches, photo blinds, and water control structures.

Action Items:

Planning

§ Incorporate invasive species prevention and control planning into facility layout, design, and alternatives evaluation.

Contracts

§ Incorporate invasive species prevention and control practices in standard language for contracting stipulations. Incorporate into

	contracts language requiring use of native seeds and soil stabilization materials that are free of noxious weed seeds.
Pre-activity reviews	§Conduct pre-activity site reviews to identify potential invasive species problems and coordinate project actions that will minimize risk from invasive species.
Site restoration	§Native species (and when practical, local genotypes of native species) should be used when restoring or rehabilitating sites impacted by construction (or reconstruction) activities to prevent or exclude invasive plant species. [See 42 and 43.] Nonnative, non-invasive plants and seeds should only be used when required as a cover crop for temporary site stabilization until natives can become established, or when reestablishment of a native species is not feasible.
Decommissioned facilities	§ Use the HACCP planning process to evaluate potential for invasives spread, and evaluate possible ramifications when determining infrastructure needs and designs. Minimize facilities, and where feasible, decommission unnecessary facilities, and restore/rehabilitate those decommissioned areas to prevent the introduction or expansion of invasive species.. [Note: Be sure that habitat restoration efforts are consistent with refuge management plans.]
Revegetation	§Revegetate disturbed areas as soon as practical. (Revegetation may include planting, seeding, fertilizing, irrigating, and weed-free mulching as recommended by local guidelines, when available.) Use only laboratory-tested seed lots, certified free of invasive weed species, and weed free mulch. Monitor, evaluate, and document the success of revegetation efforts.
Weed-free areas	§Maintain weed-free areas around buildings, signs, and storage sites using manual/mechanical and chemical techniques to prevent spread, reduce fire hazard, and maintain access.
Construction materials	§Require mulch, sand, gravel, dirt, and other construction materials to be certified as free of noxious weed seeds. Avoid stockpiles of weed-infested materials.
Highway corridors	§Cooperate with state highway district offices and county/province road maintenance crews to implement invasive weed control along highway corridors that pass through Refuge lands.
Public-use areas	§Use appropriate physical, cultural, biological, or chemical control techniques to maintain an invasive species-free environment in public use areas, parking lots, boat launches, and other related facilities. Inspect these areas often and control new infestations immediately.

2. Aquatic Habitats Management

Action Items:

Planning	§Include invasive species prevention actions into all refuge aquatic and riparian habitat management planning efforts. (Wetlands and other aquatic habitats, and associated riparian areas, are prone to infestation by invasive species and should be considered high-risk areas in some ecosystems.)
State and federal identification and cooperation	§Identify wetlands and watersheds at risk to invasive species infestation by working with states and other federal agencies, and then develop plans and measures to prevent invasion in these areas.
Restoration and rehabilitation	§Maximize restoration/rehabilitation of altered wetlands and other aquatic areas to minimize invasive species proliferation. Efforts that restore the natural/historical hydrological functions of a particular aquatic system may, in some cases, favor native species and discourage aquatic invasive species.
Infrastructure development	§ Minimize infrastructure development in existing managed wetland units (when practical) to reduce unnecessary levees, waterways, access roads, etc., that have become sources of infestation and pathways of spread.
Water contamination	§Avoid shipping or receiving fish or water from contaminated areas.
Water manipulation	§Use water manipulation to prevent/control invasive species. One example is to avoid water manipulation activities (such as flooding areas, diversions, drawdowns, etc.) to prevent spread when riparian invasive species such as salt cedar or perennial pepperweed are seeding. Another example is to use water drawdowns to mimic natural hydrology and give native species a competitive edge over invasive plants such as Chinese water chestnut.
Permit language	§Include invasive species prevention and control language in Section 404 permits, special use permits, or other kinds of permits.
Artificially created wetlands	§Evaluate potential invasive species risks in designing, establishing and managing green-tree reservoirs and other artificially created wetland areas. Incorporate practices to minimize or prevent invasive species in these areas.
Exotic aquatic species	§Avoid intentional introductions of exotic aquatic species. If unavoidable, introduce exotic aquatic species by using risk evaluation criteria established by the ANS task force prior to issuance of special use permits. Use the HACCP planning process to evaluate the potential for inadvertent introduction of aquatic invasive species in transport media (such as water, sediments, vegetation, organisms, etc.).

Information and education program

§Develop an information and education program for aquatic nonindigenous species for each refuge.

3. Fire Management

AFire management@ includes prescribed burning and wildfires.

Action Items:

Planning

§Address invasive species prevention and control in fire management plans, wildland fire situation analysis, and fire effects analysis [38, 39].

Follow-up monitoring

§Develop a follow-up monitoring and rapid control program for invasive species for prescribed and wildfire burned areas. Explore opportunities to acquire Burned Area Emergency Response funding for follow-up monitoring activities. Fire restoration/rehabilitation planning should include provisions to address invasive species. Monitor burned areas, fire camps, and other fire administration sites for two growing seasons (or more during drought periods) after an incident to detect the introduction of invasive species and prevent their spread or establishment.

Fire as a control mechanism

§Include fire as part of an effective integrated approach to controlling an invasive species when used in combination with other control techniques. (Since fire is a disturbance to a site and invasive species have a competitive edge over native species, particularly in disturbed areas, fire may increase the risk of invasion. However, in some cases prescribed fire that mimics historical/natural fire cycles may limit that competitive edge.)

Site disturbance

§Minimize site disturbance when establishing fire lines; maximize use of natural fire barriers.

Fire management facilities

§Establish and use fire management facilities, heliports, airports, and staging areas that are free of invasive species. Cordon off any nearby infestations and prohibit entry.

Water sources

§Use water sources that are free of invasive species. Aquatic invasive species can be inadvertently spread from contaminated water sources.

Ground and air fire management equipment

§Inspect and clean all air and ground fire management equipment and personal fire gear before loading or transporting to new sites to prevent spread of invasive species. (See *Equipment*, p. 20.)

Natural restoration

§Let burned areas restore naturally to avoid the possibility of accidental introductions from contaminated seed sources (as long as there is little danger of soil erosion and invasive species were not known or suspected to have been in an area before the burn).

Fuels reduction

§ Consider the potential for introduction and/or spread of invasive

considerations species, or for enhancing conditions conducive to their establishment (as through ground disturbance), in fuels reduction activities.

4. Rights-of-way, Access Roads, and Waterways

This section also includes canals, drains, powerlines, pipelines, and port facilities.

Action Items:

Planning §Incorporate invasive species prevention into design and alternative evaluations in order to minimize clearance for roads and waterways and thus minimize disturbance.

Minimize and decommission §Minimize the number and size of roads, rights-of-way, and waterways. Decommission unnecessary roads, rights-of-way, and waterways.

Rehabilitation §Maintain desirable vegetation along roads, rights-of way, and waterways by rehabilitation. (See *Facilities*, p. 15.) Minimize disturbance to those areas to discourage invasive plant species.

Maintenance and construction activities §Coordinate refuge maintenance and construction operations with invasive species management activities to limit the spread or establishment of invasive species. (For example, schedule mowing, grading, or dredging operations before seed is set.)

Removal before seed production §Identify and remove, before seed production, invasive plants from roads, rights-of-way, and waterways. Use manual, mechanical, physical, biological, and chemical control techniques to prevent spread by passing vehicles and limit transport in waterways.

Source materials §Minimize the movement of existing and new invasive species caused by moving infested gravel and fill material. Use only clean source materials for road building, levee building, maintenance, and repair. Inspect material source sites to determine if invasive species infestations are present.

5. Equipment

Equipment includes vehicles, tractors, implements, road graders, heavy equipment, fire engines, boats, trailers, all-terrain vehicles (ATVs), tools, sampling equipment, nets, waders, boots, etc.

Action Items:

Cleaning §Remove all mud, dirt, and plant parts from all equipment between projects or when equipment is moved from an infested area to an uninfested one. (Cleaning must occur at designated Refuge equipment wash sites.). Wash waders and nets between aquatic sites. Examine boots and clothing for trapped seeds prior to leaving an

	infested area.
Private contractors	§Require private contractors to clean equipment before use on any project or rights-of-way maintenance/construction work on Service lands [41].
	6. Recreation
	ARecreation@ includes hunting, fishing, wildlife viewing, and photography.
	Action Items:
Education and Outreach	§Create awareness through education and outreach about invasive species, their identification, impacts, and prevention, and how recreators can help prevent introduction and spread of invasive species.
Public presentations	§Education and outreach activities should focus on external as well as internal audiences. Include invasive species messages in public presentations to groups, both on- and off-site.
Educate priority users	§Establish invasive species prevention/control programs linked to priority refuge recreational uses conducted on the refuge. (For example, provide hunters and anglers with information on how to prevent the spread of invasive aquatic species between water bodies; tell hikers about how to avoid accidentally transporting invasive species with their gear.)
Signs and brochures	§Erect invasive species awareness signs/displays in public use areas, at kiosks, and along tour routes. Include brochures on invasive species along with other informational brochures.
Cooperative agreements	§Incorporate provisions in agreements with cooperative associations, friends groups, concessionaires, etc., to ensure areas under their responsibility are kept free from invasive species.
Hunting and fishing brochures	§Incorporate invasive species information and prevention statements into all refuge brochures, including wildlife lists and hunting and fishing brochures.
Proclamations	§Coordinate with state game and fish departments to include invasive species awareness and prevention statements into hunting and fishing proclamations.
Public awareness	§Incorporate invasive species awareness into mass media presentations (such as news releases) to enhance public awareness and support for program activities and necessary treatment methods. Encourage discussion of threats of invasive species in hunter education programs.

