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Invasive Plant Protocol for Northern Colorado Plateau Parks

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Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	09/2013	D. Perkins	Editorial changes based on peer review comments	Clarity	1.01

Important Note: This sampling protocol consists of this protocol narrative and the following standard operating procedures (SOPs) and appendices:

- SOP 1: Preparations and Equipment Setup Prior to the Field Season
- SOP 2: Training Observers
- SOP 3: Monitoring Route Methods
- SOP 4: Extra Area Searches
- SOP 5: Monitoring Lite

- SOP 6: Using GPS
SOP 7: Data Management
SOP 8: Data Analysis
SOP 9: Prioritization
SOP 10: Revising the Protocol

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I. Introduction

Invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are second only to habitat loss from human development as threats to global biodiversity (Scott and Wilcove 1998) and represent one of the most serious threats to natural ecosystem integrity (National Research Council 2002). Biological invasions are occurring at accelerated rates in nearly every major ecosystem globally (Mooney and Hobbs 2000). NPS Management Policies (NPS 2001) state that “high priority will be given to managing exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controllable.” Exotic plants negatively affect park resources and visitor enjoyment by altering landscapes and fire regimes, reducing native plant and animal habitat, and increasing trail maintenance needs. Recognizing these challenges, Northern Colorado Plateau Network (NCPN) parks identified invasive exotic plants as a high priority vital sign.

Invasive exotic plants (IEPs) are a subset of exotic plants “whose introduction does or is likely to cause economic or environmental harm or harm to human health” (Executive Order 13112). In order to manage IEP’s effectively, strategic control methods are essential and are predicated on early detection. With the need for strategic control approaches in mind, this monitoring protocol detects early invasions, identifies existing invasions, and, to the extent possible, tracks changes in the abundance and distribution of IEPs in parks. This protocol is adaptable allowing approximately 25% of the annual effort to be directed towards “extra-area” searches (i.e., searches occurring beyond standardized methods) in places that parks need a quick rapid inventory. Examples could be a new burn, change in land management within a park or adjacent to a park, or an anecdotal report of a threatening new invasive plant. In some years there may not be any extra area searches conducted; in other years, multiple surveys may be needed.

National Parks are deluged by a whole host of new IEPs arriving through a variety of pathways and present a significant challenge to the agency’s ability to maintain natural resources “unimpaired for the enjoyment of future generations”. Predictable pathways include roads, trails, and riparian corridors. Sudden pathways include long distance dispersal through cargo containers and air freight. Anthropogenic pathways include horticultural escapes and seeds carried on shoes, in restoration seed mixes, and many more. IEPs infest an estimated 2.6 million (1,052,183 ha) acres of the 83 million acres (33,588,908 ha) managed by the NPS.”

NPS lands are infested daily despite diligent efforts to curtail the spread of IEP’s. Impacts from IEP species have been realized in most parks, resulting in an expressed need to control existing infestations and restore affected ecosystems. There is a growing urgency to be proactive—to

protect resources not yet impacted by current and future IEPs (Marler 1998). IEPs are currently, and certainly will continue to be a management priority for NPS well into the future. In 2006, the NPS drafted an Invasive Species Action Plan (NPS 2006) to address how the agency will fight current and future invasions. This document addressed strategies ranging from prevention and early detection to monitoring to restoration to public outreach and education.

Strategic control of IEP's requires a large-scale, comprehensive approach to effectively maintain and manage ecosystem landscapes in their natural state. In their review of the status of biotic invasions, Mack et al. (2000) stated in no uncertain terms that "control of biotic invasions is most effective when it employs a long-term, ecosystem-wide strategy rather than a tactical approach focused on battling individual invaders." Therefore, effective control of IEPs requires managers to match management strategies with individual tasks at hand. Prevention of plant invasions is the most effective, economical, and ecologically sound approach to managing invasive species. When preventative measures are not successful, early detection of new invasions is the next critical step. To do this, three approaches are employed: first, early detection methods should be employed to find and subsequently eradicate incipient populations of IEPs while these measures are still feasible and cost effective; second, control strategies should be applied to existing populations that require a more substantial resource investment to mitigate associated impacts; and third, containment measures should be used when populations have become so entrenched that removal and effective control are impractical.