Books	<p>§ Include books on invasive species among those being sold at refuges.</p> <p>7. Rangeland Management</p> <p>ARangeland management@ includes haying and grazing.</p> <p>Action Items:</p>
Livestock management	<p>§ Carefully managed livestock grazing can be a useful tool as part of an integrated management plan for invasive species control and/or for restoring rangeland health. Manage livestock to avoid overgrazing and/or enhancing invasive species infestations.</p>
Grazing rotations	<p>§ Design grazing rotations to minimize seed dispersal of invasive plant species by changing season of use when appropriate.</p>
Fences	<p>§ Maintain fences to exclude livestock from areas that may be predisposed to invasion or which are heavily infested.</p>
Quarantine and confinement	<p>§ Encourage the quarantine and/or confinement of animals to a noxious weed-free diet for at least 4-7 days between moving from infested to noninfested areas.</p>
Clean equipment	<p>§ Maintain clean haying/grazing equipment and gear. (See <i>Equipment</i>, p. 20.)</p>
Supplemental feeding	<p>§ Restrict or prohibit supplemental feeding. Require that supplemental feed be certified free of invasive weed seeds or tested and proven to be free of invasive species.</p>
Special use provisions and cooperative agreements	<p>§ Include provisions in special use permits and cooperative land management agreements regarding quarantine and confinement, equipment sanitation, and supplemental feeding to prevent introduction and spread of invasive species.</p> <p>8. Farming Programs</p> <p>Action Items:</p>
Restoration	<p>§ Avoid leaving farm lands fallow, particularly when lands are first acquired by the Fish and Wildlife Service. Fallow farm lands are particularly predisposed to invasion. Plant and maintain an interim nonnative, non-invasive cover crop if restoration cannot be initiated immediately. Restoration with native species should be initiated as soon as possible.</p>
Seed certification	<p>§ If seed is not manually collected on site, require that seed for restoration and farming-related operations be tested and proven to be free of invasive weed seed before it is used on the refuge.</p>

Clean equipment	§Maintain clean farming equipment. (See <i>Equipment</i> , p. 20.)
Agreement provisions	§Include provisions in cooperative farming and land management agreements about using seed that is free of invasive weeds, preventing and controlling restricted and prohibited noxious weeds, and sanitizing equipment.

9. Forest Management

Action Items:

Planning	§Incorporate invasive species prevention and control information into forest management planning efforts, including alternative evaluations and forest management operations.
Disturbance and restoration	§Minimize ground disturbance and restore disturbed areas. (See <i>Facilities</i> , p. 15.)
Equipment	§Maintain clean equipment and gear. (See <i>Equipment</i> , p. 20.)
Access roads	§Follow SOPs for access roads under <i>Rights-of-way</i> (p. 19).
Fire management	§Follow SOPs for prescribed fire and wild fire (<i>Fire Management</i> , p. 18).
Grazing	§Follow SOPs for grazing (<i>Rangeland Management</i> , p. 21).

10. Land Acquisition

Action Items:

Real estate appraisals	§During the land acquisition planning process, evaluate proposed acquisitions for invasive species (plant and animal), restoration and maintenance costs, as well as natural resource values.
Revegetation and control	§Ensure acquired farm lands are not left fallow after acquisition but are either continued as farmlands, or promptly revegetated with an interim cover crop (or native species if possible), to discourage invasions.
Control program	§Implement a control program (where feasible) for existing/potential invasive species signed and in place for rapid response (<i>Farming Programs</i> , p. 22).

B: An Integrated Pest Management Approach to Invasive Species

Introduction

[Note: **References** notated in this section can be found on p. 52.]

Definition and control criteria

Integrated Pest Management (IPM) is a systematic planning and decision-making process for reducing, to an acceptable level, populations of organisms that interfere with resource management objectives. Criteria used to determine the most appropriate control measures include, in priority order, human health and safety, ecological integrity, and cost effectiveness.

IPM uses a 3-phase process

The IPM approach to invasive species management is both integrated and comprehensive, and uses a multi-disciplinary effort to prevent, eradicate, control, and/or contain one or more target species. The IPM process involves three phases:

Phase 1: Planning and Prioritizing

Phase 2: Tactics and Implementation

Phase 3: Monitoring, Evaluation and Sustained Management

Phase 1: Planning and Prioritizing

Planning

Planning and the need for complementary actions

To be effective, invasive species management planning needs to be incorporated into all refuge management planning efforts so as to encourage complementary actions at the refuge level. Examples of such complementary actions include the following:

§ Invasive species prevention, control, and site restoration should enhance fish and wildlife habitat management objectives, while fish and wildlife habitat restoration and management activities should be designed to prevent and control invasive species.

§ Invasive species prevention, control, and restoration should be factored into refuge infrastructure design and maintenance, while refuge infrastructure design and maintenance actions should prevent the spread and encourage the control of invasive species.

Specific areas for integration

Invasive species management planning should be integrated into the following Refuge System projects and plans:

§ Refuge habitat management plans

§ Compatibility Determinations (CDs), as a stipulation [3]

	<ul style="list-style-type: none"> § Comprehensive Conservation Planning (CCP) [4] § Special Use Permits (SUPs), as special conditions § Cooperative agreements, as special conditions § Memoranda of Understanding (MOU), as specific clauses § Miscellaneous contracts, as a stipulation or specific clause § Conservation easements and rights-of-way, as a stipulation or specific clause § Refuge Maintenance Management System (MMS) projects § Refuge Operation Needs System (RONS) projects § Environmental Assessments (EAs) [5, 6, 7] and Environmental Impact Statements (EISs) for other refuge projects. § State Aquatic Nuisance Species Management Plans [10] § Public use programs
<p>Templates for management plans</p>	<p>A comprehensive IPM plan addresses all invasive species problems, both existing and anticipated, and considers the larger ecosystem of neighboring lands and waters. A Service-approved IPM plan template is being developed as part of the new IPM Policy (606 FW1). Examples of IPM templates are available now for drafting invasive species management plans [8, 9, 10].</p>
<p>Elements of Invasive Species Management Plans</p>	<p>The major elements found in most plans include the following:</p> <ul style="list-style-type: none"> § Problem definition: Identification, biology, distribution, size of infestation, and impact § Goals and objectives: Desired long- and short-term accomplishments (qualitative and quantitative descriptions) § Priorities of the program: Descriptions of the most important tasks and how are they determined, given limited resources [11, 12, 13] § Management actions § Monitoring [14, 15, 16, 17] § Resource needs (staff time, equipment, materials, budget) <p>Prioritizing</p>
<p>Benefits of prioritizing</p>	<p>Few refuges have adequate staff and funding to fully address their invasive species threats and infestations promptly. Accordingly, setting priorities (with respect both to species and the size and location of various infestations), will assist a refuge in implementing the most cost-effective long-term control and/or eradication program.</p>
<p>Applicable Levels of Priority</p>	<p>There are three applicable levels of prioritization for planning for systematic invasive species management:</p> <ol style="list-style-type: none"> 1. Strategic (game plan) 2. Tactical (control options) 3. Target (species and site)

The Strategic Level	<p>On the strategic level, the following priority order of action is generally accepted:</p> <ol style="list-style-type: none"> 1. Prevent invasion of potential invaders. 2. Detect and rapidly respond to new infestations. 3. Eradicate new and/or small infestations. 4. Control and/or contain large established infestations.
The Tactical Level	<p>A systematic approach will help achieve successful control, and a combination of control methods may be most effective. The control method (or methods) selected should be those that will accomplish control or eradication with the least negative impact. Consideration should be given to the feasibility of any and all of the following:</p> <ol style="list-style-type: none"> 1. Cultural/physical/mechanical methods (including water manipulation or establishment of competitive vegetation) 2. Biological methods (including both biological control and grazing/browsing) 3. Chemical control methods (including pesticides, soil enhancement, etc.)
Other tactical considerations	<p>The choice of control methods will depend on the scale of the infestation, the nature of the infesting species, the potential success of control, and the potential impacts (direct and/or indirect) on nontarget species such as those federally listed as threatened or endangered. Manual removal may be feasible for small-scale infestations of annual or biennial invasive plant species or even some nonplant invasives. Likewise, biological control is often not viable for small-scale infestations, yet it may be the only practical option for large scale infestations. Chemical control may be the most practical and effective approach for small- to moderate-scale infestations of perennial plant species. Often the most effective approach will be an integration of more than one of these tactics.</p>
The Target Level	<p>When confronted with infestations of multiple species with established populations, use the following order of priority to determine appropriate target actions:</p> <ol style="list-style-type: none"> 1. Smallest scale of infestation, including small satellite infestations 2. Poses greatest threat to land management objectives 3. Greatest ease of control
Other ranking systems for the target level	<p>In many cases, these factors are not mutually exclusive. Ranking systems are available for prioritizing invasive plant species. [See, for example, 12 and 13.]</p>
Alternate priority order for limited	<p>For other biological categories, the risk assessment task becomes more difficult [11]. When limited resources prevent the treatment of</p>

resources

entire populations, the following order of priority is recommended:

1. Treat the smallest infestations (satellite populations).
2. Treat infestations on pathways of spread.
3. Treat the perimeter and advancing front of large infestations.

Phase 2: Tactics and Implementation

Inventory

Inventory acquisition

An inventory of invasive species is essential to planning and setting priorities for control. Inventory includes the identity of potential target species, their abundance, and their distribution. In addition to enabling weed managers to prioritize which part of an infestation to treat first, the use of invasive weed inventories can increase the efficiency of almost any method of weed management. For instance, weed managers might combine weed inventories with information on soil type and water table depth to select the most safe and effective herbicide for a given location. Or they might keep inventory information to help plan and track volunteer weed pulling efforts. Inventory is a product of scientifically sound survey methods that are dependent on the biology of the target species and allow for reliable detection.

Available background information

Available baseline and/or background information may be an effective starting point. For instance, field personnel often already know where problem invasive species are located. In addition, standard ground and aerial avian, fish, and mammalian surveys conducted by refuge staff can be used to detect the presence or absence of invasive species. Also, records of invasive species may be available in refuge *Annual Narratives*.

Surveys

Surveys: Existing resources

Information on invasive species may already exist from prior work done by the U.S. Geological Survey (USGS), local universities, and other government and private entities. The USGS maintains a database of maps for nonindigenous aquatic species, and has recently completed a survey of invasive species on national wildlife refuges. Data on invasives found in the vicinity of refuges can be obtained from state databases, such as the California Department of Food and Agriculture, state departments of highway and transportation, county and local governments, and private entities such as Calflora and The Nature Conservancy. The U.S. Forest Service is conducting an inventory of invasives in a number of locations in the southeast, and exotic pest plant councils also may be able to provide some data. (See Associated Websites, p. 49).

<p>Surveying and trapping techniques</p>	<p>If invasive species survey information available is inadequate, standard survey protocols will be needed to generate an inventory. These will vary with the species of concern. Protocols used should be consistent or compatible with those developed by other Promises teams, particularly the Habitat Monitoring Team (WH-10).</p>
<p>Aerial surveys</p>	<p>Mobile aquatic, marine, and terrestrial species may be surveyed and trapped by various techniques that may be species, or taxa, -specific. The USGS provides methods for sampling fish communities, aquatic invertebrates, and algae on its Internet site. (See p. 50.)</p>
<p>Biology and pathways</p>	<p>Standard refuge aerial surveys are generally conducted on 2 mile center transects with 100 % visual coverage, and are limited to observing plant, avian, and mammalian species that are relatively large in stature, or populations large enough to be visible. This type of survey may be useful only to determine presence or absence, which would then indicate a need for additional on-the-ground explorations.</p>
<p>Biology and pathways</p>	<p>In general, surveys of invasive species should begin with an understanding of the biology of the target species. Knowledge of their biology will indicate habitat adaptation, mechanisms of spread, or vectors and likely pathways. Initial surveys should then target those pathways, which could include ports of entry, waterways, roads, and recreation areas. Other potential sites may include areas where natural and/or artificial landscape disturbances have occurred from fire, construction, farming, grazing, logging, or other public uses.</p>
<p>Region 5 has developed a standard survey protocol.</p>	<p>Region 5 is developing a standard survey protocol for invasive plant species that may be applicable system wide [45]. The recommended Region 5 survey procedure is a grid system using line transects to cover as much of the refuge as possible. The spacing between transect lines should reflect a distance that is the most suitable for the area/habitat type based on visibility. Spacing throughout the refuge can vary. Areas with known low expectance of invasives may have wider spaced grid/transects, while areas with a high potential for invasives may require more intensive surveys. Heavily managed areas may also receive more intensive surveys.</p>
<p>Surveys and Mapping Methods</p>	<p>Surveys may be combined simultaneously with mapping efforts for greater efficiency. Mapping information will show the size, direction of spread, rate of spread and other relevant information. Using maps and inventory information, managers can develop strategies focused on removing new and isolated infestations while containing the principle infestation; the same strategy used for wildfires. Once the infestation has been contained, it can be further reduced by working from the outside in. There are three general mapping methods useful for invasive species:</p>

- § Hand mapping
- § Global Positioning System (GPS) mapping
- § Geographic Information System (GIS) computer mapping

For each of these methods, many options exist to achieve two desired end products: 1. maps that show the near exact size and location of invasive species at the time of mapping (a snapshot in time), and 2. a list of useful attributes associated with the infestation.

Additional resources

The Montana Noxious Weed Survey and Mapping System Weed Mapping Handbook [18] is an excellent reference for practical mapping procedures. In addition, The North American Weed Management Association (NAWMA) provides standards that have been adopted by federal agencies including the U.S. Fish and Wildlife Service [37]. For the most part, the NAWMA standards are consistent with the Montana system, and applicable to all invasive species, other species of interest (including listed species), and virtually any geographical feature (including critical habitat). These mapping procedures are particularly useful for conducting spatial analysis, as spatial relationships between invasive species and listed species can be demonstrated and the potential impacts of management actions can be examined.

Mapping

Mapping: consistency and compatibility

Mapping may be accomplished using various methods; however, any system chosen should be consistently applied across refuges and regions and should be compatible with external partners and clearinghouse databases. To the extent feasible, data and metadata standards adopted by the Service and recommended in other Promises efforts (WH-8 and WH-9) should be used.

Hand Mapping

Recommend procedures for hand mapping

Hand mapping invasive species can be as simple as notating infested areas on available maps (using casual field observations) or plotting systematic field observations on 1:24,000 USGS base maps (or mylar overlays). Hand mapping methods given in the *Montana Noxious Weed Survey and Mapping System Weed Mapping Handbook* [18] are recommended. All maps should be dated according to when the survey was done and important attributes about the infestation should be indicated. Attributes should include species identification, infestation size, population density, and growth stage of the organism. However, hand mapping should only be used in the absence of GIS/GPS capability and should be transferred to GIS/GPS as soon as possible.

GPS Mapping

Recommended
GPS units and
procedures

GPS mapping requires a GPS receiver for collecting geographic coordinates. (GPS receivers are manufactured by Trimble Navigation, Ashtech, Motorola, Megellan, Garmen, Rockwell International, SOKKIA, Corvallis Microtechnology, and others, and may cost from \$300-30,000). A Resource@ grade units (such as the GeoExplorer 3 or similar units) are recommended because they are designed specifically for mapping. For the purpose of GPS mapping of invasive species on the Refuge System, the recommended procedures for Trimble GeoExplorer GPS receivers are described in the *Montana Noxious Weed Survey and Mapping System Weed Mapping Handbook* [18, 19]. [Note: This recommendation does not imply or express endorsement by the U.S. Fish and Wildlife Service.]

GIS Mapping

GIS Mapping

Geographic Information System (GIS) computer mapping requires substantial computing resources and training. Fortunately, the required computer hardware is becoming more commonplace in the Refuge System and may already exist at most field stations.

Computing and
training resources
needed

The minimum hardware needed is specified on page 11 of *Mapping Noxious Weeds in Montana* [19]. To develop a working knowledge of GIS computer mapping, refuge staff should take a training course such as AGIS Introduction for Conservation Professionals, @TEC7112, available from the NCTC.

Tactical Implementation

Tactics for invasive species management refer to all possible control actions, and more importantly, the most appropriate combination of those actions that will yield the desired result. The following tactics for invasive species management are discussed in detail. (Note that some of these tactics are not mutually exclusive but oftentimes complementary.)

- \$ Prevention
- \$ Education and awareness
- \$ Early detection/rapid response
- \$ Physical/mechanical methods
- \$ Cultural methods/restoration ecology
- \$ Biological control
- \$ Chemical formulas

Prevention

Because of the difficulty of controlling invasive species once they are introduced and established, preventing introduction of new infestations and the spread of existing ones should take top priority. Furthermore, the economic and ecological benefits of prevention far

Counter measures	<p>outweigh the cost and inconvenience of prevention measures. An economic analysis of the cost of controlling established infestations combined with an ecological assessment of the impacts of established infestations will demonstrate the superior value of prevention.</p> <p>Counter measures used to prevent the spread of invasive species include sanitation, exclusion, and quarantine (as identified in the standard operating procedures for general refuge management actions). These counter measures detect and eradicate new introductions using inventory and survey methods (as previously described), education and awareness, and early detection/rapid response programs. In addition, prevention practices for noxious weeds have been developed by the U.S. Department of Agriculture, Forest Service [22], and recommendations for aquatic nuisance species prevention are included in a handbook by the Michigan Department of Environmental Quality [23].</p>
Educational Media	<p><i>Education and Awareness</i></p> <p>Education and awareness efforts are essential to prevent humans from introducing invasive species into new areas. Distribution of information about the impacts of invasive species, their methods of spread, their identification, and available management tools can contribute significantly toward prevention and control efforts.</p> <p>Education and awareness programs may include one or more of the following media:</p> <ul style="list-style-type: none"> § Handbooks § Newsletters and bulletins § Video presentations § Brochures/posters/calendars § Internet websites § Computer programs/software § Scientific papers § Public seminars § Professional conferences § School programs § Volunteer workshops § Radio spots § Television news stories and advertisements § Newspaper articles and advertisements § Public Service announcements § Billboards § Bumper stickers § Visitor contact

Early Detection/Rapid Response

Benefits of early detection/rapid response

The greatest opportunity to control and eradicate invasive species, short of prevention, is early detection/rapid response. A cost analysis could easily demonstrate the economic benefits of an early detection/rapid response program compared to a containment/maintenance program for an established invasive species population. Moreover, early detection rapid response approaches minimize ecological impacts resulting from invasion and subsequent management actions potentially eliminating the need for restoration.