Detecting invasive species before they become established has been a longstanding practice in agriculture, with point-of-entry and distribution inspections, insect traps, and nursery certification, but has not been widely used by other resource land managers in invasive species monitoring and management programs. Early detection followed by rapid response is cost-effective in that it removes a species before it establishes within a park where once established, it can spread quickly (OTA 1993, Myers et al. 2000, Timmins and Braithwaite 2002, Harris et al. 2001, Rejmanek and Pitcairn 2002). Hobbs and Humphries (1995) identified a significant time lag between the initial establishment of an invasive exotic plant and its rapid expansion toward local carrying capacity. Control efforts initiated during this lag phase are likely to cost less and achieve higher success rates compared to efforts begun later in the invasion cycle (Hobbs and Humphries 1995). In addition to saving money, early detection and rapid response efforts minimize ecological damage by preventing habitat fragmentation and ecosystem degradation associated with large or widespread invasive species populations.

Comprehensive monitoring for exotic plants across all areas of all NCPN parks is impractical and quite expensive and beyond the fiscal capabilities of the I&M network and the parks. Therefore, strategies to maximize the effectiveness of exotic plant surveys to maximize their usefulness are essential. Through individual park base funding, natural resource projects, and I&M Network inventory efforts, some parks have completed inventories to initially describe the distribution and abundance of exotic plant species (Dewey and Anderson 2005 a, b, c and more). However, while useful, these inventories become quickly outdated for these purposes as exotic plant invasions are quite dynamic. Therefore NCPN is concentrating surveys on the most likely infestation areas for a suite of invasive exotic plants to occur, riparian corridors, roads, trails, areas of high visitor impact (campgrounds), and park boundaries. While this approach can miss wind and animal dispersed exotic plants that invade in the interior of large parks, it is the most cost-effective approach available at this time and is outlined in this protocol.

II. Protocol Objectives

1. Detect incipient populations and new introductions of invasive exotic plant species before they become established in areas of management significance.
2. Determine status and trends of selected populations of invasive plants of management significance.

III. Sampling Design

Sampling Design Overview

Monitoring for IEPs in parks consists of three methodologies. First, IEPs are mapped along monitoring routes that are along invasive pathways. Transects, each with 3 quadrats, are placed every 500-1000 m along the monitoring routes to provide consistent interannual surveys of selected park areas that can assess long-term changes in IEP distributions and densities. Monitoring routes are conducted every 3-5 years depending on number of routes to be monitored and the extend of infestations. Second, extra- area searches are periodic surveys in locations of likely invasion that lie beyond the distribution of the monitoring routes. Third, NCPN developed a monitoring lite version of the monitoring routes. The lite methods are a simpler version of the monitoring routes without the transects and fewer species and are designed to be done by park employees or volunteers that can identify a few IEP species.

Rationale for Selecting Sampling Design

Given mapping, sampling, and modeling challenges, the sampling design for this protocol was selected to balance multiple goals, including identifying high priority invasive exotic plants, ensuring maximum spatial coverage, detecting new plant invasions, monitoring multiple species simultaneously, tracking changes in abundance and distribution of existing invasions, and ability to adaptively react and address management priorities (recent fire, change in land use on an adjacent property, site disturbance), while working within program capacity. The primary focus of this protocol is to conduct routine monitoring along areas where invasives are most likely to invade, specifically roads, trails, and riparian corridors. The protocol emphasizes the quick collection of IEP location and abundance data to maximize the area searched. Maximizing the search area provides the greatest opportunity to find new invasions and established IEPs in parks. Roads, trails, and waterways are major vectors for invasive plants, which tend to clump along these corridors. Searching these areas will capture the greatest amount of information for relatively low effort.

Unlike many other monitoring programs where the management threshold upon which a manager would take management action is often unknown, the management threshold for IEPs is known and clear. Because of the rapid invasion population dynamics of these types of plants, if there is even one IEP present, there is a management problem to consider.

A perfect map showing all IEPs in each national park unit would fully meet most basic inventory and monitoring needs. As an inventory product, maps comprehensively identify and locate IEPs, allowing natural areas resource managers to assess the scope of the problem, strategically plan management, and prescribe actions for exact locations. From a monitoring standpoint, maps with reasonably small minimum mapping units (i.e. mapping infestations less than 0.1 hectare) reproduced accurately over time would clearly detect changes in the abundance and distribution (i.e., spread) of IEPs. These maps, combined with information on the locations of treatments applied to IEPs, could also assess management effectiveness of particular treatments over time. Wide-spread interest among park staff in weed mapping reflects the potential benefit of such maps and the availability of GPS technology.