Need for partnerships

Early detection and reporting of invasive species requires financial and time commitments at all levels. In addition, training, participation, and cooperation between refuges, at the field, regional, and national levels, is critical for a successful program. To be effective, the Service must participate in federal, state, county, and private partnerships involved in early detection and emergency response to invasive species. Examples of such partnerships include the Federal Interagency Committee for the Management of Noxious Exotic Weeds (FICMNEW) [24], the Aquatic Nuisance Species Task Force, state Invasive Species Councils, local Weed Management Areas, etc. Utilization of a coordinated and trained network of volunteers and professionals can form the foundation of a successful Early Detection program.

Early detection/rapid response: 2 basic elements

An early detection/rapid response program includes two basic processes:

4. Field assessment
5. Containment and eradication

Field assessments require scientific information and reliable methods that are widely tested and accepted by practitioners to detect invasions early. (Such assessments are described, to some extent, in the previous survey section.) Once an invasive species has been discovered, standard operating procedures can then be used rapidly to contain and eradicate the infestation.

Early detection/rapid response: 7 specific actions

A successful early detection/rapid response program will likewise include the following 7 specific actions:

6. Detect or find an established population of an invasive species at or near its inception.
7. Submit a voucher specimen of the established infestation to the appropriate refuge level.
8. Identify each specimen with the help of reliable taxonomists.
9. Voucher confirmed specimens as a historical record.
10. Gather information about the target species through literature

	<p>reviews.</p> <p>6. Conduct rapid assessments, taking into account distant and on-site scientific and technical support for planning and implementation of on-the-ground initiatives. Rapid assessments should also include the location and potential impact of any proposed actions on federally listed species and their habitats.</p> <p>7. Implement a rapid response commensurate with the scale of the infestation , including on-the-ground action. (See details of Refuge System AStrike Teams, @ p. 36.)</p>
Stakeholder involvement	<p>A successful early detection/rapid response program will also involve all impacted stakeholders in order to accomplish the following tasks:</p> <ol style="list-style-type: none"> 11. Identify the problem. 12. Develop a strategic plan of action (or have one prepared in anticipation of an invasion). 13. Implement containment strategies for preventing further spread. 14. Eradicate the invasion from target sites. <p>5. Implement periodic monitoring to detect recurrences.</p>
Steps for total elimination from target sites	<p>Total elimination from target sites will involve the following activities:</p> <ol style="list-style-type: none"> 15. Identify/assemble available technical methodologies and identify funding sources. 16. Implement the action plan. 17. Maintain quality assurance/quality control through periodic assessment of progress. 18. Modify the action plan per QA/QC findings.
Early detection: basic elements of the assessment process	<p>The basic elements of the early detection assessment process include the following:</p> <ul style="list-style-type: none"> § Provide technical support. § Develop capability (by employing a state/regional resource specialist) to provide online and distant expertise and technical assistance for assessing species invasiveness, potential impacts, and available response strategies. § Develop a plant invasiveness classification system, based on invasiveness and regulatory categories, which permits land managers to assess the threat of a specific species in a specific ecosystem and to determine a proper course of action. § Conduct on-site evaluations, including on-site rapid assessment and technical assistance, using standardized methods and procedures.
Functional	<p>Functional elements of an early detection system include reporting,</p>

elements and actions	<p>identification, vouchering, and information management. Specific actions include the following:</p> <ul style="list-style-type: none"> § Actively involve field biologists/scientists and refuge volunteers. (Identify field scientists/personnel who actively observe, study and collect plants/animals in the Refuge System.) § Standardize reporting procedures. § Standardize information that should be included in reporting new plants/animals. § Utilize existing monitoring programs across the Refuge System, including the USGS-BRD Invasive Species Survey and Report program. (This interdisciplinary method uses a multi-level survey approach in which the intensity of the survey is correlated with the vulnerability of the habitat and the knowledge of invasive species at the site [25].) § Designate state/regional botanists/biologists to perform specific tasks.
State and regional botanists and biologists: specific tasks	<p>State and regional botanists and biologists can assist in developing the state/regional detection network in the following ways:</p> <ul style="list-style-type: none"> § Identify and voucher plants and animals submitted by refuges. § Maintain voucher specimens of new state, regional, refuge, or national records. § Develop identification aids and conduct training for refuge biologists/botanists. § Develop a web-based information management system. This system (internal Intranet or external Internet) should consist of a network of state and regional databases that can be simultaneously queried by one or more centralized search engines, such as the North American Biodiversity Information Network.
Rapid response: basic elements	<p>The basic elements of a successful rapid response program include the following:</p> <ul style="list-style-type: none"> § Provide technical and action-oriented support to the field. § Develop the capability to provide on-site resources for invasive species eradication or containment. <p>§ Develop ARefuge Invasive Species Strike Teams@ (similar in organizational structure and responsiveness to Ahot shot@ crews used in interagency firefighting). Strike teams would respond rapidly to invasive species problems identified by a refuge, or a grouping of refuges. Teams would work closely with partners to accomplish invasive species management objectives, such as eradication of incipient invasions.</p>

Inter- and intra-
agency partnering
and operations:
basic elements

- § Develop and follow action plans (or ensure that action plans and environmental compliance documents are ready in anticipation of an invasion).
- § Develop guiding principles, protocols, and contingency plans for rapid response to new infestations, including quality assurance and control.
- § Increase coordination between concerned parties by providing guidance and coordination for individual refuges conducting rapid response actions and by sharing successes and information with other units of the Refuge System.
- § Initiate and continue funding mechanisms. (Establish new mechanisms for funding rapid response initiatives analogous to interagency fire or natural disaster responses and maintain a coordination role at the national level in support of ecosystem/regional projects.)

The basic elements of inter- and intra-agency partnering and operations include the following:

- § Participate in multi-agency, national level partnerships (for example, FICMNEW, the ANS Task Force, the Native Plant Coalition Initiative, the Invasive Weed Awareness Coalition, etc.) to develop and implement national monitoring systems for new invasive species infestations.
- § Participate in state, county, and private partnerships (state Invasive Species Councils, Weed Management Areas, etc.) to conduct on-site assessments and rapid responses to new invasions on refuges, and to share information on the status of invasive species locally.
- § Develop standardized procedures for notification of new invasive species between refuges and other levels of the Refuge System. Increase the external (states, counties, other agencies, etc.) networking capabilities for notification of invasive species infestations.

Physical/Mechanical

Physical/
mechanical
methods:
definitions

Nonchemical physical/mechanical methods can be either preventive (such as sanitation and exclusion) or curative (removal).

Physical/mechanical options (sanitation, exclusion, tillage, mowing, and prescribed burning) are often categorized as cultural methods. However, physical barriers that prevent entry into uninfested areas or prevent the introduction of a factor necessary for the life cycle of an invasive, physical removal of individuals or groups, and tillage used to control invasive plant species are technically mechanical. Likewise, prescribed burning, or fire, is technically caused by a

chemical reaction, but here it is considered a physical method because the mechanism of control is heat. Other methods of using heat may include steam and solarization.

The various risks and benefits of physical/mechanical methods in comparison to biological and chemical methods, in terms of safety and nontarget impacts, should be considered before implementation.

Cultural/Restoration

Cultural methods include restoration, rehabilitation, and revegetation. The goal of restoration is to reestablish the natural physical and biological components and processes of disturbed areas to a close approximation of their prior condition. Grazing may also be used as part of a cultural restoration program in places where it will help achieve restoration goals and objectives.

Benefits of restoration ecology

Restoration ecology is an emerging discipline with substantial application potential for invasive species management throughout the Refuge System [32, 33, 34, 35, 36]. Staff, resource, and funding requirements for restoration projects may be equivalent to or greater than those for invasive species control projects. Nevertheless, restoration is critically important because the disturbance (or control action) responsible for the initial invasion will expose the site to a resurgence of the invasive species, as well as a secondary invasion of one or more different species. Restoration of a disturbed area *before* the initial invasion may preclude the need for future control efforts.

Limitations of restoration

Restoration may not be the appropriate method in every situation. It may also be the case, of course, that natural disturbance factors (such as flooding or wildland fire) may prevent and control invasions because of the ability of native species to adapt and the vulnerability of exotic/nonindigenous species. Conversely, some exotic/nonindigenous species (such as nutria, starlings, bull frogs, smooth cord grass, and purple loosestrife) are capable of invading areas without artificial disturbance.

Physical and biological processes are important

For a restoration effort to reestablish desirable physical and biological processes, these processes must be clearly identified and their role in the ecosystem understood.