Numerous weed mapping efforts have been initiated in many countries and by local, state, federal, and non-governmental agencies in the United States. The North American Weed Management Association (NAWMA) has issued guidelines to bring a minimum level of standardization to mapping efforts in North America (NAWMA 2002), to which the National Park Service has signed on as a participating member.

Given that complete mapping of all IEP's is generally not possible to do in a comprehensive fashion nor often enough, a few alternatives are available:

1. *Develop statistically rigorous measures of IEP cover and frequency:* A precise measurement of IEP cover or frequency would provide a strong indicator of spread over time or increasing density in a given location. However, the spatiotemporal variability in IEP populations, especially small, widely scattered populations results in numerous zeros when sampling, and eradication of detected infestations makes permanent quadrats infeasible precluding precise and powerful estimation. Additionally, a lack of spatial referencing prevents managers from determining what plants may impact areas that protect particularly valuable resources.
2. *Limit mapping or sampling to suitable habitat or likely points of invasion:* Targeting monitoring to invasion pathways or suitable habitat may greatly increase sampling efficiency and the precision of abundance and frequency estimates. However, this approach depends on the availability of an accurate habitat model for each IEP species. As with all models, sample size and methods affect model accuracy. Given the tendency of IEPs to expand their range, even accurate maps may not reflect the invasion potential of a plant. The need to monitor multiple IEP species simultaneously can also diminish the practicality of this approach. In short by the time you know enough about an IEP to develop statistically rigorous model, the IEP is already a problem in a park or area.
3. *Combine sampling with a landscape modeling approach to determine likelihood of occurrence:* Combined with spatially referenced habitat data, sampling may be used to map the probability of IEP occurrences on the landscape. These maps show a generalized area where the species may be located and can estimate the percentage of potential habitat occupied. In this regard, the maps can provide a powerful assessment tool for management planning and for improving search or sampling efficiency (see #2). Once management decisions are made, managers must still survey high probability areas for exact IEP locations. Limited data can compromise the reliability of these habitat maps since small invasions provide little site-based habitat information, requiring extrapolation from other invaded sites or from the native range. The ability of such designs to determine change in IEP abundance or frequency may suffer from the same problems mentioned above (see #1).
4. *Map changes in IEP distribution and abundance using remotely sensed imagery:* Successful identification of IEPs from remotely sensed imagery offers the potential to track changes in distribution and abundance over extremely large areas. This has been accomplished for a number of species in rangelands where interference from tree canopies is limited. Developing reliable reflectance signatures used for remote sensing for IEPs may depend on distinct phenological or habitat characteristics, as well as relatively large patch sizes (Young and Schrader 2007). Signatures can only feasibly be developed for a relatively small number of species.

Monitoring Routes

Approximately 75% of NCPN IEP monitoring efforts each year will be focused on surveys associated with transects along monitoring routes. Transects are more statistically sound than simply mapping IEPs, and increase the power of the data collected. Transects also make the samples comparable to other monitoring standards (e.g. Forest Health Monitoring, Forest Inventory and Analysis, USGS Modified- Whittaker technique and others).

Along monitoring routes, monitoring transects with quadrats are established to collect data for trend estimates. These transects provide an estimate of actual cover, a method to calibrate ocular and other cover estimates, models the patches of missed and less sampled non-native species, and a method for understanding which habitats and sites are being invaded. Within the park, NCPN and park staff identify monitoring routes of management importance, with re-visits ranging from 1 to 5 years depending on the number of routes that a park wants covered and the severity of IEP infestations along a given route.

Prioritization of Invasive Species

NCPN will work with a variety of sources in order to prioritize which invasive species to monitor and to be aware of new species that could soon invade a park. NCPN will work with park staff, county and state weed managers, and run all potential invasive species through a prioritization process (SOP 11).

III. Field Methods

Monitoring Route Methods (SOP 3)

Monitoring routes will follow roads, trails, and riparian areas in a park. As monitoring routes are traversed, locations of all target species are documented. Once a plant or patch/infestation has been discovered, a mapping crew must record: 1) the monitoring route and monitoring segment, 2) GPS location and size of infestation, 3) whether the plant was pulled, and 4) an estimate of canopy cover. Each new observation will be notated using a sequential survey number.

It is important to note that not all non-native species that are found will be mapped during these actual surveys. For example cheatgrass (*Bromus tectorum*) that may be dominant across a park or a portion of the park will not be individually mapped, however it will be recorded in the quantitative transects. These species are identified prior to surveying any individual monitoring route.

Transects with 3 1-m² vegetation quadrats are established every 500-1000 m along each monitoring segment. Along each transect quadrats are centered at 0.5, 5 and 10 m away from the route. Invasive plant and habitat cover measurements are taken within the 1-m² quadrat.

In general, IEPs at a particular park will be monitored at the same time of year. Consistency in timing of surveys should maintain consistency in detection probabilities and cover estimates for most species. For many species, sampling any time during May-September is not expected to drastically alter monitoring results. However, sampling after May could prevent detection or identification of spring blooming exotic plants and exotic cool season grasses. Surveyors will usually cover no more than five to ten kilometers of the project area per day, depending on target invasive plant densities, vegetation, and terrain.

Extra Area Searches (SOP 4)

Invasive plants are rapidly expanding and can quickly colonize new areas that may not be part of routine monitoring routes. Therefore NCPN will allocate up to 25% of their effort each year to conduct inventories in areas of highest management concern or other corridors of likely invasion. Extra-area searches will generally take place during the growing season (April to October).

Monitoring "Lite" (SOP 5)

Monitoring Lite, also known as opportunistic sampling, is a term the NCPN uses to describe a supplemental approach to gathering information about IEPs in parks. This approach uses observations of personnel that may not have comprehensive knowledge of the local flora, but can reliably detect a few high priority species. Opportunistic sampling makes use of park staff, researchers, visitors, and volunteers that travel in and around a park regularly and operates on the principal that, with proper and consistent training, each person is a potential set of eyes able to correctly identify new high priority weed infestations and record the location(s) with the highest level of accuracy possible. The technique is a simplification of the monitoring methods outlined above. This efficient, practical inventory technique has been used nationwide to increase the chances of early detection of invasive species and has the side benefit of being used to maximize detection opportunities through education and awareness. Monitoring lite sampling can take place at any time of the year.

Control of Invasives

For all of the methods outlined above, qualified surveyors may remove small populations if under a threshold size (i.e., it would take less time to remove the plants during the survey than it would to hike back out to remove them later), but larger populations require rapid response commitments from parks in order to be effective. When invasive plants are removed by surveyors, site location should still be documented.

Limitations

Prior to officially adopting this monitoring protocol, we also assessed its limitations. Substantial inter-observer error associated with visual cover class estimates applied at such a broad scale will reduce resolution to detect changes in cover over time. Because locations are not documented precisely, the amenability of these data to spatial analysis is limited. Finally, the design is not necessarily suited to assess the effectiveness of management treatments applied at local scales or to compare the effectiveness of control treatments. For example, a replicated study would be required to determine whether glyphosate or mowing provided more effective treatment of smooth brome (*Bromus inermis*). As the spatial scale of control increases with cumulative management actions, however, assessment of management effectiveness becomes increasingly feasible with this design.

IV. Data Management

Data Entry, Verification, and Editing

Data processing typically involves the following steps: data import, data entry, data verification, data validation, data quality review, and backups/storage (see SOP 7). Data entry consists of transferring data from field sheets into a database using a data entry interface. Data verification immediately follows data entry and involves checking the accuracy of computerized records against the original source. Validation procedures seek to identify generic errors (e.g., missing, mismatched, or duplicate records) as well as logical errors specific to particular projects.

Metadata Procedures

Metadata will be written using ESRI ArcGIS metadata tools and NPS Metadata Tools and Editor (SOP 7). The generated metadata file will be stored in XML. Federally listed species require that information access is restricted to NPS personnel, regulating agencies, or, with permission, NPS partners.

Data Archival Procedures

Frequent backups are critical for preventing data loss. Full backup copies of the monitoring project will be stored at an off-site location.

V. Data Analysis, and Reporting

Data of invasive exotic plant distributions acquired from surveys are time sensitive. Because these plants reproduce quickly, acting upon new detections of highly invasive species is critical. Therefore a feedback loop between monitoring and treatment programs must be established. In any surveys where exotic invasive plants are detected, the park weed manager will be notified of particularly important or significant new invasions within 30 days of monitoring (e.g., a species with high invasive potential found in a canyon that was formerly weed-free).