Physical processes

Physical processes include the following:

§ Hydrologic regimen (seasonal abundance, duration, and fluctuation of surface water in wetlands and riparian areas, and subsurface water in soil and aquifers)

§ Water quality (temperature, pH, nutrients, contaminants)

§ Fire regimen (spatial, physical, and temporal aspects)

	<p>§ Soil conditions (compaction, organic matter content, and nutrients)</p> <p>§ Nutrient cycling</p>
Biological processes	<p>Biological processes include the following:</p> <p>§ Succession Biodiversity (composition and structure, distribution and abundance of communities, keystone species, and ecotypes)</p> <p>§ Trophic elements (food webs)</p>
Rehabilitation and revegetation	<p>Sometimes full restoration is not practical and so-called Rehabilitation@ efforts should be considered. Rehabilitation may include any ecologically beneficial treatment short of full restoration. Revegetation using desirable plant species that are not necessarily native may help exclude invasive plant species.</p>
Minimizing the risk of invasion	<p>Although none of these three methods, full restoration, rehabilitation, or revegetation, will guarantee the exclusion of invasive species, without them the risk of invasion is certainly greater. In addition, short- and long-term monitoring of restoration projects is critical for making adjustments to ongoing management, to evaluating project success, and to developing future projects. (See Phase 3, p. 43.)</p>
	<p><i>Biological</i></p>
Biological control	<p>Biological control reduces population levels by intentionally using living organisms that selectively feed on, or interfere with, the life cycle of the target species. Classical biological control is the introduction and use of natural enemies, associated with the target species in its native habitat, to new areas where the target species has invaded.</p>
Bio-control agents	<p>Bio-control agents include microorganisms (bacteria, fungi, viruses, nematodes), invertebrates, and vertebrates. These agents function as antagonists toward a target species through their roles as parasites, predators, pathogens, and small or large herbivores.</p>
Benefits of bio-control agents	<p>Once established, bio-control agents reproduce, increase in number, and continue to restrict the proliferation of the host species without additional inputs. Furthermore, bio-control agents can move to new areas within their environmental adaptation and retain host specificity, thus minimizing ecological impacts. For these reasons, the Refuge System supports biological control programs and has developed a process for review of proposed new bio-control agents.</p>
Disadvantages	<p>On the down side, however, biological control may be limited by site-specific environmental conditions, may often take one or more years to produce measurable results, and (typically) will not eradicate infestations. (Biological control is most appropriate for well-established host populations that infest large areas.) Another risk is the potential for host-range expansion of bio-control agents.</p>

Implementation	To effectively implement a classical biological control program, the bio-control agent must be adapted to the environmental conditions of the target site and be cleared for release by federal and state agencies. The program also requires acquisition of appropriate and healthy bio-control species from a reliable supplier.
Need for assistance	The collection, distribution, shipping, release, and monitoring of bio-control agents is dependent on their biology, and is thus a complicated process. Regional IPM coordinators must have the capacity to assist field station staff with determining the feasibility of releasing nonindigenous bio-control agents and with implementation of such a program.
Augmentative biological control	Augmentative biological control is the use of natural enemies already present in the invaded area.
Implementation	Individuals in the target species population that appear damaged or diseased need to be located, identified, and sampled, in order to determine whether there are naturally occurring agents present within the invaded ecosystem. If the causal agent is a living organism, information about the biology of that organism needs to be acquired, and environmental factors that favor the proliferation of the organism need to be identified. If those factors can be manipulated artificially, the next step will be to determine the feasibility of implementing a plan for augmentative biological control.
Follow-up monitoring	Follow-up monitoring should be conducted for all introductions of biological controls, not only to determine if and how well they are becoming established and if they are providing effective control (they sometimes don't even when expected to do so), but also to identify and evaluate any unanticipated impacts on nontarget species.
Limitations and nontarget impacts	<p><i>Chemical</i></p> <p>Chemical control methods include herbicides, insecticides, poison baits, avicides, rodenticides, and piscicides. These methods can be an important component of many, if not most, invasive species control programs. (Regional and national IPM coordinators will be able to provide more specific guidance to the field regarding the use of these compounds.)</p> <p>Pesticides should only be used after careful evaluation of the biology and characteristics of the invasive species, a review of research on the effectiveness of alternative control technologies, and consideration of how they fit into an overall integrated management and restoration program. A thorough evaluation of nontarget impacts is also needed, especially when federally listed species and critical habitats may be impacted. The U.S. Environmental Protection Agency uses the Risk Quotient (RQ) method to determine the potential hazard to nontarget</p>

How to calculate the risk quotient (RQ)

organisms, including listed species.

Risk quotients are calculated by dividing acute and chronic exposure estimates by ecotoxicity values for various wildlife species. Risk quotients are then compared to levels of concern. Generally, the higher the RQ, the greater the potential risk. Risk characterization provides further information on the likelihood of adverse effect occurring by considering the fate of the chemical in the environment, any communities and species potentially at risk, their spatial and temporal distributions, and the nature of the effects observed in studies. This type of analysis is particularly useful for examining potential impacts on sensitive aquatic resources.

Pesticide use regulations

All pesticide use is covered by federal and state laws and regulations. In particular, the Federal Insecticide, Fungicide, and Rodenticide Act requires that all uses must conform to a particular product's label information. Anyone involved in the use of pesticides must routinely read labels and follow directions and restrictions (including the use of all required protective clothing). Failure to comply with label specifications will make the applicator vulnerable to prosecution. If applications of pesticides to water are needed, stations should contact their Regional Pesticide Use Coordinator to discuss regulatory requirements and protocols.

Pesticide Use Proposal (PUP)

In the U.S. Fish and Wildlife Service, all pesticide and other chemical applications (including adjuvants designed to enhance effectiveness) are covered by Service and departmental regulations, and a Pesticide Use Proposal (PUP) is required for all pesticide applications [26 and 27]. Regional Pesticide Use Coordinators have been designated in each region who can provide assistance.

U.S. Department of Interior
Pesticide Use Policy

In addition, if there are any federally listed threatened and endangered species, candidate species, or critical habitats in the action area, a determination must be made regarding potential impacts before using any chemical methods. U.S. Department of Interior *Pesticide Use Policy* (517 DM 1) states that it is permissible to use pesticides in habitats involving endangered and threatened animal and plant species only after it is determined that such use will not adversely affect the species or its critical habitat. This determination will be made through the Endangered Species Act consultation process prescribed in 50 CFR 402.

Implementation considerations for herbicides

Before herbicides are used for control of invasive plant infestations, six critical questions must be considered:

§ Is the plant annual, biennial or perennial?

§ What is the plant structure (tree, shrub, forb, or grass) and the depth

	<p>and nature of the particular species= root system?</p> <ul style="list-style-type: none"> § What is the size of the infestation? § How long has the infestation been established? § What are the site characteristics (such as soils, proximity to water, precipitation, threatened and endangered species presence, and site usage)? § What is the plant=s sensitivity to particular herbicides? <p>Additionally, effective control depends upon selecting the correct herbicide, concentration, and application method, as the vulnerability of invasive plants varies greatly.</p>
Timing of application	<p>The timing of applications is critical to achieve good control, as the growth stage at which an organism will be most effectively controlled varies with different species [28, 29, and 30]. Timing may also be critical to other organisms, such as insects.</p>
Successful implementation	<p>As was noted earlier, an understanding of the biology of the organisms, and their vulnerable times, may determine the overall effectiveness of a chemical control program. Also, if more than one pesticide has been shown to be effective on a particular species, then three factorsCtoxicity, potential nontarget impacts, and environmental persistenceCshould be weighed before proceeding. In addition, in well-established, large infestations, the use of multi-year applications may lead to pesticide resistance, so alternating two or more pesticides with different modes of action may be appropriate.</p>
Pesticide application methods	<p>There are a number of methods for applying pesticides:</p> <ul style="list-style-type: none"> § aerial applications § poison bait applications § broadcast spraying § wet-blade mower (which cuts and applies herbicide directly to the cut stalk) § backpack spraying § Ahack and squirt@ applications (which involve cutting into tree cambium and applying herbicide to the cut) § Aspot@ applications (using hand-carried sprayers@ § Aone-shot@ or timed releases directly into water <p>Economics and the need to minimize impacts on nontarget organisms will determine which method will achieve the desired control with the least amount of herbicide.</p>
Application rates	<p>Multi-year applications are usually needed to achieve long-term control or eradication. Single year applications, or delayed</p>

applications, can be counterproductive, setting back control programs up to several years. To ensure use of correct application rates, equipment must be carefully calibrated prior to use.

Phase 3: Monitoring, Evaluation, and Sustained Management

Need for baseline information

Integrated control programs must be monitored (like feed-back loop systems) to ensure that infestations are being evaluated using standard monitoring techniques that are dependent on a particular invasive species= biology. Baseline information can be obtained by using standard survey, sampling, and mapping procedures (as described on p.30).

Monitoring

Monitoring consists of repeated measurement over time. Observed changes can then be used to evaluate, quantitatively, rates of spread and/or efficacy of control. Monitoring intensity can be defined at three levels, low, moderate, or high, and is dependent on available resources. Implementation of monitoring standards under development by the Promises= Habitat Monitoring Team (WH 10) are recommended for invasive species. However, monitoring intensity may vary, depending on individual station resources and priorities. Until standards are established, several monitoring procedures can be useful and are described below.

Low intensity monitoring

Low intensity monitoring is most appropriate for detecting new infestations and to assess the effectiveness and effects of small-scale control operations. In low intensity monitoring efforts, the following actions should take place:

- § Annually survey the size and density of the infestation and deduce trends.
- § Consolidate information on control measures.
- § Conduct annual surveys of areas considered vulnerable to invasion but not yet infested.
- § Identify nontarget impacts

Moderate intensity monitoring

Moderate intensity monitoring is most appropriate for assessing integrated control programs for refinement or adaptive management. In moderate level intensity monitoring efforts, the following elements should be included:

- § Results of low level monitoring (as described above)
- § Photo points [16], or transects [17], or quadrats [14, 15]
- § Weather data

High intensity monitoring

- § Evaluation of education and awareness programs
- § Monitoring of funding sources and budget

High intensity monitoring is most appropriate for assessing large scale programs, experimental programs, and/or programs in environmentally sensitive action areas. In high level intensity monitoring efforts, the following elements should be included:

- § Results of low and moderate level monitoring (as above)
- § Increases in the monitoring frequency to 2-4 times per year
- § Establishment of Atest plots@ to compare different control methods (timing, rates and methods)
- § Use of databases and GIS
- § Statistical analysis
- § Chemical monitoring
- § Determination of impacts of infestations and/or control measures on sensitive species, other native species, indicator species, listed species, and general nontarget species

Evaluation

Evaluation using monitoring data is used to determine if implementation is achieving planning objectives. Analysis of monitoring data can be used to determine program efficacy and cost/benefit ratio.

Evaluation questions

A thorough evaluation should answer additional questions, including the following:

- § Was implementation consistent with planning and priority efforts?
- § Was the target population response to treatment acceptable (that is, did control efforts exceed the rate of spread, resulting in a net reduction, and can this be quantified)?
- § What were the impacts (direct, indirect, cumulative, positive and negative) to nontargets, including listed threatened and endangered species?
- § How can the program be improved?

Sustained Management

Invasive species management is a never-ending activity because of the insidious and explosive nature of the species themselves. Elimination of established populations of multiple invasive species has not yet been demonstrated in the 100-year history of the Refuge System. Examples of eradication resulting from early detection/rapid response measures are probably numerous, but these efforts can never

cease. Sustained management requires persistence and continuity and is essential to achieve a rate of control that exceeds the rate of spread. The integrated management approach provides our greatest opportunity to meet the invasive species challenge.

Cross-Linking to Other Service Programs and Efforts

Information exchange between different Service programs is needed to promote intra-agency coordination and facilitate invasive species management on the Refuge System.

Need for points of contact

Managing invasive species may involve coordination between the Division of Refuges and the Divisions of Environmental Quality and Endangered Species. Other potential interactions may include the Divisions of Realty, Fisheries, Coastal Programs, Partners for Fish and Wildlife Programs, and Migratory Birds State Programs (MBSP). To accomplish this coordination, knowledgeable points of contact (POCs) in each of these divisions must be identified.

Need for a streamlined process

Supervisory support is essential so that staff and time will be allocated to address critical invasive species issues. To minimize long-term costs to refuges and Service trust resources, POCs must be permitted to give priority to invasive species concerns and contribute to solutions. Formal or informal agreements need to be established between divisions to permit technical staff to cooperate on critical issues directly without the need for formal requests that take time and can get lost in the shuffle.

Recommendations for streamlining coordination

A model has been implemented for streamlining the U.S. Fish and Wildlife Service's review of biological control projects [31]. This model includes avenues for external coordination, although details of intra-agency coordination are lacking. These details should be included in the proposal, and the proposal should be adopted by the Service. In addition, this model should be used as an example of intra-agency coordination for all invasive species issues.

The Service plays an important regulatory and management role in the use of biological control organisms. Refuges have a responsibility for both the proper implementation of safe biological control agents, and the development of integrated biological pest management tools. One of the most effective ways to improve coordination regarding biological control agents is to implement fully the Service's streamlined process for the review of biological control agents, with each program of the Service identifying personnel responsible for review of new proposals.

The Director has recently called for the implementation of this new

streamlined process across the agency. Such implementation will greatly improve coordination and agency effectiveness related to this very important integrated pest management tool.

Information/Data Management and Reporting

Data standards

The U.S. Fish and Wildlife Service is using data standards to increase the quality and compatibility of its data. This approach will increase opportunities to share data and reduce incidents of redundant data. Standards are being developed, reviewed, and adopted according to a formal process. Current Service standards, as well development processes and definitions for those standards, are available via the Internet. (See Associate Websites, p. 49.)

Information usefulness

A tremendous amount of information on invasive species has been developed over the past several decades. Putting this information in the hands of staff, managers, and senior officials through a distributed, web-based information management system will give them the knowledge and tools they need to mount an effective and proactive campaign against invasive species.

Goal: Easy access to information

A critical goal is to facilitate the development of web-based information management systems for providing easy access to information on new invasive species. This goal encompasses three objectives, each of which includes specific action items:

- § Develop a web-based information system
- § Establish mechanisms for the Early Warning System
- § Develop and provide state-of-the-art technologies

First objective: Web-based information development

Foster the development of a web-based distribution information system that provides readily accessible information on the taxonomy, distribution, ecology, biology, classification (regulatory and ecological), impacts, and management of known and potential invasive species.

Action Item #1

Support development of and encourage information sharing between regional, national, and global invasive species databases such as the following:

- § Aquatic Nonindigenous Species Database (U.S. Geological Survey)
- § Global Invasive Species Database (Invasive Species Specialist Group, World Conservation Union)
- § Global Invasive Species Program
- § Invaders Plant Database (University of Montana)
- § Invasive Plant Atlas of New England (U-CONN) Inter-American Biodiversity Information Network (IABIN)

	<p>§ National Agricultural Pest Information System (NAPIS) (USDA Animal and Plant Health Inspection Service)</p> <p>§ Plants Database (USDA Natural Resource Conservation Service)</p> <p>§ Southwestern Exotic Mapping Program (SWEMP) (U.S. Geological Survey)</p> <p>§ Refuge System Invasive Species Inventory Database (USGS, FWS)</p>
Action Item #2	Develop a biodiversity information network to link and integrate existing invasive species databases through a central, searchable Internet gateway (such as the North American Biodiversity Information Network and the USGS NBII Invasive Species Science Node).
Action Item #3	Develop an early detection module within existing databases and include information on new invasive species, as well as information about and links to a National Early Warning and Rapid Response System for Invasive Species.
Action Item #4	Support continued development of taxonomic standards through the Integrated Taxonomic Information System (ITIS) (Smithsonian Institution and U.S. Geological Survey) and online identification aids.
Action Item #5	Develop an Early Warning Partner listserv for sharing knowledge and management experience relevant to new invasive species.
Action Item #6	Develop protocols for ensuring the quality of all data entered into the system.
Second objective: Electronic mechanisms for Early Warning System	Establish electronic mechanisms to assist the public in learning about the Early Warning System, and show them how to report suspected new invasive species.
Action #1	Establish a toll free number.
Action #2	Develop an Early Warning System website.
Third objective: State-of-the-art technologies	Develop and provide state-of-the-art technologies to ensure continued effectiveness and efficiency of all system elements.
Action Item #1	Identify system research needs.
Action Item #2	Encourage partner agencies such as the USDA Agriculture Research Service and the USGS Biological Resources Division to provide state-of-the-art technologies for early warning and rapid response activities such as remote sensing, geospatial analysis, GIS, and

| management.

Associated Websites

USFWS Invasive Species Programs <<http://invasives.fws.gov>>

Animal and Plant Health Inspection Service (APHIS) <<http://www.aphis.usda.gov/>>

Center for Integration of Natural Disaster Information (CINDI) (U.S. Geological Survey).
<<http://cindi.usgs.gov/>>

Cooperative State Research, Education, and Extension Service <<http://www.reeusda.gov/>>

Council on Environmental Quality (CEQ) <<http://www.whitehouse.gov/ceq/>>

Exotic Pest Plant Councils, including the Southeastern Exotic Pest Plant Council (<http://www.se-eppec.org>, with links to state sites), and the California Exotic Pest Plant Council (<http://www.caleppc.org>)

Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) <<http://refuges.fws.gov/FICMNEWFiles/FICMNEWHomePage.html> >

FICMNEW Early Warning Workshop Proceedings
<<http://refuges.fws.gov/FICMNEWFiles/FICMNEWHomePage.html> >

Flora of North America Project <<http://hua.huh.harvard.edu/FNA/>>

Giant Salvinia (*Salvinia molesta* D.S. Mitchell), *Fact Sheet and Distribution Map*
<http://nas.er.usgs.gov/plants/sa_molesta/docs/sa_mol.html>

Global Invasive Species Program (GISP) <<http://jasper.stanford.edu/GISP/>>

Integrated Taxonomic Information System (ITIS) <<http://www.itis.usda.gov/>>

National Invasive Species Council <<http://www.invasivespecies.gov/council/main.shtml>>

Natural Resource Conservation Service <<http://www.nrcs.usda.gov/>>

National Invasive Species Management Plan
<<http://www.invasivespecies.gov/council/nmp.shtml>>

North American Weed Management Association (NAWMA) <<http://www.nawma.org/>>

Colorado Natural Areas Program <http://parks.state.co.us/cnap>

Aquatic Nonindigenous Species Database (U.S. Geological Survey) <<http://nas.er.usgs.gov/>>

GLOBAL INVASIVE SPECIES DATABASE (Invasive Species Specialist Group, World Conservation Union) <<http://www.issg.org/database/welcome/>>

GLOBAL INVASIVE SPECIES PROGRAMME < <http://jasper.stanford.edu/GISP/>>.

INTER-AMERICAN BIODIVERSITY INFORMATION NETWORK (IABIN)
< <http://www.iabin-us.org/index.html>>

INVADERS Plant Database (University of Montana) <<http://invader.dbs.umt.edu/>>

INVASIVE PLANT ATLAS OF NEW ENGLAND (U-CONN)
<www.eeb.uconn.edu/invasives/ipane>

NATIONAL AGRICULTURAL PEST INFORMATION SYSTEM (NAPIS) (USDA Animal and Plant Health Inspection Service) <<http://www.ceris.purdue.edu/napis>>

National Park Service Alien Plants Factsheets www.nps.gov/plants/alien/factmain.htm

PLANTS Database (USDA Natural Resource Conservation Service)
<http://plants.usda.gov/plants/home_page.html>

SOUTHWESTERN EXOTIC MAPPING PROGRAM (SWEMP)
(U.S. Geological Survey) < <http://www.usgs.nau.edu/swemp/>>

The Nature Conservancy www.tnc.ucdavis.edu

United States Department of Agriculture (USDA) <<http://www.usda.gov/>>

United States Department of the Interior (DOI) <<http://www.doi.gov/>>

United States Environmental Protection Agency (EPA) <<http://www.epa.gov/>>

United States General Accounting Office (GAO) <<http://www.gao.gov/>>

United States Geological Survey (USGS) <<http://www.usgs.gov/>>

USDA Agriculture Research Service <<http://www.ars.usda.gov/>>

USDA Forest Service (FS) <<http://www.fs.fed.us/>>

USGS Biological Resources Division <<http://biology.usgs.gov/>>

California Department of Food and Agriculture, database of invasive plant species
<http://pi.cdafa.ca.gov/weedinfo/Index.html>

Calflora databases of invasive plant species available <http://www.calflora.org/>.

USGS methods for sampling fish communities, aquatic invertebrates, and algae
<http://water.usgs.gov/nawqa/protocols/>.

US Fish & Wildlife Service data and metadata standards adopted by the Service
<http://www.fws.gov/stand/>

US Fish & Wildlife Service, *Fire Management Handbook*
<http://fire.r9.fws.gov/fm/policy/HANDBOOK/>

References

[Note: A * before the citation indicates the reference is available on the National Strategy Compact Disk.]

1. *U. S. Fish and Wildlife Service, *Comprehensive Conservation Planning Process: Step-down Management Planning* (602 FW 4), 2000.
2. *U. S. Fish and Wildlife Service, *Comprehensive Conservation Planning Process; Step-down Management Planning: List of Step-down Management Plans* (602 FW 4; Exhibit 1), 2000.
3. *U. S. Fish and Wildlife Service, *Refuge System Uses: Compatibility* (603 FW 2), 2000.
4. *U. S. Fish and Wildlife Service, *Comprehensive Conservation Planning Process; Step-down Management Planning* (602 FW 3), 2000.
5. *U. S. Fish and Wildlife Service, *Environmental Assessment Development Guidance*, undated.
6. *U. S. Fish and Wildlife Service, *NEPA Compliance Checklist*, undated.
7. *U. S. Fish and Wildlife Service, *NEPA Glossary*, undated.
8. *The Nature Conservancy, *Site Weed Management Plan Template*, 1999.
9. *Colorado Natural Areas Program, *Weed Management Plan Outlines* (Appendix 3), 2000.
10. *ANS Task Force, *Guidance for State and Interstate Aquatic Species Management Plans*, undated.
11. *U.S. Environmental Protection Agency, *Guidelines for Ecological Risk Assessment* (EPA/630/R-95/002F), Washington, D.C., 1998
12. *The Nature Conservancy, *Alien Plants Ranking System* (Version 5.0), 1999.
13. *R. D. Hiebert and J. Stubbendieck, *Handbook for Ranking Exotic Plants for Management and Control* (Natural Resources Report NPS/NRMWRO/NRR-93/08), U.S. National Park Service, Midwest Regional Office, Omaha, Nebraska, 1993.
14. * *Cover: Protocol to Estimate Percent Cover by Species in a Transect*, undated.
15. * *Frequency: Protocol to Estimate Abundance by Species in a Transect*, undated.

16. * Photopoint Monitoring Protocol, undated.
17. *Colorado Natural Areas Program, *Weed Abundance and Monitoring Data Sheets*.
18. **Montana Weed Mapping Handbook: Montana Noxious Weed Survey and Mapping System* (Version 2.0), undated.
19. **Mapping Noxious Weeds in Montana*, undated.
20. Trimble Navigation, Ltd., *Mapping Systems General Reference* (Revision C, number 24177-00), Sunnyvale, CA, 2002.
21. U. S. Department of Agriculture, *Guidebook for the Preparation of HACCP Plans: Food Safety and Inspection Service*, (HACCP-1), Office of Policy, Program Development, and Evaluation, Inspection Systems Development Division, Washington, D.C., 1999.
22. *U.S. Department of Agriculture, Forest Service, *Guide to Noxious Weed Prevention Practices*, 2001.
23. *Michigan Department of Environmental Quality, *Aquatic Nuisance Species Handbook for Government Officials*, Office of Great Lakes, 1999.
24. *Federal Interagency Committed to the Management of Noxious Weeds, *National Early Warning and Rapid Response System for Invasive Plants in the United States* (draft action plan), Washington, D.C., 2002.
25. *U.S. Geological Survey, Biological Resources Division, *Invasive Species Survey and Report: Project Plan*, undated.
26. *U.S. Department of the Interior, *Pesticide Use Proposal Template*, undated.
27. *U.S. Department of the Interior, *Instructions for Completing the PUP Form*, undated.
28. *Colorado Natural Areas Program, *Herbicide Basics*, 2000.
29. *Colorado Natural Areas Program, *Herbicide Use Guideline*, 2000.
30. *Colorado Natural Areas Program, *Susceptibility of Some Colorado Noxious Weeds to 2,4-D, Dicamba, Picloram and Glyphosate Herbicides*, 2000.
31. *U.S. Fish and Wildlife Service, *Process for Streamlining the U.S. Fish and Wildlife Service=s Review of Biological Control Projects under the Technical Advisory Group for Biological Control of Weeds, the National Environmental Policy Act (NEPA), and the Endangered Species Act (ESA)*, undated.

32. *A. Clewell, J. Rieger, and J. Munro, *Guidelines for Developing and Managing Ecological Restoration Projects*. Society for Ecological Restoration, 2000. Downloadable PDF available at <http://www.ser.org>
33. *Colorado Natural Areas Program, *Native Plant Revegetation Guide*, 1998. Downloadable PDF available at http://cnap.state.co.us/Revegetation_Guide/Reveg_index.html
34. S. Packard, C.F. Mutel, et. al., *The Tall Grass Restoration Handbook*, Society for Ecological Restoration, Island Press, Washington, D.C./Covelo, CA, 1997.
35. * U.S. Dept. of Agriculture, *Stream Corridor Restoration: Principles, Processes, and Practices*, 2000. Downloadable PDF available at http://www.usda.gov/stream_restoration/newtofc.htm
36. *U.S. Dept. of Interior, *Burned Area Emergency Stabilization and Rehabilitation: General Policy and Procedures* (departmental manual, part 620 DM 3), 2001. Downloadable WPF available at <http://elips.doi.gov/elips/release/3358.htm>
37. The North American Weed Management Association (NAWMA) has further developed these procedures. (See <http://www.nawma.org>)
38. *The Role of Fire in the Control and spread of Invasive Species*, Tall Timbers Research Station, Mic Pub No. 11, undated.
39. *Wildland Fire in Ecosystems; Effects of Fire on Flora*, USDA General Technical Report, RMRSA-GTR-42, Volume 2, December 2000.
40. *Fire Management Handbook*, Chapter 5 (ABurned Area Emergency Rehabilitation@). See <http://fire.r9.fws.gov/fm/policy/HANDBOOK>
41. A. Trent, D. Karsky, and S. Gilmour, *MTDC Portable Vehicle Washer: Interim Report*, Technical Report 0234-2836, MTDC, U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center, Missoula, Montana, 2002.
42. Executive Order 13112, *Invasive Species*, February 3, 1999.
43. Executive Order 13148, *Greening the Government through Leadership in Environmental Management*, Part 2: Goals, Section 207, April 21, 2000.
44. J.D. Urban and N.J. Cook, *Hazard Evaluation Division: Standard Evaluation Procedure, Ecological Risk Assessment*, PB86-247657, EPA 540/9-86/167, U.S. Environmental Protection Agency, Office of Pesticide Programs, 1986.

C: Special Designation Areas Management

Introduction

Definition of
Aspecial
designation@

In addition to refuge status, the Aspecial@ status of lands and waters within individual refuges may be recognized by special designations, either legislatively or administratively. Special designation may also occur through the actions of other agencies or organizations.

Management
responsibility of
special land
designations

The influence that special designations have on the management of refuge lands and waters may vary considerably. A wide variety of special land designations currently overlay National Wildlife Refuges. At least 175 refuges have special management areas of one type or another. Authority for designation of some special management area types (for example, Research Natural Areas) on refuges lies solely with the Service. However, management responsibility for most special designated areas is held or shared with others.

Special
management areas

Special management areas found in the Refuge System include the following:

- \$ Biosphere reserves
- \$ Wilderness areas
- \$ Marine protected areas
- \$ Cultural resource sites
- \$ Historic sites
- \$ Land Management Research Demonstration Refuges
- \$ Public use natural areas
- \$ Research natural areas
- \$ Wild and scenic rivers
- \$ Critical habitats for endangered and threatened species
- \$ National natural landmarks and national trails.
- \$ Important Bird Areas

Additionally, some overlay designations may place refuges within internationally recognized lands, such as Western Hemisphere Shorebird Reserves and Wetland of International Importance (according to the Ramsar Convention). Refuges may also be included within much larger special management areas designated by other agencies or organizations, such as National Marine Sanctuaries, Estuarine Sanctuaries, and Biosphere Reserves.

Invasive Species Impacts and Management in Special Designation Areas

Need for proactive management alternatives

Despite what overlay designations or special management needs are in effect for these areas, invasive species can, and likely will, complicate the management situation for the refuge. In most cases, activities to prevent, control, or eradicate aquatic or terrestrial invasive species in Special Designation Areas will be no different than management efforts on more typical refuge lands and waters. However, due to management activity restrictions, special agreements with cooperators, legal constraints, or habitat sensitivities, the refuge staff may need to develop invasive species management alternatives that are compatible with the purpose and establishment of certain Special Designation Areas. Each individual situation may have unique requirements to address, yet there are some universal considerations for all refuge Special Designation Areas. The key to addressing invasive species in Special Designation Areas, as with any successful invasive species management program, is to be proactive rather than reactive.

Some Basic Considerations for Managing in Special Designation Areas

Vulnerability of Special Designation Areas

Special Designation Areas are usually established due to some significant resource, unique feature, historic or cultural value, or critical ecological value. The sensitive nature of these areas may cause them to be more vulnerable to the aggressive and threatening nature of aquatic or terrestrial invasive species.

Legal restrictions

Legal restrictions may need to be considered when attempting to prevent invasive species infestations or manage invasive species if they become established in Special Designation Areas. For example, some areas designated as critical habitats for endangered species (as defined by the Endangered Species Act) may need added emphasis on planning to prevent damage to the habitat or the endangered species.

Treaty violations and need for cooperation

Invasive species management, as outlined in Ramsar Wetlands (Wetlands of International Importance), warrants particular attention to maintain the integrity and ecological function of those wetlands and prevent degradation of the sites that would violate provisions of the treaty. An important facet of invasive species management in other areas that are established or managed under similar cooperative agreements or treaties is the need to work cooperatively with the

associated organizations or agencies to achieve effective results.

Research Natural Areas: specific approaches

To complicate matters further, areas such as Wild and Scenic Rivers or Research Natural Areas are part of a national network of reserve areas under various ownership. (The Refuge System currently has 201 Research Natural Areas totaling more than 1.9 million acres.) In Research Natural Areas, natural processes dominate the management strategy. However, since invasive species infestations are usually not considered part of the natural process of native ecosystem function, prevention and elimination of invasive species from Research Natural Areas requires particular attention. Under certain conditions, such as the establishment of an invasive species, manipulation of the habitats in a Research Natural Area may be used to maintain the unique features for which the area was established.

Additional Considerations for Certain Special Designation Areas

Wilderness Areas

More than 20 million acres of the Refuge System are part of the Wilderness Preservation System. Management of invasive species in these areas must be compatible with the provisions outlined in the Wilderness Act of 1964.

Need for prompt response

In addition, the Refuge System has developed policy for management of invasive species within wilderness areas, emphasizing a low-impact approach to alleviate the significant risk that invasive species pose to refuge wilderness and native ecosystem function. Managers must pay close attention to the actual impacts and potential degradation of wilderness from invasive species infestations, and (even more importantly) recognize that delays in responding to those infestations make it all the more difficult to employ the minimum tools to deal with the infestation.

The Wilderness Management Policy

Refuge Managers can design an effective integrated management program (including pesticides, biological control, and mechanical removal) to address invasive species threats to refuge wilderness by following the guidance provided in the US Fish & Wildlife Service's *Wilderness Management Policy* (610 FW 1-5). **Reintroduction, transplanting, or stocking of nonindigenous fish, wildlife, and plants in wilderness areas is not permitted.**

On the other hand, species traditionally stocked before wilderness designation may continue to be managed if they meet the

Control in
wilderness areas:
three conditions

criteria established in the *Wilderness Management Policy*. Suitable stocking levels and indigenous species will be determined for a given wilderness area in consultation with state fish and wildlife agencies. Local genetic strains will be used whenever possible. Fertilizer and supplemental food will not be used to enhance artificially fisheries or other wildlife resources.

Invasive species, pests, and diseases may be controlled in wilderness areas when at least one of the following three conditions is met:

§ A high probability exists that they will degrade the biological integrity, diversity, environmental health, or character of a wilderness area.

§ There is a significant threat to the health of humans.

§ There is a significant threat to the health of wildlife and habitat.

Within wilderness areas, an integrated pest management (IPM) approach will be used to prevent, control, or eradicate invasive species, pests, and diseases, subject to the criteria in 606 FW 1, 606 FW 2, and the *Wilderness Management Policy*.

Marine Protected Areas

Approximately 30 percent of the Refuge System has been designated as a Marine Protected Area (MPA), including approximately 2.6 million acres of reef and associated ocean habitats. These marine areas, and the associated land components, are particularly sensitive to exotic species infestations. Refuge managers should be aware that actions taken in the uplands have been shown to affect the marine systems and the transition areas between.

Invasive species in
Marine Protected
Areas

Obviously, the complexity of managing marine systems is exacerbated by invasive species, particularly in Marine Protected Areas and reefs. The number of invasive species is expanding worldwide, and in marine systems, they range from exotic diseases to larger invasive organisms such as nonindigenous fishes, exotic mollusks, aggressive crustaceans, and alien corals. Much like their terrestrial counterparts, native healthy coral reefs and associated marine environments have biological diversities that rival the rainforests, and they are even more sensitive to invasive species impacts. When the problem is compounded by factors such as contaminants deposition and sea-level rise, managing the invasive species problems in marine systems and related special designation

areas becomes critical.

Need for cooperation and communication

Refuge staff should work closely with marine specialists, universities, the U.S. Geological Survey, and other agencies to collect and maintain current knowledge about which invasive exotic species may be impacting these areas and to recommend steps to alleviate those impacts through prevention or other management activities.

Successful invasive species program for reefs and other marine special designated areas

A successful invasive species program for reefs and other related marine special designation areas includes five primary components:

§ Know what the situation entails. An inventory of marine fauna and flora within the MPA provides baseline data needed to determine the presence and/or extent of invasive species. (Also refer to the discussion of mapping on p.30 of this document.)

§ Monitor the marine area for change (biological, physical, and chemical). Standardized surveys are needed to document the occurrence and spread of nonnative invasive species in a timely manner. (Refer to the section on monitoring, page 43.) Maintain natural communities with the least disturbance possible.

§ Evaluate all human activities to make sure they are appropriate and compatible with the purpose of the MPA.

§ Identify pathways and vectors of possible alien species and then develop a prevention program to address their management. Remove exotic species with minimum disturbance to these delicate systems, using HACCP and other agency-endorsed prevention techniques. When populations of nonnative invasive marine species are discovered, the refuge needs to use the best method to control the invasion with minimal effect on nontarget species. By using early detection/rapid response, the refuge can address problems before they cause ecological harm and become too costly.

Glossary of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ANS	Aquatic Nuisance Species
AUM	Animal Unit Month
BRD	Biological Resources Division
CCP	Comprehensive Conservation Plan
CD	Compatibility Determination
DEM	Digital Elevation Model
DEQ	Division of Environmental Quality
DOQ	Digital Orthophoto Quadrangle
DRG	Digital Raster Graphic
EA	Environmental Assessment
EDDR	Early Detection/Early Response
EIS	Environmental Impact Statement
FICMNEW	Federal Interagency Committee for the Management of Noxious Exotic Weeds
FTE	Full-Time Employee
GIS	Geographic Information System
GPS	Global Positioning System
HACCP	Hazard Analysis and Critical Control Point
IABIN	Inter-American Biodiversity Information Network
IPM	Integrated Pest Management
ITIS	Integrated Taxonomic Information System
MBSP	Migratory Birds and State Programs
MMS	Maintenance Management System
MOU	Memoranda of Understanding

MPA	Marine Protected Areas
NAD	North American Datum
NAPIS	National Agricultural Pest Information System
NAWMA	North American Weed Management Association
NCTC	National Conservation Training Center
POC	Point of Contact
PUP	Pesticide Use Proposal
QA	Quality Assurance
QC	Quality Control
RCAR	Refuge Comprehensive Accomplishment Report
RO	Regional Office
RONS	Refuge Operations Needs System
SPCS	State Plane Coordinate System
SUP	Special Use Permit
SWEMP	Southwestern Exotic Mapping Program
T&E	Threatened and Endangered
TAG-BCW	Technical Advisory Group for Bio-control of Weeds
U-CONN	University of Connecticut
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WGS	World Geodetic System
WO	Washington Office