In addition to quick 30 day notification, annual monitoring reports will be submitted to the park which will include both newly discovered species and newly discovered infestations (i.e., locations). The I&M monitoring coordinator will meet with local park weed managers at least annually to review the program, provide and receive feedback, and make program adjustments as necessary. The annual reports will focus on reporting the locations and cover of species during the most recent survey and the amount of change since the previous survey. Reports will also include the time spent surveying and kilometers covered; maps of locations and

presence/absence of species by monitoring route. Reports will be prepared and distributed by May of the next calendar year following data collection.

Long-term trend reporting will focus on trends in species distributions in periodic trend (approximately every 5 years) reports. IEP spread rates will be analyzed/summarized by habitat type and trends will be assessed using changes in the number of detections per species per year. Regression analyses could be employed to estimate rates of change or the trajectory of change (i.e., linear or nonlinear). A repeated measures ANOVA could also be used to statistically test pre- versus post- differences. Because some portions of parks will only be sampled infrequently (e.g. every five years), statistical analyses in which sample size is equivalent to number of years (e.g., regression) should only be done after enough data points are obtained to allow sufficient statistical power.

The primary intent of surveying for IEPs is to identify locations in parks to enhance control prior to spread. As such, classical statistical analyses are of less concern as managers may act to reduce the densities of a number of the invasive species. These actions are likely to vary both spatially and temporally within parks and among parks. Unless the histories of such management actions are documented and made available to the analyst, interpretation of observed long-term patterns may prove difficult even as the value of the program remains high.

VI. Personnel Requirements

A network ecologist will serve as the project manager for IEP monitoring. Data management is the shared responsibility of the project manager and the data manager. Typically, the project manager oversees data collection, data entry, data verification and validation, as well as data summary, analysis, and reporting. The data manager designs the database and oversees data security, archiving, and dissemination. The data manager, in collaboration with the project manager, also develops data entry forms and other database features to assure data quality and to automate report generation. The data manager and project manager are responsible for building adequate QA-QC procedures into the database management system and for following appropriate data handling procedures.

For routine monitoring, a competent, detail-oriented surveyor is essential for collecting credible, high-quality IEP data. Misidentification of species decreases capacity to detect trends in IEP abundance and distribution through time. Field observers must be able to accurately identify target IEPs. Field observers must also be skilled with GPS navigation and data collection. Observers should be well organized, work well as a team member, be comfortable in the field, and work methodically under difficult conditions.

For the “lite” monitoring, observers can come from a variety of sources, and each park unit must take responsibility for creatively recruiting help for the lite program to be effective. Observers can be from any skill level, as long as they have completed minimal training in the identification of top priority species. Observers consist of (but are not limited to) the following types of individuals:

- Interpreters leading hikes and disseminating information
- Rangers patrolling the backcountry
- Maintenance staff working at remote sites, road edges, and along trails
- Resource managers, research permittees and scientists working in the backcountry
- Park contractors
- Park leasees
- Special Use permittees
- Volunteer groups (especially Native Plant Societies)
- Educational groups
- Park partners

VII. Operational Requirements

Field Season Preparations and Equipment Set-up

Sampling trips shall be scheduled and organized prior to the start of each field season. Prior to working in the field, observers must review the network safety plan and the entire protocol. Observers will review IEP identification using herbarium specimens, keys, and photographs. The crew leader will provide a refresher on plant identification, GPS navigation, compass use, and foliar cover estimation. All equipment and supplies, especially GPS units, should be organized and prepared for the field season. All files needed for navigation will be loaded onto a GPS unit for transport to the park.

Training Procedures

Training is essential for developing competent observers (see SOP 2). Observers will review exotic plant identification using herbarium specimens, keys, and photographs. The crew leader will provide a refresher on exotic plant identification, GPS navigation (SOP 6), compass use, and foliar cover estimation. Observers will be tested frequently on their ability to identify exotic plant species.

Sequence of Events During Field Season

Prior to visiting the field sites, the park will be contacted according to park procedure. All equipment required for sampling is assembled and checked (SOP 1). Each day the crew leader provides a briefing regarding safety, plant identification, and park navigation. All observers must be properly trained (SOP 2). The crew leader assigns crew members to the search areas for the day. Prior to beginning work in the field, observers collectively estimate IEP cover over a given area and compare observations in order to calibrate cover class estimates.

Post-Collection Processing of Samples

Research specimens may be collected to confirm identification of IEPs, especially those that are likely to be identified incorrectly (SOP 10). In some cases, small or partial samples may be quickly collected and stored in a field notebook. Location, description, and habitat information are recorded using an unknown specimen data sheet. Research specimens are only for confirmation of taxonomy and will not be stored in a collection. Alternatively, photographs may also be used to document unknown specimens.

VII. Literature Cited

Andersen, K. A., and S. A. Dewey. 2007. USU Wildland weed mapping methods training supplement. Master's thesis. Utah State University, Logan, Utah. 107 pp. plus appendix.

Dewey, S. A. and K. A. Andersen. 2005a. An Inventory of Invasive Non-native Plants in Black Canyon of the Gunnison National Park (2003-2004) – Final Report. Prepared for the National Park Service, Northern Colorado Plateau Network, by Utah State University; Plants, Soils, and Biometeorology Department; Weed Science Research Project Report No. SD0511A, 36 pp. plus appendices.

Dewey, S. A. and K. A. Andersen. 2005b. An Inventory of Invasive Non-native Plants in Capitol Reef National Park (2003-2004) – Final Report. Prepared for the National Park Service, Northern Colorado Plateau Network, by Utah State University; Plants, Soils, and Biometeorology; Weed Science Research Project Report No. SD0514A, 50 pp. plus appendices.

Dewey, S. A. and K. A. Andersen. 2005c. An Inventory of Invasive Non-native Plants in Cedar Breaks National Monument (2004) - Final Report. Prepared for the National Park Service, Northern Colorado Plateau Network by Utah State University; Plants, Soils, and Biometeorology Department; Weed Science Research Project Report No. SD0515A, 29 pp. plus appendices.

Harris, S., J. Brown and S. Timmins. 2001. Weed surveillance – how often to search. Science for Conservation 175. Wellington, Department of Conservation. 27pp.

- Hobbs, Richard J. and Stella E. Humphries. 1995 An integrated approach to the ecology and management of plant invasions. *Conservation Biology* 9(4): 761-770.
- Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evans, M. Clout, and F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences and control. *Ecological Applications* 10:689-710.
- Manly, B. F. J. 2001. *Statistics for Environmental Science and Management*. Chapman & Hall/CRC, Boca Raton, FL.
- Marler, M. 1998. Exotic plant invasions of federal Wilderness areas: current status and future directions. The Aldo Leopold Wilderness Research Institute. Rocky Mountain Research Station, Missoula, Montana, USA.
- Mooney, H., and R. J. Hobbs, eds. *Invasive species in a changing world*. Washington, D.C.: Island Press. 457 pp.
- Myers, J.H., D. Simberloff, A.M. Kuris and J.R. Carey. 2000. Eradication revisited: dealing with exotic species. *Trends in Ecology and Evolution* 15(8): 316-320.
- National Park Service. 2006. *Management Policies 200*. US Department of the Interior, National Park Service, Washington, D.C., USA.
- National Research Council. 2002. *Predicting invasions of nonindigenous plants and plant pests*. National Academy of Sciences, Washington, D.C.
- NAWMA. 2002. *North American Invasive Plant Mapping Standards*.
<http://www.nawma.org/Mapping/MappingMain.pdf>
- Office of Technology Assessment. 1993. *Harmful non-indigenous species in the United States*. OTA-F-565. U.S. Congress, Government Printing Office, Washington, D.C., USA.
- Rejmanek, M., and M.J. Pitcairn. 2002. When is eradication of exotic pest plants a realistic goal? Pages 249-253 in C. R. Veitch and M. N. Clout, editors. *Turning the Tide: the Eradication of Invasive Species*. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.
- Scott, J. M., and D. S. Wilcove. 1998. Improving the future for endangered species. *BioScience* 48(8):579-580.
- Timmins, S.M and H. Braithwaite. 2002. Early detection of invasive weeds on islands. In Veitch, C. R. and M. N. Clout (eds.). *Turning the tide: the eradication of invasive weeds*, pp. 311-318. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.
- Young, K.E. and T.S. Shrader. Chapter 7: Predicting risks of invasive species occurrence: remote-sensing strategies. In P.H. Geissler and B.A. Welch, editors. *Early detection of invasive plants: a handbook*. United States Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland.