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# Multi-Network Exotic Plant Monitoring Protocol and Standard Operating Procedures

*A collaboration among the Southern Plains, Chihuahuan Desert and Sonoran Desert Networks*

Natural Resource Technical Report NPS/SOPN/NRTR—2011/XXX



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# **Multi-Network Exotic Plant Monitoring Protocol and Standard Operating Procedures**

*A collaboration among the Southern Plains, Chihuahuan Desert and Sonoran Desert Networks*

Natural Resource Technical Report NPS/SOPN/NRTR—2011/XXX

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# 1 Background and Objectives

## 1.1 Issues Being Addressed and Rationale

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of the Earth's biota. Although only 10% of introduced plant species become established and only 1% become problematic or invasive (Williamson 1993, Williamson and Fitter 1996), nonnative species have profound impacts worldwide on the environment, economies, and human health.

Invasive species have been directly linked to the replacement of dominant native species (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), reduced agricultural productivity, and changes in water availability (D'Antonio and Mahall 1991). Often the damage caused by these species to natural resources is irreparable and our understanding of the consequences incomplete. Invasive species are second only to habitat destruction as a threat to wildland biodiversity (Wilcove et al. 1998). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period.

For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." The NPS emphasized the importance of invasive species issues and their associated impacts by identifying non-native species as one of three major areas of focus under the Natural Resource Challenge. More recently, the 2006 NPS Management Policies (NPS 2006) stated "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." National Parks, like other public lands, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected anthropogenic pathways (e.g., weed seeds in restoration planting mixes). Nonnative plants claim an estimated 4,600 acres of public lands each year in the United States (Asher and Harmon 1995), significantly altering local flora. For example, exotic plants comprise an estimated 43% and 36% of the flora of the states of Hawaii and New York, respectively (Rejmanek and Randall 1994). Invasive plants infest an estimated 2.6 million acres of the 83 million acres managed by the NPS.

More NPS lands are infested daily despite diligent efforts to curtail the problem. Impacts from invasive species have been realized in most parks, resulting in an expressed need to control existing infestations and restore affected ecosystems. Additionally, there is a growing urgency to be proactive—to protect resources not yet impacted by current and future invasive species (Marler 1998). Invasive exotic species most certainly will continue to be a management priority for the National Parks well into the 21st Century. Invasive exotic plants have been consistently ranked as a top vital sign for long term monitoring as part of the NPS Inventory & Monitoring (I&M) Program.

Prevention and early detection are the principal strategies for successful invasive exotic plant management. While there is a need for long-term suppression programs to address very high-impact species, eradication efforts are most successful for infestations less than one hectare in size (Rejmanek and Pitcairn 2002). Eradication of infestations larger than 100 hectares is largely unsuccessful, costly, and unsustainable (Rejmanek and Pitcairn 2002). Costs, or impacts, to ecosystem components and processes resulting from invasion also increase dramatically over time, making ecosystem restoration improbable in the later stages of invasion. Further, in their detailed review of the nonnative species problem in the United States, the US Congress, Office of Technology Assessment (1993) stated that the environmental and economic benefits of supporting prevention and early detection initiatives significantly outweigh any incurred costs, with the median benefit-to-cost ratio being 17:1 in favor of being proactive. Although preventing the introduction of invasive exotic plants is the most successful and preferred strategy for resource managers, the realities of globalization, tight fiscal constraints, and limited staff time guarantee that invaders will get through park borders. Fortunately, invasive exotic plants quite often

undergo a lag period between introduction and subsequent colonization of new areas. Managers, then, can take advantage of early detection monitoring to make certain invasive exotic species are found and successfully eradicated before populations become well established. This strategy requires resource managers to: (1) detect invasive exotic species early [i.e., find a new species or an incipient population of an existing species while the infestation is small (less than 1 hectare)], and (2) respond rapidly (i.e., implement appropriate management techniques to eliminate the invasive plant and all of its associated regenerative material).

During the vital signs selection process in 2004-05, Southern Plains Network (SOPN) parks recognized the need for exotic plant monitoring (Perkins et al. 2006). All eleven parks (ALFL, BEOL, CAVO, CHIC, FOLS, FOUN, LAMR, LYJO, PECO, SAND and WABA) identified invasive exotic plants as among their most important management issues. During final selection of vital signs in 2006, invasive exotic plant monitoring was recognized across all network parks as the most important shared monitoring need.

Exotic plant early detection and status and trends were also identified by the Sonoran Desert Network (SODN) of parks as a high priority for vital sign implementation. Exotic plant early detection and mapping has been incorporated into other SODN vital sign monitoring protocols, such as vegetation and soils monitoring, streams and the vegetation mapping inventory. However, the network recognized the importance and benefits of a protocol focused solely on invasive species, and have endeavored to couple this effort with the ongoing efforts of the individual parks.

Because invasive plants pose one of the greatest threats to natural resources in the Chihuahuan Desert Network (CHDN), early detection of invasive plants was identified by CHDN park personnel as a high priority vital sign. Because of the importance of invasive plants, work described in this document will be conducted in concert with rapid-assessment-style assessments of invasive plants conducted during surveys for upland vegetation and soils and riparian vegetation.

## **1.2 Overview of Exotics and Monitoring at Network Parks**

### **1.2.1 Southern Plains Network**

The Southern Plains Inventory and Monitoring Network (SOPN) is composed of 11 National Park Service (NPS) units: Bent's Old Fort National Historic Site (BEOL) and Sand Creek Massacre National Historic Site (SAND), Colorado; Fort Larned National Historic Site (FOLS), Kansas; Capulin Volcano National Monument (CAVO), Fort Union National Monument (FOUN), and Pecos National Historical Park (PECO), New Mexico; Chickasaw National Recreation Area (CHIC) and Washita Battlefield National Historic Site (WABA), Oklahoma; and Alibates Flint Quarries National Monument (ALFL), Lake Meredith National Recreation Area (LAMR), and Lyndon B. Johnson National Historical Park (LYJO), Texas (Figure 1.2.1). Park units within the SOPN are located in shortgrass and mixed-grass ecosystems, and range in size from 326 acres (WABA) to 46,349 acres (LAMR).

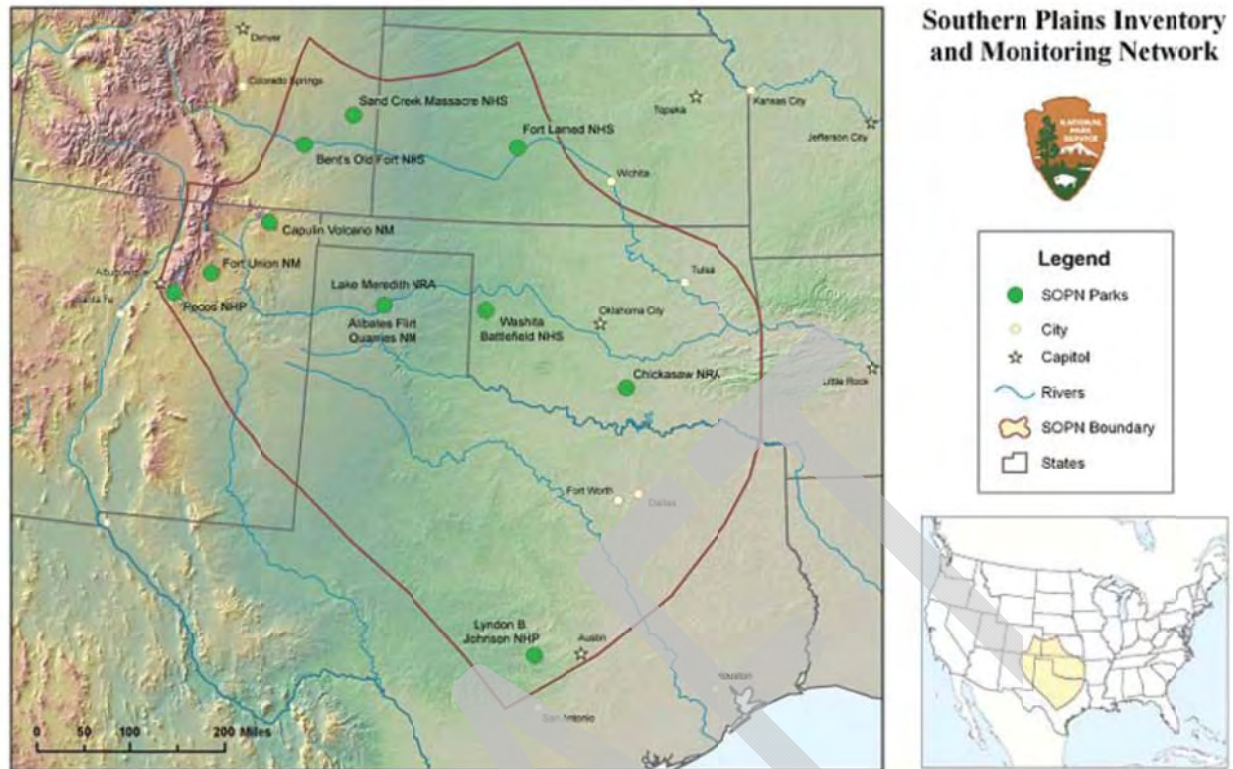


Figure 1.2.1 Parks in the Southern Plains Network

CHIC, FOLS, LYJO, and WABA are in mixedgrass prairie or savannah. ALFL, BEOL, CAVO, FOUN, LAMR, and SAND are located in shortgrass prairie, and PECO is in the ecotone between shortgrass prairie and piñon-juniper forest. At a finer scale, the SOPN parks can be placed in six different vegetative zones or biomes (Küchler 1986, Omernik 1987, Bailey 1995) and eight vegetative sections. The SOPN has a wide range of soil orders present, including dry mollisols through central Texas, central Oklahoma, and central Kansas; wet mollisols in the vicinity of CHIC; entisols and aridisols in southeastern Colorado; and aridisols and alfisols in northeastern New Mexico.

All SOPN parks have implemented exotic control programs, primarily through efforts of the NPS Exotic Plant Management Teams (EPMT), and augmented by individual park efforts. Through this program, most of the severely invasive exotics have been or are in the process of being eradicated. These exotics have been maintained on the list of SOPN exotics due to their tenacious re-sprouting and long-lived seedbanks, as well as the possibility of re-introduction from surrounding environs.

### 1.2.2 The Sonoran Desert Network

The Sonoran Desert Network of park units are located in central and southern Arizona and western New Mexico. The eleven parks occur across a broad range of elevations, vegetation types and climactic zones (Figure 1.2.2). Each park has unique vegetative characteristics and disturbance histories, making each park a novel system for invasion susceptibility. Situated in the sky island region, Saguaro National Park (SAGU), Organ Pipe National Park (ORPI) and Chiricahua National Monument (CHIR) have zones that range from low desert and thornscrub, up through open oak woodlands to coniferous forest. Coronado National Monument (CORO) and Fort Bowie National Historic Site (FOBO) are dominated by mid elevation semi-desert grasslands, with lower elevation grass dominated sites grading into evergreen oak and Pinyon Pine woodlands. Tumacácori National Historic Park (TUMA), Tonto National Monument (TONT), Casa Grande Ruins National Monument (CAGR), Montezuma Castle National Monument (MOCA), and Tuzigoot National Monument (TUZI) are all within the lower Colorado Sonoran Desertscrub or Arizona Upland Sonoran Subdivision biomes, ranging from arid creosote bush-white bursage

communities to Paloverde-cacti-mixed scrub vegetation types. TUMA and MOCA both have perennial streams within their boundaries. Gila Cliff Dwellings National Monument (GICL) is the only network unit located in New Mexico. Vegetation here exhibits traits of the Madrean, Chihuahuan and Sonoran Desert floras. The Gila river runs through a large portion of this unit, supporting vegetation typical of southwestern riparian areas

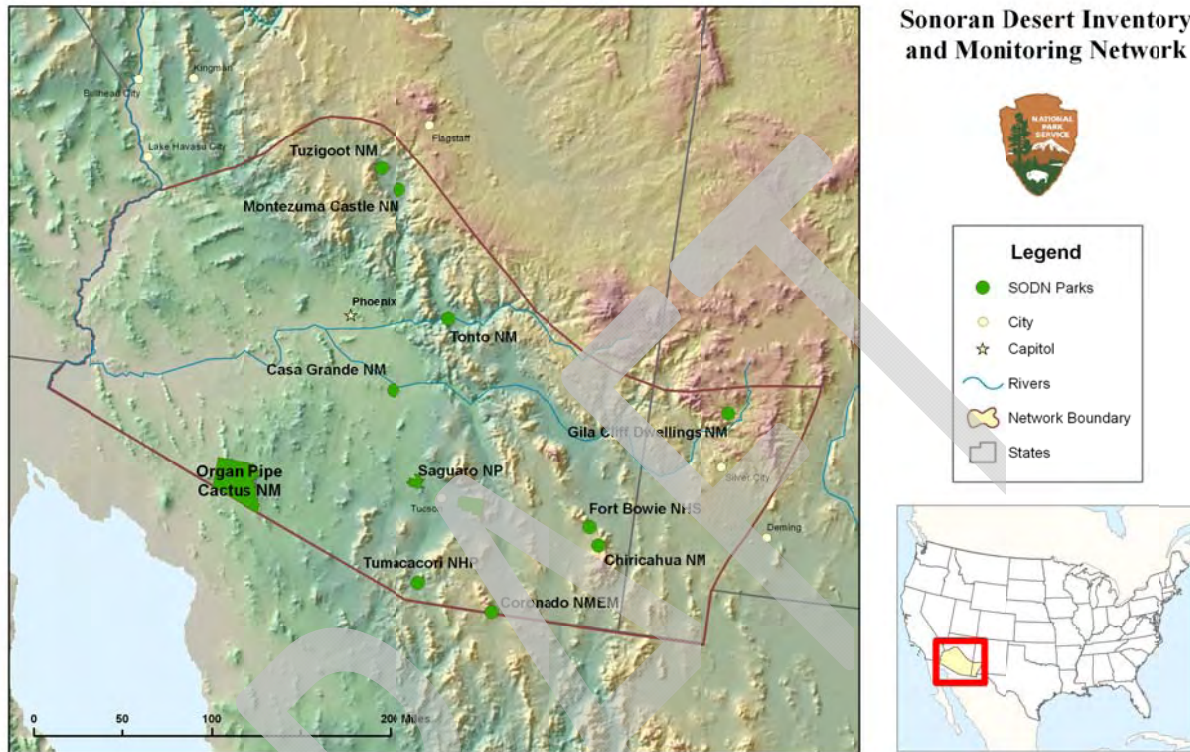


Figure 1.2.2 Parks in the Sonoran Desert Network

### 1.2.3 The Chihuahuan Desert Network

The Chihuahuan Desert Inventory and Monitoring Network (CHDN) is composed of seven National Park Service (NPS) units in New Mexico and Texas: Amistad National Recreation Area (AMIS), Big Bend National Park (BIBE), Carlsbad Caverns National Park (CAVE), Fort Davis National Historic Site (FODA), Guadalupe Mountains National Park (GUMO), Rio Grande Wild and Scenic River (RIGR), and White Sands National Monument (WNSA) (Fig. 1.2.3). The parks vary in size from almost 200 ha (500 ac) at FODA to over 300,000 ha (800,000 ac) at BIBE. Six of the seven CHDN park units are located in the Northern Chihuahuan Subregion of the Chihuahuan Desert Ecoregion. AMIS is situated primarily within the Tamaulipan Thornscrub (Mezquital) Ecoregion of southern Texas and northeastern Mexico.

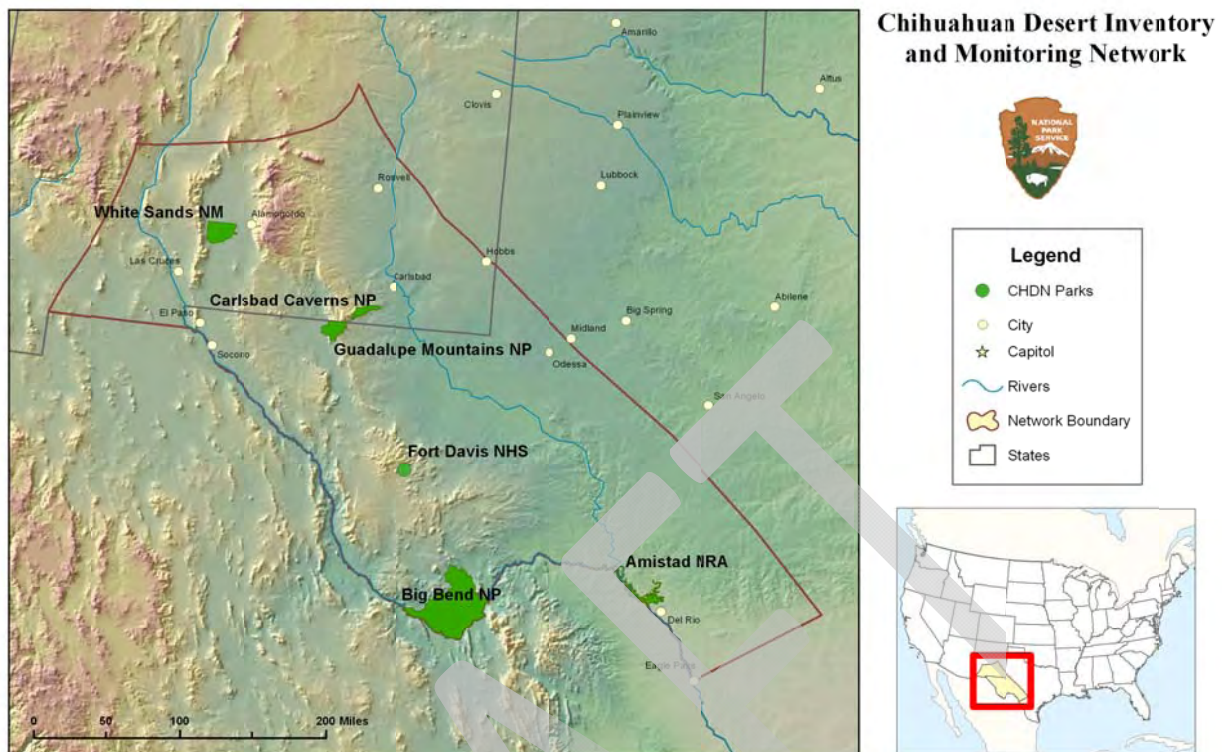


Figure 1.2.3 Parks in the Chihuahuan Desert Network

The Chihuahuan Desert Network intends to implement this protocol on a park by park basis, focusing efforts on areas that are high risk vectors and are potentially good habitat for exotics. For each park, panels will be determined using knowledge of what exotic plants already exist in each area, ongoing park treatments (if applicable), and priority areas of management concern. The field effort will be tailored to enable the most ground to be covered each year at all parks monitored. High risk vectors that are known to have high densities of exotic plants may be excluded from this effort due to low probability of new species entering these systems and to the low level of new information that would be gained. Seasonality of the surveys will be adapted to best capture the exotic flora's phenological window and to nest within CHDN's other monitoring schedules.

### 1.3 Measurable Objectives for the Exotic Plant Protocol

As a compliment to the management strategy of early detection and rapid response, the Networks have incorporated the following objectives into its monitoring plan for Exotic Plants: (1) to detect the initial occurrence for any of a subset of high priority species in areas of high and low invasion probability, (2) to determine changes in the status and trend (density, abundance or extent) of a subset of high priority species in areas of high and low invasion probability, and (3) to determine changes in species composition of a subset of high priority species in areas of high and low invasion probability, taking into account any management treatments that occurred between sampling intervals.

## 2 Sampling Design

Exotic plant monitoring has been particularly troublesome for networks because it is such a pervasive problem at most networks and can be extremely expensive to effectively implement. Consequently, many

networks have dropped invasive plants from their monitoring only because it was financially infeasible. Because of its high importance to network parks, SOPN, CHDN and SODN have developed an exotic plant monitoring effort that will satisfy much, but not all, of the major park information needs. Our approach is intended for early detection of invasive plants along the highest risk invasion vectors (e.g., roads, trails, and waterways) of our parks. The hierarchy consists of four tiers.

## 2.1 A hierarchical Four-Tiered Approach

Our overall approach incorporates four different components (tiers) of sampling, each intended to complement each other (Table 2.1):

| Table 2.1-1. The four hierarchical tiers of sampling, also showing the corresponding target population and responsible unit. |                                                                           |                                                            |
|------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------|
| Tier                                                                                                                         | Target Population                                                         | Responsible Unit                                           |
| Systematic Rotating Panel Design for the Highest Risk Vectors                                                                | All high-priority species along the highest-risk invasion vectors.        | Each Network                                               |
| Systematic Monitoring of Interior Sites as Part of our Grassland/ Riparian Monitoring                                        | All high-priority species at randomly located plots in the park interior. | Each Network                                               |
| Supplementary Monitoring of Lesser Risk Vectors Using Same Field Methods as Tier 1                                           | The highest-priority species along secondary-risk invasion vectors.       | Supplementary Park Efforts and/or Citizen's Science Groups |

### 1. Systematic Rotating Panel Design for the Highest Risk Vectors

- Highest risk vectors would be monitoring using a rapid sampling technique. This approach assigns each high priority invasive plant species observed to one of four density and distance (perpendicular from the vector) classes for 50 m blocks along the vector. The net result is a repeated (every few years) sample of each block such that trends over time can be estimated using a categorical data analysis approach... but the results can also be represented spatially and quickly communicated to park management or EPMTs.

### 2. Systematic Monitoring of Interior Sites as Part of our other vegetation monitoring

- Interior habitats away from high-risk vectors are monitored as part of our other vegetation monitoring.

### 3. Supplementary Monitoring of Lesser Risk Vectors Using Same Field Methods as Tier 1

- A second set of lower risk vectors are identified for any supplementary monitoring by parks, citizen science groups, etc.

### 4. Opportunistic Encounters using LCAS Training Products

- Identification and training aids are developed as part of the Learning Center of the American Southwest, which can be used by parks for opportunistic detection of high risk species by park personnel, visitors, etc.

Although this approach will not provide a comprehensive monitoring of interior (e.g., back country) habitats, it will provide a financially feasible means for early detection of the highest risk species along the highest risk vectors. Sampling designs for each of these tiers are presented below.

#### 2.1.1 Rotating Panel Design for the Highest Risk Vectors (Tier 1)

Preliminary pilot efforts in 2008 indicated that we are able to sample approximately 40 blocks per day (see Chapter 3), two linear kilometers for vectors with one side (e.g., park unit boundaries), or one linear kilometer for vectors with two sides (interior trails and roads. Thus, for most of the smaller parks, this will enable all of the highest risk vectors to be sampled on a 3-year rotation (Figure 2.1.1).

| Panel | Sampling Occasion |   |   |                  |   |   |                  |   |   |                  |    |    |
|-------|-------------------|---|---|------------------|---|---|------------------|---|---|------------------|----|----|
|       | 1                 | 2 | 3 | 4                | 5 | 6 | 7                | 8 | 9 | 10               | 11 | 12 |
| 1     | ■                 |   |   | ■                |   |   | ■                |   |   | ■                |    |    |
| 2     |                   | ■ |   |                  | ■ |   |                  | ■ |   |                  | ■  |    |
| 3     |                   |   | ■ |                  |   | ■ |                  |   | ■ |                  |    | ■  |
|       | Full Park Sample  |   |   | Full Park Sample |   |   | Full Park Sample |   |   | Full Park Sample |    |    |

Figure 2.1.1 A basic three-year rotating panel revisit design where a full sample of each park is completed and repeated every three years

The Networks will continue to this effort through 2011 in all parks and expect to refine our panels based on better estimates of the time required and further discussions with parks. Some of the anticipated refinements might be:

- Adjustments based on the actual time required to complete a panel.
- Changes in the investment of time that allows us to do more (or less) within a given year (panel).
- Changes in the rotation (e.g., a longer rotation for larger parks enabling more panels to be sampled).
- Changes in the inclusion or exclusion of vectors as primary or secondary. The preliminary panel structure for each park is included in Appendices A, B and C:

#### 2.1.2 Design for Monitoring of Interior Sites as Part of other vegetation Monitoring (Tier 2)

The design for Tier 2 of this effort is described in detail elsewhere (Folts et al. 2009, Hubbard et al. 2009) as part of our other monitoring.

#### 2.1.3 Design for Supplementary Monitoring of Lesser Risk Vectors (Tier 3)

The design for Tier 3 is the same as for Tier 1 (see section 2.1.1), except that it will be done where feasible by park staff or volunteers (e.g., citizens science groups). As such we might expect less consistency in effort which will need to be accounted for as part of any analysis.

#### 2.1.4 Opportunistic Encounters using LCAS Training Products (Tier 4)

Tier 4 is an opportunist effort intended only as a compliment to our systematic monitoring to aid parks in locating exotic plant species. As such, there is no sampling design and it will not be incorporated into any analyses of change or trend.

### 3 Field Methods

Areas in the interior of each park with a relatively low probability of initial invasion by exotic plants are sampled in conjunction with our other ongoing vegetation monitoring (Folts-Zettner et al. 2009, Hubbard et al, 2009). These areas are also potentially sampled through opportunistic encounters by park staff or visitors.

#### 3.1 Sampling Along Vectors with High Potential for Invasion (Tier 1).

This part of sampling (Tier 1 - Rotating Panel) is intended for detection of exotic plants along vectors (e.g., roads, trails, or boundaries) with a high potential for invasion by exotic plants. Thus, for each park, we identify vectors that have the highest potential for invasion by exotic plants (primary vectors) and those with high, but lesser potential (secondary vectors).

The primary sample units along these high-risk vectors consists of blocks, 50 meter in length along both sides (right [R] and left [L]) of the vector (except park boundaries) (Figure 3.1.). The transect (line walked by each observer) runs parallel to the vector but set into the roadside along the interior edge of the mow strip. When a mow strip is not present, the transect will be set 2 m in from the vector edge. Exceptions to this rule are discussed in detail in Section 3.4.1

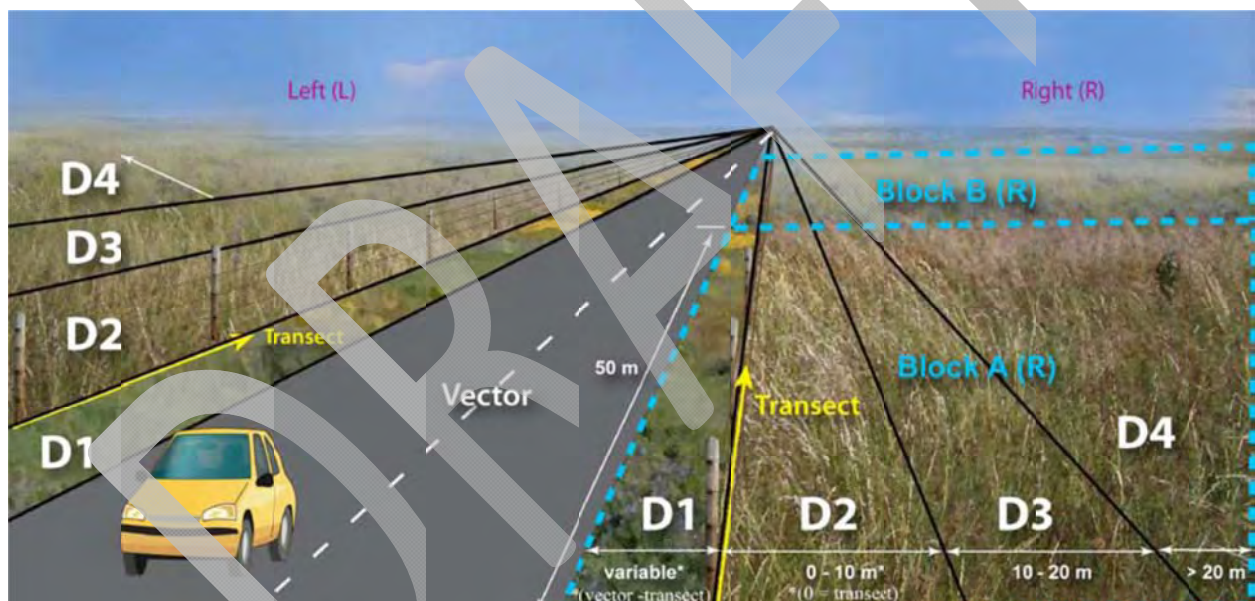


Figure 3.1. Fifty meter blocks are sampled on each side of a vector (e.g., roads and trails) in each of 4 distance classes from the vector.

Within each 50 meter sample block, only one record of a detected exotic species is noted, and its presence is recorded as a density class (see below) within each distance class (see below). This allows for a rapid assessment, gaining more distance along the vector and greater sampling area in each field day. The presence of any given exotic within a 50 meter sample block, in conjunction with the distance class, can be reasonably relocated by management teams. Additionally, the presence of a major species of concern can trigger a more thorough search by park staff or EPMTs of the area for additional occurrences.

##### 3.1.1 Distance from the Vector

Distance from the vector where plants are observed provides an indication of whether a given species has a tendency to invade the interior habitats or whether they tend to remain localized near the source from which they likely invaded. Some species, such as Mullein (*Verbascum thapsus*) appear to be equally likely found in all distance classes, indicating that it is not restricted to localized invasion near the vectors. Other species, such as spiny sowthistle (*Sonchus asper*) are most often present only in the highly disturbed mow strip. Consequently, observations of exotic plant species within a block are recorded within each of four distance classes. Distance classes from the vector are set as follows:

D1 = distance between the roadside and the transect (mowed area or 2 m)

D2 = from the transect to 10 meters into the landscape

D3 = 10 – 20 meters into the landscape from the transect

D4 = over 20 meters into the landscape from the transect

### 3.1. 2 Exotic Plant Density Classes

Within each distance class (see above) for each block we assign each observed exotic species to one of five density classes (including absent in a given distance class) which represents a range of occurrence from a small number of individual plants to a continuous matrix within the block for that species. These density classes are as follows:

0 = Not observed within that distance class

1 = 1-5 plants present within the distance class

2 = Scattered in patches within the distance class

3 = Scattered fairly evenly throughout a specific distance class

4 = Forming a matrix in the distance class

In addition, a given distance class may be assigned a missing value “.” or “X” if observation is hindered by features of terrain or dense vegetation for 60% or more of block length.

### 3.2 Field Season Preparation, Schedule and Equipment

Prior to each field season, the field crew must review this entire protocol, including all of the SOPs. It is important that each member of the field crew is thoroughly familiar with the elements of the design and standard operating procedures for this program. There are numerous tasks that must be performed to ensure a smooth and efficient field season, including generating and copying sufficient data sheets for the effort, making appropriate logistical plans, and purchasing necessary equipment and supplies to provision the field effort. These procedures are described in SOP #01.

Due to the number of procedures performed as part of the exotic plant monitoring field sampling effort, considerable preparations are necessary in order to effectively accomplish this suite of tasks. All materials and equipment must be brought on sampling trips with the crew. The suite of tasks involved in preparing for a field sampling bout include:

- Acquisition of a list of vectors to be monitored from the Principle Investigator (PI). Appropriate field forms, existing vector data and vector hazard descriptions should also be acquired from the PI.

- Review of species list compiled from previous monitoring efforts, inventories and potential threats. Prior knowledge of at least the most common exotic species at a site will facilitate faster recognition and data collection in the field. Each member of the field crew should review the lists and use reference manuals to identify species that will likely be encountered. Certified exotic species lists from NPSpecies available from the Network's data manager and/or the PI should be used to generate species lists for the field. Copies of the species list should be carried into the field for quick reference. (See Section 7.2 Qualifications and Training).

- Scheduling of sampling dates and organization of logistics prior to the start of each field season. Monitoring will be conducted during the appropriate growing season or phenological windows to best capture the majority of species. A preliminary schedule should be approved by the PI. Upon approval, resource staff of park units being visited should be notified (via an email message) of the dates the monitoring field crew will be in their parks. Collection permits have been established with the individual parks being sampled and should be carried into the field by the crew leader. Just prior to the time the field crew enters a park unit the resource staff of the park is to be provided with the actual dates crew members will be working in the park, a list of their names, and approximate locations of monitoring activity.

- All equipment should be organized and prepared at least one month in advance of the field season. This allows time to make needed repairs and order equipment.

### **3.3 Establishing and Measuring Monitored Vectors**

#### **3.3.1 Documenting Vector Block Points**

Blocks along any given vector will have their beginning/ ending points documented by taking GPS point in UTM's (SOP #02) at the survey pin during the initial sampling visit. This will enable GIS mapping of sectors sampled and allow repeat sampling of the same block units during sampling re-visits. UTM points will also allow management teams to relocate populations of exotic species of concern.

#### **3.3.2 Laying Out Vector Blocks**

During the initial visit, vector blocks will be laid out using survey stakes and 50-meter tapes. One vector block consists of 50 meters in length parallel to the vector. On paved roads that will have vehicular traffic, measurements will be taken on one side of the vector along the edge of the vector. Notate on the field sheet which side of the vector is measured. If the vector is curved, measurement should be taken on the outside of the curve or on the side with the greatest number of outer curves. Measurement for all other vectors without traffic should be taken along the center of the vector.

Place a survey pin at the beginning point for the first set of blocks to be sampled, securing the end of the measuring tape and measure 50 meters along the vector. If needed, use additional survey pins to maintain the curve of the vector. Secure the tape at the 50 meter mark. Take GPS points at the beginning and ending survey pins. If you are using a handheld mapping device equipped with software such as HGIS, you can edit the points to include the identifying name of the block being recorded. For more detailed instructions refer to SOP #02. Once data have been collected from the vector blocks, repeat the measurement process for the next set of blocks. GPS point readings will now only be needed at the ending block pins. Revisits will use previously collected UTM points to determine the beginning/end points of each vector block.

#### **3.3.3 Photographing the Vector**

Two photos should be taken of each vector sampled. The first photo should be taken at the beginning of a transect from the center of the vector pointed in the direction of travel. The second photo is taken from the center of the vector pointed at the beginning of the transect, back down the vector that has been sampled. Photos are to be taken at the beginning and end of each continuously sampled vector. Photo numbers should be notated on the data collection sheet and photos downloaded at the end of each sampling day and immediately renamed following download using approved naming conventions (see various SOP's,).

### 3.4 Field Sampling Steps

#### 3.4.1 Set up the transect

For every vector type, the transect will run parallel to the vector along the far edge of the mow strip. When a mow strip is not present, the transect should be placed 2 m from the edge of the vector. Every vector except park boundaries will have two transects, one on either side of the vector. Park boundaries will be surveyed only on the inside of the boundary, with the transect running parallel to the boundary at 2 m in from the fenceline (Fig. 3.2).

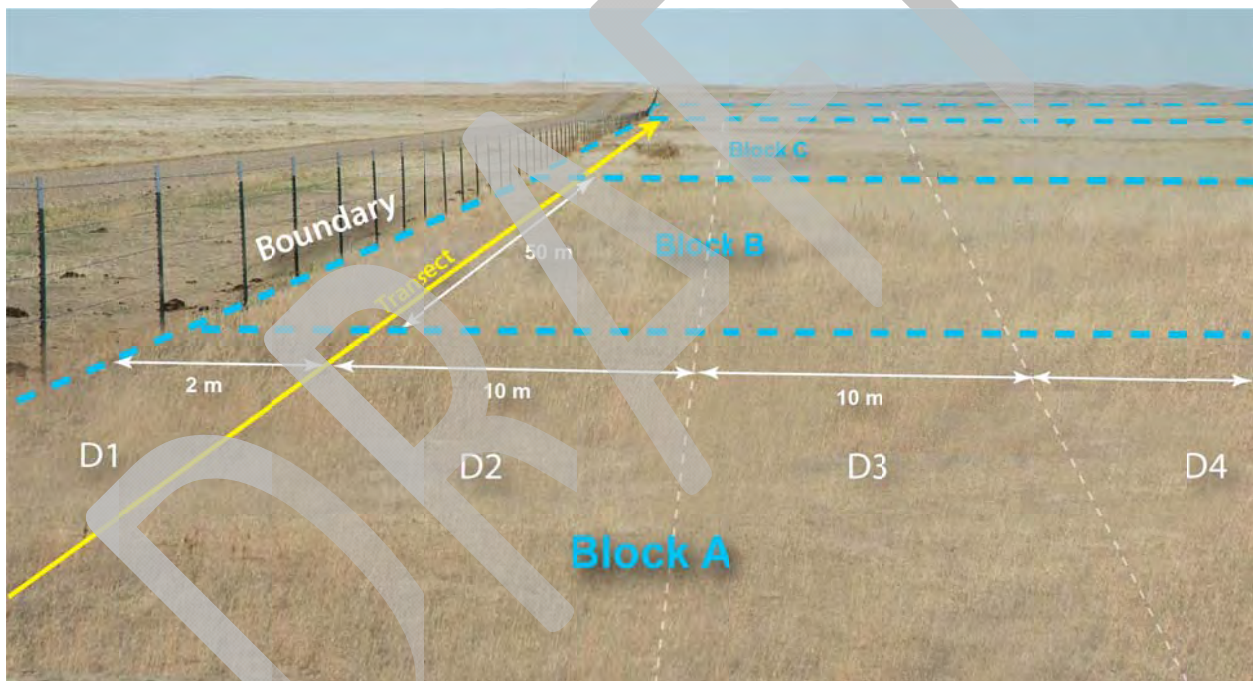


Figure 3.2 Alternate transect establishment for boundaries.

#### 3.4.2 Prepare data collection sheet

Prior to the beginning of the block sampling, two sets of data sheets should be prepared (SOP# 04), one set for each side of the vector. Notate: park, vector type (paved, unpaved, trail, etc.), side of vector surveyed, width of mow strip or Distance Class 1, date, observer, and page number of data set. Also notate photo numbers for the vector. Each vector block monitored should be assigned a consecutive number and beginning point UTMs, which, by default, are frequently the ending points of the previous vector block.

#### 3.4.3 Calibrate distant class estimation

Using a spotting scope or measuring tape (SOP #02), each team member needs to calibrate their eye to the distance class measurements at the beginning of each sampling session and several times throughout the day. This will assure that density estimates for each species are made in the proper distance class.

#### 3.4.4 Sample vector blocks

One observer should be on each side of the vector. Walking along the transect (edge of mow strip or 2 m in from the vector edge), list each exotic species observed. A tick mark can be placed in the corner of each distance class in which a specific species is observed as a reminder. Place an X in the appropriate distance class if topography, habitat, or structures precludes observation of greater than 60% of the distance class. At the end of the 50 m transect, assign a density class in each distance class for which a specific species has been observed. Place a 0 in each distance class where a species was not observed. Draw a line across the page to denote a change in block. Set up the next block transect (see 3.3.1), and repeat procedure.

There are situations when walking along the transect during sampling is precluded by vegetation or terrain. In these instances, walking along the edge of the vector is permissible. Vector blocks affected in this manner should be noted on the data collection form. Distance Classes remain as established, with Distance Class 1 as the first 2 meters off the vector.

#### 3.4.5 Preventing spread of exotic plants while surveying

Many plants have highly adapted seeds to maximize seed dispersion, such as seeds that stick to animal fur (or clothing). To reduce the likelihood of spreading exotic plants while surveying, a stiff brush should be used to remove seeds and other debris from boots (especially soles and laces), pants, shirt sleeves, backpacks, and any other items seeds can stick to or get stuck in. This procedure should be used a minimum of every 500 m sampled or prior to leaving the sample location.

### 3.5 Ancillary Data Collection

#### 3.5.1 Unknown plant species

Sometimes it may be difficult or impossible to determine the specific identity of individual plants encountered during sampling. When this situation occurs, search the immediate area, looking for specimens of the unknown plant that are more readily identifiable (e.g., due to the presence of flowers or fruits from current or previous seasons). If necessary, collect a voucher specimen for future identification. These may assist in correctly identifying the species along the vector. Most of these plants are not entirely "unknown." Rather, they represent species that are known but sometimes difficult to distinguish from other similar species at the time of sampling.

When an unknown species is encountered, create a unique name using the following code: "unk" + number + space + genus or description (e.g. unk3 *Cirsium*). Record this in the appropriate column on the data sheet instead of the species code. Because there are different species lists for each park, start numbering unknowns at "1" for each park. If you know the genus of the unknown plant, use this as its description. Otherwise, create a short description (1-3 words) that will help you remember the unknown species. Before sampling, review previously collected unknown species from the park and use existing unknown names whenever possible. When an unknown is identified at a later date, the code must be corrected globally on all data lists, species lists and in the database.

For each unknown species, fill out a corresponding "Unknown Plant Species Data Sheet" (SOP #05). Data to be notated on this sheet include: plant type and general description, most salient feature, leaf, stem and flower characteristics, general and microhabitat characteristics, and best guess. The more

detailed description of each characteristic, the greater the possibility of future identification. A small “snatch” sample is collected, containing leaf, stem and flower/fruit (when present). This sample is taped to the Unknown Plant Species Data Sheet, or pressed in a field notbook with the assigned Unk code notated on the sheet. When it is suspected that a new park species has been encountered, a formal voucher collection should be made. Collected material is mounted on acid-free herbarium paper, kept in insect proof containers, and becomes reference specimens. Voucher specimens are housed in the appropriate herbarium for each park or network. Kartez/ITIS is used as the first system for standardizing taxonomy.

### **3.6 End-of-Season Procedures**

#### **3.6.1 Equipment Maintenance**

Use the Equipment List found in SOP#1 (Field Preparation) to inventory all equipment. Clean all equipment prior to storage and remove batteries if necessary. Report any lost, broken or malfunctioning equipment and new supplies needed to the Crew Leader and PI.

#### **3.6.2 Complete ID of Unknowns**

The field-crew leader is responsible to ensure complete resolution of all unknown plants. Plants are identified to species level whenever possible, with genus or family levels as secondary options.

#### **3.6.3 Data Management**

The field crew leader is responsible to ensure that all data sheets are completed properly, and that all digital photos are processed according to labeling and naming conventions (SOP #03).

#### **3.6.4 New Species**

The crew leader is responsible to ensure that plant species not on the current park list are submitted to the PI to ensure update to NPSpecies. This requires a voucher specimen which the crew leader is responsible to acquire.

#### **3.6.5 Protocol Review Process**

Prior to the departure of the field crew, the PI will implement the annual Protocol Review procedures, which queries the field crew for problems, issues, and recommendations regarding the extant exotic plant protocol.

## **4 Data Management**

Effective data management to ensure data quality, interpretability, security, longevity, and availability is critical to the success of the Multi-Network Exotic Plant Protocol monitoring program. Data management for this monitoring effort is a cyclic process that starts in before field season begins and continues until the beginning of the field season the following year. The cycle is repeated each year monitoring data are collected.

This chapter presents an overview of the monitoring database and general procedures for organizing, entering, verifying, validating, certifying, documenting, distributing, and archiving the data collected under this protocol. Additional information and context for this chapter may be found in the “Sonoran Desert

Network Data Management Plan” (Angell 2005). Further details and instructions for the tasks in each stage of the data management cycle are contained in SOPs #07 and 08.

#### **4.1 Data organization**

This long-term monitoring project generates large quantities of data and numerous products, and a well-organized digital file structure is critical to avoid confusion and potential data corruption. Each monitoring project uses a similar folder structure replicated on both the Active and Archive network drives. Data for the current on-going field season are stored on the Active drive. At the end of each field season, certified data, completed products, and other seasonal files are transferred to the permanent project folder on the Archive drive, where they are stored in read-only format. The “Exotic Plant Index” document provides information on the contents of the folders and links to other information relevant to the project.

#### **4.2 Data model**

The Networks have developed a Microsoft Access database to manage Exotic Plant monitoring data. The database comprises a front-end file and a back-end file that are linked using the Data Table Connections tool in the database. The front-end file acts as the user interface into the back-end database and contains the forms, queries, and VBA code for the application. The back-end database file contains the data tables. This configuration allows improvements and revisions to the database front-end application without altering the actual data structure or any of the records in the back-end data tables.

The Exotic Plant monitoring database is based on the NPS Natural Resource Database Template, a set of relational database tables in Microsoft Access recommended by the NPS I&M program for these types of databases. The design includes standardized core tables for elements, such as Locations and Events, which are common to most monitoring data sets, as well as a field data table that can be duplicated and customized as needed to meet project data requirements.

Two copies of the back-end database are created, each with an associated front-end application. The “working” project database on the Active drive is used for data entry, edits, quality assurance/quality control (QA/QC), and preliminary summarization of the data collected for the current field season. The “master” project database, on the Archive drive, stores the full project data set that has passed all quality-assurance steps. It also includes a full set of summarization, analysis, and export tools.

The general data model for exotic plant monitoring consists of core tables and two principal groups of field-data tables. One group of tables manages exotic plant data and a second manages associated landscape attribute data. The two types of data are linked in time and space using standardized location and event tables that will be shared with other Network I&M protocols. When correctly linked, the exotic plant and landscape data may be transparently integrated for analysis. Species, contacts, and attribute look-up tables provide standardized values for many data fields, and metadata tables track database revisions and data edits.

The project leader should have a thorough understanding of the project database structure and procedures for using the database. While a thorough understanding of the structure is not necessary for field crew members, they must read the SOPs and the “Exotic Plant Monitoring Database User Guide” (SOP #09) and understand how to enter, edit, and QA/QC the data.

#### **4.3 Data-entry procedures**

Sampling data for exotic plants are acquired as specified in the protocol SOPs, using different methods: 1) data are entered directly into the project database on ruggedized field laptop computers, 2) data are manually recorded on paper field data sheets, or 3) data are downloaded from handheld or automated sensors.

Transcription errors are minimized and efficiency is increased when data are entered directly into the digital database. Data collected on field computers are subject to a series of backups in the field (SOP #08) and office (SOP #07) to ensure that adequate data redundancy is achieved. In the event of

equipment failure in the field, paper data sheets are completed to avoid lost information. To facilitate accuracy, QA/QC mechanisms are built into the database to eliminate as many potential data-entry errors as possible. The “Exotic Plant Monitoring Database User Guide” contains more information on these mechanisms.

Digital data-entry forms serve as the user’s portal into the database. Location and sampling event information are entered first. Then, associated exotic plant and landscape data may be entered into the targeted tables. Where appropriate, pick lists limit values entered into a field to ensure that only valid names or measures are entered.

Data recorded on paper field data sheets are entered into the digital database as soon as possible following collection (beginning data entry after the field season ends is not acceptable). Keeping current with data entry facilitates finding and correcting errors while the information is still fresh in the minds of the field crew.

Data downloaded from electronic sensors are processed as specified in SOP #08.

#### **4.4 Data-certification process**

Data verification is the process of checking the accuracy of digital data against copies of the original paper data sheets. This critical but time-consuming step has been largely eliminated through the use of field computers for direct data entry. However, data recorded on and entered from paper data sheets will need to be verified (refer to SOP #09 for guidance on QA/QC procedures for paper data sheets).

Data validation is the process of reviewing digital data for range and logic errors. Although some validation features, such as range limits, are built into the database itself via data-entry forms (see above) and queries, the project leader or another person familiar with the data further reviews the data set for these types of errors. For data that were directly input into the database in the field, a paper version of each completed data form is printed for archival purposes after data validation has been completed. Spatial data are validated according to the procedures specified in SOP #08 using the latest version of ArcGIS software (ESRI, Inc.).

Data certification is the process of ensuring that the data set (i.e., the database containing all of the records for that year) has been verified and validated for accuracy, is complete, and is fully documented. Data certification is completed annually for all tabular and spatial data and photographs. A “Project Data Certification” form is completed by the project leader to notify the data manager that data are ready for appending to the master project database, archiving, and storage. After the data set is certified, it can be used in analysis and reporting.

#### **4.5 Metadata procedures**

Metadata for the exotic plant monitoring database were developed using the NPS Database Metadata Extractor (<http://science.nature.nps.gov/nrddata/tools/dme.cfm>) and the ArcCatalog (ESRI, Inc.) metadata module in conjunction with the NPS Metadata Tools & Editor (<http://science.nature.nps.gov/nrddata/tools/index.cfm>). For further guidance on metadata development, refer to the “SODN Metadata Development Guidelines” and the NPS Data Store instructions (<http://science.nature.nps.gov/nrddata/docs/metahelp/metahelp.cfm>). All database objects (e.g., tables, fields) were defined and documented in a data dictionary and/or in Section 5 of a Federal Geographic Data Committee (FGDC)-compliant metadata file. FGDC-compliant metadata (including the NPS profile and the Biological Data Profile, where appropriate) are created for all spatial data. Both spatial and non-spatial metadata records are uploaded to the NPS Natural Resource Information Portal, where they are available to the public. All metadata records are updated as needed whenever additional data are collected and added to the data set.

## 4.6 Product integration and distribution

Data management staff is responsible for populating and updating the NPS national I&M databases, including the NRInfo Reference and NPSpecies Applications, using the certified data along with information provided in the annual and synthesis-and-trend reports. Digital copies of reports are uploaded to the NRInfo Reference Application repository and made available for downloading from network, NPS, and Learning Center of the American Southwest (LCAS) web sites.

Certified and archived non-sensitive data are posted to the NRInfo Reference Application repository, where they may be downloaded for research and management applications. Other data sets, including those containing sensitive data, may be requested in writing from the appropriate network data manager. Sensitive data are released only with a signed confidentiality agreement.

## 4.7 Data maintenance and archiving

The master and seasonal (working) databases are archived on a secure server with regularly scheduled backups. To ensure data compatibility with other existing or newly developed software programs, each database table is exported to an ASCII file using the Access\_to\_ASCII utility developed by the Northern Colorado Plateau Network. These ASCII files are stored on the S:\ drive with the master MS Access database file. All archived files are designated as read-only.

Before making revisions to either the front- or back-end database, a copy of the current version is stored to facilitate tracking of changes over time. The file name for the database includes a number indicating the version of the database (e.g., Exotic Plant\_be\_Master\_v100.mdb) appended to the file name. After storing the copy, the version number of the database undergoing revision is changed and “\_Draft” is added to the end of the file name. When the revisions have been approved, the “\_Draft” designation is removed. Frequent users of the data are notified of the updated version by data management staff.

After the data have been certified and archived, any data editing should meet the following conditions: 1) only make changes that improve or update the data while maintaining data integrity, 2) document all changes made to the data set, and 3) be prepared to recover from mistakes made during editing. All changes are documented in the database data-edits table. Printed data records are not altered, and they are reconciled to the database through the use of the edit table. Any editing of archived data is accomplished jointly by the project leader and data manager.

# 5 Analysis

## 5.1 Annual Data Summaries

Most of our analyses related to change will be conducted periodically after one or more complete panels have been sampled (see below). However, annual data summaries enable us to detect any unusual patterns in the data as well as provide valuable information for park management. These summaries will likely be limited to descriptive statistics such as frequencies or percentages of blocks with a given exotic species and density or distance classes of that species.

## 5.2 Generalized Linear Modeling Approach for Trend Detection

Detection of trends for the rotating panels would be accomplished using a generalized linear modeling approach for categorical data. The basic underlying model will be the familiar:

$$E(Y_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots \beta_k X_k$$

where  $E(Y_i)$  is the expected value of  $Y$  at time  $i$ ,  $\beta_0$  is the intercept, and  $\beta_i X_i$  is the explanatory effect  $\beta_i$  of variable  $X_i$ . It is expected however, that there could be numerous variations on this basic theme which would be incorporated into the final analyses. It is not practical to discuss in detail each potential

variation; however, some of the factors that will influence the nature and form of specific analysis are as follows:

### 5.2.1 Distributions of Response Variables

We expect that the response variables may take on any of several distributions depending on the specific analysis. The three we most likely expect to encounter are:

- **Binomial Distribution** - The Binomial Distribution reflects situations with a binary response. Probably the most common example where we might expect the response variable to take on a binomial distribution is when we are modeling the presence or absence of a given species.
- **Poisson Distribution** - This Poisson Distribution is used for count data. An example of when we are likely to encounter this distribution is when we are analyzing the number of blocks (a count) with species X, etc.
- **Multinomial Distribution** - The Multinomial Distribution reflects cases where there are several (more than two) possible outcomes of a fixed set of outcomes. An example of where we are likely to encounter this distribution is when we are exploring changes in the density classes (5 possible outcomes for any given block).

### 5.2.2 Repeated Measures

For evaluating change over time, analyses will need to take into account that these are repeated measures. Rather than a series of independent events, our approach consists of repeatedly sampling the same blocks over time. This interjects some level of dependence among sample units which must be taken into account. There are, however, numerous ways of taking this dependence into account depending on the nature of the specific analysis. For example, a given sample unit may have the right characteristics to favor a particular exotic species. That is one level of dependence; however we may also wish to take into account some treatment effects. In this case, we may wish to consider some sort of condition dependence such as the state of a given sample unit at time  $T+1$  is dependent on its state at time  $T$ , but not before time  $T$ . Thus, some analyses may consider a sequence of samples as a Markov process.

### 5.2.3 Fixed vs Random Effects

Another consideration that will change the nature of our analyses is whether the model effects being considered are fixed or random. How one considers these effects can substantially influence the assumptions about the process that generated the effect sizes, how the data are analyzed, and interpretation of the results. In “fixed” effects, the independent variable is “fixed”, such that the categories that characterize the independent variable are static (e.g., the vector, park, etc). Other variables may be considered as random effects which the levels represent a random sample from some population of possible levels of interest (e.g., stochastic events such as weather factors). There also may be many situations warranting mixed models that have both fixed and random effects.

### 5.2.4 Model Selection as a Basis for Data Analysis

A critical concept to our approach to data analysis is that a given amount of data will support only limited inference (Burnham and Anderson 1992, 2002). Given that premise, we treat data analysis as a problem of optimization, rather than strict elimination of alternative hypotheses based on arbitrary criteria (e.g.,  $\alpha$  level). We use the principle of parsimony as a basis for model selection. Our goal is to be able to make generalizations about the system we are trying to model that are supportable by the data. If we incorporate all possible effects (including their interactions) into our model, we will have the best fit of the data. The problem is that we will not have learned anything. As the number of parameters in a model is

increased, the fit of the model to data will improve. The cost, however, for increasing the number of parameters in a model is that precision of the parameter estimates decreases (i.e., the confidence intervals increase) (Burnham and Anderson 1992, Lebreton et al. 1992). Thus, the goal of our analysis is to find a good balance between having enough parameters in the model to adequately describe the underlying patterns, but not so many so as to defeat the purpose of making generalizations. Thus, a parsimonious model is one which retains only those parameters that are warranted by likelihood ratio tests and Akaike's Information Criterion [AIC] (Akaike 1973, Sakamoto et al. 1986, Shibata 1989, Anderson et al. 1994) and eliminates excessive parameters (Lebreton et al. 1992).

An hypothetical example of how this approach might be applied for trend analysis of exotic plants might be a log linear model examining changes in density class for a given species within a park over time. Some of the possible models might include a simple model where only the intercept with a single estimate for density. If this model were selected, it would indicate that the data do not support much in the way of conclusions. This could be a result of very limited variability or more likely insufficient data. Some alternative models might include a model supporting separate parameters for each year (indicating annual variation without a trend), or a model that supports parameter estimates for an intercept and slope (indicating a linear trend). By examining alternative models, with differing parameter combinations, we can better understand the underlying patterns that our data are able to support.

## **6 Reporting**

### **6.1 Hierarchical Reporting**

Reporting will be hierarchical and intended for multiple audiences and media. The primary delivery system for all reports will be the Internet, via the Learning Center of the American Southwest (LCAS), <http://www.southwestlearning.org>. However, the individual products available on the web site will also be available in a format (pdf) that will facilitate easy printing or enable us to deliver a printed version to appropriate audiences.

The LCAS is a partnership between the 48 parks of four monitoring networks (Southern Plains, Sonoran Desert, Southern Colorado Plateau, and Chihuahuan Desert), three Cooperative Ecosystem Studies Units (Desert Southwest, Colorado Plateau, and Rocky Mountain), and currently two non-profit organizations (Sonoran Institute and Big Sky Institute) (Folts- Zettner et al. 2008). Its purpose is to build stronger relationships between national parks and scientists and better communicate science results to interested park audiences. The hub of the Learning Center is a web page that gathers information about a number of resource topics in one place (Figure 6.1-1).



Figure 6.1-1. The home page of the Learning Center of the American Southwest enables navigation via a given resource or via a given park unit or network.

Information within LCAS is organized hierarchically, as a series of products within two major levels, the resource level and the project level. Resource-level products report on the condition of the resource, regardless of the source of information. This is the level that best synthesizes the available information regarding the status and trends of the resource. In contrast, project-level products report the available information from a given project, whether it be monitoring, research, etc. Thus, someone looking for the most comprehensive information about status and trend of a resource would find it at the resource level, while someone looking for the specific results from a given project would find it at the project level. I&M monitoring data will contribute to, and sometimes be the only source of information for, resource-level products, and will also be reported at the project level.

For this monitoring effort, we anticipate products at both the resource and project level each of which are described below and summarized in (Table 6-1). At the resource level we expect to produce a resource brief annually. At the project level, we anticipate producing a project report and summary annually and a synthesis report approximately every six years.

| <b>Product</b>   | <b>Primary Purpose/Scope</b>                                                                                | <b>Primary Target Audience(s)</b>       | <b>Scale</b>                               | <b>Length</b> | <b>Frequency</b> |
|------------------|-------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------|---------------|------------------|
| Resource Brief   | Status and Trend of Exotic Plants                                                                           | Superintendents/<br>Resource Managers   | Park                                       | 1-2 Pages     | Annual           |
| Project Summary  | Summary of Project Accomplishments and Results for a given year. Extracted from Annual Report               | Resource Managers                       | Each Network                               | 1-2 Pages     | Annual           |
| Annual Report    | Project Accomplishments and Results for a given year.                                                       | Resource Managers                       | Each Network with individual Park Sections | Variable      | Annual           |
| Synthesis Report | In depth synthesis of data and supporting evidence. Primary focus on Trends and Influences on those trends. | Resource Managers/<br>Science Community | Each Network with individual Park Sections | Variable      | Every 6 Years    |

### 6.1.1 Resource Brief

The resource brief is a one-page synthesis document that explains the importance of a resource, describes its status and trend, and discusses its stressors and drivers. Relevant photos, maps, and/or graphs complement the text. The resource brief page contains three parts:

- Importance. A one-paragraph description of why the resource is important that may include information on the ecological role or historical significance of the resource.
- Status and Trends. A one-paragraph summary of the status of the resource and how the resource has changed over a specified period of time.
- Discussion. A one-paragraph discussion of the key drivers and stressors for a resource. If this is not applicable or unknown, describe the issues faced in managing this resource.

### 6.1.2 Project Summary

The project summary is a two-page synthesis of the current status and results, if applicable, of a given project. The document provides the reader with a summary of a project and includes an introduction as well as sections on methods, results, and project contacts. Relevant graphs, photos, and/or maps complement the text.

### 6.1.3 Project Report

Project reports will be produced annually or as appropriate, and will synthesize the results of a given period's effort for that project. It is more limited than the synthesis report (below) in that its emphasis is on a data summary and estimates of the primary parameters being assessed. The two-page project report provides additional detail not included within the project summary, and includes the following sections:

- Introduction. Explains the purpose and background of the project.
- Methods. A brief description of the methods with reference to the full monitoring protocol.
- Results. The results of the current period's effort and trend information where appropriate.

- Discussion. A short narrative putting the current year's results into context, a discussion of patterns or trends, and a description of possible implications to management.

#### 6.1.4 Synthesis Report

The synthesis report is a more in depth assessment of the status and trend of the resource. The annual report, while also synthesizing project results, is generally limited to a data summary and estimates of the core parameters. In contrast, the synthesis report will provide a much more in depth assessment, including more comprehensive analyses and broader interpretation of the implications of the results to other resources.

### 6.2 Reporting of Spatial Data via the IMR Interactive Map Server

In addition to the hierarchy of reports disseminated through the Learning Center of the American Southwest, we also anticipate spatial products to be disseminated through the Intermountain Region's Interactive Map Server. This enables us to make available to the parks and public data that would normally be limited to our GIS in the form of downloadable, viewable and printable interactive and scalable maps in ".pdf" format. Just as with our GIS, users can designate which layers are turned on or off and at what scale a given map is presented. This is particularly well suited for parks with limited or no GIS capabilities (i.e., most of our parks). This also enables our results to quickly be available to park managers and/ or Exotic Plant Management Teams (EPMTs).

## 7 Personnel and Training

### 7.1 Roles and Responsibilities

It is anticipated that each I&M Network will manage the ongoing-training and data collection for their parks. The principal investigator is the lead ecologist for implementing the exotic plant monitoring protocol, and is supervised by the network coordinator (Table 7.1). Because of the need for a high level of consistency in implementing the protocol, the project manager will be responsible for training the seasonal and permanent personnel assisting with the monitoring efforts. The data management aspect of the monitoring effort is the shared responsibility of the project manager and the data manager. Typically, the project manager is responsible for data collection, data entry, data verification and validation, as well as data summary, analysis, and reporting. The data manager is responsible for data archiving, data security, dissemination, and database design. The data manager, in collaboration with the project manager, also develops data entry forms and other database features as part of quality assurance and automates report generation. The data manager is ultimately responsible for ensuring that adequate QA/QC procedures are built into the database management system and that appropriate data handling procedures are followed. The Crew Leader will be responsible for, among other activities, day-to-day scheduling and field operations over the Crew Members. It is anticipated that there will be two Crew Members responsible for efficient data collection.

| <b>Position</b>                       | <b>Roles</b>                                                                                                                                                                                                                          | <b>Responsibilities</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Minimum Qualifications</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Principle Investigator (each network) | -Serves as a liaison among project cooperators (cooperating agencies), other related projects (i.e., monitoring by other groups or in neighboring locales), and between other staff (crew leader and members) and the other networks. | -To hire other staff members (crew leader and members)<br>-To coordinate field schedules and availability of supplies with the crew leader<br>-To participate in the creation of (and possibly lead) training for crew leader and members<br>-To inform network staff and cooperators of the progress of monitoring and any areas where adjustments may be needed<br>-To act as a direct channel of communication between this project and others of this nature, thus building relationships and cooperation among this project and other similar projects<br>-To be the party responsible for providing data from fieldwork to network staff for analysis in a quality checked format, along with copies of all original data, and to be available for any questions pertaining to the data | -Excellence in identifying (and explaining the identification of) native and exotic plant species found in network parks.<br>-Experience hiring personnel<br>-Experience managing projects and communicating results in a clear and concise manner to all interested parties through a variety of media<br>-Experience collecting and quality checking reliable data<br>-Experience training crews and performing field work                                                                                                                                                                         |
| Crew Leader                           | -Serves as the leader of the field crew members and is the primary liaison between the project manager and the crew members                                                                                                           | -To participate in field training<br>-To act as the primary coordinator with respect to field schedules and supplies<br>-To serve as the party who is primarily responsible for the safety of crew members and to conduct safety training for crew members<br>-To accompany crew members in the field<br>-To act as a direct liaison between the project manager and the crew members<br>-To enter and quality check all data before submitting for analysis                                                                                                                                                                                                                                                                                                                                  | -Experience performing field work<br>-Experience training, leading and coordinating crews<br>-Experience with data collection, entry and quality assurance<br>-Experience communicating with a variety of audiences<br>-Experience with teaching outdoor safety and route finding<br>-Excellence in identifying (and explaining the identification of) native and exotic plant species found in network parks.<br>-Experience using a GPS unit<br>-Must be able to hike long distances and carry a heavy backpack                                                                                    |
| Crew Members                          | -Serve as the back bone of the field operation by performing all field work related to the monitoring project                                                                                                                         | -To participate in field training<br>-To alert crew leader of any scheduling conflicts or needed supplies<br>-To account for safety of yourself and others at all times<br>-To be responsible for all loaned equipment and use it properly<br>-To collect reliable, accurate data and submit it to the crew leader in a timely manner                                                                                                                                                                                                                                                                                                                                                                                                                                                         | -Capability to learn to identify native and exotic plant species<br>-Capability to learn safety and route finding<br>-Capability to learn the use of a GPS unit and undergo training if necessary<br>-Experience communicating and working with a variety of personalities in close settings under arduous conditions<br>-Must be able to hike long distances to and carry a heavy backpack<br>-Preferably have experience performing field work in vegetation measurements, have experience working with dichotomous keys and identifying species, and have extensive hiking/backpacking experience |

## 7.2 Qualifications and Training

A competent, detail-oriented observer is essential for collecting credible, high-quality data on exotic plant species. Observer bias in the estimation of density and misidentification of species will affect the ability to detect valid trends or changes in exotic plant populations through time (Elzinga et al. 1998). Field observers must be proficient at accurately identifying plants and estimating plant density and distance. Observers should also have good organizational skills, memory retention and an ability to work methodically and consistently under difficult conditions.

Training is essential for developing competent observers. Herbarium specimens and comparative notes on difficult or uncommon species should be provided for field observers. Observers should be tested frequently on their ability to identify plant species, tailoring the testing for the more problematic look-alike species. Time should also be invested in training personnel on distance estimation. Estimating distance is best taught at the start of the season in the field with all crew members present and then calibrates periodically throughout the season to reduce within-year observer differences in distance estimation. Refer to the following instructions for training observers in both plant identification and distance estimation.

### 7.3.1 Training Observers

Necessary skills to be acquired or honed before data collection begins each field season are reviewed below.

1 Knowledge of the use of a GPS is essential to document beginning/end points of vector blocks, and in the future, may be employed to record key site information. SOP#02 (Use of a GPS) should be thoroughly reviewed. Training sessions described below will require field crew members to exercise the use of a GPS.

2 Plant identification skills are critical. Only field crew members with demonstrated plant ID skills should be hired. Even so, fine-tuning ID skills for plant species is still important. The Principal Investigator or designee (e.g., lead bio-tech) will provide training for all crew members. Training will consist of field-based identification of plants anticipated to be observed during the field season, with emphasis on difficult-to-ID species. Additionally, field crews will be instructed in the use of taxonomic keys and reference materials which will be available to all crew members.

## 8 Continual Improvement

Quality assurance extends beyond data management and must be an integral component of all aspects of the monitoring program. The US Forest Service Forest Inventory and Analysis Program (FIA) identified three aspects of quality assurance (prevention, assessment and correction), which are referred to as the QA triangle (Figure 8-1). In the context of the overall monitoring program, prevention is addressed through sound development of sampling design, data management and analysis. Although prevention is extremely important, it is not sufficient by itself, due to changing programs, funding, environments, technologies, etc. Thus, this protocol includes the following section for assessment (i.e., the review process) and correction.

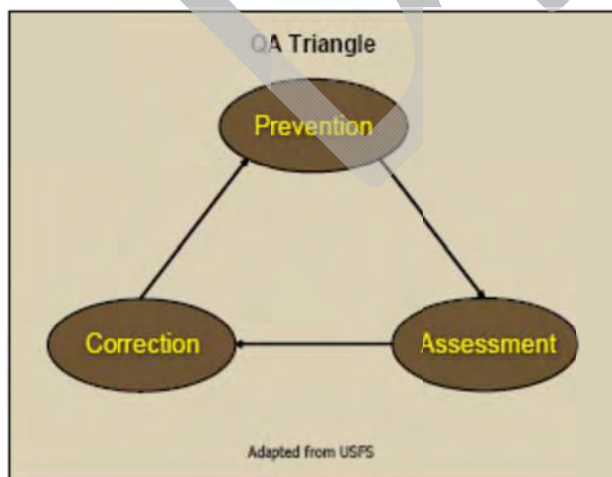


Figure 8-1. The quality assurance triangle. Adapted from the USFS.

## 8.1 Review Process

Reviews may be periodic (planned at a predefined interval) or episodic (resulting from changing mandates, funding, priorities, etc). The review process should permeate through all phases of our monitoring. It also should permeate through all thematic elements (i.e., applicability, reliability and feasibility), although it may not be the same review process for each element. Rather, the details of a given review should reflect which element(s) is being targeted. For example, a review intended to assess the scientific reliability is likely to be conducted by qualified scientists. In contrast, a scientific review panel may have little insight if a review is intended to assess whether or not the monitoring meets the needs of managers. Consequently, the review strategy should also clearly specify the purpose of the review and, at least in general terms, who should conduct the review.

## 8.2 Process for Change

Determining the status and trends of selected indicators of the condition of park ecosystems is an essential and critical goal of the I&M Program. Understanding the spatial and temporal scales over which change occurs is paramount to achieving this goal. We have considered the spatial and temporal scale in several elements of this report, including sampling design and implementation. However, many ecosystem attributes of interest operate at such long time scales that implementing a temporal sampling design requires a long-term commitment that enables teasing apart true change from environmental noise (i.e., variation). Thus, one of the key values of the I&M program is its long-term prospect. Frequent changes in monitoring protocols in the attributes being monitored and how they are being monitored would likely lead to an ever-weakening ability to meet the program goals, leading to erosion of support, further weakening the program, etc. Thus, at the outset the networks need to be vigilant about disruptive change in our monitoring, while at the same time recognizing that changing resources and management regimes may require some degree of flexibility. The difficulty lies in finding the right balance between maintaining the necessary consistency to meet our program goals with enough flexibility to meet the challenges of changing natural and political environments.

Thus, when making changes in protocols, the following questions should be addressed:

1. What are the criteria for determining whether or not a change is warranted? These should reflect the general themes identified above:

- Reliability- The data are not reliable in their present form
- Applicability- The data are not applicable to managers, the public, etc. in their present form
- Feasibility- The data are not feasible to obtain in their present form (e.g., funding, logistics, priorities, etc).

2. If it is determined that a change is required, what programmatic element needs to be changed?

- Objectives?
- Design?
- Field Methods?
- Data Management?
- Analysis?
- Reporting?

Note: Changing a vital sign or an objective is far more drastic than changing a reporting method. Thus the criteria for making changes to different elements may reflect their relative degree of severity.

3. What is the procedure for making the change?

4. What precautions will be taken to ensure that the revised protocol will be acceptable?

- Pre-change reviews by appropriate reviewers depending on changes being made. For example, changes in sampling design should be reviewed by qualified statisticians, etc. (based on planned changes)?
- Post-change reviews (based on results from implemented changes)?
- Testing concurrent with existing protocol?
- Post-change exploratory analyses using real or simulated data to ensure that resulting analyses provide fulfill information needs Post-change analyses

5. How will the transition to the revised protocol be accomplished?

- Will there be a period of overlap; if so, how?

### 8.3 Revising the Protocol

This sampling protocol consists of a protocol narrative and 10 separate SOPs. The protocol narrative provides the history and justification for the program and an overview of sampling methods. The protocol narrative will be revised only if major changes are made to the protocol. The SOPs, in contrast, are specific, step-by-step instructions for performing each task. They are expected to be revised more frequently than the protocol narrative.

Careful documentation of such revisions, including an archive of previous versions, is essential for maintaining consistency in data collection, analyses, and reporting. To summarize changes, the monitoring database for each component contains a field to identify the protocol version used to gather and analyze data. The steps for changing any aspect of the protocol are outlined in SOP #10. The narrative and each SOP contain a Revision History Log that should be completed each time the narrative or an SOP is revised. The purpose of this log is to explain why changes were made and to track document version numbers. Former and active versions of the protocol narrative and SOPs are stored on separate drives on the network server.

The Networks uses a Master Version Table and Version Key number (VK#) to track which versions of the narrative and SOPs are used in each version of the monitoring protocol. The VK# is essential if project information is to be properly analyzed and interpreted. ***The protocol narrative, SOPs, and data should never be distributed independently of the Master Version Table.***

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DRAFT

## **Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol**

### **Standard Operating Procedure (SOP) #01**

#### **Field Preparation and Equipment List**

#### **Version 1.0 (March 2011)**

##### **Revision History Log:**

| Prev.<br>Version # | Revision<br>Date | Author | Changes Made | Reason for Change | New<br>Version # |
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This Standard Operating Procedure reviews tasks to be accomplished in preparation for a field season and itemizes the equipment needed to perform exotic plant monitoring in all parks of the Southern Plains, Chihuahuan Desert and Sonoran Desert Networks. There are numerous tasks that must be performed to ensure a smooth and efficient field season, including generating and copying sufficient data sheets for the year, making appropriate logistical plans, and purchasing necessary equipment and supplies to provision the field effort. The equipment list can also be used at the end of field season to verify that all equipment is present and accounted for.

Prior to the field efforts each year, the crew members must review this entire protocol, including all of the SOPs. It is important that each member of the field crew is thoroughly familiar with the elements of the design and standard operating procedures for this program.

The suite of tasks involved in preparing for a field sampling effort include:

##### **1. Preparation of Data Sheets**

- Acquire a list of vectors to be monitored for each park from the Principle Investigator (PI). All vectors are pre-existing, requiring only data collection.
- Review previous field forms for these vectors and assemble copies of the existing data needed for the upcoming season. These will include a park map of vectors and notes regarding vector hazards.
- Prepare appropriate data files for uploading into GPS units. Block beginning/end points will be acquired during the first sampling visit and will be replicated in future sampling.
- Prepare copies of blank field forms needed to collect new data for each plot. These will include Field Data Collection forms and Unknown Plant Species forms.
- Prepare packets of the compiled information and forms for each park to be sampled. These packets should also contain the necessary collection permits (see below).

##### **2. Prepare Plant Species Lists**

- Certified exotic species lists from NPSpecies available from the network data managers and/or the PI should be used to generate species lists for the field. Review exotic species lists and previously unidentified plant species from previous monitoring efforts to identify any unique plants that may be encountered.

- Prior knowledge of at least the common exotic species at a site will facilitate faster recognition and data collection in the field. Each member of the field crew should review the lists and use reference manuals to identify exotic species that will likely be encountered. Copies of these exotic species lists should be carried into the field for quick reference.

### **3. Prepare Schedules and Notify Parks**

- Monitoring will be conducted during the proper phenological period across the Networks. A preliminary schedule should be approved by the PI. Upon approval, resource staff of park units being visited should be notified (via an email message) of the dates the monitoring field crew will be in their parks.
- In addition to submitting the preliminary field schedule, the project manager should also submit requests for park housing, permits (camping), and any other special requests (e.g., boat transportation).
- Collection permits should have been established with the individual parks being sampled for other monitoring projects and should be carried into the field by the crew leader.
- Just prior to the time the field crew enters a park unit the resource staff of the park is to be provided with the actual dates field-crew members will be working in the park, a list of their names, and approximate locations of monitoring activity.

### **4. Prepare Equipment**

- All equipment (see list below) should be organized and prepared for the field season at least one month in advance of the field season. This allows time to make needed repairs and to order/replenish equipment.

### FIELD EQUIPMENT LIST

| Activity                     | Equipment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vector Sampling              | Digital Camera<br>Photo board<br>Compass<br>GPS unit<br>Spotting scope<br>Maps<br>Measuring Tapes – 50meter<br>Survey pins<br>Batteries for electronics (including spares)<br>Battery recharger<br>Clip boards<br>Pencils/Pens/Markers<br>Data Collection Sheets<br>Unknown Specimen Forms<br>Hand lens<br>Plant Press<br>Species Identification Manuals and Taxonomy Books<br>Species lists (previous observations, potential observations)<br>Species Master Names and Codes list<br>Field Notebook |
| Required Miscellaneous Items | Backpacks<br>Bug spray/sulphur sock/clothes treatment<br>Duct Tape<br>First-Aid Kit<br>Nourishment<br>Cellular Phone or Radio for communicating<br>Sun Screen<br>Towels<br>Water<br>Reflective safety vests<br>Reflective safety cones<br>Brush (for cleaning shoes and clothing of exotic seeds)                                                                                                                                                                                                     |

## **Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol**

### **Standard Operating Procedure (SOP) # 2**

#### **Using a GPS**

#### **Version 1.0 (March 2011)**

##### **Revision History Log:**

| <u>Prev.<br/>Version #</u> | <u>Revision<br/>Date</u> | <u>Author</u> | <u>Changes Made</u> | <u>Reason for Change</u> | <u>New<br/>Version #</u> |
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This Standard Operating Procedure explains how to use a GPS as well as navigational and measurement techniques necessary for the specialized equipment used during exotic plant monitoring in the parks of the Southern Plains, Chihuahuan Desert and Sonoran Desert Networks. Each network will use either a GPS unit and paper data sheets or a handheld data collector. Future plans are to transition to a digital data collection solution that will meet the needs of all networks involved. Until then, each network will make use of their current equipment. The following section discusses GPS standards to be used by all personnel.

##### **USING A GPS**

All GPS measurements should be set to:

- UTM coordinates
- NAD83 datum
- Meters

All crew members should be familiar with the operation of their GPS unit. Each network will supply the appropriate Users Guide for their equipment and this guide should be reviewed by all crew members and carried while on sampling events. Prior to the beginning of field season, all crew members should participate in field training in the use of their respective GPS unit.

As field personnel, monitors must be able to use a GPS to mark the 50 meter block transect beginning/ending points. This is achieved by marking waypoints. If paper data sheets are used, both the UTM coordinates and the waypoint number should also be recorded on the data sheet.

##### **USING HANDHELD MAPPING UNITS (RECON or TRIMBLE)**

If handheld mapping units are in use and available at your network these can be used to both navigate to block transects and to record start and end points. A template for use with HGIS software should be created including all relevant fields for attributing point locations such as block number, start or end, date, etc. If instead a geodatabase (GDB) design is employed to store the block polygons and the field collected point data, then a blank schema can be checked out to any handheld units loaded with ArcPad. This 'check-out' system will load a blank template for data collection with all fields from the GDB onto the unit and will subsequently enable data to be checked back into the GDB with one function, requiring minimal time and processing.

Data collected via either method should be checked for completeness and edited if needed in ArcMap or ArcCatalog on return from the field. For detailed instructions on data collection using RECON units please refer to SOP #08 Using\_RECON\_Mapping\_v101.

## **Monitoring Procedure for the Exotic Plant Protocol**

### **Standard Operating Procedure (SOP) # 03**

#### **Photographing Vectors**

#### **Version 1.0 (March 2011)**

##### **Revision History Log:**

| <u>Prev.<br/>Version #</u> | <u>Revisio<br/>n Date</u> | <u>Author</u> | <u>Changes Made</u> | <u>Reason for Change</u> | <u>New<br/>Version #</u> |
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This Standard Operating Procedure explains the methods to achieve the minimum requirements for photo-documentation of vectors. Since each monitored area is different, creativity is encouraged in crew members (especially the Lead Technician for this SOP) in determining the best ways to document site characteristics with photographs. Landscape photo-pairs repeated from identical points over time are extremely valuable tools for documenting changes through time in vegetation and landscape variables. Photo-documentation provides the following benefits to the program:

1. A graphical depiction of aspects of the vegetation mosaic and the landscape context of each vector – a snapshot in time.
2. A graphical depiction of any nearby features that might prove significant in understanding changes that could occur within a plot, such as ecotones, potential sources of disturbance, and conspicuous landmarks.
3. After the first iteration of sampling, the images are an invaluable tool for accurately beginning and ending sample blocks, thereby increasing the accuracy and overall repeatability of our measurements.
4. A method to actually analyze and graphically display apparent changes in the vegetation cover of a vector – sometimes a picture will capture changes that have occurred when other sampling measurements do not capture the change.

In general, one technician will be assigned the lead role for photo-documentation. Often other technicians will shoot some of the required photos, but the lead technician for this role is responsible for ensuring all required photos for the plot are taken, good photo opportunities to illustrate the overall vector are utilized, and metadata for photos are documented. Each Network will have their own camera and it is important that their technicians review instruction manuals and are completely familiar with their respective equipment.

##### **Procedures:**

#### **I. Responsibilities of the lead technician**

1. The lead technician for the photo-documentation section of the protocol will need to become proficient in the operation and features of the digital cameras prior to going into the field.

2. The lead technician will be skilled at the following functions of the camera: image resolution, image file size, zoom or wide-angle capabilities, the 'stitch' feature that allows multi-image panoramic photos to be stored and stitched together, and the 'macro' feature. The lead technician also makes sure that the photos are documented fully on the photo data sheet, downloaded at the end of the workday, and renamed using the project naming convention (SOP #6). All photograph notes and metadata are entered into the project database. Required metadata are listed in Table 1 below.
3. The lead technician ensures the proper gear is assembled and packed for sampling trips (see equipment list below). They also ensure that a sufficient number of charged batteries and storage cards are brought into the field each day.
4. The lead technician ensures that the equipment is well-cared for, and that the camera is stored in dry conditions during inclement weather.
5. The lead technician must be familiar with the methods, hardware and software required to download the images following a trip, and is responsible for recharging the batteries such that they will be ready for use during the subsequent field excursion.
6. The lead technician will make recommendations about lessons learned and improvements to this procedure.

## **II. Shooting Photos**

1. Vector photos are taken at the beginning and end of each continuously sampled section of vector, at the same location as the beginning and ending GPS coordinates are taken. The photo location should be on the vector, if possible. If the vector is the centerline of a busy road, or highway, take the photo from a safe location on the shoulder and note the location on the data sheet.
2. Photos taken at the beginning of the continuously sampled section of vector should be taken in the direction of sampling. Photos taken at the end of the continuously sampled section of vector should be pointed back toward the beginning of the vector, showing the area that was sampled. The purpose of these photos is to document the landscape conditions along the vector and the type of vector sampled. Therefore, it is important to show minimal amounts of sky, crew members and other features that may detract from the landscape.
3. Additional photos may be taken to capture unique or unusual features in the area sampled, or to aid in identification of unknown plants. In the case of unknown plants, take an image that captures the form (shape) of the plant, and additional images that capture as much detail as possible of the leaves (top and bottom), flowers (if present), fruits (if present), stem, stipules, and any other characteristics that may be helpful in identifying the plant. Make notes in the photo data sheet about other characteristics that can't be captured in photos, such as the presence of hairs or unusual odors.
4. Every photo taken must be recorded on the photo data sheet. The camera automatically assigns a number to each image. Each number in the sequence for a particular vector must be recorded on the data sheet. If you delete an image, the camera will not re-assign that number to another image.
5. Use a medium resolution format for photos. The typical file size of photos ranges between 400 KB – 1 MB. Rarely will you need to store images in the highest resolution format for routine photo-documentation.
6. A coded photograph identification "card" should be prepared and made visible in every photograph if more than one section of vector is sampled in a day. A convenient photo board can be fashioned out of a piece of white paper (or card stock) laminated with 10 mil plastic; dry erase markers can then be used to mark the board. Such a board will last one field season. The card should display, in large black letters, the vector identification code, date (if camera is not equipped with a database), subject

code and any other information that may be useful. Have someone hold the board so that the codes are just visible in each photograph, but the board itself is as unobtrusive as possible.

### III. Rephotographing Plots

Remember that when you are photographing vectors that have already been documented, you should make every attempt to duplicate the previous photos, no matter what technique was used, unless the previous photos are poor. If possible, bring a reference photo (a color photocopy of the original) along to facilitate duplication of earlier shots.

1. Always bring a copy of the establishing photos into the field to facilitate replication of earlier shots. This can be a set of photographic prints, scanned images, or color photocopies generated for this purpose and included in the “field packet” (see SOP #1).
2. Retake the photo when the shrub and herbaceous species are at the same phenological stage as they were in the original photos whenever possible.
3. If you use multiple cameras, keep a small notebook with appropriately labeled pages or the appropriate photo data sheets in the camera bag at all times.

### IV. Required Metadata

Metadata are data about the images and its presence increases our ability to find and use photos long into the future. The following table includes the required metadata fields. Some of these fields may be held in the camera with the image, others will need to be written down.

Table 1. Required metadata fields

Title  
Author(s)  
Comments  
Subject  
Keywords  
Date  
Location  
Park Code  
Easting UTM (in NAD 83)  
Northing UTM (in NAD 83)  
GPS Datum (should always be NAD 83)  
GPS Direction

The following fields are also required, however, the data in the fields should be constant, therefore field crew members don't need to record this information.

- Copyright Notice (should be none)
- Access Constraints (should be 8)
- Contact Information (should be network data manager or other network representative)

| Park Code | Site Name | Date |
|-----------|-----------|------|
|-----------|-----------|------|

[illegible]

## Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol

### Standard Operating Procedure (SOP) #4

#### Method for Collecting Vector Data

**Version 1.0 (March 2011)**

##### Revision History Log:

| Prev. Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|-----------------|---------------|--------|--------------|-------------------|---------------|
|                 |               |        |              |                   |               |
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This Standard Operating Procedure explains the procedures that are performed to collect data using the sample block method in all parks of the Southern Plains, Chihuahuan Desert and Sonoran Desert Networks. Following these procedures is important to collect valid data used in monitoring exotic plant invasions.

Exotic plant data will be collected using a series of 50-meter sampling blocks along a designated vector (figure 1). Exotic sampling requires a two person team: one “observer” to collect data on each side of the vector (except in the case of boundaries).

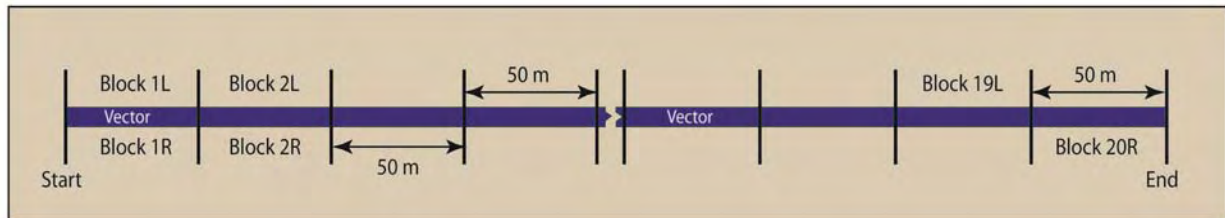


Figure 1. General block layout for sampling exotic plants.

##### **Set up the sampling block transect**

On the initial visit, use a GPS to document the coordinates of the start and end points of each 50-meter sample block. (SOP #2). On revisits, use previously collected GPS points to determine the beginning/end points for each sample block. Anchor the beginning end of the tape (using a survey stake) at the starting point for a block measurement. This stake can be placed at the center of the vector when possible (trail, dirt road or boundary) or at the edge of a paved vector. When placed at the edge of a paved vector, be certain to measure all subsequent sampling blocks on the same side of the vector (preferably along the outside curve), and to notate on the data collection sheet which side of the vector the measurement was taken. Run the tape out 50 m parallel to the vector, using additional survey stakes to maintain any vector curves. Fasten the tape so that the 50 m transect tape is taut and as close to the ground as possible. Take a GPS reading to document the end of this sample block and the beginning of the next sample block.

### **Photograph the transect**

Photos should be taken during the initial visit and each time the vector block is revisited (SOP #3). Every attempt should be made to duplicate the establishing photos. A copy of establishing photos can be taken into the field to facilitate replication of earlier shots. Photos will be more useful if they show primarily the vegetation, while space taken up by the board and the crew is minimized.

### **Prepare Data Collection Sheet(s)**

Record relevant information in the header of the Field Data Form in preparation for data collection. These data sheets are printed both front and back, allowing for continuous data collection. If you are using handheld data collection devices such as RECONs, ensure the unit is fully charged and has appropriate shapefiles and templates loaded. Only collect data using the pre-established templates, and take care to input the correct datum. Prior to beginning data collection make sure that you have an adequate horizontal accuracy or wait until more satellites are acquired and desired accuracy is achieved.

### **Calibrate Eyesight to the Distance Classes**

Select a location (or plant) that, in your judgment, is 10 m away from your position. Using the laser rangefinder or the survey tape, take a measurement to the selected location to determine true distance. Continue with this procedure until you can accurately judge a 10 m distance from your position on the transect. Repeat this procedure using 20 m distance.

During sampling, use the laser rangefinder or a second measuring tape anytime you question an exotic species presence in a Distance Class. Throughout the sampling day, recalibrate your eyesight to ensure proper Distance Class assignment.

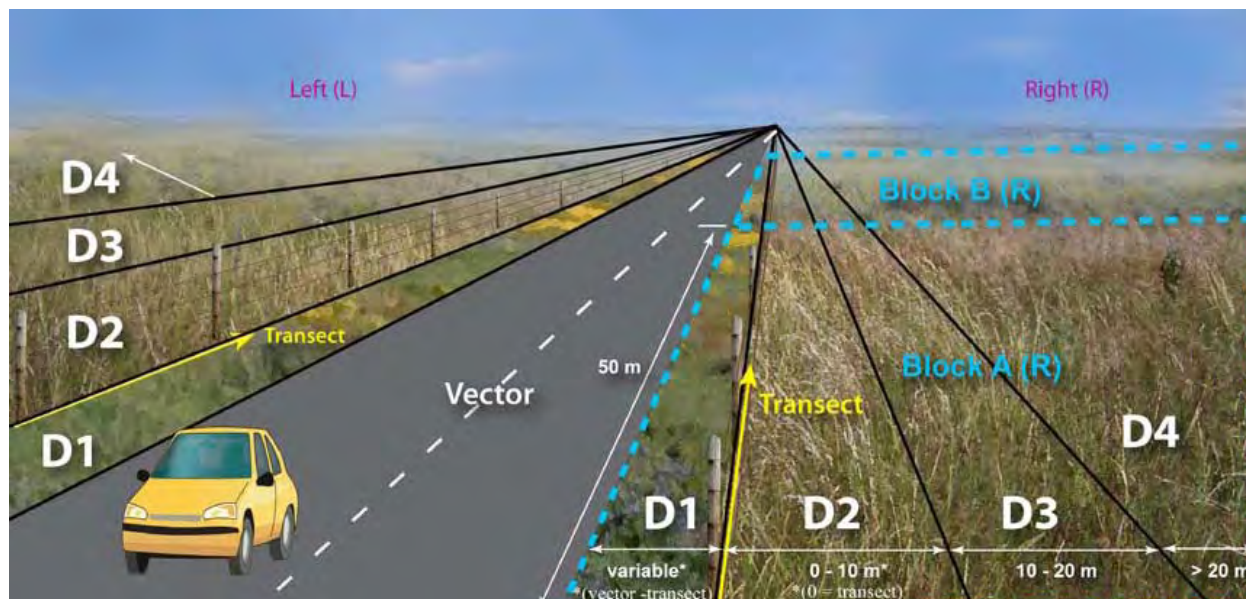
### **Collect Data**

Each 50m sample block is sampled in this protocol. Sampling occurs on both sides of the vector, with one observer for each vector side. A transect is walked between the beginning and end points of each block. This transect runs parallel to the vector and is off-set from the side of the vector at the edge of the mow strip or, when no mow strip is present, at 2 m in from the vector. Note on the data sheet the distance between the vector edge and transect walked.

An initial occurrence of an exotic species is noted on the data collection sheet as it is encountered in each sample block. Each exotic species has its own 6 letter Species Code comprised of the first three letters of the genus name and the first three letters of the species name. For example, *Melilotus officinalis* would have the Species Code of MELOFF.

The presence of a species in a specific Distance Class is notated in the appropriate column by a tick mark. The Distance classes are:

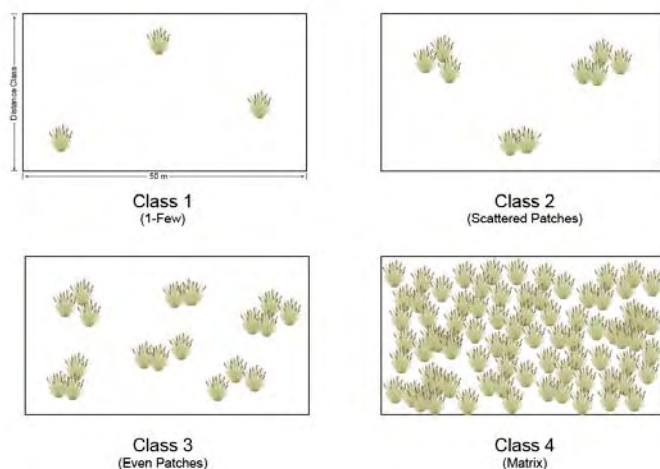
- D1 = distance between the vector-edge and the transect (mow strip or 2 m)
- D2 = from the transect to 10 meters into the landscape
- D3 = 10 – 20 meters into the landscape
- D4 = over 20 meters into the landscape



As you walk along the transect, take notice of the density and distribution of each species in each distance class. Types of Density Class are:

- 0 = Not present
- 1 = 1-5 plants present in specific Distance Class for each Sampling Block
- 2 = Scattered in patches in specific Distance Class
- 3 = Scattered fairly evenly throughout specific Distance Class
- 4 = Forming a matrix in specific Distance Class
- X = Not detectable in specific Distance Class due to features of terrain or dense vegetation

Density Classes



At the end of the 50 m transect assign a Density Class to each species for each Distance Class. If a species was not detected in a Distance Class, place a "0" in the space, which implies that the landscape in a given Distance Class could be seen, but a species was not detected. If the terrain (or dense

vegetation) obscures your ability to scan the landscape in a specific Distance Class, place an “X” in the appropriate column.

Once the data sheet has been completed for a particular sampling block, draw a line across the sheet below the collected data to start notes for a new sampling block. Take a GPS point at the end of the sampling block (which is the beginning of the next sampling block) if this is the first visit to the vector. If a re-visit, select the next GPS point reading, and repeat this procedure in the next sampling block. If this is the initial visit to this vector, lay out the next 50 m sampling block before repeating the procedure.

Prior to sampling each block, notate the block number and GPS point reading in the left column. Use this area to make any pertinent notes regarding each block.

| Vector<br>block  | Notes:       | Vector/<br>Transect | GPS Recorded? | Obstruction<br>Type | %<br>Obstructed | Dist. Class<br>Obstructed | Species Code                                                                                   | Distance Class                                                                                                                                    |   |   |   |
|------------------|--------------|---------------------|---------------|---------------------|-----------------|---------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|
|                  |              |                     |               |                     |                 |                           |                                                                                                | 1                                                                                                                                                 | 2 | 3 | 4 |
|                  | Vector Block |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  | GPS E:       |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  | GPS W        |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
| Obstruction Type |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
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|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
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|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
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|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  |              |                     |               |                     |                 |                           |                                                                                                |                                                                                                                                                   |   |   |   |
|                  |              |                     |               |                     |                 |                           | DISTANCE CLASS:<br>1 = Transect to Vector<br>2 = Transect to 10m<br>3 = 10m to 20m<br>4 = >20m | DENSITY CODES:<br>0 = no plants<br>X = non-detect (topography)<br>1 = 1–5 individuals<br>2 = scattered patchy<br>3 = scattered even<br>4 = matrix |   |   |   |

## **Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol**

### **Standard Operating Procedure (SOP) #05**

#### **Management of Unidentified Taxa (Unknowns)**

##### **Version 1.0 (March 2011)**

###### **REVISION HISTORY LOG:**

| Previous Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|--------------------|---------------|--------|--------------|-------------------|---------------|
|                    |               |        |              |                   |               |
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This global standardized operating procedure (GOP) gives step-by-step instructions on how to collect field samples, enter unidentified taxa (referred to hereafter as “unknowns”) into the protocol database and how to edit the records once the unknowns have been identified. This SOP will also provide directions on how to manage the unknown records created in the protocol’s field database species list.

#### **1. Collect field sample of unknown plants**

It may be difficult or impossible to determine the specific identify of individual plants encountered during sampling. When this situation occurs, search the immediate area surrounding the transect, looking for specimens of the unknown plant that are more readily identifiable (e.g., due to the presence of flowers or fruits from current or previous seasons). These may assist in correctly identifying the species in the transect. Collect a sample of the plant with leaves, flower and/or fruit, place it in a press or field notebook, attach a sample label it and fill in the requested information. Assign an unknown code that is unique from all other unknown codes in the park. This specific code will be used whenever the same plant is encountered again during monitoring in that park

#### **2. Assign/create an unknown taxonomic record**

Use the attached Unknown Plant Species Tracking Log to manage the record number assignments and identification of unknowns. When digital data entry is performed in the field on a laptop computer, the field crew will need to add codes for these unknowns to the database species list. The field crew assigns a code that has meaning only to the field crew to each unidentified taxon (e.g., UNKWHITEFLOWER for an unidentified plant with white flowers). Suspected Family or Genus names and/or numbers may also be used. The same assigned code is used for every record of each unknown taxon entered into the database.

#### **3. Identify unknowns from the field**

As soon as possible following collection, the field crew identifies the unknowns collected from the field. When possible, digital scans of the fresh specimen should be made at 600 dpi to preserve the specimen’s identifying features. Scans should be labeled as PARKCODE\_UNKCODE\_DATE(mmddyyyy). Further identification is done either at the network office with the assistance of the plant ecologist or at the local approved herbarium.

#### **4. Edit the unknown taxonomic records**

##### **4.1. Unknowns identified to species (or sub-species)**

- 4.1.1. The species matches an existing record in the protocol's species list – Go to step 4.1.4.
- 4.1.2. The species does not exist in the protocol's species list – Go to step 4.1.3.
- 4.1.3. Add the appropriate scientific nomenclature and associated information for the new species into the database species table.
- 4.1.4. Use the *Edit* function in the protocol database to change the field-assigned unknown code to the correct species code.
- 4.1.5. Notify the project lead that the **Field** database is ready to be appended to the **Current** database.

##### **4.2. Unknowns identified to general unknown categories**

- 4.2.1. Use the *Edit* function in the protocol database to change the field-assigned unknown code to the general unknown code already available in the protocol database (*e.g.*, UNKSHR for an unknown shrub).
- 4.2.2. Notify the project lead that the **Field** database is ready to be appended to the **Current** database.

#### **5. Manage the protocol species list**

This section will be written when SQL Server is up and running.

# Exotic Plant Monitoring

## Unknown Plant Species List, Daily Tracking

### Datasheet Version: 1.0

Proofread by: \_\_\_\_\_  
 Copied by: \_\_\_\_\_  
 Edits to DB date: \_\_\_\_\_  
 Edits to Datsh. date: \_\_\_\_\_  
 Edits to Copies date: \_\_\_\_\_

## Location and Event Information

|                                                      |  |                       |                   |
|------------------------------------------------------|--|-----------------------|-------------------|
| Park Code:                                           |  | Date (mm/dd/yyyy):    |                   |
| Plots/Polygons/Transect:                             |  |                       | Observer Name(s): |
| Protocol Name: Multi-Network Exotic Plant Monitoring |  | Protocol Version: 1.0 |                   |

[illegible]

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

Scientific Name:

MorphoName:

Collector:

Park:

Date:

Site:

Tran./sub.:

Elevation:

Aspect:

Habitat/Associates:

Habit:

Flower/Fruit:

Root:

Notes:

## **Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol**

### **Standard Operating Procedure (SOP) #06**

#### **Collecting Plant Voucher Specimen**

**Version 1.0 (March 2011)**

##### **Revision History**

| Ver. # | Revision Date | Author | Description of Change | Effective Date |
|--------|---------------|--------|-----------------------|----------------|
| 1.00   |               |        |                       |                |

This document details the appropriate collection and curation protocol for voucher specimen collections made in the course of research activities conducted by the Sonoran Desert Network (SODN), Chihuahuan Desert Network (CHDN) and Southern Plains Network (SOPN). Plant collections provide primary documentary evidence for the presence of a vascular plant species at the park unit. This document details the appropriate protocol for voucher specimen collections from collection in the field, through identification, to curation at appropriate herbaria.

##### **Field Data Collection**

Voucher specimen collection is a necessary component of any integrated data collection system for research on vascular plants. For Network researchers, this includes voucher specimen collections made in the course of monitoring, Vegetation mapping, and opportunistic collection efforts conducted at park units. Prior to any collection effort, appropriate collection permits must be obtained for each park by the Project Manager and carried in the field by the crew leader.

##### Voucher Specimens

Voucher specimens are to be collected at the discretion of the field research crews. All crews have appropriate equipment to make voucher specimen collections, including a field press and newspapers for specimen collection, GPS device for location information, and sufficient data sheets. Crews will follow this procedure for collecting plants:

1. Identify the plant as best as possible in the field, taking care to note if it is potentially rare, threatened or endangered. Potential T&E plants should not be collected. These plants should be photographed (see SOP #03) and precise location should be recorded. The 10% rule should always be observed in the collection of all plants, such that no entire plant should be collected if there are fewer than 10 specimens in the immediate vicinity.
2. Care should be taken to obtain flowers, fruits, and roots as practicable.
3. Using a single fold of newspaper per plant, the specimen should be laid out and arranged to display all floral parts for ease of future identification. Arrangement should take care to have half the leaves up and half down, resemble actual plant architecture (where appropriate given size limitations) and carefully open flowers so that all floral parts are visible upon drying. Each newspaper should be labeled with the best guess of specimen identification, the date, park code, and collector initials.
4. Fill out the Voucher Specimen Documentation Form in its entirety using pencil. Record the plants identity, all appropriate location information using UTM coordinates, elevation may be in feet or meters, and note the plant's status in the park, and whether you took a photo. Additionally, take care to fill out habitat description as clearly as possible, referring to both community type and associated species. This form remains with the specimen.

### Care of Voucher Specimens post-collection

Appropriate handling of voucher specimens does not end with collection in the field. At the earliest practical opportunity, those collections that have been made using a field press need to be transferred to an appropriate herbarium press for further drying and curing of the specimen. At the time of transfer, if no firm identification of the specimen has been made, another attempt at identification should be made using appropriate floras and literature. This identification (if different than the field identification) should replace the original on the form, do not consider this an annotation, but note the determiner (if different from the collector) in the appropriate field on the data sheet. Properly secure the specimens and allow them to cure. Upon return to the office, notify the Network botanist of the collections that have been made for transfer to the herbarium and once the plants are dried and ready for transfer place in the herbarium cabinet in the office.

### **From Field Collection to Herbarium**

Upon receipt of the specimens, the Network botanist will verify the collections and identifications prior to their transfer to the appropriate herbarium of record. The following procedures will be followed once the specimens are transferred to the herbarium:

1. Obtain the vouchering protocol from the appropriate herbarium and follow all instructions.
2. The collections are packaged appropriately and placed in the freezer to guard against insect infestation. This process takes a minimum of a week.
3. At the completion of the freezing process, the specimens are removed and placed on Network/NPS holding shelves. If further identification of unknowns is necessary, at this point an effort is made by Network botanists to clarify and identify all specimens. All those specimens deemed of insufficient quality are discarded.
4. All satisfactory specimens are then given to herbarium staff for verification of identity. All verification and annotation (if necessary) take place prior to accessioning into the appropriate herbarium collection and NPS cataloging. Once verification has taken place, all specimens will be collected by Network staff and sorted into park-specific batches.
5. For SODN vouchers: At the completion of this initial identification and verification process, the original data sheets will be provided to curators at the Western Archaeological and Conservation Center (WACC) in order to be cataloged in the Department of the Interior Collections Management System. Each specimen will receive an NPS catalog number and a copy of the completed original data sheet will be made and returned to SODN. The original will remain at WACC as a record of the specimen for archival purposes. SODN will make a copy for its own internal archives, and the completed data sheet will be returned the University of Arizona Herbarium for accessioning.
6. All specimens that have received appropriate NPS catalog numbers will then be accessioned into the herbarium collection. All labeling of these specimens will utilize appropriate NPS labels which prominently bear the arrowhead logo and the NPS catalog number.
7. As per the loan agreement, specimens will remain at the herbarium for the duration of that agreement.

## Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol

### Standard Operating Procedure (SOP) #07

#### Daily data management

#### Version 1.0 (March 2011)

##### Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|--------------------|---------------|--------|--------------|-------------------|---------------|
|                    |               |        |              |                   |               |
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#### 1. Exotic plant daily field data management protocol

This document outlines the specific daily data management tasks for all data collected in the field for this protocol. This includes tabular data, spatial data and photographs. Storage locations are SODN specific.

##### 1.1. Compile data sheets

- 1.1.1. Data sheets compiled and placed into a manila folder labeled "PARK\_Panel#\_YYYYMMDD"
- 1.1.2. If some data is collected electronically, use the database print out function to generate paper sheets for these and store with other datasheets.
- 1.1.3. Verify all datasheets complete and attempt to verify any unknown plants. Adjust datasheets and database as needed.
- 1.1.4. Copy datasheets and store separately from originals.

##### 1.2. Transfer photos

Photos are transferred onto computer (en masse) and labeled "PARK\_Panel#\_Beginning/EndingBlock#\_YYYYMMDD". For example, **GUMO\_P1\_B100(or E128)\_20100312**, where "beginning" is at the beginning of the vector from the center looking down the transect and "ending" is at the end of the transect from the center of the vector looking back up the vector.

- 1.2.1. Photos are stored on office computer in Protocol\Photos\Data...then by park
- 1.2.2. During a tour at a park (remote from network servers), photos should be backed up on external hard drive if possible each night to ensure against data loss.
- 1.2.3. Verify that all appropriate metadata for the photos has been collected (see SOP #03).

##### 1.3. Spatial data transfer

- 1.3.1. Transfer point files and/or photo points to office computer at end of tour and file in appropriate folders on the network server.
- 1.3.2. Open ArcCatalog, navigate to folder from 1.3.1.
- 1.3.3. Select point file for panel/blocks of interest and check name is in proper format "PARK\_Panel#\_Blocks (insert number range)\_YYYYMMDD"; change it in this program if needed. Example: **FOBO\_P1\_B1-22\_20110312**.
- 1.3.4. Chose preview tab in large right window of ArcCatalog interface

- 1.3.5. Within lower drop down box, chose either geography or table to view those portions of the shapefile.
- 1.3.6. Use the 'geography' to check that the points are well spaced, that there are the appropriate number of points (one per block sampled, plus one for the start point) and that there are no 'wayward' points far from other points due to loss of good reception etc.
- 1.3.7. Use the 'table' preview to check that the file has been correctly and fully attributed. If necessary utilize the editor toolbar to make any changes (see 1.4).
- 1.3.8. If all are correct, proceed to step 1.3.9.
- 1.3.9. Repeat steps 1.3.3 to 1.3.7. for the photo point files if collected, with the correct naming convention "PARK\_P#\_B##"s\_PP\_YYYYMMDD". Example **FOBO\_P1\_B1-22\_PP\_20110312**.

#### **1.4. Editing spatial files**

- 1.4.1. Open ArcMap. Use the 'add data' tool to open the files needing edits. Click through the error on projection.
- 1.4.2. "Start editing" on the Editing toolbar.
- 1.4.3. Chose proper file to edit; check the editing target on the toolbar if you have multiple field data files loaded into your project for editing.
- 1.4.4. Make changes to attributes or delete extra points etc and then chose "save edits" using the editor drop down menu on the editor tool bar.
- 1.4.5. Edit next file. When all edits are complete, choose "Stop editing" on the same drop down menu of the editor tool bar.
- 1.4.6. Highlight shapefiles on ArcMap table of contents and right click. Choose "Remove". Exit ArcMap.
- 1.4.7. It is recommended that a Master shapefile be created to house the spatial data from each park and to which field data can be appended at the end of each field day or tour. This file should be named ParkCode\_Protocol\_Master. Two folders should be made also, one called To\_be\_appended and the other Appended\_to\_master. This keeps track of what has been edited post field and also keeps all the original data in one place for archiving and back-up.
- 1.4.8. If utilizing a geodatabase for spatial data, please refer to other network specific SOP's on data transfer using the check-in check-out functions with ArcPad data manager toolbar.

#### **1.5. Electronic data entry - Backup MDB**

- 1.5.1. If data is collected electronically in the field using laptops or other units, place a copy of the most recent database backend or other file type (excel) used in the field (FIELD\_BE\_Exotics\_YYYYMMDD) – with the date distinguishing beginning of current field tour, into the appropriate folder on an external hard drive or computer for back-up.
- 1.5.2. At end of tour (or each day if working locally) transfer this file to the network server and notify project lead or data manager of status. If using a database 'field copy', this should be appended into the current version of the parent database.

#### **1.6. Update completed plots sheet**

- 1.6.1. Update "PARKCODE\_Completed\_Plots" excel spreadsheet. Do this in both most recent copy on office computer and on external hard drive. This can be found in C:\Exotics\Data\_Nonspatial\Processed\_data.

**Monitoring Procedure for the  
Multi-Network Exotic Plant Monitoring Protocol**

**Standard Operating Procedure (SOP) #08**

**Using TDS RECON to Conduct Data Collection And Mapping  
Global Operating Procedure**

**Version 1.0 (March 2011)**

**REVISION HISTORY LOG:**

| Previous Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|--------------------|---------------|--------|--------------|-------------------|---------------|
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This global standardized operating describes how to use a RECON unit with integrated GPS and HGIS (ArcPad is also available) software to conduct mapping activities. Instructions are for RECON model 200xs or 400 xs and for HGIS version 8.

**1. Preparing the unit for mapping.**

- 1.1. Prior to field mapping, prepare the unit by loading files appropriate to the mapping task such as baselayers, aerial imagery and templates from the appropriate Network GIS drive.
- 1.2. Make sure unit is fully charged and in good overall condition.

**2. To begin mapping.**

- 2.1. Power the unit on. From the start up screen tap **START** → **GPS** viewer. Follow the instructions found in V:\Global\_SOPs\Handhelds\Collecting\_GPS\_Recons to set appropriate GPS data collection standards.
- 2.2. Open **HGIS CE8** from the start menu. From the first screen chose HGIS\_Pro\_1. (If user settings have not been saved previously choose **New Set up** and select **Plus image, edit** and **PRO all features** to give you near maximum and maximum function respectively).
- 2.3. Select Start GPS. From the Open GPS Port screen make sure that: **Port** = COM2 **Baud** = 4800 **Drop down list** = Serial NMEA.
- 2.4. Once HGIS is open another drop down appears with several options for opening working files/ layers. Where available use **Open Project** to simultaneously open all layers pertaining to the current project (see below for instructions on how to create and save a project), else use **File** → **Open Layer** to access and load individual layers one at a time. Set Datum to *North America NAD83*, and select the appropriate UTM zone for your area. Draw style options will be presented.
- 2.5. Once you have an acceptable GPS fix and all base layers are open you can begin mapping. Use existing templates for data collection where available: **File** → **Layer** → **New from template**. Name the layer following guidelines set out in Global SOP # (Park code\_subject/project/location\_dateYYYYMMDD), and highlight point, polygon or line icons for the type of data to be collected in this file, hit OK. One file can be created within which you can collect point, line and polygon data, or separate files can be created for each type of feature mapped (there are limitations and benefits to both methods). Files with multiple features will be split into two (or 3) files when you save data at the end of the day (see below "**Saving Data**").

**Define layer** is used when templates do not exist. Options are presented that allow you to add any number of new fields to the attribute table (template) specific to the project at hand, such as plot number, notes, species etc. These are in addition to the fields automatically filled by the unit such as UTM's, altitude, date, time etc.

- 2.6. Before recording the first item, be sure you have the correct file in edit mode. To view which file you currently have active go to **Map** → **Layer Properties**. This screen will show all layers that you have open. Click to create a check mark next to **Edit** for the file you wish to add data to. Only one file can be edited at a time. Close this screen by tapping the **X** in the top right corner.
- 2.7. To mark a point, boundary or line feature choose **GPS draw** from the tool drop down in the top right hand corner of the screen. Once activated a new toolbar will appear from which you can choose point, polygon or line icons. The unit will begin recording data as soon as these icons are highlighted therefore position yourself where you want to mark a feature before activating this control. The first feature type you make will prompt the system to start auto numbering; hit OK. Continue to draw the feature until complete then turn GPS draw off and activate the **Select one** control from the same top right tool drop down list.
- 2.8. Select the feature you just made and then tap on the attribute table icon. Once the table is open fill out all fields. Close this screen and continue mapping. When drawing point features, the point will stay highlighted once drawn therefore you need not "select" it but just open the attribute table.
- 2.9. Note: Points are created immediately and have no "run time" whereas drawing line or polygon features occurs over time. While mapping these features, a spinning bar will be visible in the mapping toolbar. This spinning icon indicates that you are actively drawing. If you need to pause the draw, tap this icon until it reads "user pause" during which time you can move from your location (around an obstacle for example) to a new location and then resume drawing by tapping the icon again. The unit will automatically pick up the line from where it left off and continue to draw.
- 2.10. When drawing features it is advisable to be zoomed in to approximately 10m such that you can clearly view the feature being drawn. Do not cross over lines already drawn as this confuses the spatial area. Also, as the RECONS have only  $\approx 5\text{m}$  accuracy check your HDOP while mapping or avoid drawing boundary features less than 5m across, as these lines can cross as the unit fluctuates in accuracy.

### 3. Creating and saving projects.

- 3.1. Projects can be created for a particular location or area such that they contain several useful base layers or data layers that can be opened at the same time. New layers created in the field such as sampling location point files can be added (saved) to the project when you close HGIS.
- 3.2. To create a project on the RECON, open all layers individually that you wish to include in the project. Then go to **File** → **Project** → **Save Project As**. Enter the desired name for the project and save it in the Mapping\_Layers folder. Projects can also be created with ease on a desktop computer using HGIS software before field work and then loaded on to several RECONS. The process is the same except you can save the project to the appropriate folder on the server.

### 4. Templates.

- 4.1 Templates are usually created in the office using HGIS desktop and are created with a particular data collection task in mind. To create a new template open HGIS and load or define any layer. Once a layer is open you can access the define template function; go to **File** → **Template** → **Define Template**. Name the template then add, delete and move fields as needed. Save template to appropriate folder on the server.

- 4.2 Templates can be edited using the template structure tab: **File → Template → Template structure**. Pick lists can also be added to any of the fields in the attribute table. Go to **File → Template → Pick List**. A list of layers you have open will appear; chose the layer you wish to edit. Scroll through the attributes to find the one to edit then hit **New**. Type in the first item on the pick list then hit **Add** to continue entering additional items. When complete, hit done, then hit finished.

## 5. Saving data.

- 5.1 It is not necessary to save your data after every new feature is created but it should be saved every hour or so to prevent data loss should the battery fail. It is also recommended that data be saved after a great deal of time or effort has been made to access the location or record the data.
- 5.2 There are two ways to save data. Either 1) go to **Layer → Save Layer** → select the file you wish to save. Set the following fields as listed **Folder** = Field\_Data, **Type** = Map: SHP+ SHX + DBF, **Location** = Storage card, Hit OK. The datum should be set to North America NAD83, UTM zone 12. Or 2) go to **Map → Layer properties** and tap on the name of the file you wish to save. From the next screen hit **Save Layer**. Set the fields as noted above.
- 5.3 In the event that you have several different feature types in one file you will need to save the file as many times as you have different features. Using either saving method described above you will be prompted by the system to specify which features you wish to save: points, lines or polygons. Select one of the feature types first, complete the saving process then repeat the whole process selecting the next feature type to save until all feature types from the layer have been saved. In this event you will have up to three separate files saved differentiated by the system by suffixes such as point, boundary etc.
- 5.4 On the RECON 200 units programs can be backed up periodically to prevent loss when systems fail. To do this tap **Start → Programs → Sprite backup**. Do this type of backup after loading new programs. It takes less than 1 minute and will return you to the programs screen once complete. If you ever experience a hard reset on the unit you can restore your data from your last backup by tapping: **Start → Programs → Sprite backup → Restore now**. It will prompt you for permission to do a soft reset once complete. Newer units do not have this function and have built in back-up systems.

## 6. Downloading data.

- 6.1. To download data you need a specialized USB cord and Microsoft ActiveSync on your computer. Data can be downloaded to any desktop, laptop or tablet. Specific one-to-one partnerships can be established between RECONs and desktop computers such that new data will automatically be recognized and downloaded when the two units are synced. This is not necessary though and any RECON can be accessed from any computer using the *Guest* set up and then the **Explore** function. Explore allows you to access all folders on the RECON and data is then retrieved and moved to the server using copy/paste or cut/paste functions.
- 6.1.1. The ActiveSync can be put into permanent *Guest* mode on any computer (to avoid cycling through the connection/sync options when plugging in a RECON) using the following procedure. All RECONs connected to the edited computer will automatically be put in *Guest* mode. This change will need to be made on each computer you wish to have permanent *Guest* mode connection settings.
- 6.1.1.1. Open Registry Editor (as an administrator): Open the "Run.." in the start menu and type "Regedit".
- 6.1.1.2. Navigate to *HKEY\_LOCAL\_MACHINE\Software\Microsoft\Windows CE Services* through the expandable menus.
- 6.1.1.3. Create a new DWORD value called GuestOnly: Right click the "Windows CE Services" title and choose "New..." then "DWORD Value", the DWORD Value will appear in the right screen with its name highlighted. Type "GuestOnly" in that frame.

- 6.1.1.4. Set this new DWORD Value to 1: Right click your new "GuestOnly" title and choose "Modify". Enter "1" in the "Value" field, leaving the radio buttons at default values.
- 6.1.1.5. Close out the Registry Editor.
- 6.2. When units are frequently being used for various projects by different people, data can be deleted from the RECON once it has been saved to another source such as the SODN server. The next person to use the unit will then have a clean unit to work with and will not need to worry about deleting or saving your files. Removing imagery files no longer in use for example will also free up memory.

## 7. Troubleshooting.

- 7.1. If your system freezes, do a soft reset. Hold down the power button for a few seconds until a warning appears advising you that if you continue to hold a soft reset will occur. Continue to hold the button until the unit powers off, it is essentially a restart.
- 7.2. If you cannot access Com port 2 when trying to start your GPS unit you may be running an unnecessary program like Activesync which uses that same port. Go to **Start** → **System** → **Memory** → **Running programs**. From the list select and Stop all programs (other than HGIS) that may be using the port.
- 7.3. HGIS has a built in help menu notated by a "?" at the end of each menu function. Click on this question mark to bring up help menu text.
- 7.4. Occasionally the GPS card will not be recognized by the RECON even though the card is fully inserted. Remove the cap and gently slide out the GPS card and reinsert. This often fixes the problem. When properly inserted the orange light on the side of the GPS card should be lit.
- 7.5. If you experience any other issues or continued problems with the above topics contact your project leader or the cartographic data technician for assistance.

## Multi-Network Exotic Plant Monitoring Protocol

### Standard Operating Procedure (SOP) #09

#### Data Management

#### Version 1.0 (March 2011)

##### Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reason for Change | New Version # |
|--------------------|---------------|--------|--------------|-------------------|---------------|
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This standard operating procedure (SOP) describes the procedures for managing and maintaining data collected by the Multi-Network Exotic Plant (Exotic) monitoring protocol for the Sonoran Desert, Chihuahuan Desert and Southern Plains Networks. The SOP was developed in accordance with strategies and guidance for data processing and quality assurance/quality control (QA/QC) specified in the network data management plan (Angell 2005). The instructions are presented within the framework of the typical annual workflow for a monitoring project, which includes three phases: 1) implementation, 2) product integration, and 3) evaluation and closure. Staff role(s) primarily responsible for ensuring the completion of each step are indicated in parentheses. Refer to SOP #08 for detailed instructions on specific daily data management tasks.

##### Project Implementation

The project leader oversees all aspects of the project implementation phase, which is repeated each field season. Data management staff acts primarily as facilitators to support database applications, GIS, GPS, data QA/QC and certification procedures, data summarization, and data analysis. The implementation phase is further subdivided into three stages: 1) preparation, 2) data acquisition and processing, and 3) product delivery and review.

##### Preparation

1. Conduct the kick-off meeting for the current field season approximately one month prior to beginning sampling. Schedule at least two pace meetings during the field season to assess progress and address any problems that may affect completing the work on schedule. Save the kick-off meeting notes in the **Project\_Mgmt** subfolder of the project **Admin** folder on the Active drive. Refer to Section 8.1 of the protocol narrative for additional information on the annual project schedule and workflow. **(Project Leader)**
2. Ensure that the “product tracking” portion of the kick-off meeting notes is completed. **(Project Leader)**
3. Ensure that the “project tracking” web application has been reset and is ready for the current field season. Update this application during the season to track the progress of work through the three phases of the monitoring project. **(Project Leader/Data Manager; Project and Data Management Staff)**
4. Ensure that the Exotic project workspace is in place on the Active drive and contains only files relevant to the current year/season. Files from the previous year should have been transferred to the master Exotic project file on the Archive drive. **(Project Leader/Data Management Staff)**

5. Ensure that the current front-end database and a blank copy of the current back-end database are installed in the project workspace and on any field computer(s) that will be used for data entry in the field. Refer to the “Database Work Flow” GOP for the recommended file structure.  
**(Assistant Data Manager)**
6. Upload necessary GIS layers/maps and associated background layers to the project GPS units.  
**(Assistant Data Manager or Field Crew Leader)**
7. Print paper data sheets, sampling point maps, and lists of park-taxa for use in the field. **(Project or Field Crew Leader)**
8. Ensure that names and contact information for field crew members are entered into the *Contacts* data table. **(Project Leader/Assistant Data Manager)**

### **Data acquisition and processing**

Acquire field data as specified in this protocol and associated SOPs. Data are acquired using one of three methods: 1) manually recording data on paper field data sheets, 2) entering data directly into the project database on the field computer(s), or 3) downloading data from handheld or automated sensors.  
**(Field Crew)**

### ***Tabular data collection and entry***

*Paper field data sheets* (also refer to the “*Paper Data Sheet Management*” guidance document for further details)

1. Record data neatly and legibly on the data sheet in the appropriate spaces, including all fields in the **Location and Event Information** box. Record data in the correct formats and use only values from printed code lists, where applicable. **(Field Crew)**
2. Before moving to the next field data sheet or sampling location, review each data sheet to ensure that all required parameters have been recorded and there are no obvious errors. If corrections are required, incorrect values may be erased and replaced with correct values. **(Data Recorder)**
3. At the end of each field day, review all the field data sheets for that day. If corrections are required, incorrect values may be erased and corrected on the data sheet. Initial and date the “proofread by” space on each data sheet. **(Project or Field Crew Leader)**
4. At the end of each day or other logical period of time, photocopy each data sheet, ensuring that the copies are legible and complete (i.e., nothing is cut off at the edges). Initial and date the “copied by” space on the original data sheet before making the copy. File the originals in the seasonal fireproof file cabinet, and retain the copies for data entry and verification. **(Field Crew)**
5. Conduct a data entry trial and quality review after one day (or another logical period) of manual data collection.
  - a. Enter the test data into the database and verify them according to the instructions in the “tabular data verification, validation, and certification” section of this SOP. **(Field Crew)**
  - b. Review the test data set. **(Project Leader/Data Manager)**
  - c. If the data meet overall project quality requirements, continue data collection. **(Field Crew)**
  - d. If data quality is not acceptable, provide additional training to the observers, who then repeat the data-entry trial and quality test. **(Project Leader/Data Management Staff)**
  - e. If data quality has not improved to meet standards after the second trial, examine other aspects of the protocol and the database for factors that may be contributing to the difficulty in meeting data-quality requirements. Implement any desired changes and repeat the steps in this section until data quality meets the requirements. **(Project Leader/Data Management Staff)**

6. Regularly enter the data into the project database according to the instructions in the “Exotic Monitoring Database User Guide.” Do not wait until the end of the field season to begin entering data. Keeping current with data entry aids in finding and correcting errors while the information is still fresh in the minds of the field crew. Initial and date the “entered by” space on each data sheet after the data are entered. **(Field Crew)**

Electronic data entry (also refer to the “Digital Data Sheet Management” guidance document for further details)

1. Use the data entry forms to enter data directly into the digital project database. The database has built-in checks and drop-down lists to streamline data entry and help ensure data quality. **(Field Crew)**
2. Before moving to the next field form or sampling location, review each digital data form to ensure that all required parameters have been entered and there are no obvious errors. If corrections are required, make them at this time. **(Field Crew)**
3. At the end of each day, print out the digital data forms for that day and review them. If corrections are required, make them in the digital database using the *Edit data* function and print a new copy of the data form. Initial and date the “proofread by” space on each data sheet. **(Project or Field Crew Leader)**
4. Photocopy each printed data sheet, ensuring that the copies are legible and complete (i.e., nothing is cut off at the edges). Initial and date the “copied by” space on the original printout before making the copy. File the printouts and the copies in the seasonal fireproof file cabinet. **(Field Crew)**
5. The first day of electronic data collection serves as the data entry trial. The field crew leader's review of the data collected that day serves as the quality review. If data quality is not acceptable, follow the procedures in Step 5 of the previous section (“Conduct a data entry trial and quality review after one day (or another logical period) of manual data collection”). **(Field Crew, Project or Field Crew Leader)**
6. Transfer the field back-end database(s) to the V:\ drive at regular intervals and append the data to the current back-end project database. Refer to the “Database Work Flow” GOP for step-by-step instructions. **(Project Leader/Assistant Data Manager)**

Automated data collection (e.g., data loggers)

1. Download the data according to the instructions in the SOPs. **(Field Crew)**
2. Perform any field validation routines specified in the SOPs. **(Field Crew)**
3. Transfer the files to the **Raw\_Data** subfolder of the **Data\_Nonspatial** folder in the project workspace on the V:\ drive. **(Field Crew)**
4. If applicable, import the data into the project database. **(Field Crew Leader/Assistant Data Manager)**

**Tabular data verification, validation, and certification**

Paper field data sheets

1. Follow the instructions in the “QA/QC Procedures for Digital Data Entered from Paper Field Sheets” GOP to verify, validate, and certify the seasonal data set. **(Field Crew/Project Leader)**
2. File the copied data sheets and the verification printouts in the seasonal fireproof file cabinet after the data are certified. **(Field Crew)**

Electronic data entry

The need for data verification has been eliminated by entering data directly into the database, and the data set has been partially validated during data entry and subsequent reviews of the data forms.

1. Follow any additional validation procedures specified in the data collection SOPs, and run any automated database validation checks. **(Project Leader)**
2. Review the results and make any necessary changes. **(Project Leader)**
3. Keep a list of all corrections made and relevant comments about the data set. Make note of any extreme values determined to be correct to confirm their validity for future users of the data. Report this information in the “quality assurance review” section of the “Project Data Certification” form. **(Project Leader)**
4. Certify the seasonal data set by completing all sections of the “Project Data Certification” form and submitting it to the data manager. (See Section 3 in the “QA/QC Procedures for Digital Data Entered from Paper Field Sheets” GOP for further details.) **(Project Leader)**

#### Automated data collection (e.g., data loggers)

1. Validate the data set according to the validation procedures specified in the SOPs, including any automated database validation checks. **(Project Leader)**
2. Keep a list of any inconsistencies or problems with the data set, all corrections made, and relevant comments about the data set. Make note of any extreme values determined to be correct to confirm their validity for future users of the data. Report this information in the “quality assurance review” section of the “Project Data Certification” form. **(Project Leader)**
3. Certify the seasonal data set by completing all sections of the “Project Data Certification” form and submitting it to the data manager. (See Section 3 in the “QA/QC Procedures for Digital Data Entered from Paper Field Sheets” GOP for further details.) **(Project Leader)**

#### **Spatial data collection**

1. Collect spatial data of the highest possible quality according to the instructions in the data collection SOPs and the network GOPs on using the various handheld units. **(Field Crew)**
2. Download the data to the **Raw\_Data** subfolder of the **Data\_Spatial** folder in the project workspace on the V:\ drive. **(Field Crew or Assistant Data Manager)**
3. Inform the assistant data manager if post-processing is needed. **(Field Crew Leader)**
4. Post-process the data, if needed. **(Assistant Data Manager)**

#### **Photograph acquisition**

1. Take digital photographs of the highest possible quality, as specified in the SOPs. Refer to the “Taking Quality Photos” GOP for further guidance on using SODN cameras for project photos. **(Field Crew)**
2. Download the images daily (if possible; if not, as soon as practical) to the appropriate subfolder (**Data**, **General**, or **Identification**) in the **Photographs** folder of the project workspace. **(Field Crew)**
3. Review the photos and delete poor-quality or unnecessary duplicate photos of the same subject. You may retain a poor-quality photo if the subject is highly unique or unusual. **(Project or Field Crew Leader)**
4. Rename the photos as specified in the SOPs or, if not specified in an SOP, in the “Digital Photograph Management Strategy” document. **(Project or Field Crew Leader)**

#### **Sensitive data**

1. Evaluate the data set according to the information and procedures in the “Sensitive Data Management Strategy” guidance document, “Director’s Order #66”, and “Reference Manuals 66A and 66B” to determine whether it includes any potentially sensitive data or policy implications that should be withheld from public distribution. **(Project Leader/Data Manager)**

2. Document the results of this evaluation in the “sensitive data” section of the “Project Data Certification” form, so that appropriate steps may be taken when reporting and distributing the data. **(Project Leader)**

#### ***Voucher specimens and photographs***

1. Process any voucher specimens collected during field work according to the instructions in the “Collection and Processing of Specimens” guidance document. **(Project or Field Crew Leader)**
2. Process any voucher photographs taken during field work according to the instructions in the “Digital Photograph Management Strategy” guidance document. **(Project or Field Crew Leader)**

#### ***Master database***

1. Append seasonal certified data to the master database in the project directory on the S:\ drive. Refer to the “Database Work Flow” GOP for detailed instructions. **(Assistant Data Manager)**
2. Notify the project leader and data manager that the data are ready for analysis and reporting. **(Assistant Data Manager)**

#### ***Product development, delivery, and review***

##### ***Analysis and reporting***

The project leader is responsible for analyzing monitoring data and reporting the results, with support from the data management staff. Refer to SOP # # (insert number of the analysis SOP) and # # (insert number of the reporting SOP) for further information and the “Report Management Strategy” guidance document for the workflow.

1. Maintain the automated data analysis and reporting queries in the master project database. **(Data Management Staff)**
2. Design new analysis and report functions when necessary (refer to the “Data Maintenance/Database revisions” section of this SOP). **(Project Leader/Data Management Staff)**
3. Store the results of summaries and analyses in the **Analysis** folder in the project workspace. **(Project Leader)**
4. Store current-season project reports, resource briefs, and similar products in the appropriate subfolders in the **Reports** folder in the project workspace. **(Project Leader)**

##### ***Spatial data development***

1. Create spatial data layers required by the project in the **Processed\_Data** subfolder in the **Data\_Spatial** folder. Follow the instructions in SOP # # when editing spatial data files. Retain final products in the **Processed\_Data** folder; delete interim layers that are no longer needed. **(Field Crew/Project Leader)**
2. Validate spatial data according to the instructions in SOP # # using ArcGIS 9.x (ESRI, Inc.). Visually check the positions of point, line, and polygon features against a backdrop of other spatial layers, such as digital raster graphics, DOQQs, park boundary layers, etc. Certify all spatial data sets by completing a “Project Data Certification” form. **(Project Leader)**
3. Append any new spatial data to the master shapefile. **(Assistant Data Manager)**

##### ***Photographs***

1. Catalog project photos using the ThumbsPlus photo management software. Refer to the “Digital Photograph Management Strategy” guidance document for detailed information on adding keywords during cataloging. **(Project or Field Crew Leader)**

2. Ensure that photos are appropriately organized in the **Photographs** subfolders; you may create additional subfolders as needed. **(Project Leader)**

### ***Metadata development***

#### ***Project database***

Update the FGDC-compliant metadata record and the data dictionary for the tabular database. **(Data Manager/Project Leader)**

#### ***Other digital data sets***

Create an initial FGDC-compliant metadata record and a data dictionary for the digital data set using the NPS Metadata Tools & Editor and the NPS Database Metadata Extractor. Update these documents as needed after each field season. **(Data Manager/Project Leader)**

#### ***Spatial data***

1. Create an FGDC-compliant metadata record for each newly-created shapefile using the NPS Metadata Tools & Editor and ESRI's ArcCatalog software. Update existing metadata records as needed. **(Project or Field Crew Leader/Assistant Data Manager)**
2. Include the Biological Data Profile, if appropriate. **(Project or Field Crew Leader/Assistant Data Manager)**

#### ***Photographs***

Create metadata for each photo using the ThumbsPlus software program. Refer to the "Digital Photograph Management Strategy" document for detailed instructions on creating photo metadata. **(Project or Field Crew Leader)**

### ***Data delivery and product review***

1. Review all raw and derived data products (tabular and spatial), metadata, photographs, reports, and other products to ensure that they fulfill the project objectives and meet the Networks product specifications. Digital files should be clearly named according to network standards and stored in the appropriate folders in the project workspace. Return products that do not pass the review to the originator for revision. **(Project Leader/Assistant Data Manager)**
2. Deliver the final products by entering the delivery date in the "product tracking" portion of the kick-off meeting notes, and notify the data manager via e-mail that they are complete. **(Project Leader)**
3. Review the completed products to ensure they have all been received, are in the right formats, and are ready for cataloging, integration, and distribution. Return products that do not pass the review to the project leader for revision. **(Data Manager/Science Writer-Editor)**

### ***Product Integration***

Data management staff is responsible for most of the tasks in the product integration phase, with some assistance from the project leader and staff. During this phase, project data are integrated into national databases and metadata records and non-sensitive products are cataloged, archived, stored, and distributed to their intended audiences. Follow the guidance in the "Sensitive Data Management Strategy" guidance document and handle sensitive data products appropriately.

### ***National databases and applications***

#### ***IRMA (Integration of Resource Management Applications)***

Use the online IRMA Natural Resource Information Portal (NRPortal) to catalog and upload metadata and products:

### NPSpecies Database

Add new species and supporting evidence recorded during the field season through the NRInfo NPSpecies Application **(Data Manager)**

**OR**

Submit the entire seasonal database to NPSpecies staff for uploading to the database. **(Data Manager)**

### NRInfo Reference Application

1. Catalog annual and synthesis-and-trend reports and upload the pdf(s). **(Data Manager)**
2. Catalog and upload the project database and metadata. **(Data Manager)**
3. Catalog and upload spatial data and metadata. **(Assistant Data Manager)**

## **Network databases and applications**

### ***Network Web Sites***

The Networks' Internet and Intranet web sites automatically query the NR Reference Application and display links to the uplands monitoring project reports.

Notify parks of report publication. **(Project Leader)**

### ***Learning Center of the American Southwest (LCAS) Web Site***

The LCAS web site automatically queries the NR Reference Application and displays links to all Networks' monitoring project reports.

1. Add links to resource briefs (and other LCAS products as listed in Table 6.1 of the protocol narrative) and upload the pdfs to the LCAS repository. **(LCAS Webmaster/Data Management Staff)**
2. Notify parks when these products are available. **(Project Leader)**

### ***Networks' Reference Library***

Store a printed copy of each annual and synthesis-and-trend report in individually labeled folders in the Network Reference Library files. **(Data Management Staff)**

## **Archiving and records management**

### ***Project folder review***

Go through the seasonal folders and ensure that all files are appropriately named and versioned. Determine which ones to retain on the Active drive, which ones to transfer to the master project file on the Archive drive (refer to the "Archiving Instructions" guidance document for more information), and which files to delete (refer to "Director's Order #19" and the accompanying "Records Disposition Schedule" and "Management Handbook" for detailed information on what constitutes a record and which records may be destroyed). **(Project Leader/Data Management Staff)**

### ***Seasonal files***

1. Transfer digital files to the master project folder on the Archive drive. **(Data Management Staff)**
2. Export the tables in the master project database as ASCII text files and store them with the master project database. **(Data Manager)**
3. Transfer copies of paper files (e.g., paper data sheets) to the central project files in the SODN conference room (refer to the "Archiving Instructions" guidance document for more information). **(Data Management Staff)**

4. Transfer original paper and other project files to the designated off-site repository. **(Data Management Staff)**

### ***Backup procedures***

1. Store a copy of the master project database on a CD or DVD in the on- and off-site Networks' media cabinets. **(Data Management Staff)**
2. Make external tape backups of data on the Archive drive on a quarterly basis and store at the Western Archeological and Conservation Center between scheduled backups. At the end of each calendar year, send this backup tape to the Washington Support Office for permanent off-site storage. **(Data Management Staff)**
3. Make external tape backups of all data on the Active drive daily (Monday-Friday) and store in an on-site, fireproof file cabinet. **(Data Management Staff)**

### **Evaluation and Closure**

The evaluation and closure phase involves all project and data management staff in an annual review to evaluate the success of the field season and to verify that all data and products are complete and available.

### **Season close-out meeting**

1. Conduct the season close-out meeting within two weeks of completing the product integration phase to assess how well the project met its objectives and to determine what might be done to improve various aspects of the methodology, implementation, and formats of the resulting information. Refer to the close-out meeting checklist for additional information on evaluating the field season. **(Program Manager, Project Staff, and Data Management Staff)**
2. Create a list of action items to be addressed before the next field season begins. Assign responsibility for each item and set a target completion date. **(Program Manager, Project Staff, and Data Management Staff)**

### **Data Maintenance**

Although all data are carefully checked before being analyzed and reported, certification does not guarantee that the data are entirely free of errors; the next section provides guidelines for making and tracking edits to certified data, if necessary. Similarly, changes in sampling methods and techniques may lead to revisions of the structure or functions of the database; the next section also provides guidelines for making and documenting necessary revisions to the project database.

### **Data editing**

1. The project leader and data management staff work together on any edits to certified archived data. At this stage, printed, original, and copied data sheets are not altered. Field data sheets are reconciled to the database using the edit table and reports. **(Project Leader/Data Manager)**
2. Before beginning the edits, make a backup copy of the database so the original data may be recovered in case mistakes are made during the editing process. Store the backup copy in the **Backups** folder in the **Processed\_Data** folder on the Archive drive. **(Assistant Data Manager)**
3. Make the changes in the master digital database. **(Project Leader/Data Management Staff)**
4. Track changes in *tbl\_Db\_Data\_Edits* in the master project database. **(Project Leader/Data Management Staff)**
5. Print a copy of the "Data Edit Report" and file it with the field data sheets; file a copy of the report with the copied data sheets. **(Project Leader/Data Management Staff)**

### Database revisions

1. Before making any major revisions to either the structure or functions of the front- or back-end database, make an archive copy to allow tracking of changes over time. **(Assistant Data Manager)**
2. Store the archive copy in the **Archive** folder in the **Processed\_Data** folder on the Archive drive. **(Assistant Data Manager)**
3. Rename the master database using the next appropriate version number, and make the changes. Refer to the “Digital File Management Strategy” guidance document for detailed instructions on database versioning. **(Data Management Staff)**
4. Track changes in *tbl\_Db\_Revisions* in the master project database. **(Data Management Staff)**
5. Notify frequent users of the database about the updated version. **(Data Management Staff)**

### REFERENCES

Angell, Deborah L. 2005. Sonoran Desert Network data management plan. National Park Service Inventory and Monitoring Program, Sonoran Desert Network, Tucson, AZ.  
<http://science.nature.nps.gov/im/units/sodn/datamanagement.cfm>

Guidance documents, global operating procedures (GOPs), and forms mentioned in this SOP may be downloaded from the SODN online Data Management Guidance Library at  
<http://science.nature.nps.gov/im/units/sodn/datamanagement/guidancelibrary.cfm>

## **Monitoring Procedure for the Multi-Network Exotic Plant Monitoring Protocol**

### **Standard Operating Procedure (SOP) #10**

#### **Revising the Protocol Narrative and SOPs**

**Version 1.0 (March 2011)**

##### **Revision History Log**

| <b>Previous Version #</b> | <b>Revision date</b> | <b>Author</b> | <b>Changes made</b> | <b>Reason for change</b> | <b>New Version #</b> |
|---------------------------|----------------------|---------------|---------------------|--------------------------|----------------------|
|                           |                      |               |                     |                          |                      |
|                           |                      |               |                     |                          |                      |
|                           |                      |               |                     |                          |                      |

This SOP explains how to make and track changes to the protocol narrative and related SOPs. Following these guidelines ensures that previous data collection and processing procedures are documented and retained for use and interpretation of historical data sets. Similarly, clear articulation of new methods is crucial to credible interpretation of data acquired since the implementation of changes.

Project staff should refer to this SOP when any changes to an approved protocol document are necessary. They must ensure that the proper level of review is conducted and that documentation standards are followed. They should also understand protocol versioning methods to ensure that the active version of a protocol document is revised and make the revisions in a timely manner in order to minimize disruptions to project operations.

##### **Protocol Review**

This protocol attempts to incorporate the soundest methodologies for collecting, managing, analyzing, and reporting terrestrial vegetation and soils data. However, the protocol will be updated as necessary when new technologies, methods, or equipment is adopted. Changes should first be evaluated in terms of cost and benefit, then subjected to appropriate review and, if approved, implemented in a timely manner.

All modifications should be reviewed for clarity and technical soundness. Small changes to existing documents, such as formatting, simple clarification of existing content, minor changes to the monitoring schedule or budget, or general updates to data management SOPs, are reviewed in-house by appropriate Network staff and cooperators. More substantial changes that are significant in scope and impact, such as those made to the sampling design, data-collection methods, or analysis techniques, generally require an outside review coordinated by the NPS Intermountain Regional Office, using reviewers familiar with terrestrial vegetation and soils monitoring and data analysis.

##### **Document Life Cycle**

Protocol documents are maintained as separate MS Word files for each component (e.g., narrative, SOP). During its life cycle, each document can be classified into one of six life cycle stages:

1. Draft documents: Documents that have been drafted or revised but have not yet been reviewed and approved.
2. Review documents: Draft documents distributed for peer or administrative review.
3. Active documents: Documents that have been reviewed and approved and are currently implemented for active monitoring projects.
4. Archived documents: Comprehensive set of active protocol documents, published NPS Natural Resource Report (NRR) series versions of the complete protocol, and inactive documents (see above). These are stored on the S:\ drive as read-only and provide the history of protocol components through time.
5. Distribution copies: .pdf versions of approved protocol components for posting to web sites or otherwise sharing outside the NPS.

### Revision Procedures

The project leader is primarily responsible for protocol revisions, including making the actual edits and ensuring document review at the appropriate level. The process for revising protocol documents is shown in Figure 1 (adapted from J. Boetsch, North Coast and Cascades Network) and explained below.

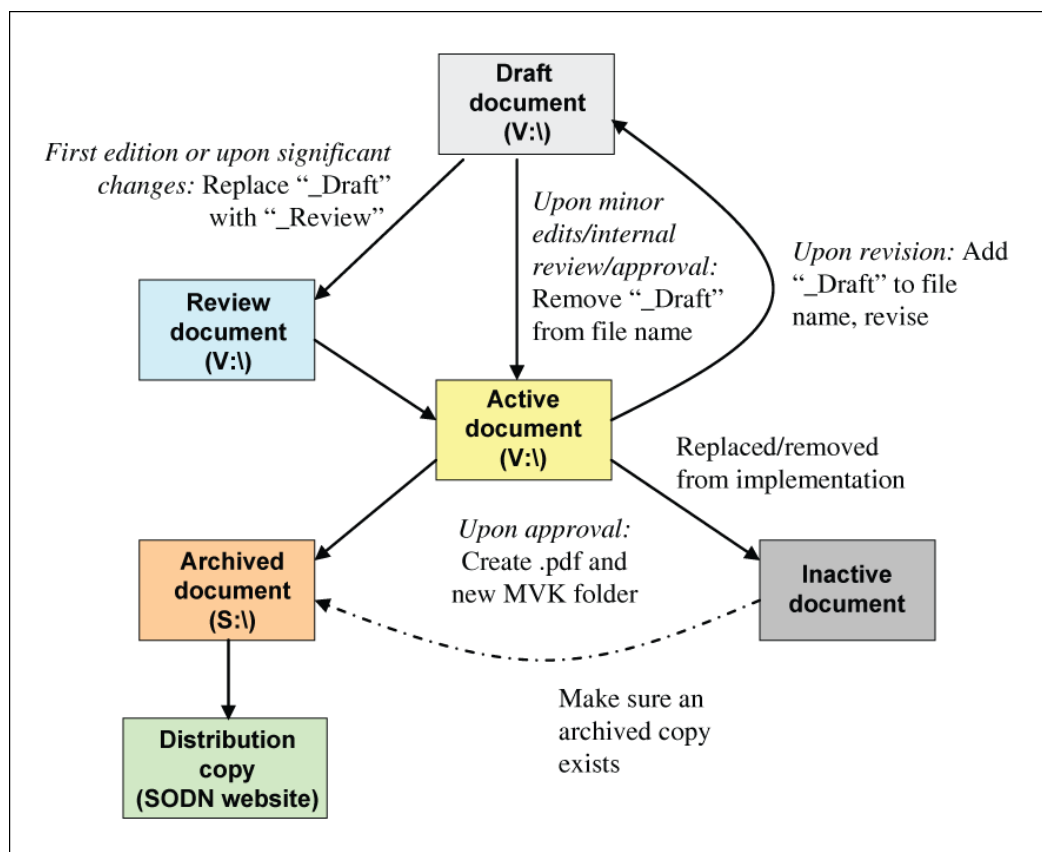


Figure 1. Process for creating and revising protocol documents. Boxes represent document life cycle stages (with the file location in parentheses); connecting arrows indicate procedures.

Be aware that a change in one document may trigger changes in other documents. For example, a change in the protocol narrative may require edits in several SOPs, or renumbering an SOP may require changing references to that SOP in other protocol documents. Remember that appendices may also require updating.

1. Discuss changes. Project staff should evaluate proposed modifications prior to revising any documents. Consulting with the data management staff is particularly important prior to making changes to ensure that data set integrity and continuity will be maintained. To avoid interference with project operations, advance notice of changes is also important, because they may lead to revisions to the database structure or functions that require a significant amount of time to complete. Project and data management staff should agree on who will make the changes and establish a timeline for completion.
2. Revise document.
  - a. Create the *draft* of the protocol document to be revised by making a copy of the *active* MS Word document. Change the version number and add “\_Draft” to the base file name of the protocol document. Refer to the SODN “Digital File Management Strategy” guidance document for accepted naming standards and conventions.
  - b. Turn on the *Track Changes* feature in MS Word prior to making any edits.
  - c. Change the version number in the document header and title sections; change the effective date. Refer to the SODN “Digital File Management Strategy” guidance document for detailed instructions on protocol versioning.
  - d. Add “ – Draft” to the document header and “(Draft)” after the version number in the title section.
  - e. Update the file name and path in the document footer.
  - f. If desired, you may also add “D R A F T” to display as a diagonally printed watermark on each page.
  - g. Make the agreed-upon revisions.
3. Track revision history. Use the “Revision History Log” to document edits in only the document that is modified. Record the previous version number, date of revision, author of revision, a brief description of the changes, paragraphs and pages where changes were made, the reason(s) for the changes, and the new version number.
4. Circulate for review.
  - a. For minor changes, circulate the revised *draft* among network staff and cooperators.
  - b. If changes are substantial enough to merit peer review, create the *review* copy of the document by replacing “\_Draft” with “\_Review” in the file name.
  - c. Submit the document for peer review according to the instructions in the “Report Management Strategy” guidance document.
5. Finalize document. After approval and final changes:
  - a. Ensure that version numbers, file names, etc., are updated appropriately throughout the protocol documents.

- b. Remove “\_Draft” or “\_Review” from the file name to designate it as the active document. Remove the “D R A F T” watermark, if one was used.
  - c. Remove all editing markup and comments for the final (*active*) version.
  - d. Enter all narrative and SOP version changes in the Master Version Table (MVT), which is maintained at the end of this SOP. Create and record a new Version Key number (VK#) in the MVT, along with the date of change and the version of the current narrative and each SOP. The VK# increases incrementally by integers (e.g., 1, 2, 3, 4, 5; no zeroes).  
**NOTE:** The Version Key number is essential for project information to be properly analyzed and interpreted. *Do not distribute the protocol narrative, SOPs, or data independently of this table.*
  - e. Update the “Protocol Version” to the new VK# on the master copy of all field data sheets and in the project database.
  - f. Inform the data manager which protocol documents have been updated.
  - g. For minor edits to only the protocol's SOP(s) proceed to the distribution portion of this SOP. For any major edits to the SOP(s) or for any edits to the protocol's narrative; refer to the “Reports Management Strategy” guidance document for procedures to follow if the protocol is to be republished in the Natural Resource Report (NRR) series.
6. Create *distribution* copies. Data management staff is responsible for document distribution and archiving (Step 7).
- a. Create a pdf version of the new *active* MS Word document for posting to the SODN Internet site for sharing with others. This pdf should have the same name as the MS Word file.
  - b. A pdf version of this SOP, with the updated MVT, which will also be posted to the SODN Internet site.
  - c. Replace the previous *distribution* copy on the SODN monitoring web page with the revised pdf.
  - d. Notify known users of the former version of the revised document that a new version is now available.
7. Archive document.
- a. On the S:\ drive; under the project's protocols folder in the **Narrative\_SOP** folder, create a new folder with the name of the new Master Version Key.
  - b. If the revision to any of the protocol's SOP(s) causes the protocol to be republished, then a pdf and Indesign version of the entire protocol will be placed into this folder. Along a pdf copy of the protocol narrative and each SOP. Ensure that each file is named in accordance with “Digital File Management Strategy.”
  - c. If the protocol has been republished, catalog the NRR in the online NRInfo Reference Application and upload the new pdf.
  - d. Place a printed copy of the NRR in the SODN Reference Library.
  - e. If the protocol was not republished; place the pdf of the protocol's narrative and each SOP in the folder.

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**Master Version Table**

| <b>Version<br/>Key #</b> | <b>Date of<br/>Change</b> | <b>Narrative</b> | <b>SOP<br/>#1</b> | <b>SOP<br/>#2</b> | <b>SOP<br/>#3</b> | <b>SOP<br/>#4</b> | <b>SOP<br/>#5</b> | <b>SOP<br/>#6</b> |
|--------------------------|---------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                          |                           |                  |                   |                   |                   |                   |                   |                   |
|                          |                           |                  |                   |                   |                   |                   |                   |                   |
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|                          |                           |                  |                   |                   |                   |                   |                   |                   |
|                          |                           |                  |                   |                   |                   |                   |                   |                   |
|                          |                           |                  |                   |                   |                   |                   |                   |                   |

## APPENDIX A

### Overview of Exotics and Monitoring at SOPN Parks

The Southern Plains Inventory and Monitoring Network (SOPN) is composed of 11 National Park Service (NPS) units: Bent's Old Fort National Historic Site (BEOL) and Sand Creek Massacre National Historic Site (SAND), Colorado; Fort Larned National Historic Site (FOLS), Kansas; Capulin Volcano National Monument (CAVO), Fort Union National Monument (FOUN), and Pecos National Historical Park (PECO), New Mexico; Chickasaw National Recreation Area (CHIC) and Washita Battlefield National Historic Site (WABA), Oklahoma; and Alibates Flint Quarries National Monument (ALFL), Lake Meredith National Recreation Area (LAMR), and Lyndon B. Johnson National Historical Park (LYJO), Texas (Figure A.1). Park units within the SOPN are located in shortgrass and mixed-grass ecosystems, and range in size from 326 acres (WABA) to 46,349 acres (LAMR).

CHIC, FOLS, LYJO, and WABA are in mixedgrass prairie or savannah. ALFL, BEOL, CAVO, FOUN, LAMR, and SAND are located in shortgrass prairie, and PECO is in the ecotone between shortgrass prairie and piñonjuniper forest. At a finer scale, the SOPN parks can be placed in six different vegetative zones or biomes (Küchler 1986, Omernik 1987, Bailey 1995) and eight vegetative sections. The SOPN has a wide range of soil orders present, including dry mollisols through central Texas, central Oklahoma, and central Kansas; wet mollisols in the vicinity of CHIC; entisols and aridisols in southeastern Colorado; and aridisols and alfisols in northeastern New Mexico.

All SOPN parks have implemented exotic control programs, primarily through efforts of the NPS Exotic Plant Management Teams, and augmented by individual park efforts. Through this program, most of the severely invasive exotics have been or are in the process of being eradicated. These exotics have been maintained on the list of SOPN exotics due to their tenacious re-sprouting and long-lived seedbanks, as well as the possibility of re-introduction from surrounding environs.

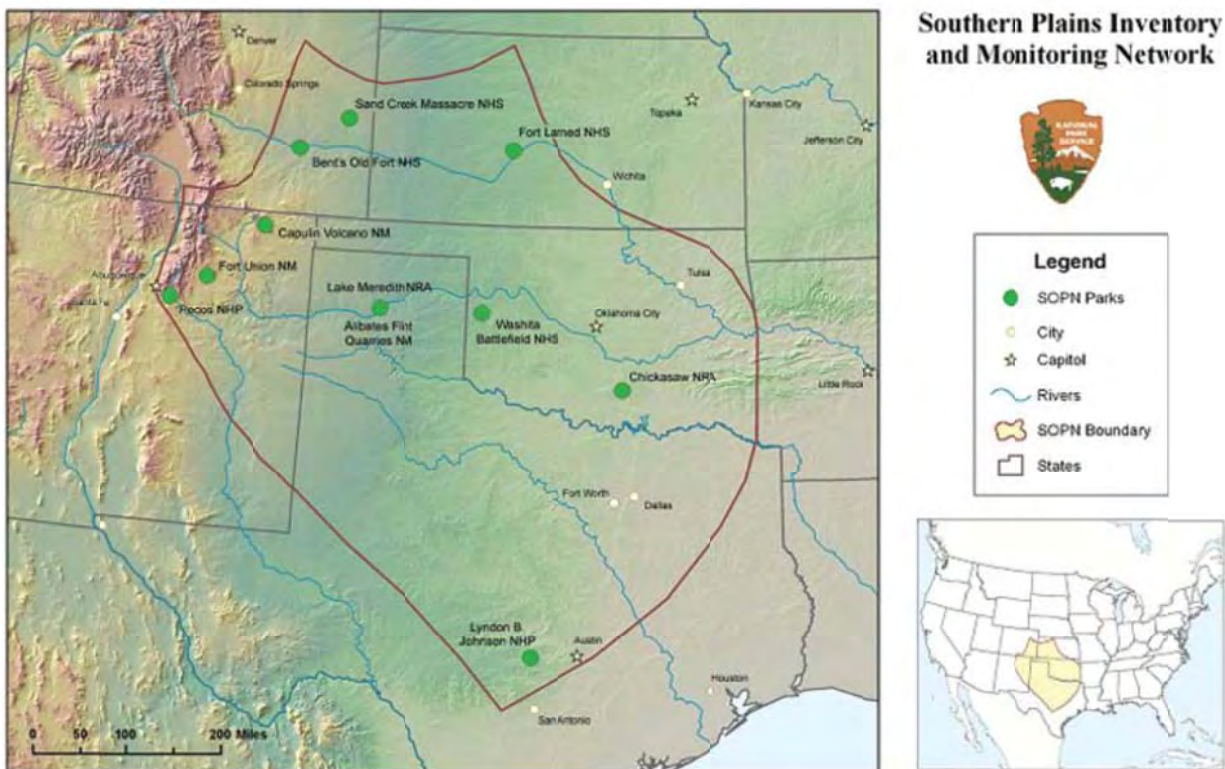


Figure A.1. Park location within the Southern Plains I&M Network.

## A.1 Alibates Flint Quarries NM

Alibates Flint Quarries National Monument (ALFL) (1,371 acres [555 ha] in size and adjacent to LAMR) was created in 1965, to preserve the extensive flint quarries that were once used by prehistoric humans as a source of raw material for weapons and tools. ALFL also protects the ruins of several village sites of the Plains Village Indians, who inhabited the area circa 1200–1450 A.D. A total of 486 species have been documented and supported by vouchers from ALFL and LAMR (Wright and Meador 1981, Nesom et al. 2005). Vegetation at ALFL is dominated by yucca grassland (36%), vegetated cliffs (34%), mixed-grassland (18%), mesquite grassland (8%), and mixed forest (3%) (Lake Meredith National Recreation Area 2002). Bell et al. (2000) also provides a list of plant species from ALFL but it is un-vouchered. Bell and Coffman (2000) identified a number of major introduced plant species at ALFL. There are no known endangered or threatened plants within the boundaries of the park. ALFL is administered by the staff at LAMR. All current plant inventories include ALFL in the larger LAMR, so refer to that section for more detailed information. Roughly one mile of paved road runs along the boundary of ALFL. Public access to the park interior is limited to scheduled guided tours along one walking trail; no other recreational activity occurs within the park. One dirt maintenance road travels across and through the top section of ALFL and one active natural gas well within park boundaries requires maintenance access. One-half of the boundary of ALFL is shared with LAMR, while the remaining boundary abuts private rangeland. There are no active riparian areas within ALFL. Panel selections for ALFL can be found incorporated into the LAMR map (Figure A-7).

## A.2 Bent's Old Fort NHS

Bent's Old Fort National Historic Site (BEOL) covers 799 acres (323 ha) along the Arkansas River in southeastern Colorado. The original adobe fort was constructed in 1833, to serve as a trade center on the Santa Fe Trail and became a staging area for the U.S. Army during the U.S.– Mexican War in 1846. The fort was abandoned in 1849, and established as a national historic site in 1960. A 2003 restoration management plan (Ladyman 2003) determined that approximately 124 acres (50 ha) were upland prairie, 271 acres (110 ha) were riparian grassland and 300 acres (121 ha) were riparian shrub- and grasslands recovering from tamarisk invasion. Grazing by livestock used in cultural interpretation still occurs (Ladyman 2003). Prairie restoration efforts continue at BEOL.

BEOL is bounded on the north side by a paved county road, with paved road leading into the park to a visitor parking area. Improved trails lead to the historic fort. Improved gravel road runs from the fort to the administration building through restored agricultural fields. Dirt maintenance roads are used on both sides of the Arkansas River, which bisects the park. An active railroad track travels along and through the southern park boundary, cutting off a long narrow strip of park land. Private agricultural fields are along both the western and eastern park boundaries, as well as the opposite side of the county road to the north. Grazing by oxen used in the park's interpretive program still occurs in areas around the historic fort on the north side of the Arkansas River.

Ladyman's (2003) restoration plan states that all grasslands had varying amounts of the exotic plants, including several listed on Colorado's noxious plant list. NPSpecies lists 43 species of exotic plants, 18 of which are considered noxious: poison hemlock (*Conium maculatum*), Russian knapweed (*Acroptilon repens*), Canada thistle (*Cirsium arvense*), white top (*Cardaria draba*), blue mustard (*Chorispora tenella*), flixweed (*Descurainia sophia*), broad-leaved pepperweed (*Lepidium latifolium*), Russian thistle (*Salsola tragus*), field bindweed (*Convolvulus arvensis*), velvetleaf (*Abutilon theophrasti*), flower-of-an-hour (*Hibiscus trionum*), jointed goatgrass (*Aegilops cylindrical*), cheatgrass (*Bromus tectorum*), green brome (*Setaria viridis*), Johnsongrass (*Sorghum halepense*), mullein (*Verbascum thapsus*), tamarisk (*Tamarix ramosissima*), and puncturevine (*Tribulus terrestris*). Narrowleaf cattail (*Typha angustifolia*) is found throughout the Arch Wetland. Eradication efforts are on-going at BEOL.

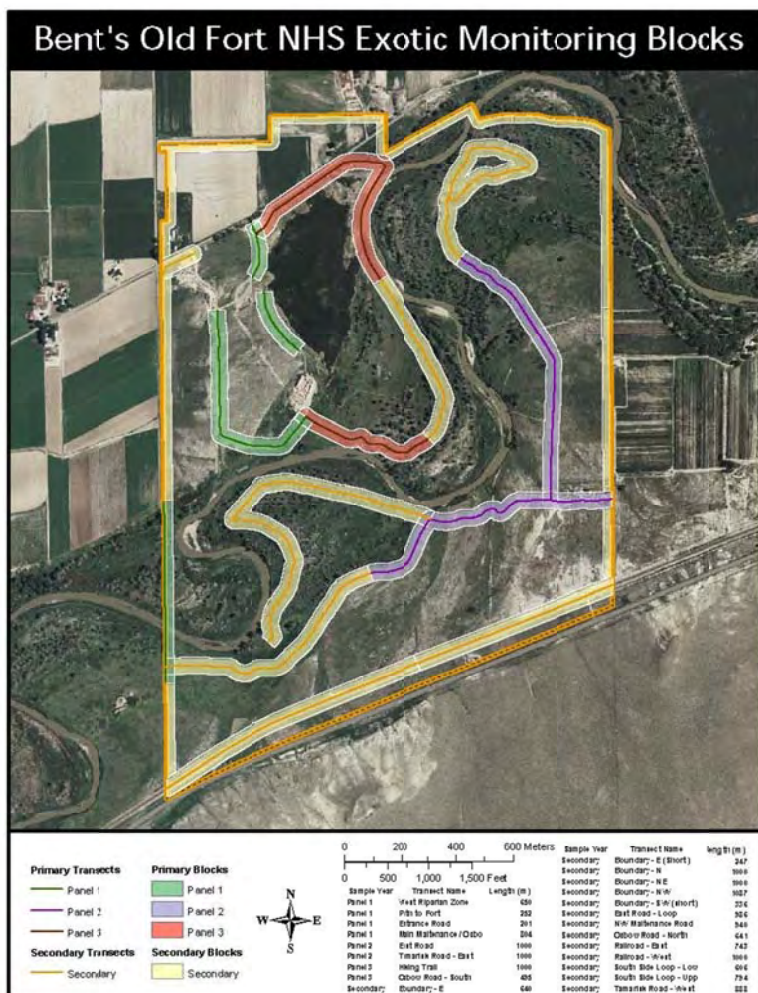


Figure A-2. Panel selection for BEOL

The highest-priority (primary) vectors include public access road and trails, high use administrative (Panel 1), and maintenance roads used by multiple entities south of the river (Panels 2 & 3) in restoration and natural areas. A small section of western boundary on the upstream side of the Arkansas River has been included to detect introduction from neighboring private lands.

### A.3 Capulin Volcano NM

Capulin Volcano National Monument (CAVO) was established to preserve a volcanic cinder cone that formed more than 60,000 years ago. The park includes 793 acres (321 ha) in northeastern New Mexico. Six communities are identified by Natural Heritage New Mexico's (NHNM) Vegetation Community Classification system: crater grassland, disturbed grassland, piñon-juniper, lowland grassland, gamble oak and ponderosa (Johnson et al. 2003). No threatened or endangered plants were located during the field survey conducted by NHNM in 2002. Two hundred and fortythree species (92%) of the 255 potential species were documented (Johnson et al. 2003).

A paved county road runs along the western boundary of CAVO. Paved road provides access to the Visitor Center, picnic area and winds around the volcano cone to a parking area at the top of the crater. Dirt maintenance roads receive limited use. Paved trails lead into the bottom of the crater, around the rim

of the crater and along a short nature loop. There are also three miles of unimproved trail. There is no grazing occurring at CAVO, nor is there a riparian area within the park boundary.

Johnson et al. (2003) identified twenty-two introduced plant species at CAVO. NPSpecies documents the presence of 25 exotic species. Wilson et al. (2008) ranked and mapped 21 exotic species at CAVO, identifying four species, field bindweed (*Convolvulus arvensis*), cheatgrass (*Bromus tectorum*), Japanese brome (*Bromus japonicus*) and horehound (*Marrubium vulgare*) in need of aggressive control efforts. One exotic species, field bindweed (*Convolvulus arvensis*) is found on the New Mexico Noxious Weed list. Nine other species at CAVO are listed on the noxious weed lists of neighboring states: cheatgrass (*Bromus tectorum*), chicory (*Cichorium intybus*), houndstongue (*Cynoglossum officinale*), flaxweed (*Descurainia sophia*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*), yellow bristlegrass (*Setaria pumila*), green bristlegrass (*Setaria viridis*) and mullein (*Verbascum thapsus*).

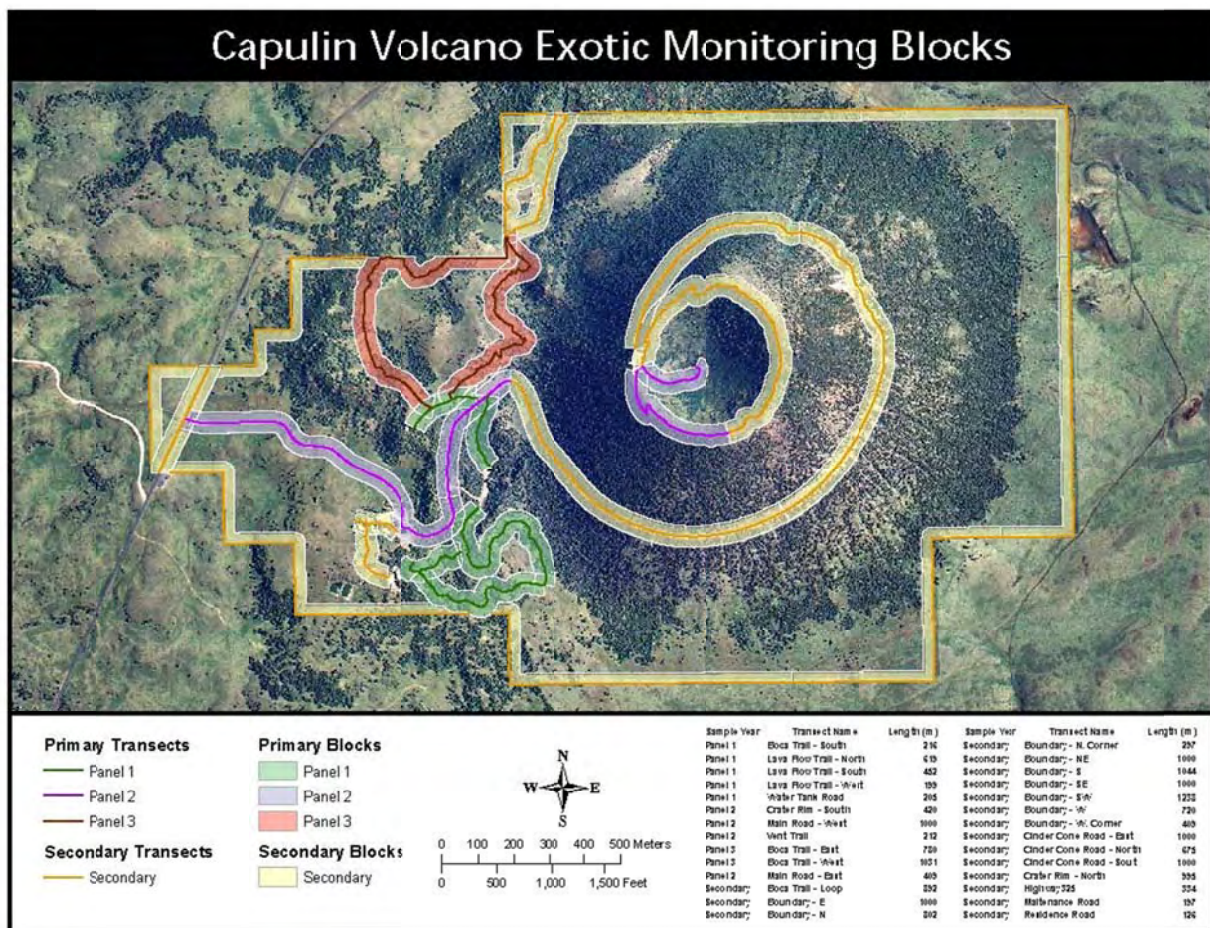


Figure A-3. Panel selection for CAVO.

The highest-priority (primary) vectors include public access road up to the cone ascent (Panel 2) and highest use trail segments (Panels 1 & 3).

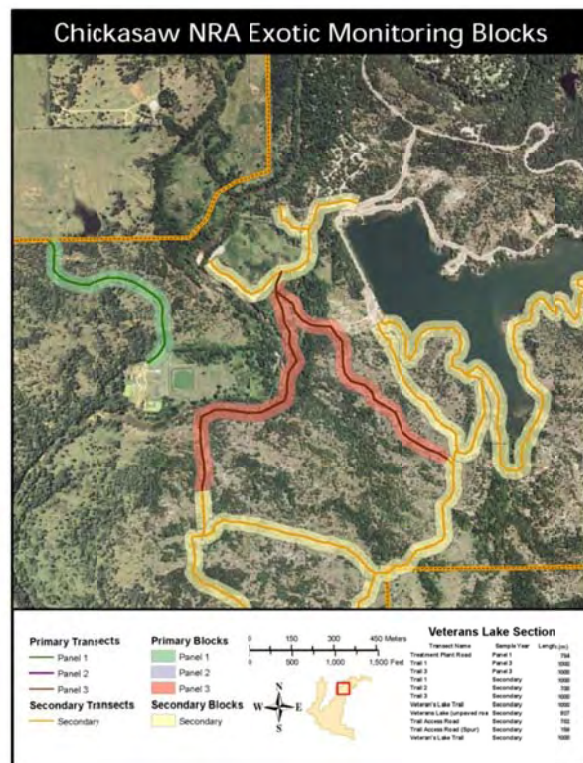
#### A.4 Chickasaw NRA

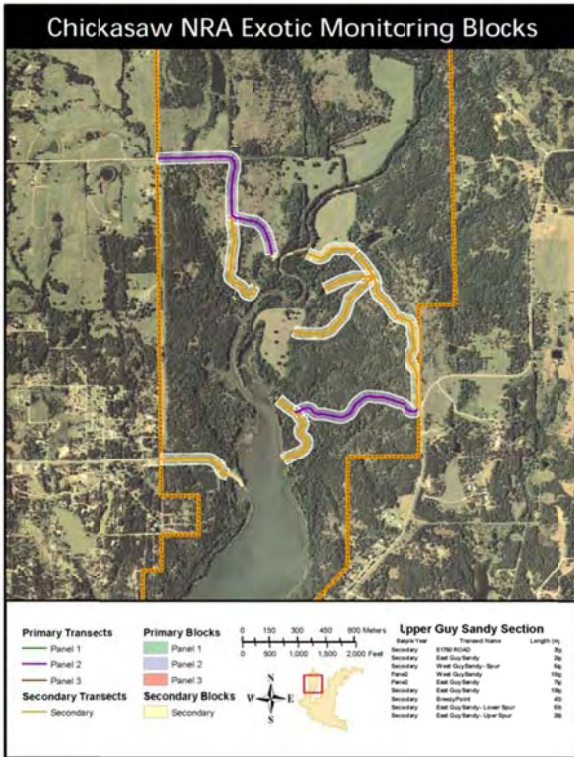
Chickasaw National Recreation Area (CHIC) comprises 9,889 acres (4,002 ha) in south-central Oklahoma. In the late 1800s, the Chickasaw and Choctaw Native American tribal units recognized threats to the freshwater and mineral springs in this area and, consequently, requested that the federal

government establish sustainable management practices (Wikle et al. 1998). Mixed grasslands (primarily *Schizachyrium scoparium*–*Sorghastrum nutans*) and oak forests cover a large portion of the upland areas, while riparian vegetation dominates the lowlands. There are no federally threatened or endangered plant species known to exist in the recreation area (Chickasaw National Recreation Area 1999). Oklahoma Biological Survey documented 582 taxa during an inventory in 2000 and noted there was a floristic affinity with the Edwards Plateau. Ten species are tracked by the Oklahoma Natural Heritage Inventory.

The original Platt District at CHIC has seen a century of human use as a family gathering area, containing a Nature Center, day-use facilities, camping and extensive springs and riparian area, all used for recreational purposes. The more recent, larger addition of lands surrounding Lake of the Arbuckles was carved out of long-term agricultural and range land, and is now surrounded by residential development. Numerous paved and unpaved roads lead to boat ramps and camping areas throughout this area. Hunting and horseback riding are popular forms of recreation, resulting in moderate use of dirt-track maintenance roads. Utility and pipeline corridors criss-cross the park. Grazing was allowed throughout much of the park until 1986 (Chickasaw National Recreation Area 1997) but continues today only within a fenced pasture containing reintroduced bison (Chickasaw National Recreation Area 1999).

NPSpecies lists 88 exotic species for CHIC. Only one species, field bindweed (*Convolvulus arvensis*) is on the Oklahoma Noxious Weed list. However, fifteen exotic species found at CHIC are on the noxious weed lists of neighboring states: shepard's purse (*Capsella bursapastoris*), charlock (*Sinapsis arvensis*), bouncingbet (*Saponaria officinalis*), yellow nutsedge (*Cyperus esculentus*), sericea lespedeza (*Lespedeza cuneata*), redstem stork'sbill (*Erodium cicutarium*), velvetleaf (*Abutilon theophrasti*), jointed goat grass (*Aegilops cylindrica*), cheatgrass (*Bromus tectorum*), pearl millet (*Pennisetum glaucum*), Johnsongrass (*Sorghum halepense*), sulphur cinquefoil (*Potentilla recta*), mullein (*Verbascum thapsus*), tamarisk (*Tamarix chinensis*) and puncturevine (*Tribulus terrestris*). Three additional park-specific species of concern are crownvetch (*Coronilla varia*), horehound (*Marrubium vulgare*), and yellow bluestem (*Bothriochloa ischaemum*).





A-4. Panel selection for CHIC>

The highest-priority (primary) vectors include public access road to Buckhorn Dam and campgrounds (Panel 1), unpaved maintenance and public access roads (Panel 1 & 2) and equestrian trail segments (Panels 3).

## A.5 Fort Larned NHS

Fort Larned National Historical Site (FOLS) encompasses 718 acres (291 ha) along the banks of the Pawnee River, most of which falls within the Pawnee River floodplain. Fort Larned, originally established to protect traffic along the Santa Fe Trail, became a key U.S. military base during the Indian Wars. The detached Trail Ruts unit is found on gently rolling uplands 4.5 miles (7.2 km) southwest of the Fort unit. It is estimated that at least 400 acres (162 ha) (60%) of FOLS is considered grassland habitat (Becker et al. 1986). It is estimated that 76% of FOLS is formerly cropped grassland that has undergone continuing prairie restoration since 1964 (Delisle and Busby 2004). There are no known federally threatened or endangered plant or animal species at Fort Larned.

The main unit of FOLS is bounded on the north and west boundaries by paved state and county roads, respectively. A short paved road leads into the park to a visitor parking area. Active agricultural fields about the south and east boundaries of the park, separated from parkland by a dirt track. One gravel maintenance road travels through the northwest quadrant of the park. Walking and access trails consist of mowed swaths of buffalo grass (*Buchloe dactyloides*) through the northern section of the park. The Pawnee River, heavily impacted by surrounding agriculture, meanders through the northern section of the park from west to east. No recreational activities or grazing occurs at FOLS. Past land use at FOLS converted the prairie surrounding the fort to plowed agriculture, resulting in a matrix of agricultural weeds modestly responding to restoration efforts. The separate Trail Ruts Unit is surrounded by agricultural fields, with a gravel county road along its western boundary. This unit is home to an extensive prairie dog colony.

NPSpecies lists 58 exotic species at FOLS. Of these, three are on the Kansas Noxious Weed list: Canada thistle (*Cirsium arvense*), field bindweed (*Convolvulus arvensis*) and Johnsongrass (*Sorghum halepense*). Seventeen exotic species are on the Noxious Weed lists of neighboring states: shepard's purse (*Capsella bursa-pastoris*), flixweed (*Descurainia sophia*), kochia (*Kochia scoparia*), Russian thistle (*Salsola kali*), hedge bindweed (*Calystegia sepium*), Russian olive (*Elaeagnus angustifolia*), velvetleaf (*Abutilon theophrasti*), jointed goat grass (*Aegilops cylindrica*), cheatgrass (*Bromus tectorum*), pearl millet (*Pennisetum glaucum*), yellow bristlegrass (*Setaria pumila*), green bristlegrass (*Setaria viridis*), Siberian elm (*Ulmus pumila*) and puncturevine (*Tribulus terrestris*). Of particular concern to the park are yellow bluestem (*Bothriochloa ischaemum*) and smooth brome (*Bromus inermis*), a remnant from past agricultural activities that is proving difficult to eradicate from park restoration areas.

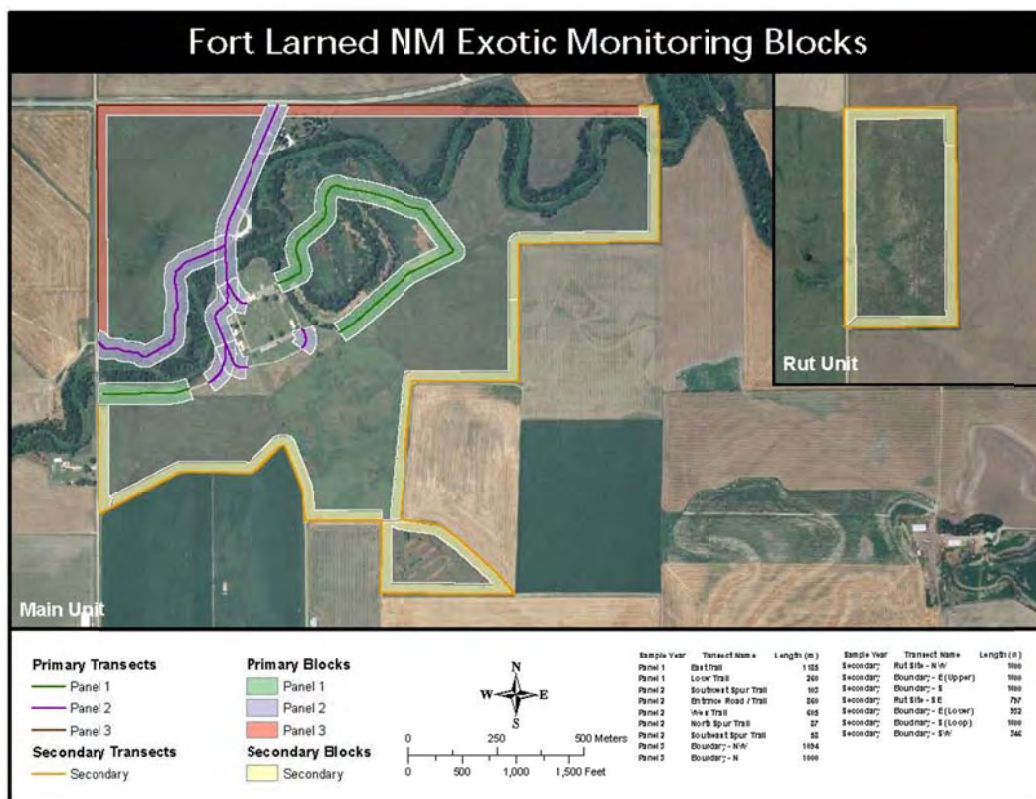


Figure A-5. Panel selection for FOLS.

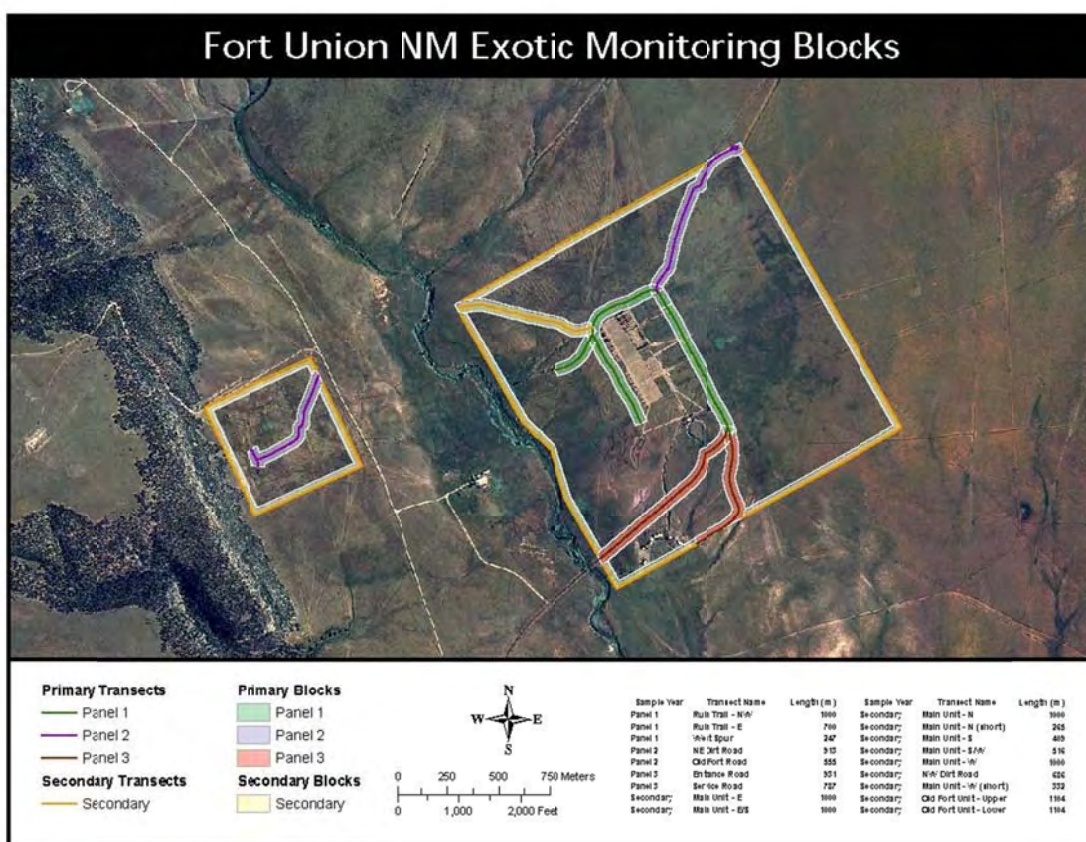
The highest-priority (primary) vectors include public access road (Panel 2), all trails (Panels 1 & 2), and maintenance roads (Panel 1 & 2). Panel 3 will sample boundary along major paved road. The Trail Ruts Unit will not be sampled in this protocol.

## A.6 Fort Union NM

Fort Union National Monument (FON) (721 acres [292 ha]) was established in 1956, to preserve and protect the mid-19th century fort situated on the Santa Fe Trail in New Mexico. An assessment of prairie carried out by Stubbendieck and Willson (1986) classified the majority of the monument as native prairie "in excellent condition" with blue grama as the dominant grass, thought to be similar to conditions of 1884." A more recent survey of vegetation by Natural Heritage New Mexico in 2004 described the plant life at FON as relatively diverse, with the shortgrass prairie still dominant yet reflecting the impacts of historic use. Drought was prevalent during the three summer seasons of this survey, resulting in the identification of 142 taxa, 16 plant associations and 11 alliances.

Both the main unit and the “old fort” unit are surrounded by the long-term range land of Fort Union Ranch. One paved county road leads into the park to the Visitor Center. Dirt maintenance roads are present in the park, but no walking trails exist outside of the cultural resource. An area of housing and maintenance yard exist in the southeast corner of the park and represent the area of highest disturbance. No recreational activities or grazing occur in the park.

The vegetation survey carried out by Natural Heritage New Mexico found only 12 species they considered “non-native alien introductions,” with none posing significant threats to native species (Muldavin et al. 2004). Wilson et al. (2008) mapped and ranked 22 exotic species at FOUN, identifying field bindweed (*Convolvulus arvensis*) as the only major species of concern. NPSpecies lists 23 exotic species for FOUN, three of which are on the New Mexico Noxious Weed list: field bindweed (*Convolvulus arvensis*), musk thistle (*Carduus nutans*) and Siberian elm (*Ulmus pumila*). Five additional exotic species appear on the Noxious Weed lists of neighboring states: cheatgrass (*Bromus tectorum*), redstem stork’s-bill (*Erodium cicutarium*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*), and mullein (*Verbascum thapsus*). Horehound (*Marrubium vulgare*) is of specific concern to the park.



A-6. Panel selection for FOUN.

The highest-priority (primary) vectors include public access road (Panel 3) and highest use maintenance roads (Panels 1, 2 & 3). There are no trails outside of the cultural use exclusion zone.

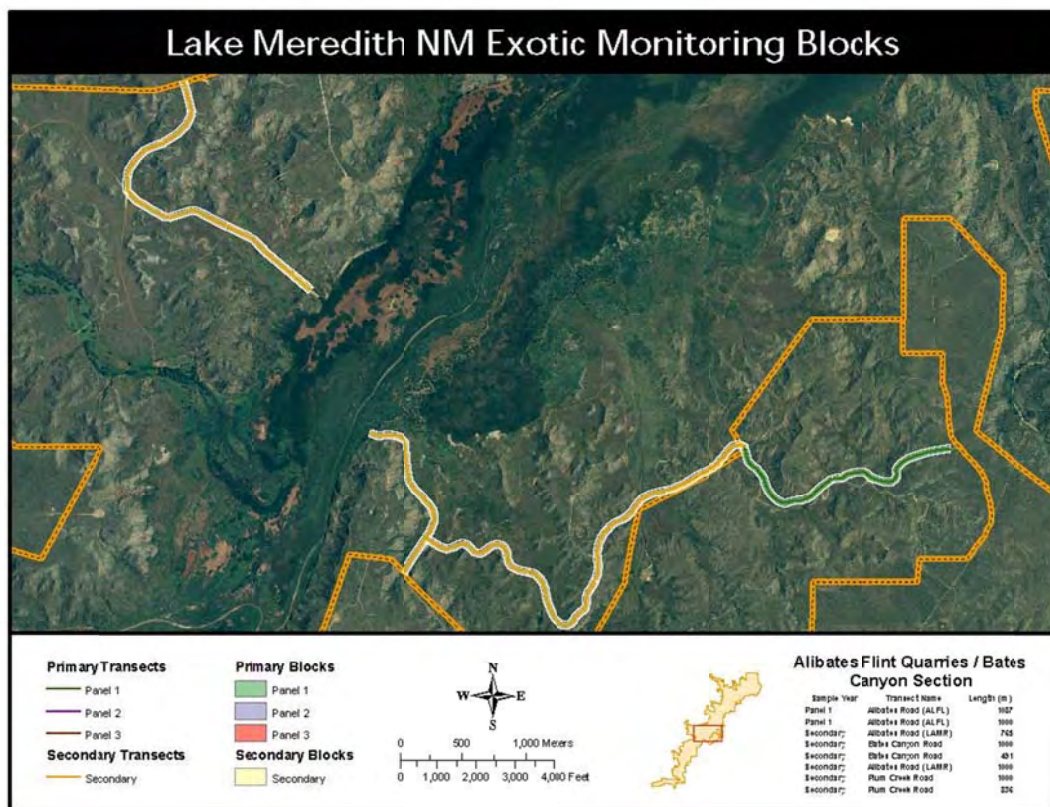
## A.7 Lake Meredith NRA

Lake Meredith National Recreation Area (LAMR) was formed in 1962, when the U.S. Bureau of Reclamation constructed the Sanford Dam on the Canadian River. LAMR was designated as a national recreation area in 1990, at which time its management was transferred from the U.S. Bureau of Land

Management to the NPS. LAMR, covering 46,349 acres (18,757 ha), is located on the High Plains of the Llano Estacado, specifically along the Breaks created by the Canadian River as it meanders west-east across the Texas Panhandle. A total of 486 species have been documented and supported by vouchers from the park (Wright and Meador 1981, Nesom et al. 2005). There are no known endangered or threatened plants within the boundaries of the parks.

The narrow boundary of LAMR surrounds a portion of the Canadian River, the river impoundment of Lake Meredith and major drainages. Surrounding land use is a mixture of private residences and rangeland, with extensive oil and natural gas exploration and extraction (also occurring within park boundaries). Recreational activities include boating, fishing, hunting, horseback riding, off-road driving, camping and day-use. Paved road access extends to a number of public boat ramps, while dirt roads to gas well sites criss-cross the park.

Nesom et al. (2005) detected 47 exotic species, from the park based on vouchered specimens. A review of NPSpecies reveals a total of 68 species of exotic plants, with two listed on the Texas Noxious Weed list: field bindweed (*Convolvulus arvensis*) and the aquatic Eurasian water-milfoil (*Myriophyllum spicatum*). Fifteen species of LAMR exotics are listed on the noxious weed list of neighboring states: jointed goat grass (*Aegilops cylindrica*), chicory (*Cichorium intybus*), yellow nutsedge (*Cyperus esculentus*), flaxweed (*Descurainia sophia*), Russian olive (*Elaeagnus angustifolia*), redstem stork's-bill (*Erodium cicutarium*), kochia (*Kochia scoparia*), proso millet (*Panicum milliaceum*), Russian thistle (*Salsola tragus*), yellow bristlegrass (*Setaria pumila*), green bristlegrass (*Setaria viridis*), Johnsongrass (*Sorghum halepense*), tamarisk (*Tamarix* spp.), puncturevine (*Tribulus terrestris*) and Siberian elm (*Ulmus pumila*). Two additional species, horehound (*Marrubium vulgaris*) and yellow bluestem (*Bothriochloa ischaemum*), are of particular concern to the park. Tamarisk, Russian olive and Siberian elm continue to be actively eradicated, while field bindweed and yellow bluestem are likely to persist through roadside maintenance procedures. and are especially problematic around most of the 169 gas wells.



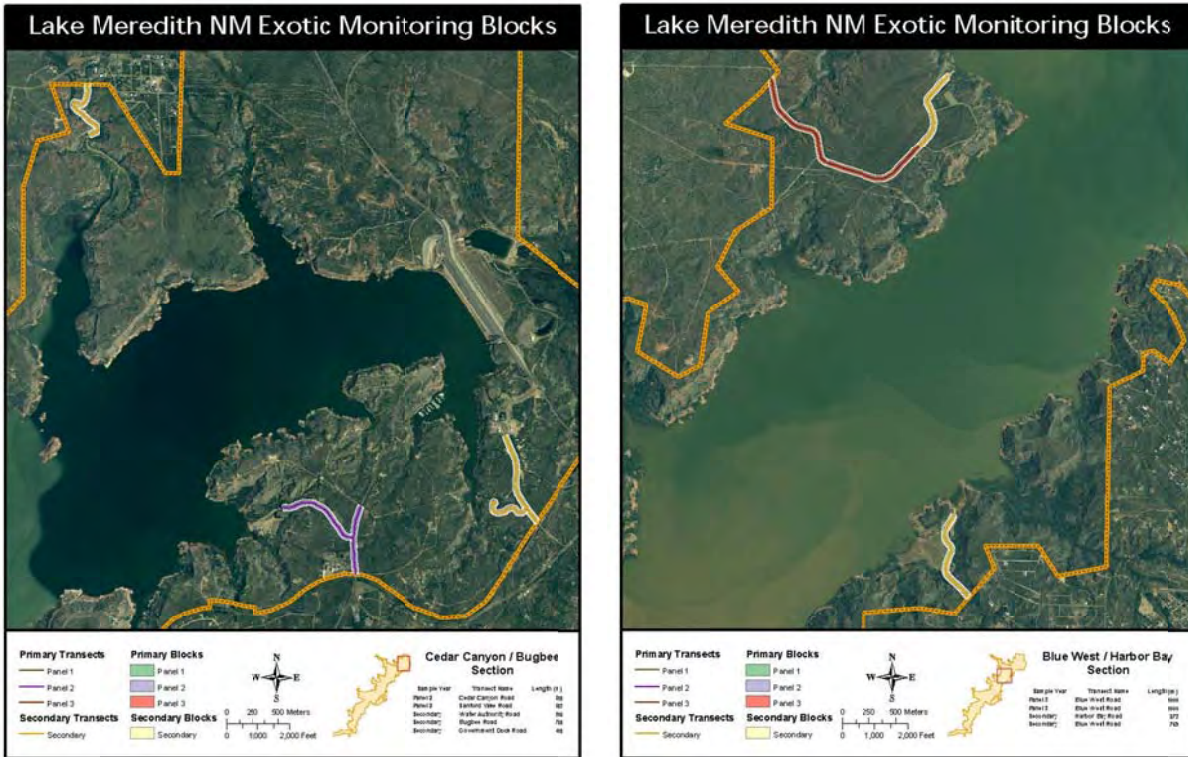


Figure A-7. Panel selection for LAMR and ALFL.

The highest-priority (primary) vectors include a sample of public access road (Panels 2 & 3) and unpaved access road (Panel 1).

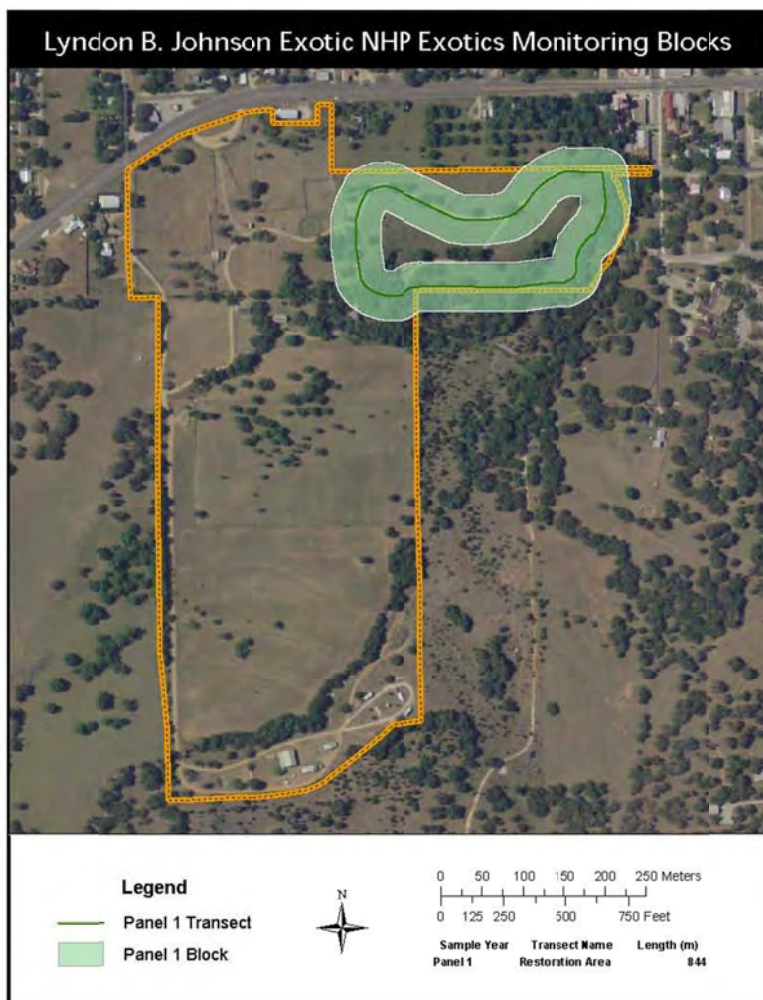
## A.8 Lyndon B. Johnson NHP

Lyndon B. Johnson National Historical Park (LYJO) preserves the birthplace, boyhood home, ranch, and final resting place of the 36<sup>th</sup> president of the United States. The two districts of LYJO, one consisting of the LBJ Ranch and the other of properties in Johnson City, Texas, total 674 acres (273 ha). The majority of the Ranch District is managed as improved range with exotic plant species. The Johnson City District has approximately 39 acres that can be classified as prairie or semi-natural prairie (Stubbendieck and Willson 1986), however these areas also contain a large number of exotic species. Two floristic inventories have documented 660 native and cultivated species (including distinct varieties, cultivars, and hybrids) present in the park; of these 510 are naturally occurring (Sanders and Gallyoun 2004, Sanders 2005).

The Johnson City Unit sits in an urban area, surrounded by private residences and small-acreage rangeland. Gravel maintenance roads run throughout the park area and one leads to a picnic/event area in the middle of the unit. The maintenance area and small VIP campground is located at the back of the park (south end). Foot paths exist around the cultural resource. Town Creek and one of its drainages run through the park. The Ranch Unit contains a paved road circumnavigating the unit and a large paved air strip. Private vehicles, once limited to accessing the Texas White House, are now allowed throughout the park. The Pedernales River flows through the southern portion of the Ranch Unit. Recreational activities are limited throughout both units. The Ranch Unit was a private residence up to two years ago and is an on-going cattle operation, while interpretive grazing by longhorn cattle continues at the Johnson City Unit.

Recent floristic inventory documents 120 nonnative species at LYJO (Sanders and Gallyoun 2004, Sanders 2005). A great number of these exotics are cultivars and hybrids used in landscaping and

agricultural endeavors. Two exotic species appear on the Texas Noxious Weed list: giant reed (*Arundo donax*) and Chinese tallow tree (*Triadica sebifera*). Eight species appear on the Noxious Weed lists of neighboring states: shepard's purse (*Capsella bursa-pastoris*), musk thistle (*Carduus nutans*), poison hemlock (*Conium maculatum*), yellow nutsedge (*Cyperus esculentus*), redstem stork's-bill (*Erodium cicutarium*), ox-eye daisy (*Leucanthemum vulgare*), Johnsongrass (*Sorghum halepense*), and mullein (*Verbascum thapsus*). Five additional species are of concern to the park: yellow bluestem (*Bothriochloa ischaemum*), Italian thistle (*Carduus tenuiflorus*), Malta starthistle (*Centaurea melitensis*), horehound (*Marrubium vulgare*) and nandina (*Nandina domestica*).



a-8. Panel selection for LYJO.

One vector has been chosen for monitoring due to highly maintained landscape within both park units. The gravel walking trail surrounding and through the prairie restoration project will be monitored (Panel 1).

## A.9 Pecos NHP

Pecos National Historical Park (PECO) (6,670 acres [2,699 ha]) was designated in 1965, to preserve an exceptional cultural and natural area with a long human history. Paleo-Indians, archaic people, basket makers, and Puebloan peoples all left evidence of early use in the valley, followed by Spanish and Anglo settlement. Riparian corridors, grasslands of old pastures, and predominant piñon/juniper woodland are

found at PECO (Parmenter and Lightfoot 1996). A vegetation survey conducted by PECO between 1992 and 1994 resulted in 354 species of vascular plants (Reed et al. 1999). There are no threatened or endangered plants or animals documented at PECO.

PECO shares its southern and eastern boundary with an Interstate highway, has a paved state road running through the main unit and along its northern boundary. A short paved road leads to the Visitor Center and nearby Administrative Offices. Numerous dirt track maintenance roads criss-cross the area. A walking trail leads to the cultural resource. Both the Pecos River and Glorieta Creek run through the park. Recreational activity is currently limited to fishing at PECO. The Pigeon Ranch Unit and Glorieta Unit are not currently open to the public. The Pigeon Ranch has a paved state highway running through it, while the Glorieta Unit has numerous gravel roads leading to private in-holdings. Grazing generally ceased in June 1967 when the boundary fence was completed. The 64-acre core of the monument has been closed to grazing since the 1940s, while the newest acreage was protected from grazing in 1978 (Stubendieck and Willson 1986).

Reed et al. (1999) lists 57 exotic species at PECO. NPSpecies lists 78 exotic species. Eight species are found on the New Mexico Noxious Weed list: whitetop (*Cardaria draba*), Canada thistle (*Cirsium arvense*), poison hemlock (*Conium maculatum*), field bindweed (*Convolvulus arvensis*), Russian olive (*Elaeagnus angustifolia*), Scotch thistle (*Onopordum acanthium*), tamarisk (*Tamarix chinensis*) and Siberian elm (*Ulmus pumila*). Fourteen additional exotic species appear on the Noxious Weed lists of neighboring states: common burdock (*Arctium minus*), cheatgrass (*Bromus tectorum*), shepard's purse (*Capsella bursa-pastoris*), chicory (*Cichorium intybus*), bull thistle (*Cirsium vulgare*), flixweed (*Descurainia sophia*), quackgrass (*Elymus repens*), redstem stork's-bill (*Erodium cicutarium*), kochia (*Kochia scoparia*), ox-eye daisy (*Leucanthemum vulgare*), Russian thistle (*Salsola tragus*), green bristlegrass (*Setaria viridis*), puncturevine (*Tribulus terrestris*), and mullein (*Verbascum thapsus*). One other species, horehound (*Marrubium vulgare*) is of park-specific concern.

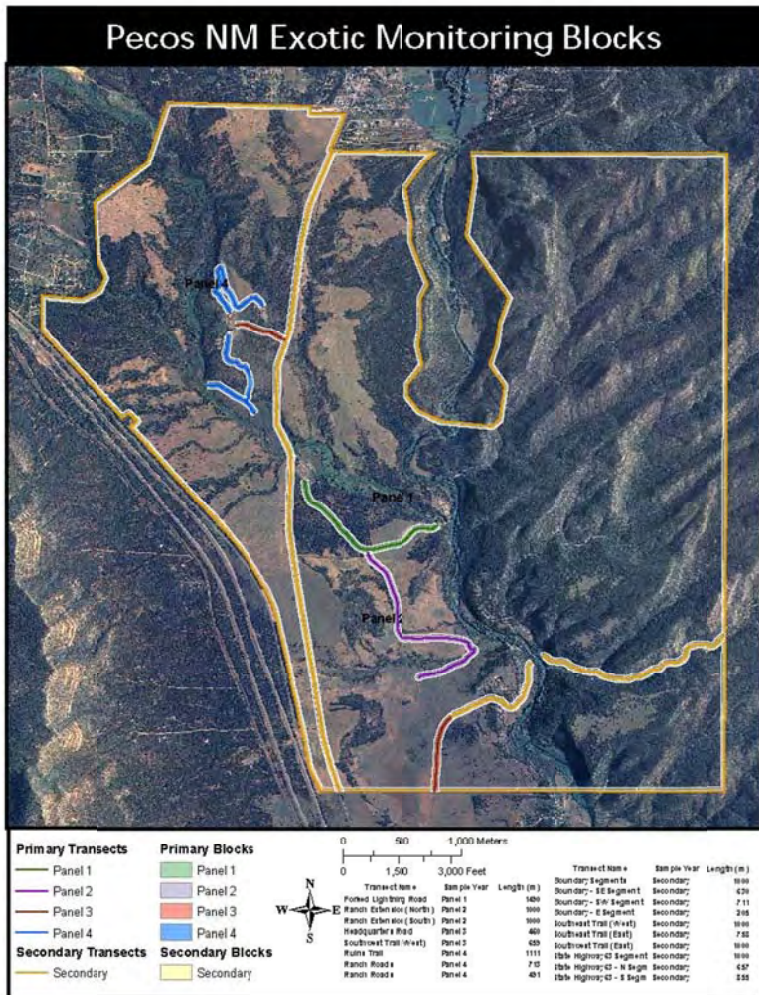


Figure A-9. Panel selection for PECO

Vectors chosen for monitoring include paved trails and road from Visitor Center to Administrative building (Panel 4), paved entrance and unpaved maintenance roads (Panel 3), and unpaved maintenance roads to Forked Lightning Ranch house and adjacent ranch lands (Panels 2 & 3).

## A.10 Sand Creek Massacre NHS

The recently formed Sand Creek Massacre National Historic Site (SAND) (2,400 acres [971 ha]) lies along a 5.5-mile (8.85 km) stretch of Big Sandy Creek in southeastern Colorado. Established in 2007, SAND commemorates the Sand Creek Massacre of November 1864. There are three types of habitat identified: riparian cottonwood along sections of the creek, short-grass prairie north of Big Sandy Creek; and the sand sage (*Artemisia filifolia*) community to the south. Sand sage has gained a foothold on drier slopes and where grazing has been excessive (National Park Service 2000). Habitat exists at SAND to support one rare plant, but the preliminary T&E survey being conducted does not document an occurrence.

SAND is bounded to the south by a gravel county road, with an unimproved road leading into the southern portion to Visitor Parking and Administrative/Maintenance offices at an old homestead. A short walking trail leads to the overlook of the accepted massacre site. A dirt track maintenance road runs throughout the park. A section of park land on the northern border was once plowed agricultural land. The

park is surrounded by private rangeland. Big Sandy Creek intermittently flows through the park and a remnant of the breached Chivington irrigation canal is found in the southeast sector of the park. Prairie dog towns are found in the southeast corner of the park and encroaching into the northwest corner. There are no recreational activities at SAND, although the cottonwood grove is used occasionally by tribal members. Grazing no longer occurs at SAND.

NPSpecies lists 18 exotic species at SAND. Six species are listed on the Colorado Noxious Weed List: field bindweed (*Convolvulus arvensis*), quackgrass (*Elymus repens*), leafy spurge (*Euphorbia esula*), kochia (*Kochia scoparia*), yellow toadflax (*Linaria vulgaris*) and Russian thistle (*Salsola tragus*).

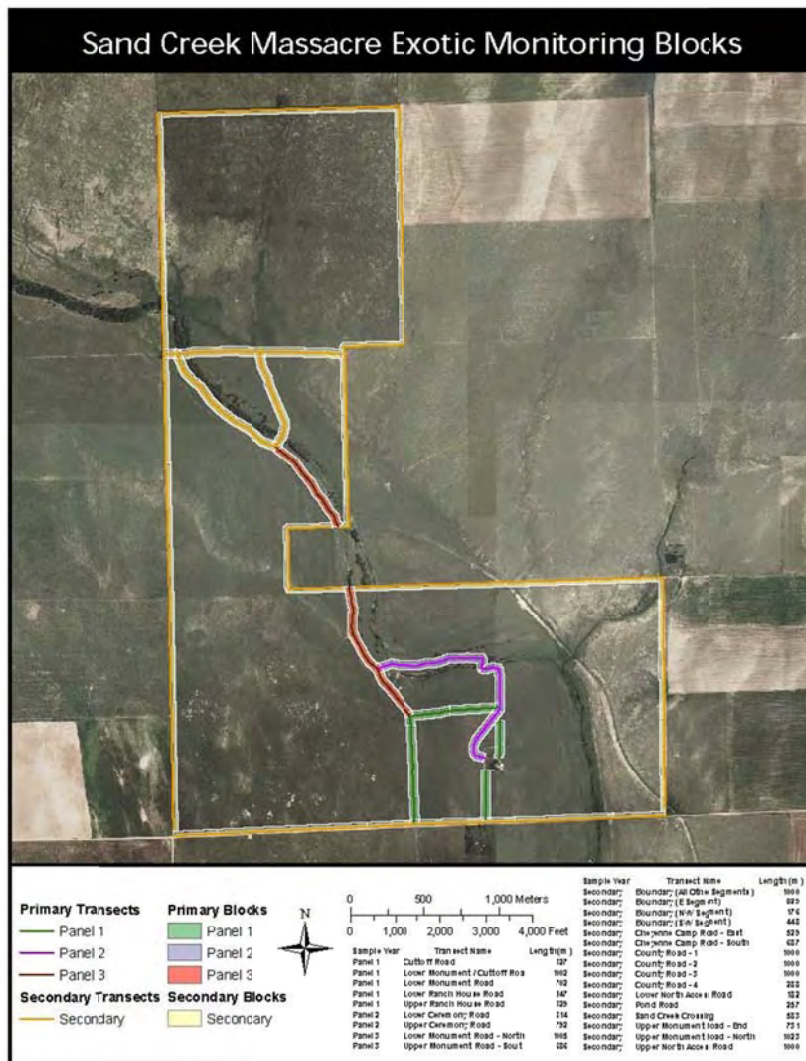


Figure A-10. Panel selection for SAND.

The highest-priority (primary) vectors include unpaved public access roads (Panel 1) and unpaved maintenance roads and all trails (Panel 2 & 3).

## A.11 Washita Battlefield NHS

Washita Battlefield National Historic Site (WABA) (326 acres [132-ha]), located on the banks of the Washita River, protects and interprets the site where the 7th U.S. Cavalry, led by George Armstrong

Custer, attacked the Southern Cheyenne village of Chief Black Kettle in November 1868. It is estimated that historically, riparian areas covered 19 acres (8 ha) of park, while grassland dominated 316 acres (128 ha) (Hoagland et al. 2005). Baseline vegetation data was collected under drought conditions by Stotts and DuBey (1998). The Oklahoma Biological Survey conducted a vascular flora inventory in 2002, collecting over eight months. They documented 272 species of vascular plants, 32 of which were trees, shrubs or vines. Five species tracked by the Oklahoma Natural Heritage Inventory were found (Hoagland et al. 2005). There are no endangered or threatened species found at WABA.

WABA is bounded on the south by a paved county road, with a paved turnout for visitor parking. A dirt track maintenance road travels east to west through the western portion of the park along the south bank of the Washita River. Surrounding land use includes plowed agricultural fields to the east, rangeland to the north and south, and private residences to the west. A paved walking trail is planned to replace an unimproved walking trail through the heart of the historic camp. The Washita River meanders west to east through the park. An abandoned, elevated railroad grade divides the park east to west. Previous plowed and terraced agricultural fields make up a large portion of WABA. There are no recreational activities or grazing occurring currently at WABA.

Thirty-two exotic species were documented, representing 11.8% of the flora collected at Washita Battlefield (Hoagland et al. 2005). NPSpecies lists 37 exotic species at WABA. Canada thistle (*Cirsium arvense*) is the only exotic species listed by the State of Oklahoma as a noxious weed. Six additional species are listed as noxious weeds by neighboring states: Russian knapweed (*Acroptilon repens*), whitetop (*Cardaria draba*), bull thistle (*Cirsium vulgare*), proso millet (*Panicum milliaceum*), sulphur cinquefoil (*Potentilla recta*), Russian thistle (*Salsola kali*) and Siberian elm (*Ulmus pumila*). Two additional species, horehound (*Marrubium vulgare*) and nandina (*Nandina domestica*) are of park-specific concern.

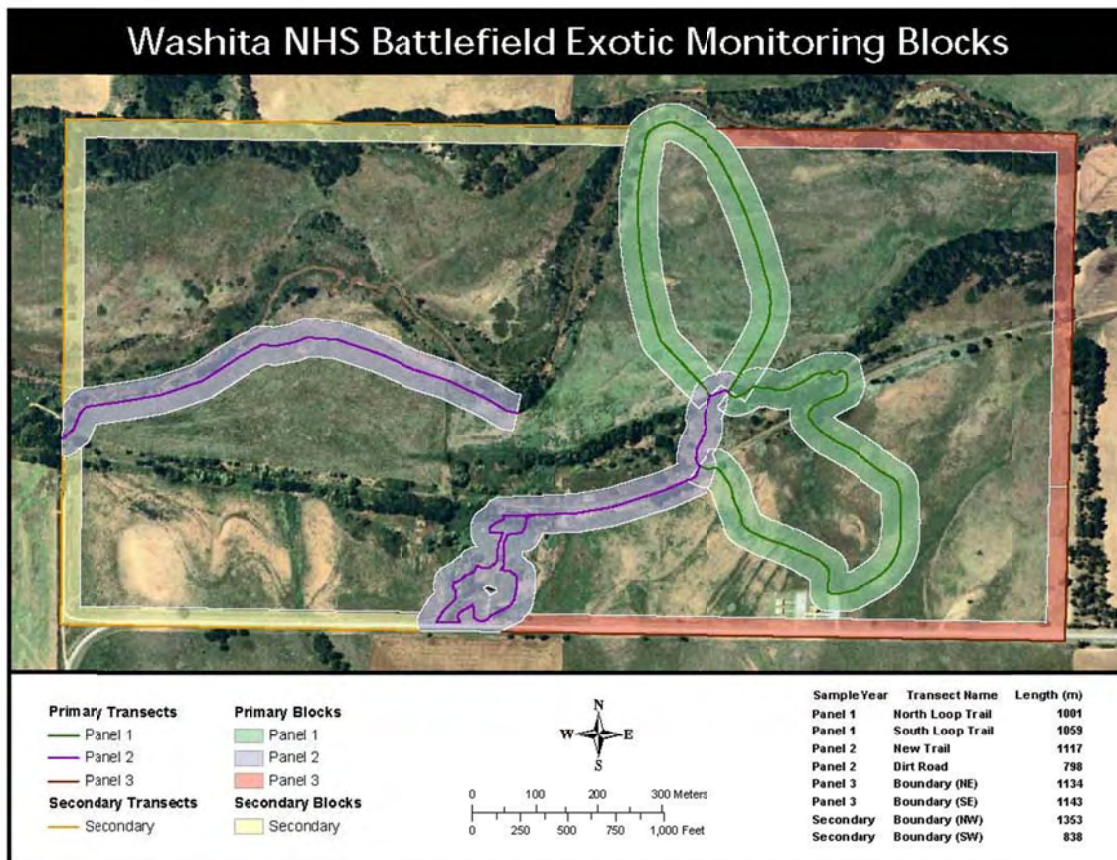


Figure A-11. Panel selection for WABA.

The highest-priority (primary) vectors include the maintenance road (Panel 2), all trails (Panel 1 & 2), and the eastern boundaries of the park next to active agricultural fields.

| Family          | Scientific Name                | Common Names             | BEOL | CAVO | CHIC | FOLS | FOUN | LAMR/ALFL | LYJO | PECO | SAND | WABA |
|-----------------|--------------------------------|--------------------------|------|------|------|------|------|-----------|------|------|------|------|
| Malvaceae       | <i>Abutilon theophrasti</i>    | velvetleaf Indian mallow | •    |      | •    | •    |      |           |      |      |      |      |
| Asteraceae      | <i>Achillea millefolium</i>    | western yarrow           |      |      | •    |      |      | •         | •    | •    |      |      |
| Asteraceae      | <i>Acroptilon repens</i>       | Russian knapweed         | •    |      |      |      |      |           |      |      |      | •    |
| Poaceae         | <i>Aegilops cylindrica</i>     | jointed goatgrass        | •    |      | •    | •    |      | •         |      |      |      |      |
| Poaceae         | <i>Agropyron cristatum</i>     | crested wheatgrass       |      | •    |      |      |      |           |      |      | •    | •    |
| Poaceae         | <i>Agropyron desertorum</i>    | clustered wheatgrass     |      |      |      |      |      |           |      | •    |      |      |
| Poaceae         | <i>Agrostis gigantea</i>       | redtop bentgrass         |      |      | •    |      | •    | •         |      | •    |      |      |
| Fabaceae        | <i>Albizia julibrissin</i>     | mimosa                   |      |      | •    |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Alliaria petiolata</i>      | garlic mustard           |      |      |      | •    |      |           |      |      |      |      |
| Liliaceae       | <i>Allium ampeloprasum</i>     | broadleaf wild leak      |      |      |      |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Alyssum minus</i>           | European alyssum         |      |      |      |      |      |           |      | •    |      |      |
| Amaranthaceae   | <i>Amaranthus blitoides</i>    | prostrate pigweed        |      |      |      |      |      | •         |      |      |      |      |
| Amaranthaceae   | <i>Amaranthus retroflexus</i>  | redroot pigweed          | •    |      | •    | •    |      | •         |      |      | •    | •    |
| Brassicaceae    | <i>Arabis hirsuta</i>          | hairy rockcress          |      | •    |      |      |      |           |      | •    |      |      |
| Asteraceae      | <i>Arctium minus</i>           | lesser burdock           |      |      |      |      |      |           |      | •    |      |      |
| Caryophyllaceae | <i>Arenaria serpyllifolia</i>  | thymeleaf sandwort       |      |      | •    |      |      |           | •    |      |      |      |
| Poaceae         | <i>Arundo donax</i>            | giant reed               |      |      |      |      |      |           | •    |      |      |      |
| Liliaceae       | <i>Asparagus officinalis</i>   | garden asparagus         |      |      | •    |      |      |           | •    | •    |      | •    |
| Poaceae         | <i>Avena sativa</i>            | common oat               |      |      |      |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Barbarea vulgaris</i>       | yellow rocket            |      |      |      |      |      |           |      | •    |      |      |
| Bignoniaceae    | <i>Bignonia capreolata</i>     | cross vine               |      |      |      |      |      |           | •    |      |      | •    |
| Poaceae         | <i>Bothriochloa bladhii</i>    | Australian beardgrass    |      |      |      | •    |      |           |      |      |      |      |
| Poaceae         | <i>Bothriochloa ischaemum</i>  | Turkestan beardgrass     |      |      | •    |      |      | •         | •    |      |      | •    |
| Brassicaceae    | <i>Brassica nigra</i>          | black mustard            |      |      |      |      |      |           | •    |      |      |      |
| Poaceae         | <i>Bromus arvensis</i>         | field brome              |      |      |      |      |      |           |      | •    |      |      |
| Poaceae         | <i>Bromus catharticus</i>      | rescue brome             |      |      | •    |      | •    | •         | •    |      |      | •    |
| Poaceae         | <i>Bromus commutatus</i>       | meadow brome             | •    |      |      | •    |      |           |      | •    |      |      |
| Poaceae         | <i>Bromus japonicus</i>        | Japanese brome           |      | •    | •    | •    | •    | •         | •    | •    |      |      |
| Poaceae         | <i>Bromus lanceolatus</i>      | Mediterranean brome      |      |      |      |      |      |           | •    | •    |      |      |
| Poaceae         | <i>Bromus tectorum</i>         | cheatgrass               | •    | •    | •    | •    | •    |           |      | •    |      |      |
| Moraceae        | <i>Broussonetia papyrifera</i> | paper mulberry           |      |      | •    |      |      |           |      |      |      |      |
| Boraginaceae    | <i>Buglossoides arvensis</i>   | corn gromwell            |      |      | •    |      |      |           | •    |      | •    |      |
| Asteraceae      | <i>Calyptracarpus vialis</i>   | straggler daisy          |      |      |      |      |      |           | •    |      |      |      |
| Convolvulaceae  | <i>Calystegia sepium</i>       | hedge bindweed           |      |      |      | •    |      |           |      |      |      |      |
| Brassicaceae    | <i>Camelina microcarpa</i>     | smallseed false flax     |      |      |      |      |      | •         |      | •    |      |      |
| Cannabaceae     | <i>Cannabis sativa</i>         | hemp                     |      |      |      | •    |      |           |      |      |      |      |

| Family          | Scientific Name                 | Common Names          | BEOL | CAVO | CHIC | FOLS | FOUN | LAMR/ALFL | LYJO | PECO | SAND | WABA |
|-----------------|---------------------------------|-----------------------|------|------|------|------|------|-----------|------|------|------|------|
| Brassicaceae    | <i>Capsella bursa-pastoris</i>  | shepard's purse       |      |      | •    | •    |      |           | •    | •    |      |      |
| Brassicaceae    | <i>Cardaria draba</i>           | whitetop              |      |      |      |      |      |           |      | •    |      | •    |
| Asteraceae      | <i>Carduus nutans</i>           | musk thistle          |      |      |      |      | •    |           | •    |      |      |      |
| Asteraceae      | <i>Carduus tenuiflorus</i>      | Itlaian thistle       |      |      |      |      |      |           | •    |      |      |      |
| Asteraceae      | <i>Centaurea melitensis</i>     | Malta starthistle     |      |      |      |      |      |           | •    |      |      |      |
| Caryophyllaceae | <i>Cerastium glomeratum</i>     | sticky chickweed      |      |      | •    |      |      |           | •    |      |      |      |
| Chenopodiaceae  | <i>Chenopodium album</i>        | common lambsquarters  |      | •    | •    | •    |      |           | •    | •    | •    |      |
| Chenopodiaceae  | <i>Chenopodium ambrosioides</i> | Mexican tea           |      |      | •    |      |      |           | •    |      |      |      |
| Chenopodiaceae  | <i>Chenopodium glaucum</i>      | oakleaf goosefoot     |      |      |      |      |      | •         |      |      |      |      |
| Brassicaceae    | <i>Chorispora tenella</i>       | blue mustard          | •    |      |      |      |      |           |      |      |      |      |
| Asteraceae      | <i>Cichorium intybus</i>        | chicory               |      | •    |      |      |      | •         |      | •    |      |      |
| Asteraceae      | <i>Cirsium arvense</i>          | Canada thistle        | •    | •    |      | •    |      |           |      | •    |      | •    |
| Asteraceae      | <i>Cirsium vulgare</i>          | bull thistle          |      |      |      | •    |      |           |      | •    |      | •    |
| Cucurbitaceae   | <i>Citrullus lanatus</i>        | watermelon            |      |      |      |      |      | •         |      |      |      |      |
| Ranunculaceae   | <i>Clematis terniflora</i>      | sweet autumn clematis |      |      | •    |      |      |           |      | •    |      |      |
| Apiaceae        | <i>Conium maculatum</i>         | poison hemlock        | •    |      |      | •    |      |           | •    | •    |      |      |
| Convolvulaceae  | <i>Convolvulus arvensis</i>     | field bindweed        | •    | •    | •    | •    | •    | •         |      | •    | •    |      |
| Fabaceae        | <i>Coronilla varia</i>          | crownvetch            |      |      | •    |      |      | •         |      |      |      |      |
| Poaceae         | <i>Cynodon dactylon</i>         | Bermudagrass          | •    |      | •    | •    |      | •         | •    |      |      |      |
| Boraginaceae    | <i>Cynoglossum officinale</i>   | houndstongue          |      | •    |      |      |      |           |      |      |      |      |
| Cyperaceae      | <i>Cyperus esculentus</i>       | yellow nutsedge       |      |      | •    |      |      | •         | •    |      |      |      |
| Cyperaceae      | <i>Cyperus rotundus</i>         | purple nutsedge       |      |      |      |      |      | •         | •    | •    |      |      |
| Poaceae         | <i>Dactylis glomerata</i>       | orchardgrass          | •    |      |      | •    |      |           |      | •    |      |      |
| Solanaceae      | <i>Datura stramonium</i>        | jimsonweed            |      |      | •    |      |      |           |      |      |      |      |
| Apiaceae        | <i>Daucus carota</i>            | Queen Anne's lace     |      |      |      |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Descurainia sophia</i>       | herb sophia           | •    | •    |      | •    |      | •         |      | •    |      |      |
| Poaceae         | <i>Desmazeria rigida</i>        | ferngrass             |      |      |      |      |      |           | •    |      |      |      |
| Caryophyllaceae | <i>Dianthus chinensis</i>       | rainbow pink          |      |      |      |      |      |           | •    |      |      | •    |
| Poaceae         | <i>Dichanthium annulatum</i>    | Kleburg bluestem      |      |      |      |      |      |           | •    |      |      |      |
| Poaceae         | <i>Digitaria ciliaris</i>       | southern crabgrass    |      |      |      |      |      |           | •    |      |      |      |
| Poaceae         | <i>Digitaria sanguinalis</i>    | large crabgrass       |      |      | •    | •    |      | •         |      |      |      |      |
| Dipsacaceae     | <i>Dipsacus fullonum</i>        | Fuller's teasel       | •    |      |      |      |      |           |      | •    | •    |      |
| Poaceae         | <i>Echinochloa colona</i>       | jungle ricegrass      |      |      | •    |      |      |           | •    |      |      |      |
| Poaceae         | <i>Echinochloa crus-galli</i>   | barnyardgrass         | •    | •    | •    | •    |      | •         | •    |      |      |      |
| Elaeagnaceae    | <i>Elaeagnus angustifolia</i>   | Russian olive         |      |      |      | •    |      | •         |      | •    |      |      |
| Elaeagnaceae    | <i>Elaeagnus pungens</i>        | thorny olive          |      |      |      |      |      |           | •    |      |      |      |

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|-----------------|-------------------------------|---------------------------|------|------|------|------|------|-----------|------|------|------|------|
| Poaceae         | <i>Elymus repens</i>          | quackgrass                |      |      |      |      |      |           |      | •    | •    |      |
| Poaceae         | <i>Eragrostis barrelieri</i>  | Mediterranean lovegrass   |      |      |      |      |      | •         | •    | •    |      |      |
| Poaceae         | <i>Eragrostis cilianensis</i> | stinkgrass                |      |      | •    | •    |      | •         | •    |      |      |      |
| Poaceae         | <i>Eragrostis curvula</i>     | weeping lovegrass         |      |      |      |      |      | •         |      |      |      |      |
| Geraniaceae     | <i>Erodium cicutarium</i>     | redstem storksbill        |      |      | •    |      | •    | •         | •    | •    |      |      |
| Brassicaceae    | <i>Erysimum repandum</i>      | bushy wallflower          |      |      | •    |      |      | •         |      |      |      |      |
| Celastraceae    | <i>Euonymus japonica</i>      | Japanese spindletree      |      |      |      |      |      |           | •    |      |      |      |
| Euphorbiaceae   | <i>Euphorbia davidii</i>      | David's spurge            |      | •    |      |      | •    | •         |      | •    |      |      |
| Euphorbiaceae   | <i>Euphorbia dentata</i>      | toothed spurge            | •    |      | •    | •    |      |           | •    |      |      | •    |
| Euphorbiaceae   | <i>Euphorbia esula</i>        | leafy spurge              |      |      |      |      |      |           |      |      | •    |      |
| Asteraceae      | <i>Facelis retusa</i>         | annual trampweed          |      |      |      |      |      |           | •    |      |      |      |
| Moraceae        | <i>Fatoua villosa</i>         | hairy crabweed            |      |      |      |      |      |           | •    |      |      |      |
| Rubiaceae       | <i>Galium divaricatum</i>     | Lamarck's bedstraw        |      |      |      |      |      |           | •    |      |      |      |
| Geraniaceae     | <i>Geranium pusillum</i>      | small-flower crane's-bill |      |      |      |      |      |           |      |      |      | •    |
| Liliaceae       | <i>Hemerocallis fulva</i>     | orange daylily            |      |      |      |      |      |           | •    |      |      |      |
| Malvaceae       | <i>Hibiscus trionum</i>       | flower-of-an-hour         | •    |      |      | •    |      |           |      |      |      |      |
| Caryophyllaceae | <i>Holosteum umbellatum</i>   | jagged chickweed          |      |      | •    |      |      |           |      |      |      |      |
| Poaceae         | <i>Hordeum murinum</i>        | mouse barley              |      |      |      |      |      |           | •    |      |      |      |
| Poaceae         | <i>Hordeum vulgare</i>        | cereal barley             |      |      |      |      |      |           | •    |      |      |      |
| Convolvulaceae  | <i>Ipomoea purpurea</i>       | common morningglory       |      |      |      |      | •    |           |      |      |      |      |
| Iridaceae       | <i>Iris germanica</i>         | German iris               |      |      | •    |      |      |           | •    |      |      |      |
| Iridaceae       | <i>Iris lutescens</i>         | Crimean iris              |      |      |      |      |      |           | •    |      |      | •    |
| Iridaceae       | <i>Iris sanguinea</i>         | Japanese iris             |      |      | •    |      |      |           |      |      |      |      |
| Oleaceae        | <i>Jasminum nudiflorum</i>    | winter jasmine            |      |      | •    |      |      |           |      |      |      | •    |
| Chenopodiaceae  | <i>Kochia scoparia</i>        | kochia                    | •    | •    |      | •    | •    | •         |      | •    | •    |      |
| Fabaceae        | <i>Kummerowia stipulacea</i>  | Korean lespedeza          |      |      | •    |      |      |           |      |      |      |      |
| Asteraceae      | <i>Lactuca serriola</i>       | prickly lettuce           | •    | •    | •    | •    | •    | •         | •    | •    | •    |      |
| Asteraceae      | <i>Lactuca tatarica</i>       | blue lettuce              | •    |      |      |      |      |           |      |      |      |      |
| Lamiaceae       | <i>Lamium amplexicaule</i>    | henbit                    |      |      | •    | •    |      | •         | •    |      |      |      |
| Fabaceae        | <i>Lathyrus hirsutus</i>      | singletary pea            |      |      | •    |      |      |           | •    |      |      |      |
| Fabaceae        | <i>Lathyrus latifolius</i>    | everlasting peavine       |      |      |      |      |      |           |      | •    |      |      |
| Lamiaceae       | <i>Leonurus cardiaca</i>      | motherwort                | •    |      |      |      |      |           |      |      |      |      |
| Lamiaceae       | <i>Leonurus sibiricus</i>     | honeyweed                 |      |      |      |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Lepidium latifolium</i>    | broadleaf pepperweed      | •    |      |      |      |      |           |      |      |      |      |
| Fabaceae        | <i>Lespedeza cuneata</i>      | sericea lespedeza         |      |      | •    |      |      |           |      |      |      |      |
| Asteraceae      | <i>Leucanthemum vulgare</i>   | oxeye daisy               |      |      |      |      |      |           | •    | •    |      |      |

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| Oleaceae         | <i>Ligustrum japonicum</i>     | Japanese privet           |      |      |      |      |      |           | •    |      |      |      |
| Oleaceae         | <i>Ligustrum lucidum</i>       | glossy privet             |      |      |      |      |      |           | •    |      |      |      |
| Oleaceae         | <i>Ligustrum sinense</i>       | Chinese privet            |      |      |      |      |      |           | •    |      |      |      |
| Oleaceae         | <i>Ligustrum vulgare</i>       | European privet           |      |      | •    |      |      |           |      |      |      |      |
| Scrophulariaceae | <i>Linaria vulgaris</i>        | yellow toadflax           |      |      |      |      |      |           |      |      | •    |      |
| Poaceae          | <i>Lolium arundinaceum</i>     | tall fescue               |      |      |      | •    |      | •         | •    | •    |      |      |
| Poaceae          | <i>Lolium perenne</i>          | perennial ryegrass        |      |      | •    | •    |      | •         | •    | •    |      | •    |
| Poaceae          | <i>Lolium pratense</i>         | meadow fescue             |      |      | •    |      |      |           |      |      |      |      |
| Poaceae          | <i>Lolium temulentum</i>       | Darnel ryegrass           |      |      |      |      |      | •         |      |      |      |      |
| Caprifoliaceae   | <i>Lonicera japonica</i>       | Japanese honeysuckle      |      |      | •    |      |      |           | •    |      |      |      |
| Caprifoliaceae   | <i>Lonicera maackii</i>        | Amur honeysuckle bush     |      |      | •    |      |      |           |      |      |      | •    |
| Solanaceae       | <i>Lycium barbarum</i>         | matrimony vine            |      |      | •    |      |      |           |      |      |      |      |
| Rosaceae         | <i>Malus pumila</i>            | paradise apple            |      |      |      |      |      |           |      | •    |      |      |
| Rosaceae         | <i>Malus sylvestris</i>        | European crabapple        |      |      |      |      |      |           |      | •    |      |      |
| Malvaceae        | <i>Malva neglecta</i>          | roundleaf mallow          |      |      |      |      |      | •         |      | •    |      | •    |
| Malvaceae        | <i>Malva parviflora</i>        | small-whorl mallow        |      |      |      |      |      |           | •    |      |      |      |
| Lamiaceae        | <i>Marrubium vulgare</i>       | horehound                 |      | •    | •    |      | •    | •         | •    | •    |      | •    |
| Fabaceae         | <i>Medicago lupulina</i>       | black medic clover        |      |      | •    | •    | •    | •         | •    | •    |      |      |
| Fabaceae         | <i>Medicago minima</i>         | little burclover          |      |      | •    |      |      | •         | •    |      |      |      |
| Fabaceae         | <i>Medicago polymorpha</i>     | California burclover      |      |      |      | •    |      |           | •    |      |      | •    |
| Fabaceae         | <i>Medicago sativa</i>         | alfalfa                   |      |      | •    |      |      | •         |      | •    |      |      |
| Meliaceae        | <i>Melia azedarach</i>         | Chinaberry tree           |      |      | •    |      |      |           | •    |      |      |      |
| Fabaceae         | <i>Mellilotus alba</i>         | white sweetclover         |      |      |      | •    |      |           |      |      | •    |      |
| Fabaceae         | <i>Mellilotus indicus</i>      | annual yellow sweetclover |      |      |      |      |      | •         |      | •    |      |      |
| Fabaceae         | <i>Mellilotus officinalis</i>  | yellow sweetclover        |      | •    | •    | •    | •    | •         | •    | •    | •    |      |
| Lamiaceae        | <i>Mentha spicata</i>          | spearmint                 |      |      | •    |      |      |           | •    |      |      |      |
| Nyctaginaceae    | <i>Mirabilis jalapa</i>        | common four o'clock       |      |      |      |      |      |           | •    |      |      | •    |
| Lamiaceae        | <i>Moluccella laevis</i>       | shellflower               |      |      |      |      |      | •         |      |      |      |      |
| Moraceae         | <i>Morus alba</i>              | white mulberry            |      |      |      | •    |      | •         | •    |      |      |      |
| Haloragaceae     | <i>Myriophyllum spicatum</i>   | Eurasian water-milfoil    |      |      |      |      |      | •         |      |      |      |      |
| Berberidaceae    | <i>Nandina domestica</i>       | heavenly bamboo           |      |      |      |      |      |           | •    |      |      | •    |
| Lamiaceae        | <i>Nepeta cataria</i>          | catnip                    |      |      | •    | •    |      |           |      | •    |      |      |
| Asteraceae       | <i>Onopordum acanthium</i>     | Scotch thistle            |      |      |      |      |      |           |      | •    |      |      |
| Liliaceae        | <i>Ornithogalum umbellatum</i> | Star-of-Bethlehem         |      |      | •    |      |      |           |      |      |      |      |
| Poaceae          | <i>Panicum coloratum</i>       | klinegrass                |      |      |      |      |      |           | •    |      |      | •    |
| Poaceae          | <i>Panicum miliaceum</i>       | proso millet              |      |      |      |      |      | •         |      |      |      | •    |

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|-----------------|------------------------------------|-----------------------------|------|------|------|------|------|-----------|------|------|------|------|
| Asteraceae      | <i>Parthenium hysterophorus</i>    | ragweed parthenium          |      |      | •    |      |      |           |      |      |      |      |
| Poaceae         | <i>Paspalum dilatatum</i>          | dallis grass                |      |      | •    |      |      |           | •    |      |      |      |
| Poaceae         | <i>Paspalum urvillei</i>           | Vasey grass                 |      |      |      |      |      |           | •    |      |      |      |
| Poaceae         | <i>Pennisetum glaucum</i>          | yellow foxtail              |      |      | •    | •    |      |           |      |      |      |      |
| Poaceae         | <i>Phalaris arundinacea</i>        | reed canarygrass            | •    |      |      |      |      |           |      | •    |      |      |
| Poaceae         | <i>Phleum pratense</i>             | common timothy              |      |      |      |      |      |           |      | •    |      |      |
| Pinaceae        | <i>Pinus nigra</i>                 | Australian pine             |      |      |      | •    |      |           |      |      |      | •    |
| Plantaginaceae  | <i>Plantago lanceolata</i>         | buckhorn plaintain          |      |      | •    |      |      |           |      | •    |      |      |
| Poaceae         | <i>Poa annua</i>                   | annual bluegrass            |      |      | •    |      | •    |           | •    |      |      |      |
| Poaceae         | <i>Poa compressa</i>               | flat-stem blue grass        |      |      |      |      |      |           |      | •    |      |      |
| Poaceae         | <i>Poa pratensis</i>               | Kentucky bluegrass          |      | •    | •    | •    | •    | •         |      | •    | •    |      |
| Caryophyllaceae | <i>Polycarpon tetraphyllum</i>     | fourleaf manyseed           |      |      |      |      |      |           | •    |      |      |      |
| Polygonaceae    | <i>Polygonum arenastrum</i>        | prostrate knotweed          |      |      |      | •    |      | •         |      |      |      |      |
| Polygonaceae    | <i>Polygonum aviculare</i>         | yard knotweed               |      |      |      |      |      | •         |      | •    |      |      |
| Polygonaceae    | <i>Polygonum convolvulus</i>       | climbing buckwheat          |      | •    | •    |      |      | •         |      | •    |      |      |
| Polygonaceae    | <i>Polygonum hydropiper</i>        | annual smartweed            |      |      | •    |      |      |           |      |      |      |      |
| Poaceae         | <i>Polypogon monspeliensis</i>     | annual rabbitsfoot grass    | •    |      |      |      |      | •         | •    |      | •    |      |
| Poaceae         | <i>Polypogon viridis</i>           | beardless rabbitsfoot grass |      |      |      |      |      | •         |      |      |      | •    |
| Salicaceae      | <i>Populus alba</i>                | white poplar                | •    |      |      |      |      |           |      |      |      |      |
| Rosaceae        | <i>Potentilla recta</i>            | sulphur cinquefoil          |      |      | •    |      |      |           |      |      |      | •    |
| Rosaceae        | <i>Prunus mahaleb</i>              | Mahaleb cherry              |      |      | •    |      |      |           |      |      |      |      |
| Poaceae         | <i>Psathyrostachys juncea</i>      | Russian wildrye             |      |      |      |      |      |           |      | •    |      |      |
| Asteraceae      | <i>Pseudognaphalium luteoalbum</i> | Jersey cudweed              |      |      |      |      |      |           | •    |      |      |      |
| Rosaceae        | <i>Pyrus communis</i>              | common pear                 |      |      |      | •    |      |           | •    |      |      |      |
| Ranunculaceae   | <i>Ranunculus acris</i>            | meadow buttercup            |      |      |      |      |      |           |      | •    |      |      |
| Euphorbiaceae   | <i>Ricinus communis</i>            | castor bean                 |      |      |      |      |      |           | •    |      |      | •    |
| Brassicaceae    | <i>Rorippa sylvestris</i>          | creeping yellow cress       |      |      |      |      |      |           |      | •    |      |      |
| Polygonaceae    | <i>Rumex crispus</i>               | curley dock                 | •    |      | •    | •    |      | •         |      | •    | •    |      |
| Polygonaceae    | <i>Rumex obtusifolius</i>          | bluntleaf dock              | •    |      |      |      |      |           |      |      |      | •    |
| Polygonaceae    | <i>Rumex patientia</i>             | patience dock               |      |      |      | •    |      |           |      |      |      | •    |
| Polygonaceae    | <i>Rumex pulcher</i>               | fiddle dock                 |      |      | •    |      |      |           | •    |      |      |      |
| Polygonaceae    | <i>Rumex stenophyllus</i>          | narrowleaf dock             |      |      |      | •    |      | •         |      |      |      | •    |
| Chenopodiaceae  | <i>Salsola collina</i>             | slender Russian thistle     |      |      |      |      |      | •         |      |      |      |      |
| Chenopodiaceae  | <i>Salsola kali</i>                | prickly Russian thistle     |      |      |      | •    |      |           |      |      |      | •    |
| Chenopodiaceae  | <i>Salsola tragus</i>              | prickly Russian thistle     | •    | •    |      |      | •    | •         |      | •    | •    |      |
| Lamiaceae       | <i>Salvia uliginosa</i>            | bog sage                    |      |      |      |      |      |           | •    |      |      | •    |

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|-----------------|-------------------------------|-------------------------|------|------|------|------|------|-----------|------|------|------|------|
| Caryophyllaceae | <i>Saponaria officinalis</i>  | bouncingbet             |      |      | •    |      |      |           |      |      |      |      |
| Asteraceae      | <i>Scorzonera laciniata</i>   | cutleaf vipergrass      |      |      |      |      |      | •         |      | •    |      | •    |
| Poaceae         | <i>Setaria pumila</i>         | yellow bristlegrass     |      | •    |      | •    |      | •         |      |      |      |      |
| Poaceae         | <i>Setaria viridis</i>        | green bristlegrass      | •    | •    |      | •    |      | •         |      | •    |      |      |
| Rubiaceae       | <i>Sherardia arvensis</i>     | blue fieldmadder        |      |      |      |      |      |           | •    |      |      |      |
| Malvaceae       | <i>Sida abutifolia</i>        | prostrate sida          |      |      | •    |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Sinapis arvensis</i>       | charlock mustard        |      |      | •    |      |      |           |      |      |      |      |
| Brassicaceae    | <i>Sisymbrium altissimum</i>  | tumble mustard          |      |      | •    |      |      | •         |      | •    |      |      |
| Brassicaceae    | <i>Sisymbrium irio</i>        | London rocket           |      |      |      |      |      |           | •    |      |      |      |
| Brassicaceae    | <i>Sisymbrium officinale</i>  | hairypod hedgemustard   |      |      |      |      |      |           | •    |      |      |      |
| Asteraceae      | <i>Sonchus asper</i>          | spiny sowthistle        |      |      | •    | •    | •    | •         | •    | •    |      |      |
| Asteraceae      | <i>Sonchus oleraceus</i>      | annual sowthistle       |      |      |      |      |      |           | •    |      |      |      |
| Poaceae         | <i>Sorghum halepense</i>      | Johnsongrass            | •    |      | •    | •    |      | •         | •    |      |      |      |
| Caryophyllaceae | <i>Stellaria media</i>        | common chickweed        |      |      | •    | •    |      |           | •    |      |      |      |
| Oleaceae        | <i>Syringa vulgaris</i>       | common lilac            |      |      |      | •    |      |           |      |      |      |      |
| Tamaricaceae    | <i>Tamarix chinensis</i>      | Chinese tamarisk        |      |      | •    |      |      | •         |      | •    |      |      |
| Tamaricaceae    | <i>Tamarix gallica</i>        | French tamarisk         |      |      |      |      |      | •         |      |      |      |      |
| Tamaricaceae    | <i>Tamarix ramosissima</i>    | saltcedar               | •    |      |      |      |      | •         |      |      |      |      |
| Asteraceae      | <i>Taraxacum laevigatum</i>   | red-seed dandelion      |      | •    |      |      |      |           |      |      |      |      |
| Asteraceae      | <i>Taraxacum officinale</i>   | common dandelion        |      |      | •    | •    | •    | •         | •    | •    |      |      |
| Poaceae         | <i>Thinopyrum intermedium</i> | intermediate wheatgrass | •    |      |      |      |      |           |      | •    |      |      |
| Poaceae         | <i>Thinopyrum ponticum</i>    | rush wheatgrass         | •    |      |      |      |      |           |      | •    |      |      |
| Brassicaceae    | <i>Thlaspi arvense</i>        | field pennycress        | •    |      |      | •    |      |           |      | •    |      |      |
| Apiaceae        | <i>Torilis arvensis</i>       | spreading hedgeparsley  |      |      | •    |      |      |           | •    |      |      |      |
| Apiaceae        | <i>Torilis nodosa</i>         | knotted hedgeparsley    |      |      |      |      |      |           | •    |      |      |      |
| Asteraceae      | <i>Tragopogon dubius</i>      | western salsify         | •    | •    | •    | •    |      | •         |      | •    | •    |      |
| Asteraceae      | <i>Tragopogon pratensis</i>   | meadow salsify          |      | •    |      |      | •    |           |      | •    |      |      |
| Euphorbiaceae   | <i>Triadica sebifera</i>      | Chinese tallow tree     |      |      |      |      |      |           | •    |      |      |      |
| Zygophyllaceae  | <i>Tribulus terrestris</i>    | puncturevine            | •    |      | •    | •    |      | •         |      | •    |      |      |
| Fabaceae        | <i>Trifolium campestre</i>    | big-hop field clover    |      |      | •    |      |      |           |      |      |      |      |
| Fabaceae        | <i>Trifolium dubium</i>       | small hop clover        |      |      | •    |      |      |           |      |      |      |      |
| Fabaceae        | <i>Trifolium pratense</i>     | red clover              |      |      |      |      |      |           |      | •    |      |      |
| Fabaceae        | <i>Trifolium repens</i>       | white clover            |      |      |      | •    |      | •         | •    | •    |      |      |
| Poaceae         | <i>Triticum aestivum</i>      | common wheat            |      |      | •    | •    |      |           |      |      |      | •    |
| Typhaceae       | <i>Typha angustifolia</i>     | narrowleaf cattail      | •    |      | •    |      |      |           |      |      |      |      |
| Ulmaceae        | <i>Ulmus pumila</i>           | Siberian elm            |      |      |      | •    | •    | •         |      | •    |      | •    |

| Family           | Scientific Name             | Common Names      | BEOL | CAVO | CHIC | FOLS | FOUN | LAMR/ALFL | LYJO | PECO | SAND | WABA |
|------------------|-----------------------------|-------------------|------|------|------|------|------|-----------|------|------|------|------|
| Urticaceae       | <i>Urtica dioica</i>        | stinging nettle   |      |      |      |      | •    |           |      |      |      | •    |
| Scrophulariaceae | <i>Verbascum thapsus</i>    | common mullein    | •    | •    | •    |      | •    |           | •    | •    |      |      |
| Verbenaceae      | <i>Verbena brasiliensis</i> | Brazilian vervain |      |      |      |      |      |           | •    |      |      |      |
| Scrophulariaceae | <i>Veronica agrestis</i>    | field speedwell   |      |      | •    |      |      |           |      |      |      |      |
| Scrophulariaceae | <i>Veronica arvensis</i>    | corn speedwell    |      |      |      |      |      |           | •    |      |      |      |
| Fabaceae         | <i>Vicia sativa</i>         | narrowleaf vetch  |      |      | •    |      |      |           | •    |      |      |      |
| Fabaceae         | <i>Vicia villosa</i>        | hairy vetch       |      |      |      |      |      |           | •    |      |      |      |
| Apocynaceae      | <i>Vinca minor</i>          | lesser periwinkle |      |      | •    |      |      |           | •    |      |      |      |

## APPENDIX B

### Exotic plant monitoring in Sonoran Desert Network Parks.

The Sonoran Desert Network will implement this protocol on a park by park basis, focusing efforts on monitoring areas that are high risk vectors, with suitable habitat suitable for exotic plant establishment and that are not currently monitored in a superior manner by any other SODN protocol. Panels for each park will be determined by taking into consideration the extensive knowledge of which exotic plants already exist in each area, ongoing park treatments (if applicable) and priority areas of management concern. Field effort will be tailored to enable the most ground to be covered each year at all parks monitored. High risk vectors known to be currently highly invaded may be excluded from this effort due to low probability of new species establishment and low level of new information to be gained. Seasonality of the surveys will be adapted to best capture the exotic flora's phenological window and to nest within SODN's other monitoring schedules. At some units, multiple season surveys may be conducted due to the Sonoran Desert's bi-modal precipitation patterns; however this accommodation may require a reciprocal reduction in the amount of ground monitored in each season.

Saguaro National Park (SAGU) and Organ Pipe National Monument (ORPI) are excluded from this preliminary effort, due to extensive park efforts to monitor and treat known exotics as well as difficulties in accessing many of the known vectors at ORPI. Efforts will be made to work in concert with these park-based efforts and for SODN to compliment this work by surveying areas that the parks currently do not have the resources to monitor.

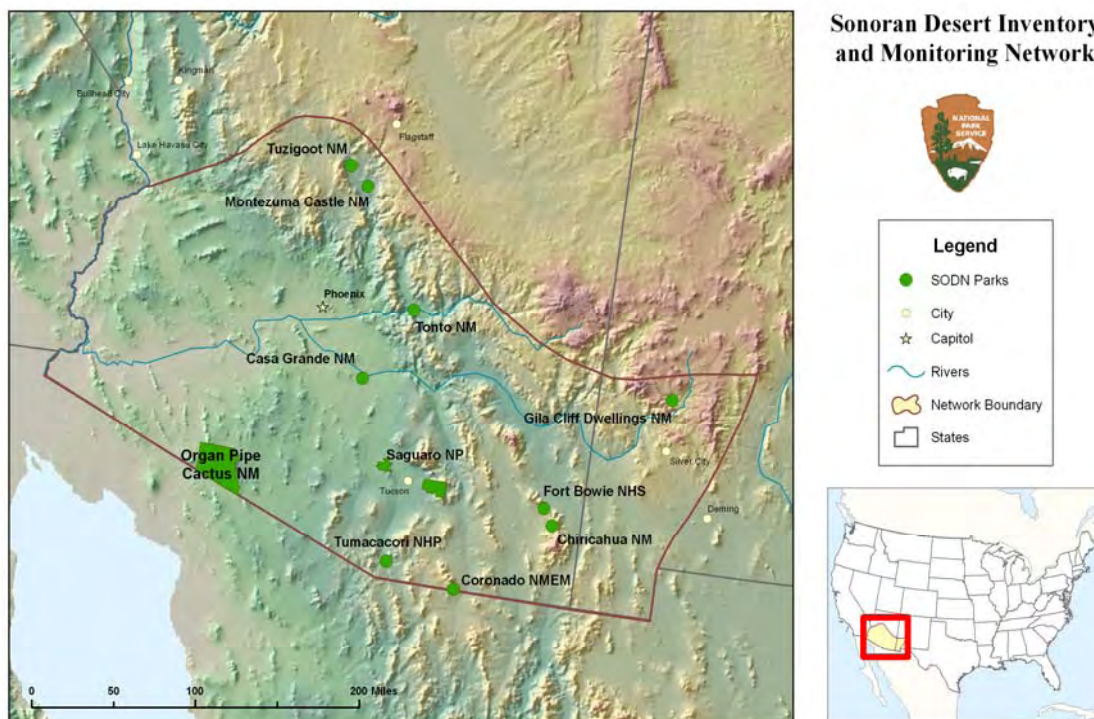


Figure B-1. Park locations within the Sonoran Desert I&M Network.

## B.1 Casa Grande Ruins NM

Casa Grande Ruins National Monument (CAGR) is located in Coolidge, Arizona, 40 miles southeast of Phoenix. It was established in 1918 by Theodore Roosevelt to preserve a large prehistoric Hohokam structure, the "Great House", and numerous other field sites. The 191 ha (471acre) unit is surrounded on three sides by a paved road and on the fourth by a canal and associated dirt access road. CAGR hosts two unpaved trails leading to the main house structure and ball court respectively. These areas are predominantly un-vegetated presumably due to the long history of human presence and activity. One paved road provides entrance to the park and adjoins a short paved road to the administrative buildings.

Several small parcels of nearby state land have recently been proposed as expansion lands for the park (Fig. B-2). Adamsville is the largest of these units (52 ha) and is bisected by Highway 287. To the south of the road lays an abandoned cotton mill and associated dirt access roads. The northern part of this unit has a seldom-used dirt road, and adjacent housing parcels. All main road right-of-ways surrounding the units are mowed by the city or park staff to keep vegetation low.

The vegetation at all units is dominated by creosote bush (*Larrea tridentata*) with other shrubs such as wolfberry (*Lycium fremontii*), globemallow (*Sphaeralcea* spp.), and little leaf ratany (*Krameria erecta*) occurring as uncommon associates in some areas. Due to a lowered ground water table, the main unit has suffered the loss of many mesquite trees (*Prosopis velutina*) with little regeneration. Scattered saguaro and barrel cacti (*Carnegie giganteus* & *Ferocactus wislizenii*) occur across the monument but in no great numbers. During spring and late summer, rains generate the germination of multiple annual herbaceous species, including the exotic Mediterranean grasses (*Schismus arabicus* and *barbartus*), red brome (*Bromus rubens*) and Sahara mustard (*Brassica tournefortii*).

In spring 2006 SODN, in cooperation with the Arizona Sonora Desert Museum Invaders volunteers and the Sonoran Institute, conducted a full census mapping effort of exotic plants at the main unit (Studd, 2007). During this effort 16 exotic plants were mapped (either with points or polygons) to document their distribution and abundance. All 16 species had been recorded at the park during previous inventories (Halverson 2003, Powell et al 2004); however three species formerly observed were not seen during this effort: African daisy (*Dimorphotheca*), buffelgrass (*Pennisetum ciliare*) and Lehman lovegrass (*Eragrostis lehmanniana*). This SODN inventory showed the interior and exterior perimeters of the park to be highly invaded, with surrounding private land serving as source infestations for many of the species recorded. Agriculture is prevalent in the local area and several common agricultural weeds have been documented at the main unit. Due to the close proximity of these fields (<10m), continued establishment of these species is likely. All of these inventory efforts provided locational information and led to limited management efforts to eradicate certain species, particularly buffelgrass (*Pennisetum ciliare*) and Malta star thistle (*Centaurea melitensis*).

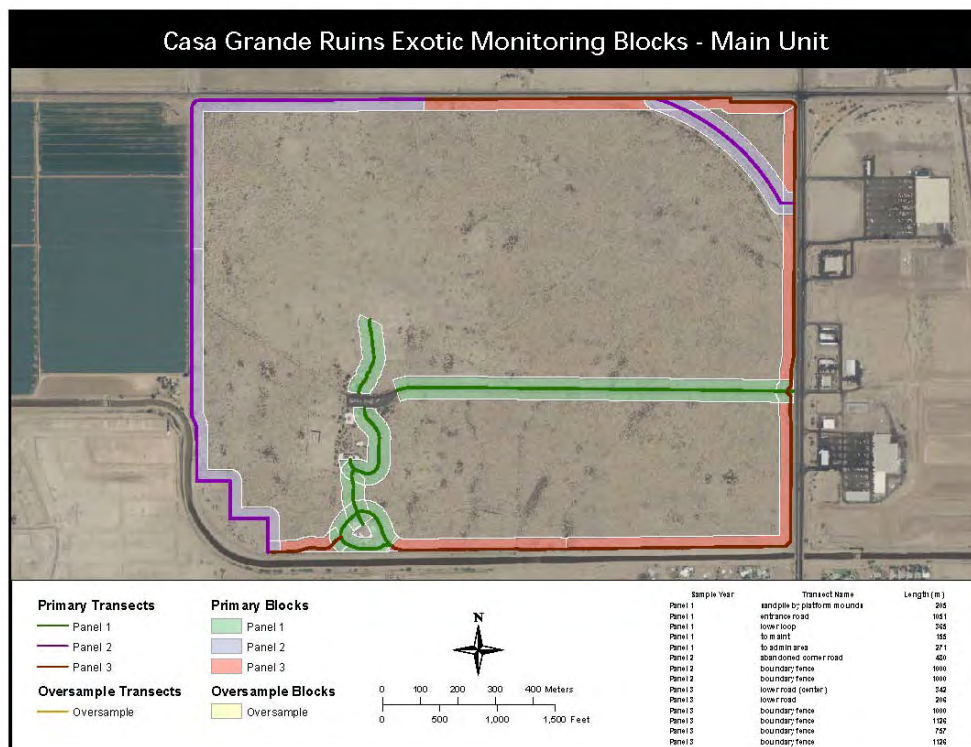
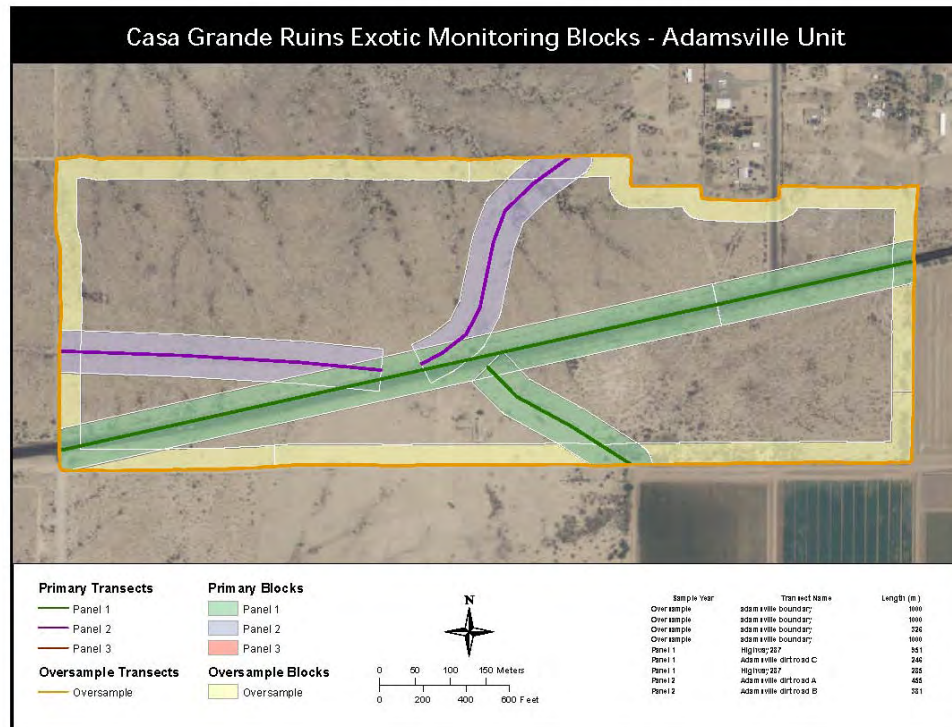


Figure B-2. Panel selections for CAGR

## B.2 Tonto NM

Tonto National Monument (TONT) is located 48 km (30 miles) northwest of Globe in central Arizona. The monument was established in 1907 to preserve 14<sup>th</sup> century masonry cliff dwellings and other archeological sites of the prehistoric Salado culture. TONT is near the northern boundary of the Sonoran Desert and is comprised of 453 ha (1,120 acres). The monument has one main entrance road leading to the visitor center and two trails that lead to two cave dwellings open to the public (Fig. B-3). The upper ruin trail is open by guided tour only and closed during the hotter summer months. The lower ruin trail is paved and open to the public year round. The remainder of the monument is without trails and the entire unit is fenced to exclude cattle. Lands surrounding the monument are entirely managed by the United States Forest Service (USFS). A state maintained highway (Hwy 88) runs through the northern part of the monument separating a small triangular section of the lower alluvial fan.

Grazing and fire may have played a role in shaping Tonto's current vegetation communities and the presence and extent of exotic plant species. The "History of Fire and Fire Impacts" report (Philips 1997) notes that Lehmann lovegrass (*Eragrostis lehmanniana*), among other grasses, was seeded by the USFS in the 1960s and 1970s as a post-fire re-vegetation effort. The area seeded was predominantly in the southeast portion of the park near the Upper Ruin and beyond the south boundary in Tonto National Forest land. This area burned severely in the Schultz Fire of 1964, which damaged many saguaro cacti (*Carnegie gigantea*), cholla and prickly pear (*Opuntia* spp.) and Paloverde (*Parkinsonia* spp). Additional fires in 1970, 1976 and 1980 re-burned portions of the Schultz fire area. Currently few cacti and shrubs dot these hills.

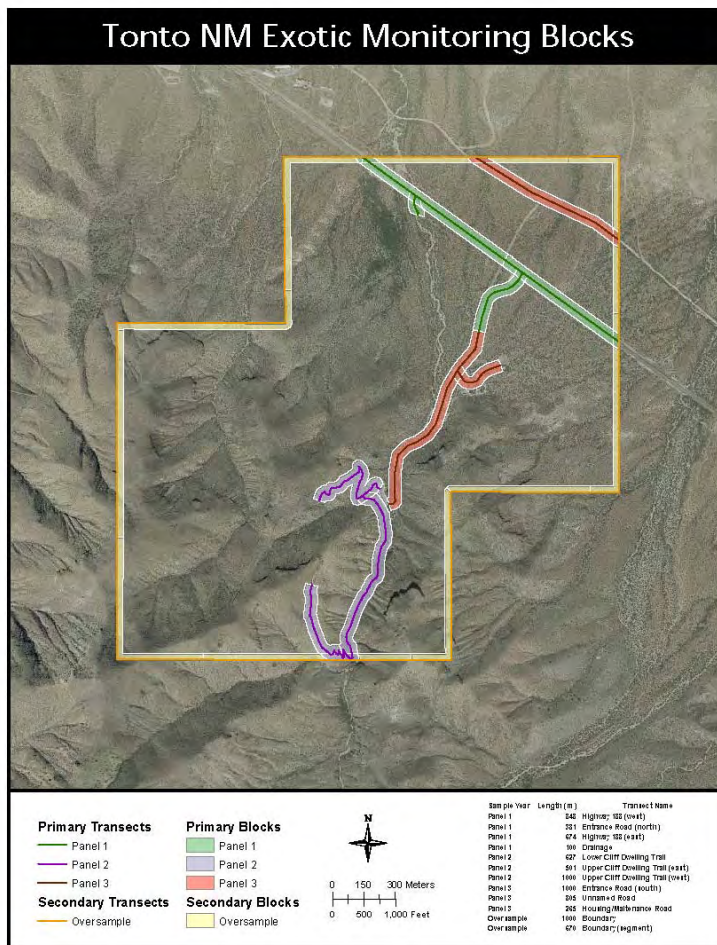


Figure B-3. Panel selection at TONT.

Multiple studies have either documented the presence of exotic species or have collected spatial data on the presence and abundance of these species. Jenkins et al. (1995) reported on the status of both native and non-native plants, citing the general location and abundance of each species. In 1992, B. Philips completed the "Status of Non-native Plant Species" at Tonto NM. During this study, efforts were made to concentrate on areas where disturbance had been intense due to fire or human activity. The general location and abundance of 13 exotic species were marked on topographic maps. In 2003, P. Guertin completed a multi season, multi-year study documenting the "status of introduced plants in Southern Arizona parks". Efforts were made to cover 100% of the grounds and to search for any of 50 target species, of which 21 species were documented.

SODN completed a census-style mapping inventory over several weeks in the fall of 2005 (Studd et al 2006). Sixteen exotic species were observed and mapped. Four species, all grasses, were recorded in both high densities and over large areas: wild oats (*Avena fatua*), red brome (*Bromus rubens*), ripgut brome (*Bromus rigidus*), and Lehmann lovegrass (*Eragrostis lehmanniana*). Buffelgrass (*Pennisetum ciliare*) and Sahara mustard (*Brassica tournefortii*) both were documented in small numbers along the edges of Hwy 88. Efforts were made immediately to curb the spread of buffelgrass due to the highly invasive nature of the plant and its ability to increase fire hazard in desert environs. TONT has continued to seek out and remove this species regularly and to date it has not been found within the monument boundary.

### **B.3 Montezuma Castle NM and Tuzigoot NM**

Located midway between the cities of Flagstaff and Phoenix along Interstate 17, Montezuma Castle National Monument (MOCA) occupies 671 ha (1658 acres) of the upper Verde Valley in central Arizona. The Verde Valley is typified by lowland riparian areas, dominated by sycamore, willow, ash, and cottonwood trees and riparian shrubs. Upland areas consist of upper Sonoran desert shrubs and grasses such as crucifixion thorn, (*Canotia holacantha*), littleleaf ratany (*Krameria erecta*) and creosote bush (*Larrea tridentata*). Mesquite (*Prosopis velutina*) and palo verde (*Parkinsonia microphyllum*) open woodlands/ mixed shrublands are also common.

MOCA is comprised of two units located approximately 7 km (4 mi) apart: the Castle unit (containing the primary cliff dwelling ruins and visitor center), and the Well unit, both located along the perennial Beaver Creek (Fig. B-4). The Castle unit was established to preserve a 20-room prehistoric cliff dwelling built by the Sinagua culture ~600 years ago. The Well unit (MOWE) preserves a unique limestone sinkhole (or well) located on a mesa overlooking Beaver Creek. Tuzigoot National Monument (TUZI) preserves 324 ha (800 acres) and is located 34 km (21 mi) west of MOCA. It was established in 1939 to protect Tuzigoot pueblo, a 110-room multistory structure. Tavasci Marsh, a 94 ha (232 acre) wetland adjacent to the east was recently acquired as an expansion to the monument.

Each unit has a trail open to visitors leading either to a ruin or to the well, as well as paved entrance roads and a dirt or paved road used for access to maintenance or housing units. TUZI has several trails open to the public, one that leads down to and overlooks the ruins and another that leads to the marsh. In addition there is a paved road adjacent to the full length of the marsh running along the western boundary. Several other smaller road sections are used solely for access by park staff and are not open to the public.

All three units are administrated by a single management team. Park staff has continued to collect data on exotic plants for several years and have implemented several ongoing control measures at all units. Specifically, efforts have been made to eradicate tamarisk (*Tamarix spp.*) from the riparian corridor at MOCA, as well as other riparian invasives: Russian olive (*Elaeagnus angustifolia*), giant reed (*Arundo donax*), Tree of Heaven (*Ailanthus altissima*) and pampasgrass (*Cortaderia selloana*). Burningbush (*Kochia scoparia*), Russian thistle (*Salsola kali*), Russian knapweed (*Acroptilon repens*), Dalmation toadflax (*Linaria dalmatica*) and redstem storksbill

(*Erodium cicutarium*) are some of the herbaceous species that have extensive cover at the pasture-like areas at MOCA and MOWE.

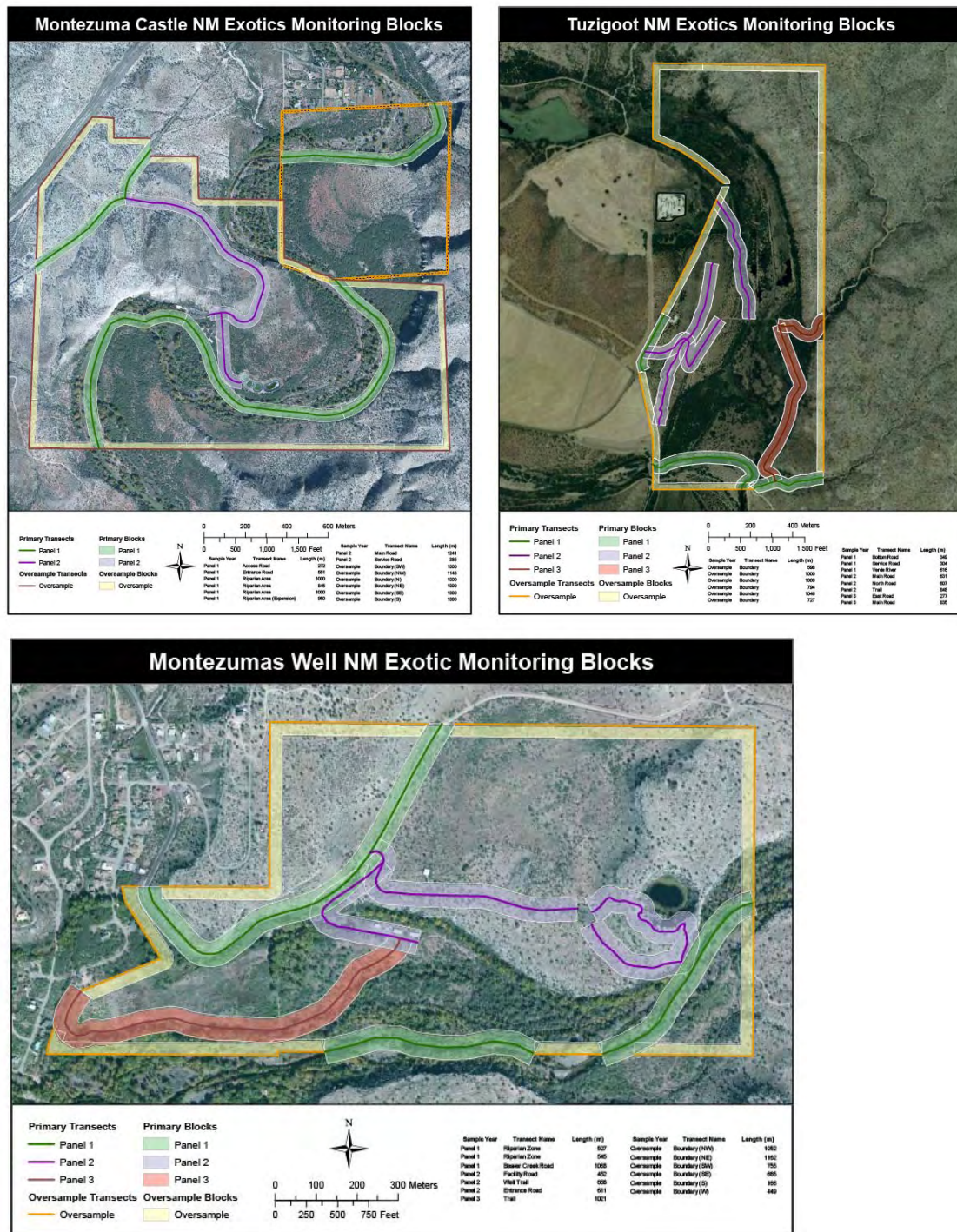


Figure B-4. Panel selections for MOCA and TUZI.

SODN conducted census style exotic plant inventories at all three units during 2003 and 2004 (Mau-crimmins et al, 2009). Of the 50 target species for this project, 36 species were encountered and mapped in at least one of the three park units. Notable species with both wide distribution and high abundance included Bermudagrass (*Cynodon dactylon*), red brome (*Bromus*

*rubens*), ripgut brome (*Bromus rigidus*), redstem storksbill (*Erodium cicutarium*) and common barley (*Hordeum leporinum*).

## B.4 Chiricahua NM

Chiricahua National Monument (CHIR), located ~38 mi (61 km) southeast of Willcox, AZ, was established in 1924 to preserve the fantastic 'wonderland' of various volcanic rock formations. The monument is situated in the northwestern part of the Chiricahua Mountains and is bounded to the north, south and east by US Forest Service lands and to the west by privately owned ranching properties. It covers 4,852 ha (11,989 acres), of which 3,852 ha (9518 acres) are designated wilderness. CHIR is one of the many 'sky islands' of the region, with elevations ranging from 762 - 2743 m (2,500 - 9,000 ft). The topography varies greatly throughout the unit from lower elevation grassy meadows to steep rocky canyons and high plateaus. Vegetation follows these gradients ranging from grass dominated savannas to mid-elevation chaparral, scrub and oak woodlands, to upper elevation pine and fir forests. Two major intermittently flowing drainages, Bonita and Rhyolite creeks, support riparian communities.

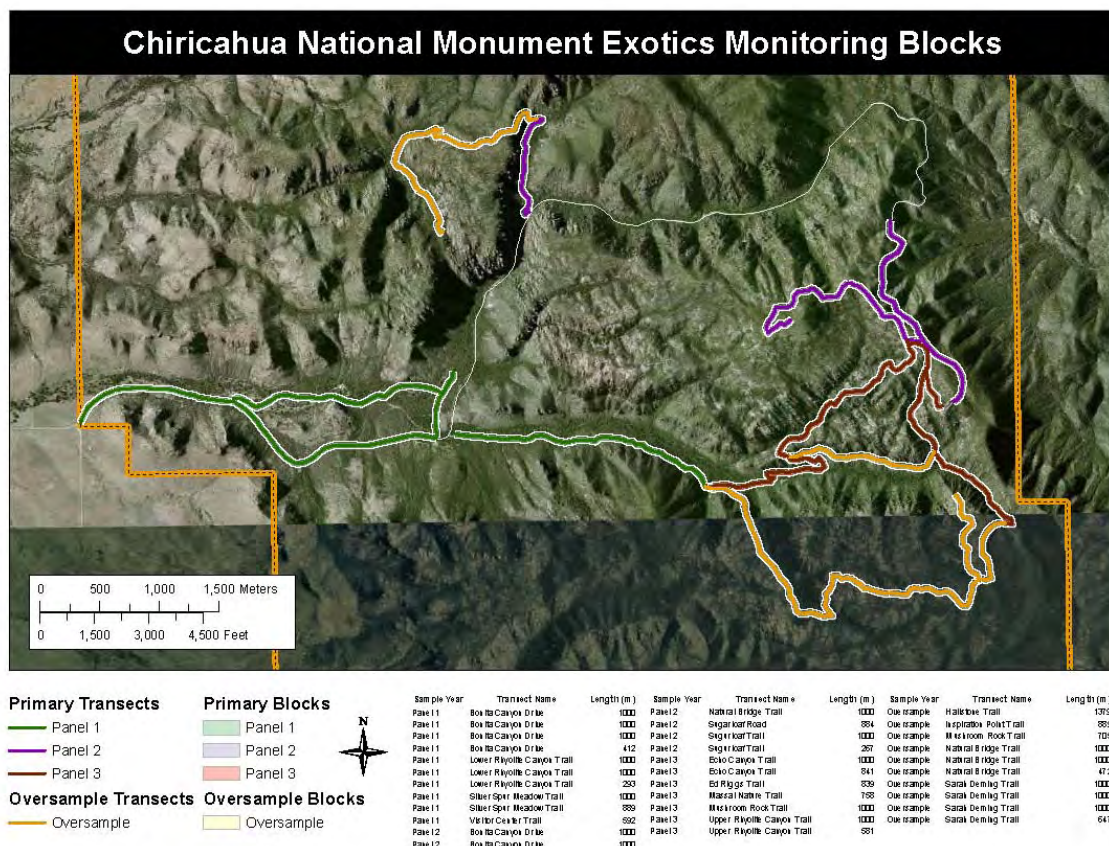


Figure B-5. Panel selection for CHIR.

The monument has one main road that begins on the western boundary (Fig. B-5), leads to the visitor center then winds upwards to the Sugar Loaf parking area and trail heads. Shorter unpaved access roads branch off the main road providing access to administrative buildings and a private inholding, King of Lead mine. There is one established campground located centrally in the unit. Several miles of foot trail are maintained (some permitting equestrian use), the majority of which are located in and around the upper Rhyolite canyon area.

Exotic species recorded during the biological inventory and other studies (Powell et al 2008) list several non-native plants, however extent of distribution or intensity of invasion is not reported. Exotic species of note include horehound (*Marrubium vulgare*), red brome (*Bromus rubens*), Maltese start thistle (*Centaurea melitensis*), Bermudagrass (*Cynodon dactylon*), and Lehmann lovegrass, stinkgrass, and weeping lovegrass (*Eragrostis lehmanniana*, *E. cilianensis*, *E. curvula*).

### B.5 Gila Cliff Dwellings NM

Gila Cliff Dwellings National Monument (GICL) is located approximately 46 miles (74 km) northwest of Silver City, New Mexico, (Fig. B-6). The monument includes sections of both the West and Middle forks of the Gila River and is surrounded by the Gila National Forest and Gila Wilderness, both administered by the U.S. Forest Service (USFS). The monument is positioned at the end of a minor highway that connects Silver City and the town of Mimbres, New Mexico. It was established in 1907 to preserve 15<sup>th</sup> century Mogollon cliff dwellings and was originally managed by the USFS until control was passed to the park service in 1933. The park currently consists of two separate units; the main unit containing the cliff dwellings and river corridor is 194 ha (479 acres) and the smaller TJ ruins unit at a mere 21 ha (51 acres). Elevation ranges from 1700 - 1900 m (5,577 - 6,233 ft). The monument lies within a large caldera that collapsed millions of years ago during a volcanic eruption. Geology around the monument reflects this, with rhyolite, andesite, basalt and welded tuff commonly found.

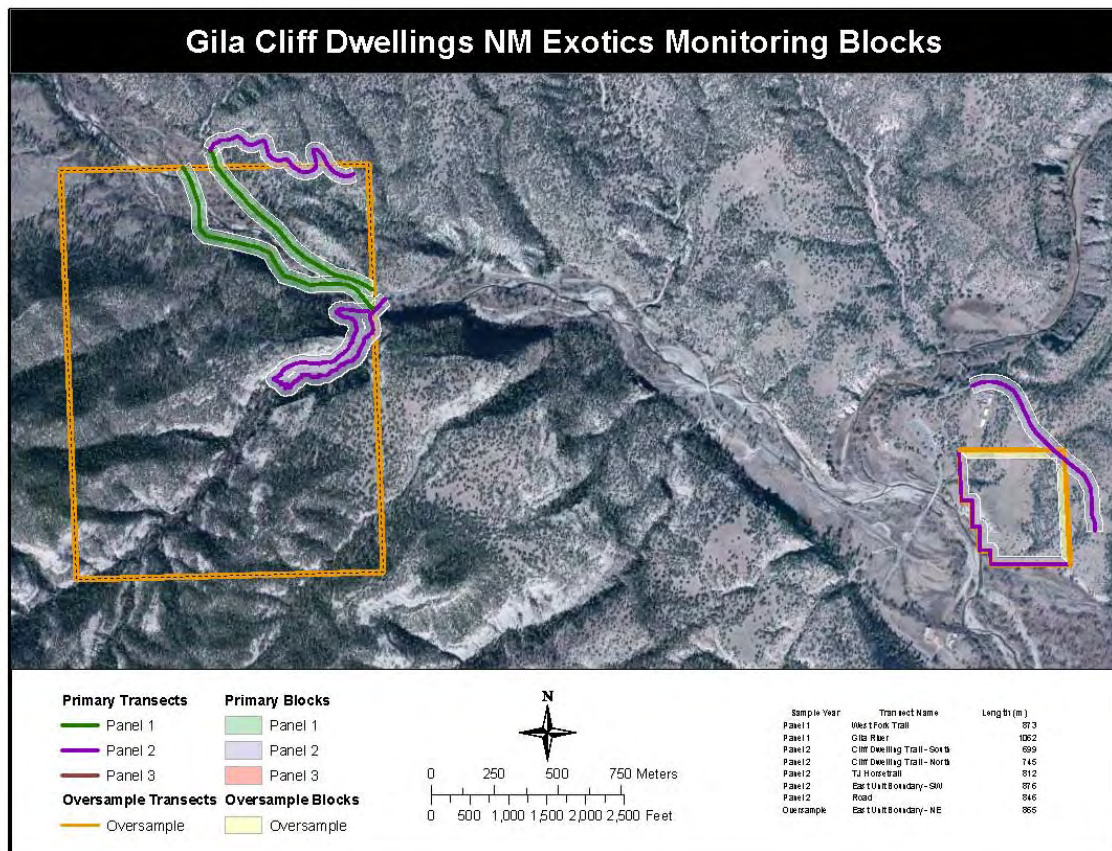


Figure B-6. Panel selection for GICL.

The vegetation of the monument is typically of the Madrean ecoregion, with Madrean evergreen woodlands (*Quercus arizonica*, *Q. grisea* and *Q. gambelii*) and juniper (*Juniperus monosperma*)

savannas on south facing slopes, Ponderosa pine (*Pinus ponderosa*) forests on north facing slopes and riparian gallery forest dominated by cottonwood (*Populus angustifolia*), ash (*Fraxinus velutina*) and walnut (*Juglans major*) lining the river channel.

The first inventory to extensively document exotic plants in the monument was conducted from 2001-2003 (Powell et al 2006). During this effort 38 non-native plants were observed, all of which are herbaceous or graminoid species. Notably, no tamarisk has ever been reported at the monument.

## **B.6 Fort Bowie NHS**

Fort Bowie National Historic Site (FOBO) is located ~28 miles (45 km) southeast of Wilcox, AZ, in the southeastern part of Arizona. It sits between the Chiricahua and Dos Cabezas mountain ranges, in Apache pass, a long time stronghold of the Apache Indians. In 1862 the U.S. army established a fort here, inhabited by up to 300 men and their families until it was decommissioned in 1894. With the Fort came wood cutting, grazing of horses and stock, and substantial infrastructure in the form of buildings, roads and trails. In addition, the Butterfield stage route criss-crossed the unit running from east to west (Fig. B-7). Today the site offers a maintained trail network, leading visitors through the site from the northern boundary to the visitor center located at the old fort ruins. Disabled access is gained via the paved road entering the park from the eastern boundary. This road also serves as the only vehicular access route to the administrative buildings and park housing.

Although only 405 ha (1000 acres), FOBO boasts complex topography, geomorphology and vegetative communities. A limestone fault arises in the eastern portion of the site where ocotillos (*Fouquieria splendens*), mariola (*Parthenium incanum*) and winterfat (*Krascheninnikovia lanata*) thrive. Most other parent material is of granitic origin, forming the hills to the south and west. Three major drainages run through the unit supporting riparian forests. Upland areas vary from mesquite dominated shrublands and savannas, to mixed-shrub oak woodlands (*Quercus emoryi*, *Quercus turbinella*). FOBO is unique in that the flora represents both the Chihuahuan, Madrean and Sonoran desert influences and has one of the most impressive species diversity for a unit its size, with over 700 species documented.

As part of the 'USGS Weeds in the West project: status of introduced plants in southern Arizona parks' (Halverson & Guertin 2003), the presence and abundance of 50 pre-selected introduced plants was assessed and mapped. During this survey effort (1999-2001) 26 non-native, introduced plant species were recorded at Fort Bowie, 12 of which were grasses. Most of the other species were annual forbs, with notable perennials: horehound (*Marrubium vulgare*), tamarisk (*Tamarix* spp., one individual – current status unknown), Boer's lovegrass (*Eragrostis curvula*), Lehmann lovegrass (*Eragrostis lehmanniana*) and Bermudagrass (*Cynodon dactylon*). In 2002-2003 the NPS (Powell et al 2005) conducted a vascular plant inventory adding one more species to the non-native list, wand mullein (*Verbascum virgatum*). None are found in any great abundance nor substantially distributed.

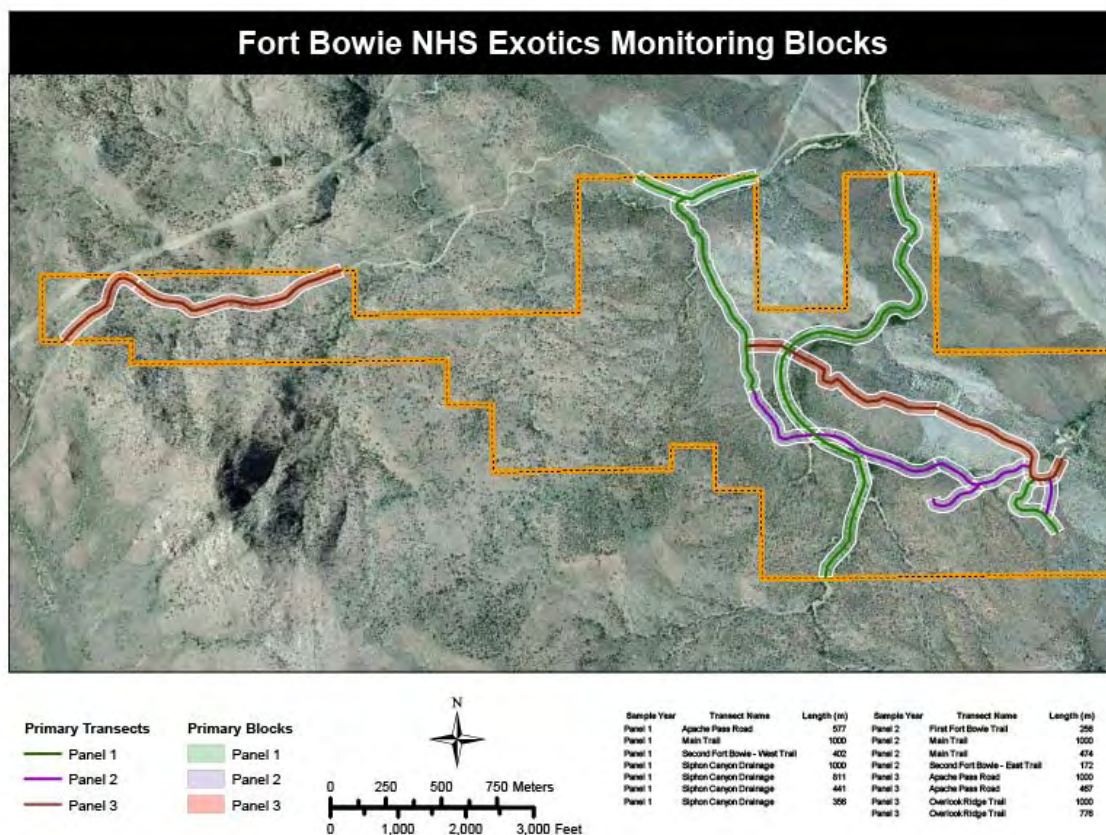


Figure B-7. Panel selection for FOBO.

## B.7 Coronado NM

Coronado National Memorial (CORO) is situated on the Mexico/Arizona border approximately 20 miles south of Sierra Vista (Fig. B-8). The 1,923 ha (4751 acres) memorial was established in 1941 to commemorate and interpret the significance of Francisco Vasquez de Coronado's expedition into the area. The memorial is located at the southern end of the Huachuca Mountains, one of the region's sky island mountain ranges. Topography is steep, climbing from the lower elevation 1,470 m (4,825 ft) grasslands to Montezuma Peak at 2385 m (7,825 ft). The perennial grasslands contain scattered desert shrubs and succulents (yucca, agave), and the rocky slopes commonly host mixed oak woodland (*Quercus emoryi*, *Quercus turbinella*), manzanita (*Arctostaphylos pungens*) and alligator juniper (*Juniperus deppeana*).

The memorial has an extensive network of trails spanning approximately half the length of the park, used frequently by visitors and undocumented immigrants crossing from Mexico. A section of the Arizona trail runs north-south through the western portion of the memorial and intersects with Joe's Canyon trail. One main road bi-sects the unit, running east to west providing access to the monument and a cut-through to circumvent the south end of the Huachuca range. This road is mostly paved but turns to gravel in the upper western elevations. One shorter road segment runs through the grasslands but is currently not open to the public and rarely used by park staff. As with many other border units, off road vehicle use by border patrol and un-authorized foot trail networks are common and present additional disturbance and vector opportunities.

The grasslands at CORO are known to be dominated by the exotic Lehmann lovegrass (*Eragrostis lehmanniana*), which has replaced many native species. Several other species have

been documented through various inventory efforts (Schmidt et al 2007). Notable species include Tree of Heaven (*Ailanthus altissima*), mullein (*Verbascum thapsus*), Johnsongrass (*Sorghum halepense*), perennial ryegrass (*Lolium perenne*), smooth barley (*Hordeum murinum*), weeping lovegrass and stinkgrass (*Eragrostis curvula* and *E. cilianensis*), Bermudagrass (*Cynodon dactylon*), rescuegrass (*Bromus catharticus*), Sahara mustard (*Brassica tournefortii*) and Russian thistle (*Salsola spp.*).

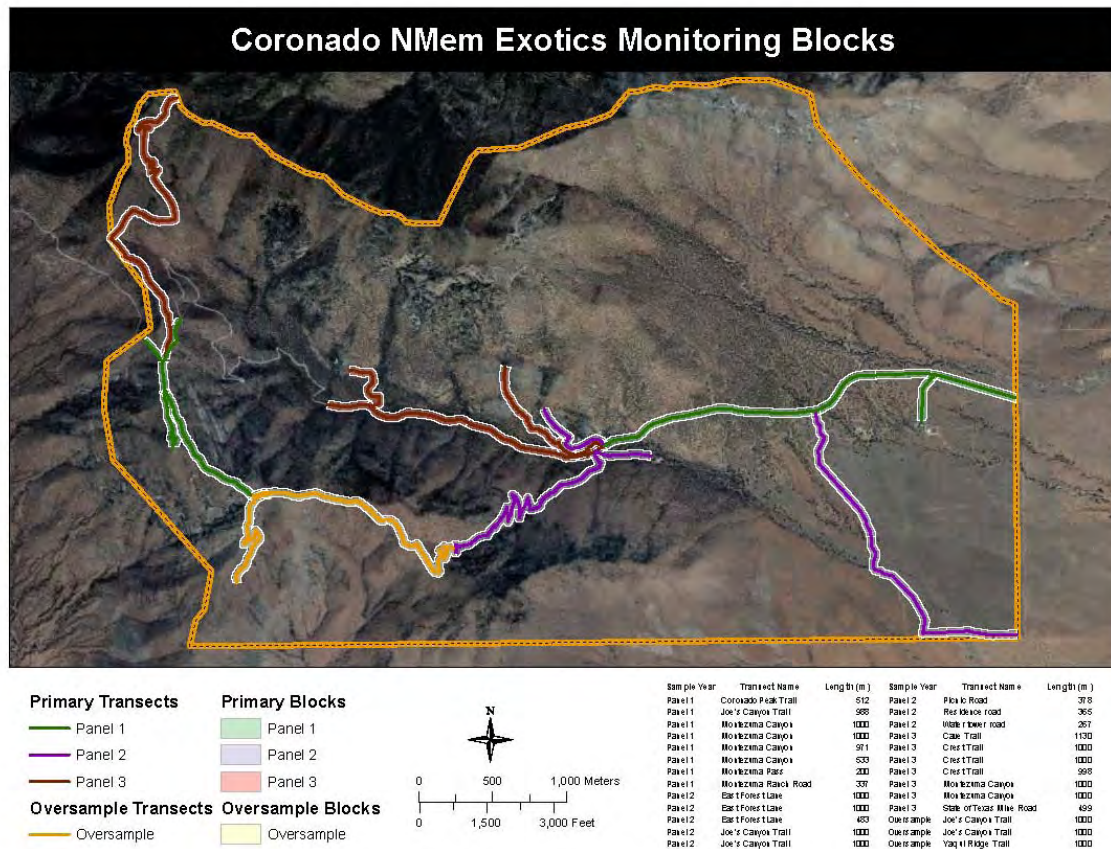


Figure B-8. Panel selection for CORO.

## B.8 Tumacacori NHP

Tumacacori National Historical Park (NHP) is located in the upper Santa Cruz River Valley of southern Arizona. The park comprises three units, each housing abandoned ruins of Spanish colonial missions. San José de Tumacacori and Los Santos Ángeles de Guevavi, established in 1691, are the two oldest missions in Arizona. The third unit, San Cayetano de Calabazas, was established in 1756. The park is approximately 146 ha (360 acres). Tumacacori, with 131.5 ha (325 acres), is the largest unit; Calabazas is 11 ha (28 acres) and Guevavi 2.83 ha (7 acres). Tumacacori is open to the public year-round and has a self-guided walking tour around the ruins. Guided tours to the other two units are provided once a month by reservation only. The Calabazas and Guevavi units are located 15 km and 23 km SSE of Tumacacori, respectively. This exotic protocol will be implemented at the main unit (Figure B-9).

The Tumacacori unit was recently expanded with the acquisition of more than 121 ha of land adjacent to the mission site. The Santa Cruz River runs through the length of the expansion lands and supports a rich riparian habitat of cottonwoods and willows. The Juan Bautista de Anza National Historic Trail winds through the Tumacacori unit, with access from several locations.

Both the river and the trail provide continuous opportunities for exotic plant introduction and spread. The park, or more specifically the De Anza trail that runs through the park, does allow for horseback riding and this too presents another potential source of exotic seed introduction through animal droppings or carried via the animals themselves. Tumacácori also has a considerable amount of illegal foot traffic with migrants and smugglers utilizing the cover and shade of the riparian forests to make passage into Arizona. Some horticultural plants seen growing at the park, such as tomato (*Solanum lycopersicum*), marijuana (*Cannabis sativa*) and common garden cucumber (*Cucumis sativus*) are thought to have been introduced either via the river from local homesteads or perhaps remnants of discarded foods from migrants.

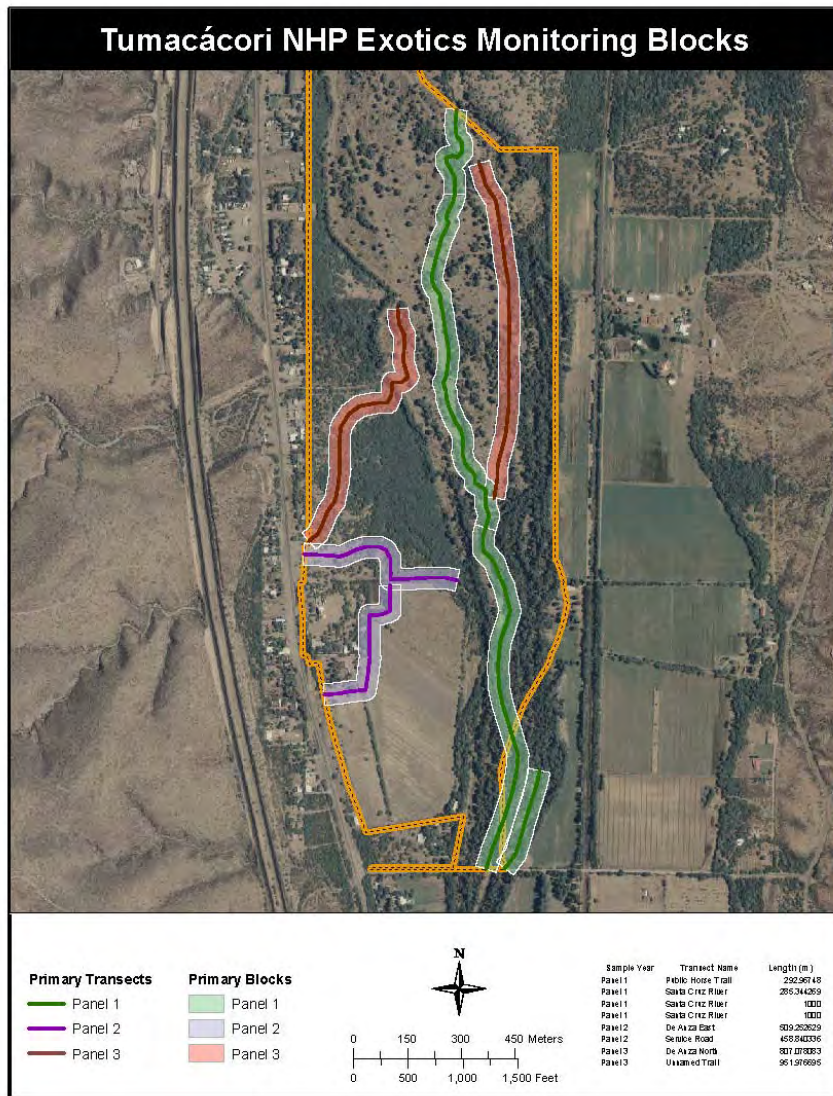


Figure B-9. Panel selection for TUMA.

The Santa Cruz River is a perennial, but effluent driven river, with regulated flow from the Nogales water treatment plant. However, during late summer Monsoon season, tributaries from the surrounding watersheds feed into the river and produce very high flows and scouring events. This serves to introduce, reintroduce and spread exotic species at the park.

Many exotic plant surveys have been completed at the park; most recently in 2006 a comprehensive inventory was completed by SODN. Fourteen 14 species were observed during

roaming surveys at Tumacácori NHP main unit. Of these same 14 species, only 5 were recorded at the Calabazas and Guevavi units (these two sites were affected by the same suite of five species). All of these species had been recorded previously at these units during either the 2003 biological inventory or during other projects (Powell et al. 2005). Of the 14 non-native species mapped, 5 are members of the grass family (*Poaceae*). Species recorded were: Palmer's amaranth (*Amaranthus palmeri*), stink grass (*Eragrostis cilianensis*), Lehmann lovegrass (*Eragrostis lehmanniana*), Russian thistle (*Salsola tragus*), Bermuda grass (*Cynodon dactylon*), tamarisk (*Tamarix chinensis*), Johnson grass (*Sorghum halepense*), horehound (*Marrubium vulgare*), poison hemlock (*Conium maculatum*), sowthistles (*Sonchus* spp.), tree of heaven (*Ailanthus altissima*), London rocket (*Sisymbrium irio*), cheese weed (*Malva parviflora*), and giant reed (*Arundo donax*). Since this inventory was completed the park has extensively treated the Tamarisk population with good success.

## **B.9 Saguaro National Park**

Saguaro National Park consists of two units: Rincon Mountain District (RMD) and Tucson Mountain District (TMD). The RMD is on the east side of Tucson, Arizona and the TMD is on the west side of Tucson. The park districts were formed to protect the forests of Saguaro cactus. Both units contain designated wilderness areas, totaling 57,930 acres (23,444 ha). The TMD ranges from an elevation of 664 -1428 m (2,180 - 4,687 ft.) and contains both desert shrublands and desert grassland communities. The RMD ranges from an elevation of 814 – 2641 m (2,670 - 8,666 ft.) and is considered a “sky-island” area. Vegetation communities here range from desert scrub and grassland, oak woodland, pine-oak woodland, to pine forest and mixed conifer forest at the highest elevations.

The two districts offer more than 165 miles (264 km) of hiking trails. The Tucson Mountain District is partially bounded by main roads on three sides and by increasing urban development on the fourth. Golden gate road (a maintained dirt road) runs through the middle of this district connecting the north and west sides of the park. There are multiple trailhead access points, picnic areas and nature trails along this interior road.

At Rincon Mountain District there is an 8 mile paved, scenic loop drive “cactus forest loop”, from which many trailheads begin. Hikers can obtain overnight camping permits and travel into the backcountry wilderness, reaching the highest point of Manning Cabin, a historical structure built in 1905. Pack animals and recreational equestrian use are allowed on many but not all trails at RMD.

Both districts have known exotic plants in varying numbers and distributions, however in recent years a single species, buffelgrass (*Pennisetum ciliare*), has increased in both distribution and density. This species is currently the park's main focus for mapping, eradication, education and restoration efforts. While the park has quite extensive knowledge about locations of buffelgrass at RMD, there is less information for the TMD. SODN has agreed to opportunistically record locations and abundances of this species while conducting all other monitoring efforts at this district.

Other species of concern at one or both districts are tamarisk (*Tamarix* spp), malta star thistle (*Centaurea melitensis*), Lehman's lovegrass (*Eragrostis lehmanniana*), Sahara mustard (*Brassica tournefortii*), fountain grass (*Pennisetum setaceum*), horehound (*Marrubium vulgare*), stinkgrass, weeping lovegrass, African lovegrass (*Eragrostis cilianensis*, *E. curvula*, *E. echinochloidea*), Bermuda grass (*Cynodon dactylon*), and red brome (*Bromus rubens*) just to name a few.

## B.10 Organ Pipe National Monument

Organ Pipe NM (ORPI) is located along the US/ Mexican border, almost directly south of Ajo, AZ and approximately 170 miles (274 km) southwest of Tucson, AZ. ORPI is the largest of all SODN units at 330,829 acres (133,882 ha), of which 95% are designated wilderness. The Monument was established in 1937 by Franklin D. Roosevelt, to preserve and protect a 'representative area of the Sonoran Desert' including the locally restricted habitat of the Organ Pipe Cactus (*Stenocereus thurberi*). The park boasts both natural and cultural resources, which reflect the long and diverse occupations by American Indian, Mexican and European groups. Both grazing and mining were allowed to continue on the monument up through the mid to late 1970's.

Elevation ranges from 509 m (1,670 ft) at the visitor center to 1466m (4,808 ft) at Mount Ajo peak. The entire southern border is the international boundary with Mexico. The western boundary is shared with the Tohono O'Odham Indian Reservation, while the western boundary and part of the northern boundary are shared with the Cabeza Prieta National Wildlife Refuge. Only one road traverses the length of the park, Hwy 85, which provides access to the park and for travellers going on to Puerto Penasco, Mexico. There is a 21 mile paved scenic loop drive on the east side of the park, providing views of the Ajo Mountains and valleys below and serving as access to two hiking trails in the Ajo range. Other paved and dirt roads and other trails have been closed to the public due to border related safety issues. Access to many of these areas necessitates an armed escort, and therefore will not be discussed here in any detail.

The areas open to researchers fluctuates somewhat as illegal activity corridors shift over time. This means that while some areas could be opened in the future, others currently open could be closed, therefore any exotic plant monitoring implemented would require flexibility in accommodating this. However, as part of other SODN monitoring protocols including washes, upland vegetation and soils, and seeps, springs and tinajas, exotic species are recorded both when encountered at a monitoring site and when encountered en route to sites. This information is typically recorded using a GPS unit and data is stored in a geodatabase at SODN and sent to park managers.

ORPI has had an extensive exotics monitoring and removal program for several years headed by their vegetation ecologist. Much of the historic field work was supplemented with volunteer staff however since illegal border activity has increased the efforts have been restricted to only some small areas of the park. Like many other SODN parks, ORPI has known populations of buffelgrass (*Pennisetum ciliare*). This species is extensively planted (and subsidized) in Mexico for forage, and so increased and ongoing infestations are likely. In addition to buffelgrass some of the other species known at ORPI include: Red brome (*Bromus rubens*), Sahara mustard (*Brassica tournefortii*), cheat grass (*Bromus tectorum*), Lehman's lovegrass and stinkgrass (*Eragrostis lehmanniana* and *E. cilianensis*), fountain grass (*Pennisetum setaceum*), Mediterranean grasses (*Schismus arabicus* and *S. barbatus*), and Tamarisk (*Tamarix ramosissima* and *T. aphylla*).

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| Family         | Scientific Name                                  | Common Names             | CAGR | CHIR | CORO | FOBO | GICL | MOCA | MOWE | ORPI | SAGE | SAGW | TONT | TUMA | TUZI |
|----------------|--------------------------------------------------|--------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Asteraceae     | <i>Acroptilon repens</i>                         | Russian knapweed         |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Poaceae        | <i>Agrostis gigantea</i>                         | redtop bentgrass         |      |      |      |      | •    |      |      |      | •    |      | •    |      |      |
| Simaroubaceae  | <i>Ailanthus altissima</i>                       | tree of heaven           |      |      | •    |      |      | •    | •    |      |      |      |      | •    | •    |
| Amaranthaceae  | <i>Amaranthus blitoides</i>                      | prostrate pigweed        |      | •    |      |      |      |      |      | •    | •    |      | •    |      | •    |
| Amaranthaceae  | <i>Amaranthus crassipes</i>                      | spreading amaranth       |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Primulaceae    | <i>Anagallis arvensis</i>                        | scarlet pimpernel        |      | •    |      |      |      |      |      | •    |      | •    |      |      | •    |
| Poaceae        | <i>Arundo donax</i>                              | giant reed               |      |      |      |      |      |      |      | •    |      | •    |      | •    |      |
| Liliaceae      | <i>Asparagus officinalis</i>                     | garden asparagus         |      | •    | •    |      |      |      |      |      |      |      |      |      |      |
| Poaceae        | <i>Avena fatua</i>                               | wild oats                | •    |      |      | •    |      | •    | •    | •    | •    | •    | •    | •    | •    |
| Poaceae        | <i>Avena sativa</i>                              | common oat               |      |      |      |      |      | •    |      |      | •    |      |      |      |      |
| Brassicaceae   | <i>Barbarea vulgaris</i>                         | yellow rocket            |      |      |      |      | •    |      |      |      |      |      |      |      |      |
| Chenopodiaceae | <i>Bassia hyssopifolia</i>                       | fivehook bassia          |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Asteraceae     | <i>Bidens pilosa</i>                             | beggar's ticks           |      |      |      |      | •    |      |      |      |      |      |      |      |      |
| Poaceae        | <i>Bothriochloa ischaemum</i>                    | Turkestan beardgrass     |      |      |      |      |      |      |      |      | •    | •    |      |      |      |
| Brassicaceae   | <i>Brassica nigra</i>                            | black mustard            |      |      |      |      |      |      |      | •    | •    | •    |      |      |      |
| Brassicaceae   | <i>Brassica rapa</i>                             | birdrape                 |      | •    |      |      |      |      |      |      |      | •    |      |      |      |
| Brassicaceae   | <i>Brassica tournefortii</i>                     | African mustard          | •    |      | •    |      |      | •    | •    | •    | •    | •    | •    |      |      |
| Poaceae        | <i>Bromus berterianus</i>                        |                          |      |      |      |      |      |      |      |      |      |      | •    |      |      |
| Poaceae        | <i>Bromus arvensis</i>                           | field brome              |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Poaceae        | <i>Bromus catharticus</i>                        | rescue brome             |      | •    | •    |      |      | •    | •    | •    | •    |      |      | •    | •    |
| Poaceae        | <i>Bromus diandrus</i>                           | ripgut brome             |      |      |      |      |      | •    | •    |      |      | •    | •    |      | •    |
| Poaceae        | <i>Bromus hordeaceus</i>                         | soft brome               |      | •    |      |      | •    |      |      |      |      |      |      |      |      |
| Poaceae        | <i>Bromus japonicus</i>                          | Japanese brome           |      |      |      |      | •    | •    |      |      |      |      |      |      |      |
| Poaceae        | <i>Bromus madritensis</i>                        | compact brome            |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Poaceae        | <i>Bromus rubens</i>                             | red brome                | •    |      |      | •    | •    | •    | •    | •    | •    | •    | •    |      | •    |
| Poaceae        | <i>Bromus tectorum</i>                           | cheatgrass               |      |      |      | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    |
| Fabaceae       | <i>Caesalpinia gilliesii</i>                     | Mexican bird of paradise |      |      | •    |      |      |      |      |      |      | •    |      |      |      |
| Fabaceae       | <i>Canavalia ensiformis</i>                      | wonderbean               | •    |      |      | •    |      | •    |      |      |      |      | •    |      |      |
| Brassicaceae   | <i>Capsella bursa-pastoris</i>                   | shepherd's purse         |      | •    |      |      | •    | •    | •    |      | •    | •    | •    | •    | •    |
| Solanaceae     | <i>Capsicum annuum</i> var. <i>glabriusculum</i> | chilipequin              |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Cyperaceae     | <i>Carex bonplandii</i>                          | Bonpland's sedge         |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Asteraceae     | <i>Carphochaete bigelovii</i>                    | Bigelow's bristlehead    |      | •    | •    | •    |      |      |      |      | •    |      |      |      |      |
| Asteraceae     | <i>Carthamus tinctoris</i>                       | safflower                |      |      |      |      |      |      |      | •    |      | •    |      |      |      |
| Poaceae        | <i>Cenchrus ciliaris</i>                         | buffelgrass              | •    |      |      |      | •    |      |      | •    | •    | •    |      |      |      |
| Poaceae        | <i>Cenchrus setaceus</i>                         |                          |      |      |      |      |      |      |      | •    | •    | •    | •    |      |      |
| Asteraceae     | <i>Centaurea melitensis</i>                      | Malta starthistle        | •    | •    |      |      |      | •    | •    | •    | •    | •    | •    |      | •    |

| Family          | Scientific Name                  | Common Names             | CAGR | CHIR | CORO | FOBO | GICL | MOCA | MOWE | ORPI | SAGE | SAGW | TONT | TUMA | TUZI |
|-----------------|----------------------------------|--------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Asteraceae      | <i>Centaurea solstitialis</i>    | yellow starthistle       |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Caryophyllaceae | <i>Cerastium fontanum</i>        | big chickweed            |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Caryophyllaceae | <i>Cerastium gracile</i>         | slender chickweed        |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Chenopodiaceae  | <i>Chenopodium glaucum</i>       | oakleaf goosefoot        |      |      |      |      | •    |      |      |      |      |      |      |      |      |
| Chenopodiaceae  | <i>Chenopodium murale</i>        | nettleleaf goosefoot     | •    |      |      | •    |      |      |      | •    | •    | •    |      |      |      |
| Brassicaceae    | <i>Chorispora tenella</i>        | blue mustard             |      |      |      |      |      | •    |      |      |      |      |      |      | •    |
| Asteraceae      | <i>Cichorium intybus</i>         | chicory                  |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Cleomaceae      | <i>Cleome viscosa</i>            | Asian spiderflower       |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Apiaceae        | <i>Conium maculatum</i>          | poison hemlock           |      |      |      |      | •    |      |      |      |      |      |      | •    |      |
| Convolvulaceae  | <i>Convolvulus arvensis</i>      | field bindweed           |      | •    |      | •    |      | •    | •    |      | •    | •    | •    | •    | •    |
| Poaceae         | <i>Cortaderia selloana</i>       | pampas grass             |      |      |      |      |      |      |      |      | •    | •    |      |      |      |
| Apiaceae        | <i>Cyclospermum leptophyllum</i> | marsh parsley            |      |      |      |      |      |      |      | •    |      | •    |      | •    |      |
| Poaceae         | <i>Cynodon dactylon</i>          | Bermudagrass             | •    | •    | •    | •    |      | •    | •    | •    | •    | •    | •    | •    | •    |
| Cyperaceae      | <i>Cyperus rotundus</i>          | purple nutsedge          |      |      |      |      |      |      |      |      |      | •    |      |      |      |
| Poaceae         | <i>Dactyloctenium aegyptium</i>  | crowfoot grass           |      |      |      |      |      |      |      | •    | •    |      |      | •    |      |
| Solanaceae      | <i>Datura inoxia</i>             | prickly datura           |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Solanaceae      | <i>Datura stramonium</i>         | jimsonweed               |      |      | •    |      |      |      |      |      |      |      |      |      |      |
| Brassicaceae    | <i>Descurainia sophia</i>        | herb sophia              | •    | •    | •    | •    | •    |      | •    |      | •    | •    |      | •    | •    |
| Asteraceae      | <i>Dimorphotheca sinuata</i>     | glandular Cape marigold  | •    |      |      |      |      |      |      |      | •    | •    |      |      |      |
| Poaceae         | <i>Echinochloa colona</i>        | jungle ricegrass         |      | •    | •    | •    |      |      |      | •    | •    | •    |      | •    |      |
| Poaceae         | <i>Echinochloa crus-galli</i>    | barnyardgrass            |      | •    |      | •    | •    | •    | •    | •    | •    |      |      | •    | •    |
| Elaeagnaceae    | <i>Elaeagnus angustifolia</i>    | Russian olive            |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Poaceae         | <i>Enneapogon mollis</i>         | soft feather pappusgrass |      |      |      |      |      |      |      | •    |      | •    |      |      |      |
| Poaceae         | <i>Eragrostis barrelieri</i>     | Mediterranean lovegrass  |      |      |      |      |      |      |      |      |      | •    |      | •    |      |
| Poaceae         | <i>Eragrostis cilianensis</i>    | stinkgrass               |      | •    | •    | •    |      | •    | •    | •    | •    | •    | •    | •    | •    |
| Poaceae         | <i>Eragrostis curvula</i>        | weeping lovegrass        |      | •    | •    | •    | •    | •    | •    |      | •    | •    | •    | •    |      |
| Poaceae         | <i>Eragrostis echincholeidea</i> | African lovegrass        |      |      |      |      |      |      |      |      | •    | •    |      |      |      |
| Poaceae         | <i>Eragrostis lehmanniana</i>    | Lehmann's lovegrass      | •    | •    | •    | •    |      | •    | •    | •    | •    | •    | •    | •    | •    |
| Poaceae         | <i>Eragrostis superba</i>        | Wilman lovegrass         |      |      | •    |      |      |      |      |      |      |      |      |      |      |
| Geraniaceae     | <i>Erodium cicutarium</i>        | redstem storksbill       | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    |
| Brassicaceae    | <i>Eruca vesicaria</i>           | rocketsalad              |      |      |      |      |      |      |      | •    |      | •    |      |      |      |
| Brassicaceae    | <i>Erysimum repandum</i>         | bushy wallflower         |      |      |      |      |      |      |      |      |      |      |      | •    |      |
| Euphorbiaceae   | <i>Euphorbia esula</i>           | leafy spurge             |      |      |      |      | •    |      |      |      |      |      |      |      |      |
| Moraceae        | <i>Ficus carica</i>              | common fig               |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Asteraceae      | <i>Galinsoga parviflora</i>      | gallant soldier          |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Caryophyllaceae | <i>Herniaria hirsuta</i>         | hairy rupturewort        |      |      |      |      |      |      |      | •    | •    | •    | •    |      |      |

| Family           | Scientific Name                      | Common Names              | CAGR | CHIR | CORO | FOBO | GICL | MOCA | MOWE | ORPI | SAGE | SAGW | TONT | TUMA | TUZI |
|------------------|--------------------------------------|---------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Poaceae          | <i>Hordeum marinum</i>               | seaside barley            |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Poaceae          | <i>Hordeum murinum</i>               | mouse barley              | •    | •    | •    | •    |      | •    | •    | •    | •    | •    | •    | •    | •    |
| Poaceae          | <i>Hordeum vulgare</i>               | cereal barley             | •    |      |      |      |      |      |      |      | •    |      | •    | •    |      |
| Convolvulaceae   | <i>Ipomoea coccinea</i>              | Mexican morningglory      |      | •    | •    | •    | •    |      |      | •    | •    |      | •    | •    | •    |
| Convolvulaceae   | <i>Ipomoea hederacea</i>             | ivy leaf morningglory     |      | •    | •    | •    |      | •    | •    | •    | •    | •    |      | •    |      |
| Convolvulaceae   | <i>Ipomoea purpurea</i>              | common morningglory       |      | •    | •    | •    | •    |      |      |      | •    |      |      | •    |      |
| Euphorbiaceae    | <i>Jatropha spathula</i>             |                           |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Chenopodiaceae   | <i>Kochia scoparia</i>               | kochia                    |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Asteraceae       | <i>Lactuca saligna</i>               | willow leaf lettuce       |      |      |      |      |      | •    | •    |      |      |      |      |      |      |
| Asteraceae       | <i>Lactuca serriola</i>              | prickly lettuce           | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    | •    |
| Poaceae          | <i>Lamarckia aurea</i>               | goldentop grass           |      |      |      |      |      |      |      |      | •    | •    | •    |      |      |
| Lamiaceae        | <i>Lamium amplexicaule</i>           | henbit                    |      |      |      | •    |      | •    | •    |      |      | •    |      | •    | •    |
| Scrophulariaceae | <i>Linaria dalmatica</i>             | Dalmatian toadflax        |      |      |      | •    |      | •    |      |      |      |      |      |      |      |
| Linaceae         | <i>Linum usitatissimum</i>           | cultivated flax           |      |      |      | •    |      |      |      | •    |      |      |      |      |      |
| Poaceae          | <i>Lolium perenne</i>                | perennial ryegrass        |      |      | •    |      |      | •    |      |      |      |      |      |      |      |
| Caprifoliaceae   | <i>Lonicera japonica</i>             | Japanese honeysuckle      |      | •    |      |      |      |      |      |      |      |      |      |      |      |
| Fabaceae         | <i>Lotus corniculatus</i>            | birdfoot deervetch        |      |      |      |      |      | •    | •    |      |      |      |      |      |      |
| Fabaceae         | <i>Macroptilium gibbosifolium</i>    | variable leaf bushbean    |      | •    | •    | •    | •    |      |      |      | •    |      |      |      |      |
| Rosaceae         | <i>Malus pumila</i>                  | paradise apple            |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Malvaceae        | <i>Malva neglecta</i>                | round leaf mallow         |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Malvaceae        | <i>Malva parviflora</i>              | small-whorl mallow        | •    |      | •    |      |      |      |      | •    | •    | •    | •    | •    |      |
| Lamiaceae        | <i>Marrubium vulgare</i>             | horehound                 |      | •    |      | •    | •    | •    | •    |      | •    |      | •    | •    | •    |
| Asteraceae       | <i>Matricaria discoidea</i>          | pineapple weed            | •    |      |      |      |      |      |      |      |      | •    |      |      |      |
| Brassicaceae     | <i>Matthiola longipetala</i>         | night-scented stock       |      |      |      |      |      | •    |      | •    | •    |      |      |      | •    |
| Fabaceae         | <i>Medicago lupulina</i>             | black medic clover        |      |      | •    |      | •    |      |      |      |      |      |      |      | •    |
| Fabaceae         | <i>Medicago minima</i>               | little burclover          |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Fabaceae         | <i>Medicago polymorpha</i>           | California burclover      | •    |      |      |      |      | •    | •    | •    |      | •    | •    | •    | •    |
| Fabaceae         | <i>Medicago sativa</i>               | alfalfa                   |      | •    |      |      |      | •    | •    |      |      | •    |      |      | •    |
| Asteraceae       | <i>Melampodium sericeum</i>          | rough blackfoot           |      |      |      |      | •    |      |      |      |      |      |      |      |      |
| Fabaceae         | <i>Melilotus alba</i>                | white sweetclover         |      |      |      |      | •    | •    |      |      |      |      |      |      | •    |
| Fabaceae         | <i>Melilotus indicus</i>             | annual yellow sweetclover | •    |      | •    |      | •    | •    | •    | •    |      | •    | •    | •    | •    |
| Fabaceae         | <i>Melilotus officinalis</i>         | yellow sweetclover        |      | •    |      |      | •    | •    | •    |      | •    |      |      | •    | •    |
| Poaceae          | <i>Melinis repens</i>                | rose Natal grass          |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Lamiaceae        | <i>Mentha spicata</i>                | spearmint                 |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Aizoaceae        | <i>Mesembryanthemum crystallinum</i> | common iceplant           |      |      |      |      |      |      |      | •    |      |      |      |      |      |

| Family         | Scientific Name                    | Common Names                | CAGR | CHIR | CORO | FOBO | GICL | MOCA | MOWE | ORPI | SAGE | SAGW | TONT | TUMA | TUZI |
|----------------|------------------------------------|-----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Aizoaceae      | <i>Mesembryanthemum nodiflorum</i> | slenderleaf iceplant        |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Poaceae        | <i>Mnesithea granularis</i>        | pitscale grass              |      | •    | •    |      |      |      |      |      |      |      |      |      |      |
| Molluginaceae  | <i>Mollugo cerviana</i>            | threadstem carpetweed       |      |      |      |      |      |      |      | •    | •    | •    |      |      |      |
| Moraceae       | <i>Morus alba</i>                  | white mulberry              |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Haloragaceae   | <i>Myriophyllum spicatum</i>       | Eurasian water-milfoil      |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Lamiaceae      | <i>Nepeta cataria</i>              | catnip                      |      | •    |      |      |      |      |      |      |      |      |      |      |      |
| Solanaceae     | <i>Nicotiana glauca</i>            | tree tobacco                | •    |      |      |      |      |      |      | •    |      | •    | •    | •    |      |
| Asteraceae     | <i>Oncosiphon piluliferum</i>      | stinknet                    |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Cactaceae      | <i>Opuntia ficus-indica</i>        | Indian fig                  |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Poaceae        | <i>Panicum antidotale</i>          | blue panicgrass             |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Poaceae        | <i>Panicum miliaceum</i>           | proso millet                |      | •    |      |      |      |      |      |      |      | •    |      |      |      |
| Papaveraceae   | <i>Papaver rhoeas</i>              | corn poppy                  |      |      |      |      |      |      |      |      |      | •    |      | •    |      |
| Poaceae        | <i>Paspalum dilatatum</i>          | dallis grass                |      |      |      |      |      | •    | •    |      | •    |      |      | •    |      |
| Polygonaceae   | <i>Persicaria maculosa</i>         |                             |      |      |      |      | •    |      |      |      | •    |      |      |      |      |
| Poaceae        | <i>Phalaris aquatica</i>           | bulbous canarygrass         |      |      |      |      |      |      |      |      |      |      |      |      | •    |
| Poaceae        | <i>Phalaris canariensis</i>        | annual canarygrass          |      |      |      |      |      |      |      |      |      |      | •    |      |      |
| Poaceae        | <i>Phalaris minor</i>              | littleseed canarygrass      | •    |      |      |      |      |      |      | •    | •    | •    | •    |      |      |
| Poaceae        | <i>Phalaris para</i>               |                             |      |      |      |      |      |      |      |      |      |      | •    |      |      |
| Poaceae        | <i>Phleum pratense</i>             | common timothy              |      |      |      |      |      |      |      |      | •    |      |      |      |      |
| Pinaceae       | <i>Pinus pinea</i>                 | Italian stone pine          |      |      | •    |      |      |      |      |      |      |      |      |      |      |
| Plantaginaceae | <i>Plantago lanceolata</i>         | buckhorn plantain           |      |      |      |      |      | •    | •    |      |      |      |      |      | •    |
| Poaceae        | <i>Poa annua</i>                   | annual bluegrass            |      |      |      | •    |      |      |      | •    | •    |      |      |      |      |
| Polygonaceae   | <i>Polygonum argyrocoleon</i>      | silver sheath knotweed      | •    |      |      |      |      |      |      | •    |      |      |      | •    |      |
| Polygonaceae   | <i>Polygonum aviculare</i>         | yard knotweed               | •    | •    | •    |      |      | •    | •    |      | •    |      |      |      | •    |
| Polygonaceae   | <i>Polygonum convolvulus</i>       | climbing buckwheat          |      |      |      | •    | •    |      |      |      |      |      |      |      |      |
| Poaceae        | <i>Polypogon monspeliensis</i>     | annual rabbitsfoot grass    |      | •    | •    |      |      | •    | •    | •    | •    | •    | •    | •    | •    |
| Poaceae        | <i>Polypogon viridis</i>           | beardless rabbitsfoot grass |      | •    |      | •    |      | •    | •    | •    | •    |      |      |      |      |
| Portulacaceae  | <i>Portulaca oleracea</i>          | common purslane             |      | •    | •    | •    | •    | •    |      | •    | •    | •    |      | •    |      |
| Lythraceae     | <i>Punica granatum</i>             | pomegranate                 |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Rosaceae       | <i>Pyracantha koizumii</i>         | Formosa firethorn           |      |      | •    |      |      |      |      |      |      |      |      |      |      |
| Brassicaceae   | <i>Rorippa microphyllum</i>        | onerow yellowcress          |      |      |      |      |      |      |      | •    |      |      |      |      |      |
| Rosaceae       | <i>Rubus rigidus</i>               |                             |      |      |      |      |      | •    | •    |      |      |      |      |      |      |
| Polygonaceae   | <i>Rumex acetosella</i>            | common sheep sorrel         |      |      |      |      | •    |      |      |      | •    |      |      |      |      |
| Polygonaceae   | <i>Rumex crispus</i>               | curley dock                 |      | •    |      | •    | •    | •    | •    |      | •    |      |      | •    | •    |
| Chenopodiaceae | <i>Salsola kali</i>                | prickly Russian thistle     |      | •    | •    | •    |      |      |      |      | •    | •    | •    | •    | •    |
| Chenopodiaceae | <i>Salsola tragus</i>              | prickly Russian thistle     | •    |      | •    | •    |      | •    | •    | •    | •    | •    |      |      | •    |

[illegible]

## APPENDIX C

### Overview of Exotics and Monitoring at CHDN Parks

The Chihuahuan Desert Inventory and Monitoring Network (CHDN) is composed of seven National Park Service (NPS) units in New Mexico and Texas: Amistad National Recreation Area (AMIS), Big Bend National Park (BIBE), Carlsbad Caverns National Park (CAVE), Fort Davis National Historic Site (FODA), Guadalupe Mountains National Park (GUMO), Rio Grande Wild and Scenic River (RIGR), and White Sands National Monument (WNSA)(Figure C-1). The parks vary in size from almost 200 ha (500 ac) at FODA to over 300,000 ha (800,000 ac) at BIBE. Six of the seven CHDN park units are located in the Northern Chihuahuan Subregion of the Chihuahuan Desert Ecoregion. AMIS is situated primarily within the Tamaulipan Thornscrub (Mezquital) Ecoregion of southern Texas and northeastern Mexico.

In the CHDN, non-native invasive plants pose one of the greatest threats to natural resources of our parks and have been identified as a high-priority vital sign. Highway and park road margins and banks along water courses are common conduits for dispersal by invasive non-native plants in the CHDN. Hydrological function and high-value indigenous biodiversity in riparian areas are threatened by woody invaders such as saltcedar (*Tamarix* spp.). Other non-native species that are impacting riparian areas include Russian olive (*Elaeagnus angustifolia*) and giant reed (*Arundo donax*). Exotic grass species such as buffelgrass (*Cenchrus ciliaris*), and Lehmann lovegrass (*Eragrostis lehmanniana*) are impacting endangered cactus by altering fire regimes.

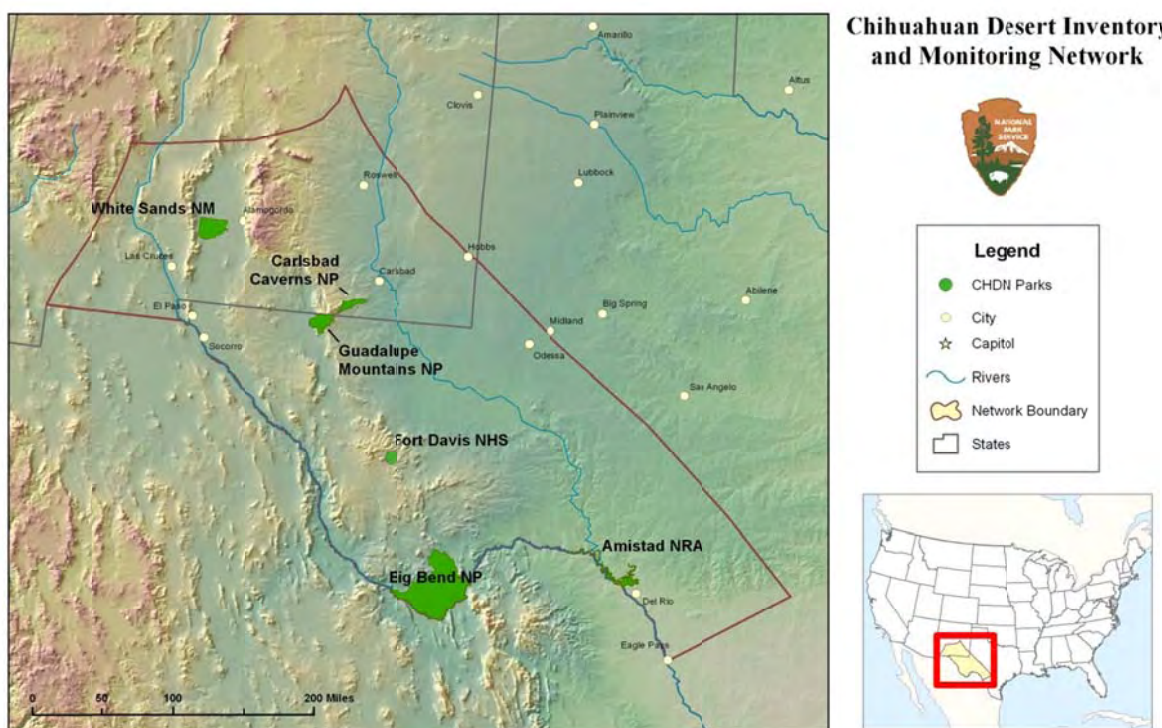


Figure C-1. Park locations within the Chihuahuan Desert I&M Network.

The Chihuahuan Desert Network intends to implement this protocol on a park by park basis, focusing efforts on areas that are high risk vectors and are potentially good habitat for exotics. For each park,

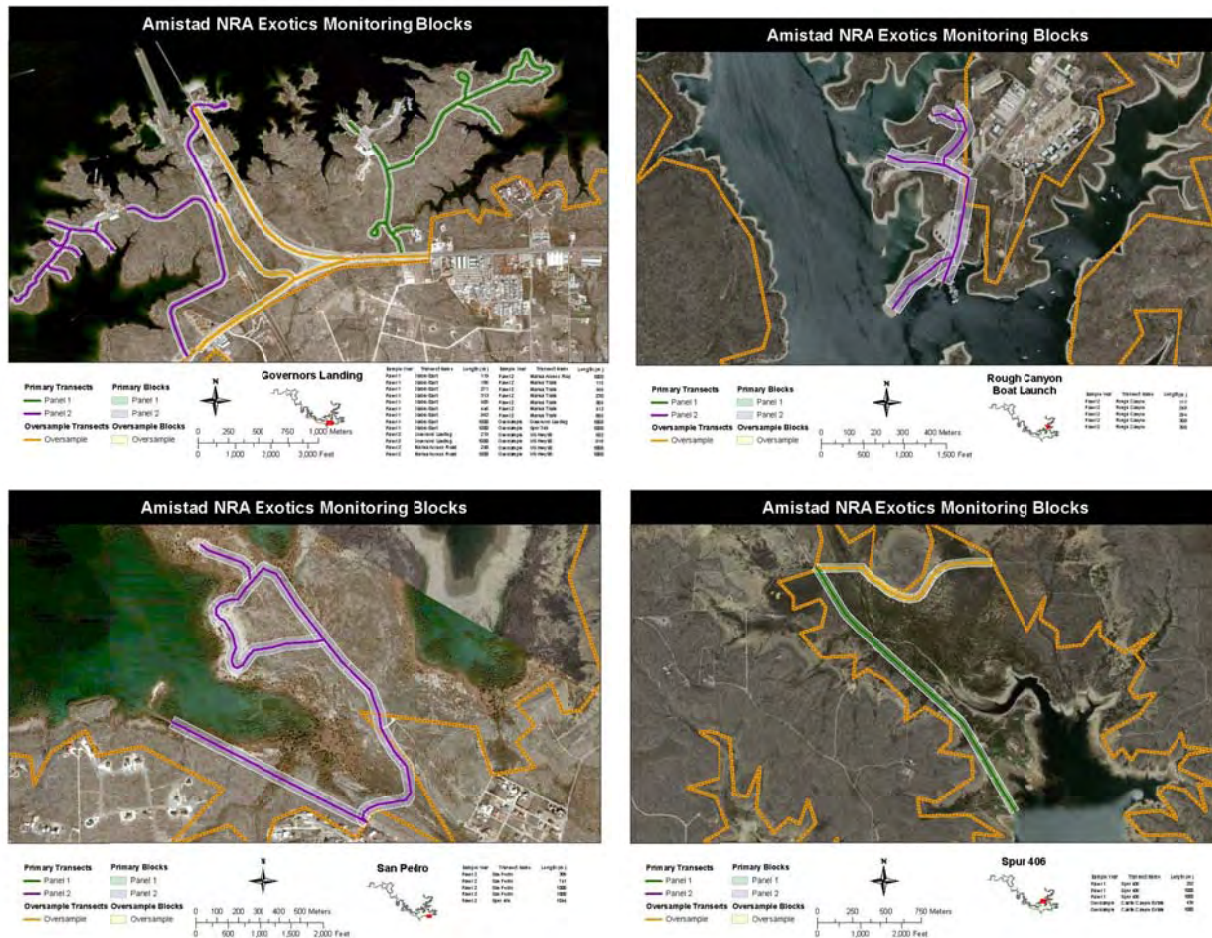
panels will be determined using knowledge of what exotic plants already exist in each area, ongoing park treatments (if applicable), and priority areas of management concern. The field effort will be tailored to enable the most ground to be covered each year at all parks monitored. High risk vectors that are known to have high densities of exotic plants may be excluded from this effort due to low probability of new species entering these systems and to the low level of new information that would be gained. Seasonality of the surveys will be adapted to best capture the exotic flora's phenological window and to nest within CHDN's other monitoring schedules. No exotic monitoring will take place at WHSA at the parks request. Yearly monitoring of all vectors of concern will take place at GUMO and CAVE. All other parks will be monitored under a two-year rotation.

### **C.1 Amistad National Recreation Area**

Amistad National Recreation Area (AMIS) is located along the Rio Grande in southwest Texas, and encompasses 23,195 ha (57,292 ac) of land. Mexico borders the park on the south and shares administration of the lake with the park. When the reservoir water level is at its conservation elevation of 340 m (1117 ft), then there is 7,211 ha (17,820 ac) of land in this unit. AMIS includes more than 864 km (540 miles) of park boundary on the US side, and extends 118 km (74 miles) along the Rio Grande, 22 km (14 miles) up the Pecos River, and 38 km (24 miles) up the Devils River. AMIS was established as part of a cooperative effort with Mexico to develop a combination of recreation, flood control, water storage, and power generation facilities (Figure C-2).

The vegetation at AMIS, subjected to fluctuating lake levels, has been drastically changed. Many recently emergent sites are vegetated by a combination of non-native and primary successional native species. The substrate and soil have been highly altered, with soils washed away. Past land-use history, including fire suppression, cattle grazing, bulldozing, root-plowing, chaining, and hand-clearing of woody, native vegetation, has altered the vegetation. Some soils may have been plowed and seeded with non-native grasses such as King Ranch bluestem (*Bothriochloa ischaemum* var. *songarica*), Bermuda grass (*Cynodon dactylon*), and buffelgrass (*Pennisetum ciliaris*; Poole 2004). AMIS is not fenced along its boundary and the vegetation community is increasingly degraded by free-ranging livestock.

NPSpecies shows a total of 702 vascular plant taxa present or previously confirmed in the park. Forty-eight non-native species are documented. Additionally, a CHDN initiated vascular plant inventory at AMIS resulted in 13 non-native plant species identified as potentially occurring (Poole 2004). Species on the Texas Noxious Weeds list include: giant cane (*Arundo donax*), field bindweed (*Convolvulus arvensis*), hydrilla (*Hydrilla verticillata*), and saltcedar (*Tamarix* spp.).



Figures C-2. Panel selection for AMIS.

## C.2 Big Bend National Park and Rio Grande Wild and Scenic River

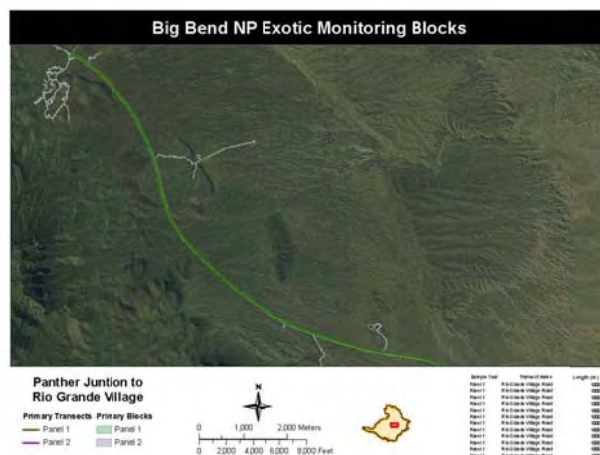
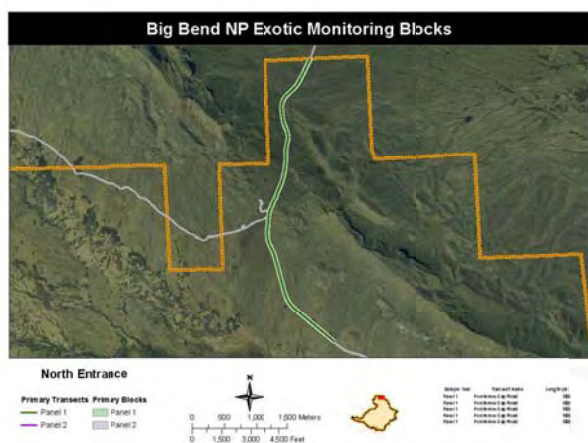
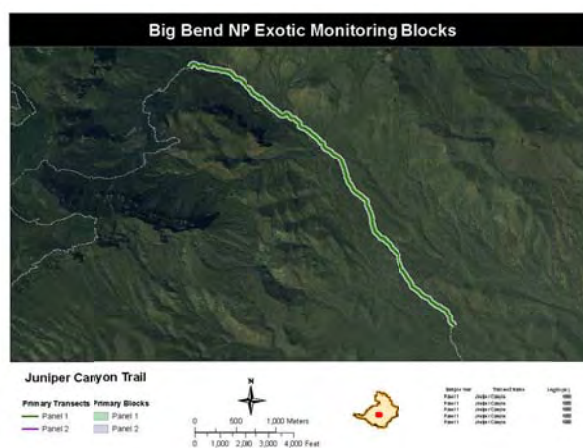
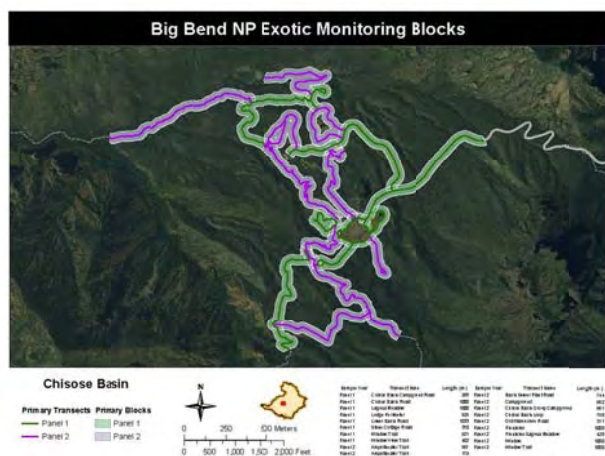
Big Bend National Park (BIBE) is located along the U.S. border within the bend of the Rio Grande in southwestern Texas. BIBE shares much of its boundary with Mexico (Figure C-3). In the United States much of the adjacent land is private with some state lands. Neighbors to the park, either adjacent or in close proximity, include Big Bend Ranch State Park, Black Gap State Wildlife Management Area, State of Texas General Land Office, and the Nature Conservancy. Park elevations range from 548 m (1,800 ft) at the Rio Grande to 2,377 m (7,800 ft) atop Emory Peak in the Chisos Mountains. Overall change in elevation is approximately 1,829 m (6,000 ft).

The Rio Grande Wild & Scenic River (RIGR) is managed as a unit of the national park system by BIBE. RIGR includes 196 miles of river from Mariscal Canyon to the Terrell-Val Verde county line. Vegetation along the Rio Grande is dominated by saltcedar (*Tamarix* sp.), mesquite (*Prosopis* spp.), cottonwood (*Populus deltoides*), willow (*Salix* spp.), tree tobacco (*Nicotiana glauca*), Bermuda grass (*Cynodon dactylon*), and giant reed (*Arundo donax*; Young et al. 2007).

Formerly extensive desert grasslands and shrub lands that protected soils, retained moisture, and supported diverse plant and animal communities were damaged by pre-park agricultural practices. Thin,

fragile soils began eroding when grazing, plowing, development, and hydrologic alteration for water catchments reduced vegetative cover. Irreparable loss of fragile topsoil and the slow rate of soil development have resulted in continued degradation despite current land protection policies within park boundaries. Reduced soil cover diminishes organic soil structure and moisture retention. Consequently, when intensive thunderstorms increase runoff, back-cutting and downstream erosion are escalated. Increased erosion, in turn, further threatens surviving grass and shrublands. Vegetative reproduction becomes compromised or limited by more disturbance-tolerant, invasive, and exotic species. Resource managers also acknowledge a major challenge in managing vegetation at the park is invasion of fire-adapted nonnative plant species which threaten to displace native species primarily along the riparian corridor and drainages (BIBE 2005).

NPSpecies lists 86 non-native plant species present in BIBE and RIGR. Non-native plants that prove the greatest threat include saltcedar (*Tamarix* sp.), buffelgrass (*Pennisetum ciliare*), Bermuda grass (*Cynodon dactylon*), Lehmann's lovegrass (*Eragrostis lehmanniana*), Johnson grass (*Sorghum halepense*) and giant reed (*Arundo donax*; Young et al. 2007). Saltcedar and giant reed are the only species located in BIBE listed on the Texas Noxious Weed list.



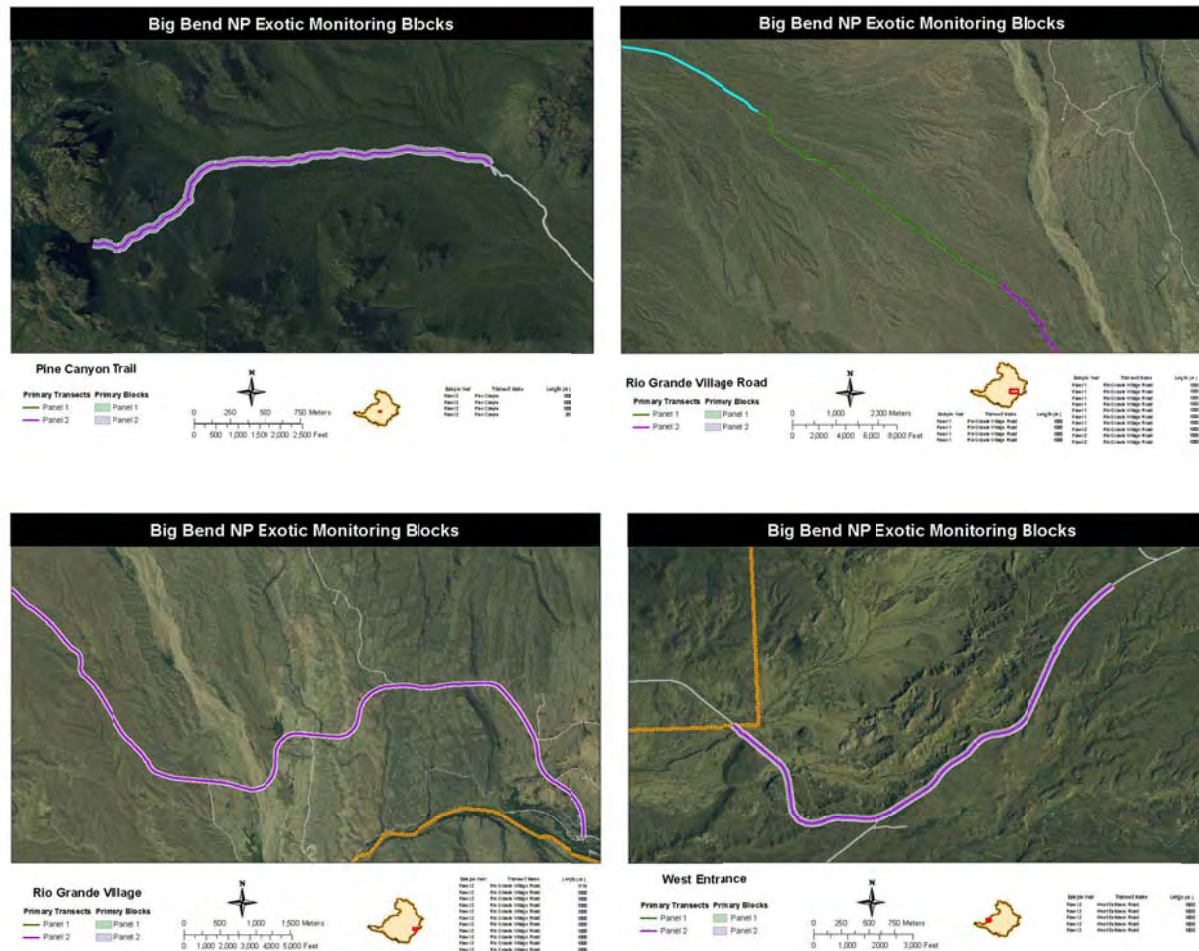


Figure C-3. Panel selection for BIBE.

### C.3 Carlsbad Caverns National Park

Carlsbad Caverns National Park (CAVE) is located in southeastern New Mexico and shares boundaries with private land and public lands managed by the US Forest Service (Lincoln National Forest), Bureau of Land Management, and the New Mexico State Lands Office. Land use surrounding the park is a mix of cattle ranching, oil and gas development, and irrigated agriculture. The elevation in the park ranges from 1,096 m (3,595 ft) in the desert lowlands to 1,987 m (6,520 ft) atop the Capitan Reef. The total relief is 891 m (2,925 ft).

In 1978, Congress designated 71% of the park's surface area as Wilderness. Riparian communities at Rattlesnake Springs and adjacent non-park lands are magnified in importance due to the rarity of similar habitat in the region and the diversity of plant and animal life found there (Figure C-4).

CAVE lies in the northern reaches of the Chihuahuan Desert ecosystem, where desert-scrub and grassland plant communities dominate. Small pockets of coniferous woodland are found at higher elevations in the western third of the park.

NPSpecies lists 58 plant species that are non-native. Species posing a significant/major/widespread problem in the park include tree of heaven (*Ailanthus altissima*), Johnson grass (*Sorghum halepense*) and Lehmann's lovegrass (*Eragrostis lehmanniana*; CAVE 2006). Non-native plants, especially Russian olive (*Elaeagnus angustifolia*) and Johnsongrass (*Sorghum halepense*), are now major components of the vegetation at Rattlesnake Springs. These species may suppress the cottonwood-willow riparian woodlands and native grasses that occur there. Other non-native plants that have potential to spread in disturbed areas include Malta starthistle (*Centaurea melitensis*), common horehound (*Marrubium vulgare*), and tree-of-heaven (*Ailanthus altissima*). Species on the New Mexico Noxious Weed list include: tree of heaven (*Ailanthus altissima*), Malta starthistle (*Centaurea melitensis*), yellow starthistle (*C. solstitialis*), Russian olive (*Elaeagnus angustifolia*), scotch thistle (*Onopordum acanthium*), African Rue (*Peganum harmala*), saltcedar (*Tamarix* spp.), and Siberian elm (*Ulmus pumila*).

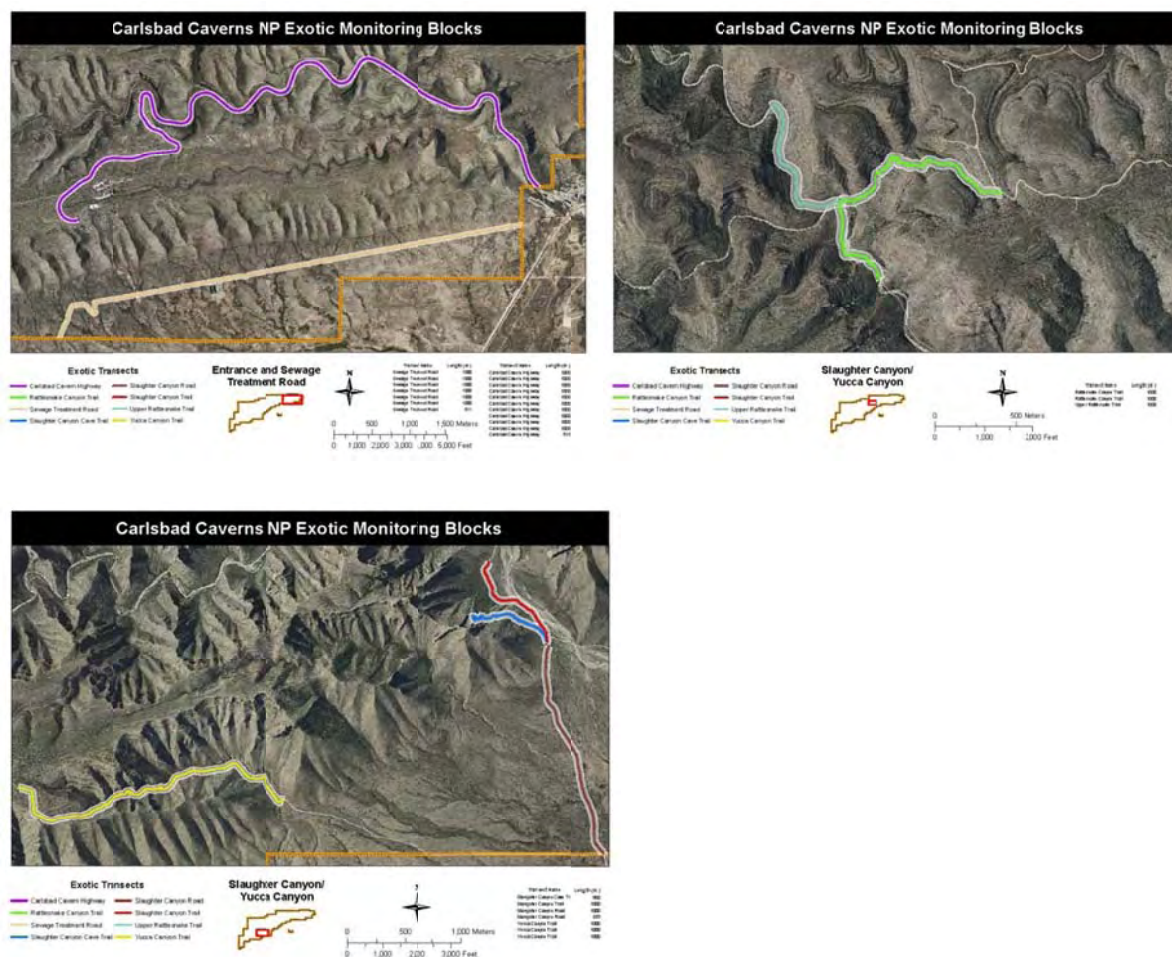


Figure C-4. Vector selection for CAVE. All vectors will be monitored every year.

#### C.4 Fort Davis National Historic Site

Fort Davis National Historic Site (NHS) is located at the southeast edge of the Davis Mountains in the Trans-Pecos region of West Texas. The site is bordered to the northwest by Davis Mountain State Park and by private land on the other sides. The Nature Conservancy is a neighbor in close proximity, as is the McDonald Observatory and the Chihuahuan Desert Research Institute. The elevation at Fort Davis NHS

ranges from approximately 1,487 m (4,880 ft) at the fort to approximately 1,591 m (5,220 ft) in the Davis Mountains. Overall change in elevation is approximately 104 m (340 ft). The park preserves 110 historic buildings, ruins, and foundations and the landscape associated with two forts (active from 1854-1862 and 1867-1891).

The entrance area of the site features the Chihuahuan Desert grassland community common to the Davis Mountains, and provides visitors with their first view of the fort (Figure C-5). It also contains a spring and associated historic grove of cottonwood trees. The fort is located in the middle of an alluvial floodplain and natural drainages run through the site. Historic ditches and dikes are maintained for flood control. Behind the main fort area rise the volcanic cliff walls of Hospital Canyon and a rugged steep escarpment running north/south that forms the prominent backdrop view from the lower elevations. Mixed vegetative cover is found throughout this zone, where desert-scrubland intermixes with cacti and pinyon-juniper woodland. Flood inflows to Hospital Canyon Arroyo provide potential habitat for exotic plant infiltration.

Haynie (2000) documented 16 non-native species at FODA. NPSpecies lists 20 non-native plant species for FODA, including Malta starthistle (*Centaurea melitensis*), Johnsongrass (*Sorghum halapense*), common horehound (*Marrubium vulgare*), barnyard grass (*Echinochloa crus-galli*), and Bermuda grass (*Cynodon dactylon*). None of the non-native species in FODA are on the Texas Noxious Weed list.

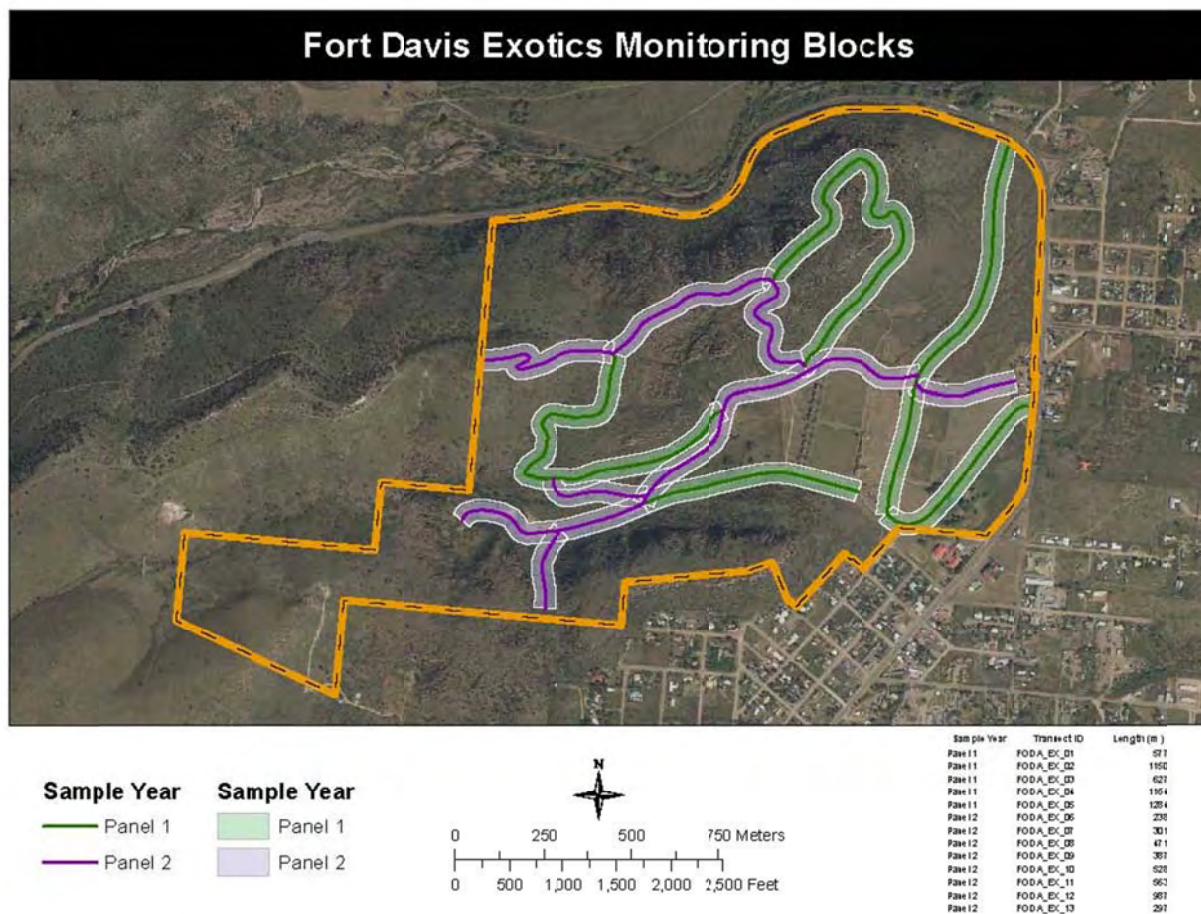


Figure C-5. Panel selection for FODA.

## C.5 Guadalupe Mountains National Park

Guadalupe Mountains National Park (GUMO) is located in the Trans-Pecos region of west Texas on the south side of the Texas/New Mexico border. Most of the lands surrounding GUMO are private lands. The only public land is owned by the Texas General Land Office or the Texas Department of Transportation. In New Mexico adjacent land owners include private, State of New Mexico, Bureau of Land Management, and U.S. Forest Service lands of the Lincoln National Forest. The elevation at GUMO ranges from approximately 1,204 m (3,624 ft) on the alkali flats to 2,584 m (8,749 ft) atop Guadalupe Peak, the highest point in Texas. Approximately half of the park (18,968 ha [46,850 ac]) is designated as Wilderness area.

Forest occurs at higher elevations in the Guadalupe Mountains. The mountains contain a number of deep, sheer-sided canyons, distinguished by high levels of biodiversity. The most notable, McKittrick Canyon, contains the park's only perennial stream, McKittrick Creek. The creek, as well as a number of springs, seeps, and ephemeral washes, support riparian plant communities.

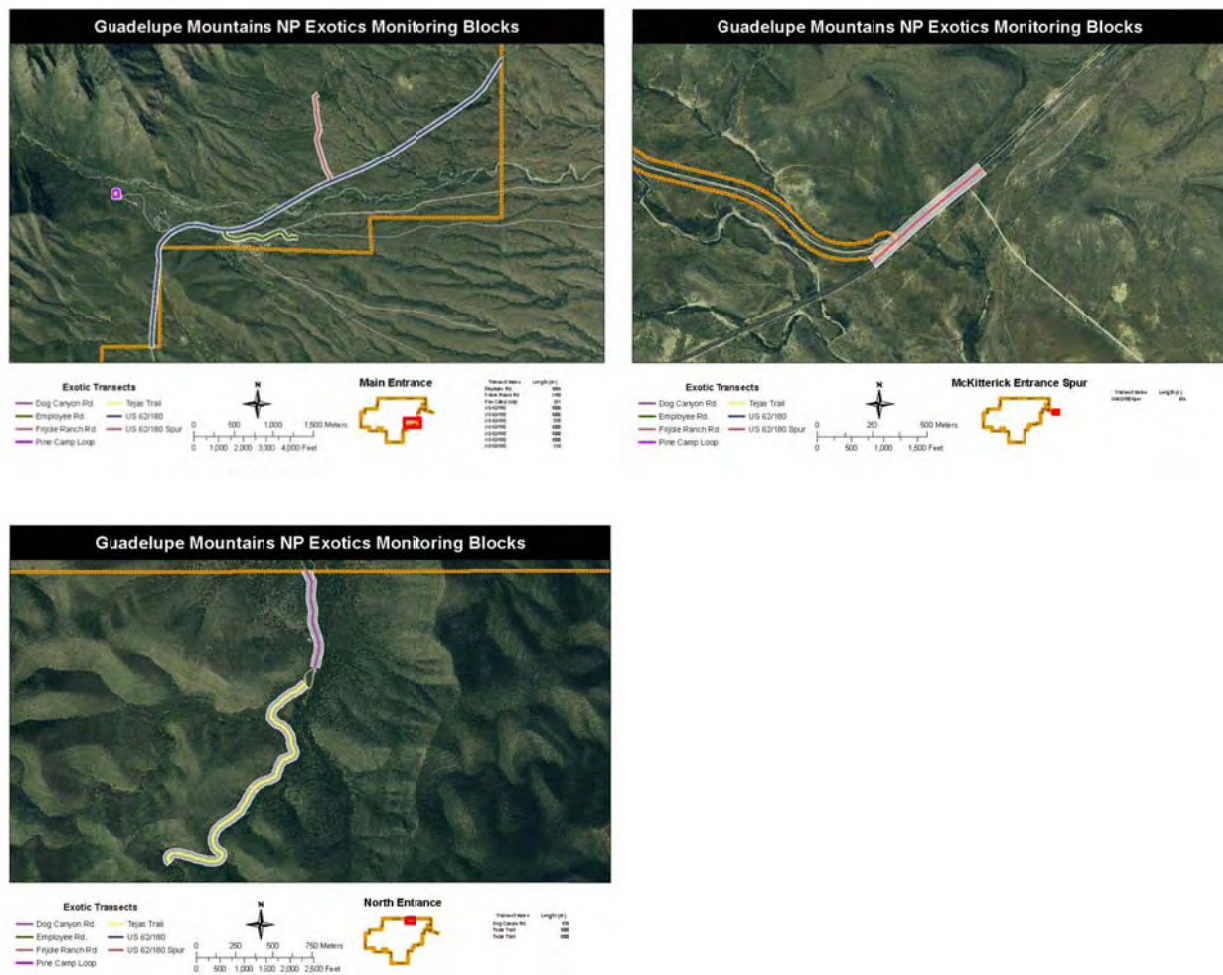


Figure C-6. Vector selection for GUMO. All vectors will be monitored every year.

The westernmost portion of the park encompasses several square miles of the alkali flats that dominate the valley west of the mountains (Figure C-6). Today, wind has eroded sections of the flats, piling quartz

and gypsum sand dunes up against the western foothills of the Guadalupe Mountains. The mountain foothills and surrounding plains are characterized by Chihuahuan Desert vegetation, including specialized desert scrub communities found in the salt flat and dune areas.

NPSpecies contains 44 non-native plant species for GUMO. Anderson and Mueller (2003) reported the following non-native plant species in a recent baseline inventory at Choza, Smith and Juniper Springs: watercress (*Rorippa nasturtium-aquaticum*), common horehound (*Marrubium vulgare*), barnyard grass (*Echinochloa crusgalli*), and Bermuda grass (*Cynodon dactylon*). Species listed on the Texas Noxious Weed list include field bindweed (*Convolvulus arvensis*) and saltcedar (*Tamarix* spp.).

## **C.6 White Sands National Monument**

White Sands National Monument (WNSA) is located in south-central New Mexico. WNSA is surrounded by military land, White Sands Missile Range. The elevation within the monument ranges from 1,186 m (3,891 ft) at Lake Lucero to 1,254 m (4,114 ft) in the foothills of the San Andreas Mountains on the west side of the monument. WNSA was established in 1933 and preserves more than half of the world's largest gypsum sand dune field.

Gypsum content and mobility of dune soils can limit existence or productivity to plant life. Current inventories for NPSpecies indicates 300 plant species, 16 of which are non-native, occur in WNSA. Those on the New Mexico Noxious Weed list include: Russian knapweed (*Acroptilon repens*), Malta starthistle (*Centaurea melitensis*), Russian olive (*Elaeagnus angustifolia*), African Rue (*Peganum harmala*), Dalmatian toadflax (*Linaria dalmatica*), and saltcedar (*Tamarix* spp.).

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| Family          | Scientific Name                  | Common Names             | AMIS | BIBE | CAVE | FODA | GUMO | WHSa |
|-----------------|----------------------------------|--------------------------|------|------|------|------|------|------|
| Asteraceae      | <i>Achillea millefolium</i>      | western yarrow           |      |      | •    |      | •    |      |
| Asteraceae      | <i>Acroptilon repens</i>         | Russian knapweed         |      |      |      |      |      | •    |
| Simaroubaceae   | <i>Ailanthus altissima</i>       | tree of heaven           |      |      | •    |      |      |      |
| Amaranthaceae   | <i>Amaranthus blitoides</i>      | prostrate pigweed        | •?   | •    |      |      |      |      |
| Amaranthaceae   | <i>Amaranthus retroflexus</i>    | redroot pigweed          |      | •    | •    |      | •    | •    |
| Apiaceae        | <i>Ammi visnaga</i>              | toothpickweed            |      |      |      |      | •    |      |
| Primulaceae     | <i>Anagallis arvensis</i>        | scarlet pimpernel        | •    | •    |      |      |      |      |
| Apiaceae        | <i>Apium graveolens</i>          | wild celery              |      |      | •    |      | •    |      |
| Poaceae         | <i>Arundo donax</i>              | giant reed               | •    | •    |      |      |      | •    |
| Liliaceae       | <i>Asparagus officinalis</i>     | garden asparagus         |      | •    | •    |      |      |      |
| Chenopodiaceae  | <i>Atriplex rosea</i>            | redscale saltbush        |      | •    |      |      |      |      |
| Poaceae         | <i>Avena fatua</i>               | wild oats                | •    |      | •    |      | •    |      |
| Chenopodiaceae  | <i>Bassia hyssopifolia</i>       | fivehook bassia          |      |      |      | •    |      | •    |
| Poaceae         | <i>Bothriochloa ischaemum</i>    | Turkestan beardgrass     | •    | •    |      |      |      |      |
| Brassicaceae    | <i>Brassica juncea</i>           | India mustard            | •?   |      |      |      |      |      |
| Brassicaceae    | <i>Brassica rapa</i>             | birdrape                 |      | •    |      |      |      |      |
| Poaceae         | <i>Bromus catharticus</i>        | rescue brome             | •    | •    | •    | •    | •    |      |
| Poaceae         | <i>Bromus japonicus</i>          | Japanese brome           |      |      | •    |      | •    |      |
| Poaceae         | <i>Bromus rubens</i>             | red brome                | •    |      | •    |      |      |      |
| Poaceae         | <i>Bromus tectorum</i>           | cheatgrass               |      | •    |      |      | •    |      |
| Fabaceae        | <i>Caesalpinia gilliesii</i>     | Mexican bird of paradise |      | •    |      | •    | •    |      |
| Asteraceae      | <i>Calyptocarpus vialis</i>      | straggler daisy          | •    | •    |      | •    |      |      |
| Asteraceae      | <i>Carduus tenuiflorus</i>       | Italian thistle          | •    |      |      |      |      |      |
| Cyperaceae      | <i>Carex muricata</i>            | rough sedge              |      |      | •    |      |      |      |
| Asteraceae      | <i>Centaurea melitensis</i>      | Malta starthistle        | •    | •    | •    |      | •    | •    |
| Asteraceae      | <i>Centaurea solstitialis</i>    | yellow starthistle       |      |      | •    |      |      |      |
| Caryophyllaceae | <i>Cerastium glomeratum</i>      | sticky chickweed         |      | •    |      |      |      |      |
| Chenopodiaceae  | <i>Chenopodium album</i>         | common lambsquarters     |      | •    |      | •    |      |      |
| Chenopodiaceae  | <i>Chenopodium ambrosioides</i>  | Mexican tea              |      | •    |      |      |      |      |
| Chenopodiaceae  | <i>Chenopodium murale</i>        | nettleleaf goosefoot     |      | •    |      |      |      |      |
| Apiaceae        | <i>Ciclospermum leptophyllum</i> | marsh parsley            | •    | •    |      |      |      |      |
| Ranunculaceae   | <i>Consolida ajacis</i>          | rocket larkspur          |      |      |      | •    |      |      |
| Convolvulaceae  | <i>Convolvulus arvensis</i>      | field bindweed           | •    |      | •    |      | •    |      |
| Chenopodiaceae  | <i>Corispermum nitidum</i>       | shiny bugseed            |      | •    |      |      |      |      |
| Cucurbitaceae   | <i>Cucurbita pepo</i>            | field pumpkin            |      |      |      | •    |      |      |
| Poaceae         | <i>Cynodon dactylon</i>          | Bermudagrass             | •    | •    | •    | •    | •    |      |

| Family           | Scientific Name                    | Common Names            | AMIS | BIBE | CAVE | FODA | GUMO | WHSa |
|------------------|------------------------------------|-------------------------|------|------|------|------|------|------|
| Cyperaceae       | <i>Cyperus esculentus</i>          | yellow nutsedge         |      | •?   |      |      | •    |      |
| Solanaceae       | <i>Datura innoxia</i>              | prickly datura          | •    | •    | •    |      |      |      |
| Solanaceae       | <i>Datura quercifolia</i>          | Chinese thornapple      |      | •    | •    |      | •    |      |
| Brassicaceae     | <i>Descurainia sophia</i>          | herb sophia             |      | •    | •    |      | •    |      |
| Poaceae          | <i>Dichanthelium scabriusculum</i> | woolly rosette grass    |      | •    |      |      |      |      |
| Poaceae          | <i>Dichanthium annulatum</i>       | Kleburg bluestem        | •    |      |      |      |      |      |
| Poaceae          | <i>Digitaria sanguinalis</i>       | large crabgrass         |      | •    | •    | •    |      |      |
| Brassicaceae     | <i>Diploaxis tenuifolia</i>        | perennial wallrocket    |      |      |      |      |      | •    |
| Poaceae          | <i>Echinochloa colona</i>          | jungle ricegrass        | •    | •    |      | •    |      |      |
| Poaceae          | <i>Echinochloa crus-galli</i>      | barnyardgrass           |      | •    | •    | •    | •    |      |
| Poaceae          | <i>Echinochloa muricata</i>        | rough barnyard grass    | •    | •    |      |      |      |      |
| Elaeagnaceae     | <i>Elaeagnus angustifolia</i>      | Russian olive           |      |      | •    |      |      | •    |
| Poaceae          | <i>Eleusine indica</i>             | goose grass             | •?   |      | •    |      |      |      |
| Poaceae          | <i>Eragrostis barrelieri</i>       | Mediterranean lovegrass | •    | •    | •    | •    | •    |      |
| Poaceae          | <i>Eragrostis cilianensis</i>      | stinkgrass              | •    | •    | •    | •    | •    |      |
| Poaceae          | <i>Eragrostis curvula</i>          | weeping lovegrass       |      |      | •    |      |      |      |
| Poaceae          | <i>Eragrostis lehmanniana</i>      | Lehmann's lovegrass     | •    | •    | •    |      |      |      |
| Geraniaceae      | <i>Erodium cicutarium</i>          | redstem storksbill      | •    | •    | •    | •    | •    |      |
| Brassicaceae     | <i>Eruca vesicaria</i>             | rocketsalad             | •?   | •    |      |      |      |      |
| Euphorbiaceae    | <i>Euphorbia davidii</i>           | David's spurge          |      | •    | •    | •    |      |      |
| Euphorbiaceae    | <i>Euphorbia dentata</i>           | toothed spurge          | •    | •    |      |      | •    |      |
| Moraceae         | <i>Ficus carica</i>                | common fig              |      | •    |      |      |      |      |
| Verbenaceae      | <i>Glandularia peruviana</i>       | Peruvian mock vervain   |      |      | •    |      |      |      |
| Poaceae          | <i>Hemarthria altissima</i>        | African jointgrass      | •    | •    |      |      |      |      |
| Poaceae          | <i>Hordeum marinum</i>             | seaside barley          |      |      | •    |      |      |      |
| Papaveraceae     | <i>Hunnemannia fumariifolia</i>    | Mexican tulip poppy     |      | •    |      |      |      |      |
| Hydrocharitaceae | <i>Hydrilla verticillata</i>       | hydrilla                | •    |      |      |      |      |      |
| Convolvulaceae   | <i>Ipomoea purpurea</i>            | common morningglory     |      | •    | •    | •    |      |      |
| Chenopodiaceae   | <i>Kochia scoparia</i>             | kochia                  | •?   |      | •    |      |      |      |
| Asteraceae       | <i>Lactuca serriola</i>            | prickly lettuce         | •    |      | •    |      |      |      |
| Lamiaceae        | <i>Lamium amplexicaule</i>         | henbit                  |      |      | •    |      |      |      |
| Boraginaceae     | <i>Lappula squarrosa</i>           | bristly sheepburr       |      |      | •    |      |      |      |
| Scrophulariaceae | <i>Linaria dalmatica</i>           | Dalmatian toadflax      |      |      |      |      |      | •    |
| Linaceae         | <i>Linum usitatissimum</i>         | cultivated flax         | •?   |      |      |      |      |      |
| Poaceae          | <i>Lolium perenne</i>              | perennial ryegrass      | •    | •    | •    |      |      |      |
| Rosaceae         | <i>Malus pumila</i>                | paradise apple          |      |      | •    |      |      |      |

| Family         | Scientific Name                   | Common Names              | AMIS | BIBE | CAVE | FODA | GUMO | WHSa |
|----------------|-----------------------------------|---------------------------|------|------|------|------|------|------|
| Rosaceae       | <i>Malus sylvestris</i>           | European crabapple        |      |      | •    |      |      |      |
| Malvaceae      | <i>Malva parviflora</i>           | small-whorl mallow        | •?   | •    |      |      |      |      |
| Malvaceae      | <i>Malvastrum coromandelianum</i> | threelobe false mallow    | •    |      |      |      |      |      |
| Lamiaceae      | <i>Marrubium vulgare</i>          | horehound                 | •    | •    | •    | •    | •    |      |
| Fabaceae       | <i>Medicago arabica</i>           | spotted burclover         | •    |      |      |      |      |      |
| Fabaceae       | <i>Medicago lupulina</i>          | black medic clover        |      |      | •    |      | •    |      |
| Fabaceae       | <i>Medicago minima</i>            | little burclover          |      |      |      | •    |      |      |
| Fabaceae       | <i>Medicago polymorpha</i>        | California burclover      |      | •    |      |      |      |      |
| Fabaceae       | <i>Medicago sativa</i>            | alfalfa                   |      | •    |      |      | •    | •    |
| Meliaceae      | <i>Melia azedarach</i>            | Chinaberry tree           | •    |      |      |      |      |      |
| Fabaceae       | <i>Melilotus alba</i>             | white sweetclover         |      | •    |      |      |      |      |
| Fabaceae       | <i>Melilotus indicus</i>          | annual yellow sweetclover | •    | •    |      |      |      |      |
| Fabaceae       | <i>Melilotus officinalis</i>      | yellow sweetclover        |      | •    | •    |      | •    | •    |
| Lamiaceae      | <i>Mentha spicata</i>             | spearmint                 |      | •    | •    |      | •    |      |
| Lamiaceae      | <i>Mentha x piperita</i>          | peppermint                |      | •?   |      |      |      |      |
| Molluginaceae  | <i>Mollugo cerviana</i>           | threadstem carpetweed     |      | •    |      |      |      |      |
| Moraceae       | <i>Morus alba</i>                 | white mulberry            | •    | •    |      |      |      |      |
| Moraceae       | <i>Morus celtidifolia</i>         |                           |      | •?   |      |      |      |      |
| Apocynaceae    | <i>Nerium oleander</i>            | oleander                  |      | •    |      |      |      |      |
| Solanaceae     | <i>Nicotiana glauca</i>           | tree tobacco              | •    | •    | •    |      |      |      |
| Acanthaceae    | <i>Nomaphila stricta</i>          |                           | •?   |      |      |      |      |      |
| Asteraceae     | <i>Onopordum acanthium</i>        | Scotch thistle            |      |      | •    |      |      |      |
| Poaceae        | <i>Oplismenus hirtellus</i>       | bristle basketgrass       |      | •    |      |      |      |      |
| Cactaceae      | <i>Opuntia ficus-indica</i>       | Indian fig                |      | •    | •    |      |      |      |
| Oxalidaceae    | <i>Oxalis corniculata</i>         | creeping oxalis           |      |      | •    |      |      |      |
| Poaceae        | <i>Panicum antidotale</i>         | blue panicgrass           | •    | •    | •    |      | •    |      |
| Poaceae        | <i>Panicum coloratum</i>          | klinegrass                |      |      | •    |      |      |      |
| Poaceae        | <i>Panicum miliaceum</i>          | proso millet              |      |      |      |      | •    |      |
| Asteraceae     | <i>Parthenium hysterophorus</i>   | ragweed parthenium        | •    | •?   |      |      | •    |      |
| Poaceae        | <i>Paspalum dilatatum</i>         | dallis grass              | •    | •    |      |      |      |      |
| Poaceae        | <i>Paspalum urvillei</i>          | Vasey grass               | •    |      |      |      |      |      |
| Zygophyllaceae | <i>Peganum harmala</i>            | African rue               |      |      | •    |      | •    | •    |
| Poaceae        | <i>Pennisetum ciliare</i>         | buffelgrass               | •    | •    |      |      |      |      |
| Poaceae        | <i>Pennisetum glaucum</i>         | yellow foxtail            |      |      |      | •    |      |      |
| Poaceae        | <i>Phalaris canariensis</i>       | annual canarygrass        |      |      | •    |      |      |      |
| Arecaceae      | <i>Phoenix dactylifera</i>        | date palm                 |      | •    |      |      |      |      |

| Family          | Scientific Name                    | Common Names                | AMIS | BIBE | CAVE | FODA | GUMO | WHSa |
|-----------------|------------------------------------|-----------------------------|------|------|------|------|------|------|
| Solanaceae      | <i>Physalis philadelphica</i>      | Mexican groundcherry        |      | •    |      |      |      |      |
| Asteraceae      | <i>Picris sprengeriana</i>         | bitterweed                  |      |      |      | •    |      |      |
| Plantaginaceae  | <i>Plantago lanceolata</i>         | buckhorn plantain           |      |      | •    |      | •    |      |
| Poaceae         | <i>Poa annua</i>                   | annual bluegrass            | •X   |      | •    |      | •    |      |
| Polygonaceae    | <i>Polygonum argyrocoleon</i>      | silver sheath knotweed      |      |      |      | •    |      |      |
| Polygonaceae    | <i>Polygonum convolvulus</i>       | climbing buckwheat          |      | •    |      |      |      |      |
| Polygonaceae    | <i>Polygonum lapathifolium</i>     | curlytop knotweed           |      | •    |      |      |      |      |
| Polygonaceae    | <i>Polygonum persicaria</i>        | ladysthumb smartweed        | •    | •    |      |      |      |      |
| Poaceae         | <i>Polypogon monspeliensis</i>     | annual rabbitsfoot grass    | •    | •    | •    |      | •    |      |
| Poaceae         | <i>Polypogon viridis</i>           | beardless rabbitsfoot grass | •    | •    | •    |      | •    |      |
| Salicaceae      | <i>Populus nigra</i>               | black cottonwood            |      |      | •    |      |      |      |
| Rosaceae        | <i>Prunus armeniaca</i>            | apricot                     |      |      | •    |      |      |      |
| Rosaceae        | <i>Prunus cerasus</i>              | sour cherry                 |      |      | •    |      |      |      |
| Rosaceae        | <i>Prunus domestica</i>            | European plum               |      |      | •    |      |      |      |
| Rosaceae        | <i>Prunus persica</i>              | peach                       |      | •    |      |      |      |      |
| Asteraceae      | <i>Pseudognaphalium luteoalbum</i> | Jersey cudweed              | •    |      |      |      |      |      |
| Euphorbiaceae   | <i>Ricinus communis</i>            | castor bean                 | •    |      |      |      |      |      |
| Polygonaceae    | <i>Rumex crispus</i>               | curley dock                 | •    | •    | •    |      |      |      |
| Polygonaceae    | <i>Rumex stenophyllus</i>          | narrowleaf dock             | •    |      |      |      |      |      |
| Salicaceae      | <i>Salix X sepulcralis</i>         | weeping willow              |      |      | •    |      |      |      |
| Chenopodiaceae  | <i>Salsola kali</i>                | prickly Russian thistle     |      | •    | •    | •    |      | •    |
| Chenopodiaceae  | <i>Salsola tragus</i>              | prickly Russian thistle     | •    | •    | •    |      | •    | •    |
| Primulaceae     | <i>Samolus valerandi</i>           | seaside brookweed           | •    |      |      |      |      |      |
| Asteraceae      | <i>Sanvitalia procumbens</i>       | Mexican creeping zinnia     |      | •    |      |      |      |      |
| Poaceae         | <i>Setaria adhaerens</i>           | burr bristlegrass           |      | •    |      |      |      |      |
| Poaceae         | <i>Setaria italica</i>             | Italian bristle grass       |      | •    |      |      |      |      |
| Poaceae         | <i>Setaria pumila</i>              | yellow bristlegrass         | •    |      |      | •    | •    |      |
| Poaceae         | <i>Setaria verticillata</i>        | hooked bristlegrass         | •?   |      |      |      |      |      |
| Poaceae         | <i>Setaria viridis</i>             | green bristlegrass          | •    | •    | •    |      | •    |      |
| Malvaceae       | <i>Sida abutifolia</i>             | prostrate sida              | •    | •    | •    | •    | •    |      |
| Caryophyllaceae | <i>Silene gallica</i>              | windmill catchfly           |      |      |      |      | •    |      |
| Brassicaceae    | <i>Sinapis arvensis</i>            | charlock mustard            |      | •    |      |      |      |      |
| Brassicaceae    | <i>Sisymbrium altissimum</i>       | tumble mustard              |      |      | •    |      |      |      |
| Brassicaceae    | <i>Sisymbrium irio</i>             | London rocket               | •    | •    | •    | •    |      | •    |
| Solanaceae      | <i>Solanum sisymbriifolium</i>     | sticky nightshade           |      | •    |      |      |      |      |
| Solanaceae      | <i>Solanum villosum</i>            |                             |      | •    |      |      |      |      |

| Family           | Scientific Name               | Common Names           | AMIS | BIBE | CAVE | FODA | GUMO | WHSA |
|------------------|-------------------------------|------------------------|------|------|------|------|------|------|
| Asteraceae       | <i>Sonchus asper</i>          | spiny sowthistle       |      | •    | •    |      | •    |      |
| Asteraceae       | <i>Sonchus oleraceus</i>      | annual sowthistle      | •    | •    | •    |      | •    |      |
| Poaceae          | <i>Sorghum bicolor</i>        | broomcorn              |      | •    |      |      |      |      |
| Poaceae          | <i>Sorghum halepense</i>      | Johnsongrass           | •    | •    | •    | •    | •    |      |
| Tamaricaceae     | <i>Tamarix aphylla</i>        | Athel tamarisk         | •    | •    |      |      |      |      |
| Tamaricaceae     | <i>Tamarix chinensis</i>      | Chinese tamarisk       |      | •    |      |      |      | •    |
| Tamaricaceae     | <i>Tamarix gallica</i>        | French tamarisk        |      | •    |      |      | •    | •    |
| Tamaricaceae     | <i>Tamarix ramosissima</i>    | saltcedar              | •    | •    |      |      | •    | •    |
| Asteraceae       | <i>Taraxacum officinale</i>   | common dandelion       |      |      | •    | •    | •    |      |
| Poaceae          | <i>Thinopyrum pycnanthum</i>  | tick quackgrass        | •?   |      |      |      |      |      |
| Brassicaceae     | <i>Thlaspi arvense</i>        | field pennycress       |      |      | •    |      |      |      |
| Apiaceae         | <i>Torilis arvensis</i>       | spreading hedgeparsley | •    | •    |      |      |      |      |
| Commelinaceae    | <i>Tradescantia wrightii</i>  | Wright's spiderwort    |      | •    |      |      |      |      |
| Asteraceae       | <i>Tragopogon dubius</i>      | western salsify        |      |      | •    | •    | •    |      |
| Asteraceae       | <i>Tragopogon porrifolius</i> | purple salsify         |      |      | •    |      | •    |      |
| Euphorbiaceae    | <i>Triadica sebifera</i>      | Chinese tallow tree    | •    |      |      |      |      |      |
| Zygophyllaceae   | <i>Tribulus terrestris</i>    | puncturevine           |      | •    | •    | •    | •    |      |
| Fabaceae         | <i>Trifolium dubium</i>       | small hop clover       |      |      | •    |      |      |      |
| Poaceae          | <i>Triticum aestivum</i>      | common wheat           |      |      |      |      | •    |      |
| Typhaceae        | <i>Typha angustifolia</i>     | narrowleaf cattail     |      | •    | •    |      | •    | •    |
| Ulmaceae         | <i>Ulmus pumila</i>           | Siberian elm           | •    | •    | •    | •    | •    |      |
| Scrophulariaceae | <i>Verbascum thapsus</i>      | common mullein         | •    |      | •    |      | •    |      |
| Verbenaceae      | <i>Verbena brasiliensis</i>   | Brazilian vervain      |      | •    |      |      |      |      |
| Verbenaceae      | <i>Vitex agnus-castus</i>     | chaste tree            | •    |      |      |      |      |      |
| Asteraceae       | <i>Xanthium spinosum</i>      | spiny cocklebur        |      |      |      |      | •    |      |
| Rhamnaceae       | <i>Ziziphus mauritiana</i>    | Indian jujube          |      |      |      | •    |      |      |

## **APPENDIX D**

### **Comparison of Exotic Species Among Networks**

## **APPENDIX D**

### **Comparison of Exotic Species Among Networks**

| Family          | Scientific Name                | Common Names             | SODN | CHDN | SOPN |
|-----------------|--------------------------------|--------------------------|------|------|------|
| Malvaceae       | <i>Abutilon theophrasti</i>    | velvetleaf Indian mallow |      |      | •    |
| Asteraceae      | <i>Achillea millefolium</i>    | western yarrow           |      | •    | •    |
| Asteraceae      | <i>Acroptilon repens</i>       | Russian knapweed         | •    | •    | •    |
| Poaceae         | <i>Aegilops cylindrica</i>     | jointed goatgrass        |      |      | •    |
| Poaceae         | <i>Agropyron cristatum</i>     | crested wheatgrass       |      |      | •    |
| Poaceae         | <i>Agropyron desertorum</i>    | clustered wheatgrass     |      |      | •    |
| Poaceae         | <i>Agrostis gigantea</i>       | redtop bentgrass         | •    |      | •    |
| Simaroubaceae   | <i>Ailanthus altissima</i>     | tree if heaven           | •    | •    |      |
| Fabaceae        | <i>Albizia julibrissin</i>     | mimosa                   |      |      | •    |
| Brassicaceae    | <i>Alliaria petiolata</i>      | garlic mustard           |      |      | •    |
| Liliaceae       | <i>Allium ampeloprasum</i>     | broadleaf wild leak      |      |      | •    |
| Brassicaceae    | <i>Alyssum minus</i>           | European alyssum         |      |      | •    |
| Amaranthaceae   | <i>Amaranthus blitoides</i>    | prostrate pigweed        | •    | •    | •    |
| Amaranthaceae   | <i>Amaranthus crassipes</i>    | spreading amaranth       | •    |      |      |
| Amaranthaceae   | <i>Amaranthus retroflexus</i>  | redroot pigweed          |      | •    | •    |
| Apiaceae        | <i>Ammi visnaga</i>            | toothpickweed            |      | •    |      |
| Primulaceae     | <i>Anagallis arvensis</i>      | scarlet pimpernel        | •    | •    |      |
| Apiaceae        | <i>Apium graveolens</i>        | wild celery              |      | •    |      |
| Brassicaceae    | <i>Arabis hirsuta</i>          | hairy rockcress          |      |      | •    |
| Asteraceae      | <i>Arctium minus</i>           | lesser burdock           |      |      | •    |
| Caryophyllaceae | <i>Arenaria serpyllifolia</i>  | thymeleaf sandwort       |      |      | •    |
| Poaceae         | <i>Arundo donax</i>            | giant reed               | •    | •    | •    |
| Liliaceae       | <i>Asparagus officinalis</i>   | garden asparagus         | •    | •    | •    |
| Chenopodiaceae  | <i>Atriplex rosea</i>          | redscale saltbush        |      | •    |      |
| Poaceae         | <i>Avena fatua</i>             | wild oats                | •    | •    |      |
| Poaceae         | <i>Avena sativa</i>            | common oat               | •    |      | •    |
| Brassicaceae    | <i>Barbarea vulgaris</i>       | yellow rocket            | •    |      | •    |
| Chenopodiaceae  | <i>Bassia hyssopifolia</i>     | fivehook bassia          | •    | •    |      |
| Asteraceae      | <i>Bidens pilosa</i>           | beggar's ticks           | •    |      |      |
| Bignoniaceae    | <i>Bignonia capreolata</i>     | cross vine               |      |      | •    |
| Poaceae         | <i>Bothriochloa bladhii</i>    | Australian beardgrass    |      |      | •    |
| Poaceae         | <i>Bothriochloa ischaemum</i>  | Turkestan beardgrass     | •    | •    | •    |
| Brassicaceae    | <i>Brassica juncea</i>         | India mustard            |      | •    |      |
| Brassicaceae    | <i>Brassica nigra</i>          | black mustard            | •    |      | •    |
| Brassicaceae    | <i>Brassica rapa</i>           | birdrape                 | •    | •    |      |
| Brassicaceae    | <i>Brassica tournefortii</i>   | African mustard          | •    |      |      |
| Poaceae         | <i>Bromus berterioanus</i>     |                          | •    |      |      |
| Poaceae         | <i>Bromus arvensis</i>         | field brome              | •    |      | •    |
| Poaceae         | <i>Bromus catharticus</i>      | rescue brome             | •    | •    | •    |
| Poaceae         | <i>Bromus commutatus</i>       | meadow brome             |      |      | •    |
| Poaceae         | <i>Bromus diandrus</i>         | riggut brome             | •    |      |      |
| Poaceae         | <i>Bromus hordeaceus</i>       | soft brome               | •    |      |      |
| Poaceae         | <i>Bromus japonicus</i>        | Japanese brome           | •    | •    | •    |
| Poaceae         | <i>Bromus lanceolatus</i>      | Mediterranean brome      |      |      | •    |
| Poaceae         | <i>Bromus madritensis</i>      | compact brome            | •    |      |      |
| Poaceae         | <i>Bromus rubens</i>           | red brome                | •    | •    |      |
| Poaceae         | <i>Bromus tectorum</i>         | cheatgrass               | •    | •    | •    |
| Moraceae        | <i>Broussonetia papyrifera</i> | paper mulberry           |      |      | •    |
| Boraginaceae    | <i>Buglossoides arvensis</i>   | corn gromwell            |      |      | •    |
| Fabaceae        | <i>Caesalpinia gilliesii</i>   | Mexican bird of paradise | •    | •    |      |
| Asteraceae      | <i>Calyptracarpus vialis</i>   | straggler daisy          |      | •    | •    |
| Convolvulaceae  | <i>Calystegia sepium</i>       | hedge bindweed           |      |      | •    |
| Brassicaceae    | <i>Camelina microcarpa</i>     | smallseed false flax     |      |      | •    |
| Fabaceae        | <i>Canavalia ensiformis</i>    | wonderbean               | •    |      |      |

| Family          | Scientific Name                          | Common Names          | SODN | CHDN | SOPN |
|-----------------|------------------------------------------|-----------------------|------|------|------|
| Cannabaceae     | <i>Cannabis sativa</i>                   | hemp                  |      |      | •    |
| Brassicaceae    | <i>Capsella bursa-pastoris</i>           | shepard's purse       | •    |      | •    |
| Solanaceae      | <i>Capsicum anuum var. glabriusculum</i> | chilipequin           | •    |      |      |
| Brassicaceae    | <i>Cardaria draba</i>                    | whitetop              |      |      | •    |
| Asteraceae      | <i>Carduus nutans</i>                    | musk thistle          |      |      | •    |
| Asteraceae      | <i>Carduus tenuiflorus</i>               | Itlaian thistle       |      | •    | •    |
| Cyperaceae      | <i>Carex bonplandii</i>                  | Bonpland's sedge      | •    |      |      |
| Cyperaceae      | <i>Carex muricata</i>                    | rough sedge           |      | •    |      |
| Asteraceae      | <i>Carphochaete bigelovii</i>            | Bigelow's bristlehead | •    |      |      |
| Asteraceae      | <i>Carthamus tinctoris</i>               | safflower             | •    |      |      |
| Poaceae         | <i>Cenchrus ciliaris</i>                 | buffelgrass           | •    |      |      |
| Poaceae         | <i>Cenchrus setaceus</i>                 |                       | •    |      |      |
| Asteraceae      | <i>Centaurea melitensis</i>              | Malta starthistle     | •    | •    | •    |
| Asteraceae      | <i>Centaurea solstitialis</i>            | yellow starthistle    | •    | •    |      |
| Caryophyllaceae | <i>Cerastium fontanum</i>                | big chickweed         | •    |      |      |
| Caryophyllaceae | <i>Cerastium glomeratum</i>              | sticky chickweed      |      | •    | •    |
| Caryophyllaceae | <i>Cerastium gracile</i>                 | slender chickweed     | •    |      |      |
| Chenopodiaceae  | <i>Chenopodium album</i>                 | common lambsquarters  |      | •    | •    |
| Chenopodiaceae  | <i>Chenopodium ambrosioides</i>          | Mexican tea           |      | •    | •    |
| Chenopodiaceae  | <i>Chenopodium glaucum</i>               | oakleaf goosefoot     | •    |      | •    |
| Chenopodiaceae  | <i>Chenopodium murale</i>                | nettleleaf goosefoot  | •    | •    |      |
| Brassicaceae    | <i>Chorispora tenella</i>                | blue mustard          | •    |      | •    |
| Asteraceae      | <i>Cichorium intybus</i>                 | chicory               | •    |      | •    |
| Apiaceae        | <i>Ciclospermum leptophyllum</i>         | marsh parsley         |      | •    |      |
| Asteraceae      | <i>Cirsium arvense</i>                   | Canada thistle        |      |      | •    |
| Asteraceae      | <i>Cirsium vulgare</i>                   | bull thistle          |      |      | •    |
| Cucurbitaceae   | <i>Citrullus lanatus</i>                 | watermelon            |      |      | •    |
| Ranunculaceae   | <i>Clematis terniflora</i>               | sweet autumn clematis |      |      | •    |
| Cleomaceae      | <i>Cleome viscosa</i>                    | Asian spiderflower    | •    |      |      |
| Apiaceae        | <i>Conium maculatum</i>                  | poison hemlock        | •    |      | •    |
| Ranunculaceae   | <i>Consolida ajacis</i>                  | rocket larkspur       |      | •    |      |
| Convolvulaceae  | <i>Convolvulus arvensis</i>              | field bindweed        | •    | •    | •    |
| Chenopodiaceae  | <i>Corispermum nitidum</i>               | shiny bugseed         |      | •    |      |
| Fabaceae        | <i>Coronilla varia</i>                   | crownvetch            |      |      | •    |
| Poaceae         | <i>Cortaderia selloana</i>               | pampas grass          | •    |      |      |
| Cucurbitaceae   | <i>Cucurbita pepo</i>                    | field pumpkin         |      | •    |      |
| Apiaceae        | <i>Cyclospermum leptophyllum</i>         | marsh parsley         | •    |      |      |
| Poaceae         | <i>Cynodon dactylon</i>                  | Bermudagrass          | •    | •    | •    |
| Boraginaceae    | <i>Cynoglossum officinale</i>            | houndstongue          |      |      | •    |
| Cyperaceae      | <i>Cyperus esculentus</i>                | yellow nutsedge       |      | •    | •    |
| Cyperaceae      | <i>Cyperus rotundus</i>                  | purple nutsedge       | •    |      | •    |
| Poaceae         | <i>Dactylis glomerata</i>                | orchardgrass          |      |      | •    |
| Poaceae         | <i>Dactyloctenium aegyptium</i>          | crowfoot grass        | •    |      |      |
| Solanaceae      | <i>Datura inoxia</i>                     | prickly datura        | •    | •    |      |
| Solanaceae      | <i>Datura quercifolia</i>                | Chinese thornapple    |      | •    |      |
| Solanaceae      | <i>Datura stramonium</i>                 | jimsonweed            | •    |      | •    |
| Apiaceae        | <i>Daucus carota</i>                     | Queen Anne's lace     |      |      | •    |
| Brassicaceae    | <i>Descurainia sophia</i>                | herb sophia           | •    | •    | •    |
| Poaceae         | <i>Desmazeria rigida</i>                 | ferngrass             |      |      | •    |
| Caryophyllaceae | <i>Dianthus chinensis</i>                | rainbow pink          |      |      | •    |
| Poaceae         | <i>Dichanthelium scabriusculum</i>       | woolly rosette grass  |      | •    |      |
| Poaceae         | <i>Dichanthium annulatum</i>             | Kleburg bluestem      |      | •    | •    |
| Poaceae         | <i>Digitaria ciliaris</i>                | southern crabgrass    |      |      | •    |
| Poaceae         | <i>Digitaria sanguinalis</i>             | large crabgrass       |      | •    | •    |

| Family           | Scientific Name                  | Common Names              | SODN | CHDN | SOPN |
|------------------|----------------------------------|---------------------------|------|------|------|
| Asteraceae       | <i>Dimorphotheca sinuata</i>     | glandular Cape marigold   | •    |      |      |
| Brassicaceae     | <i>Diplotaxis tenuifolia</i>     | perennial wallrocket      |      | •    |      |
| Dipsacaceae      | <i>Dipsacus fullonum</i>         | Fuller's teasel           |      |      | •    |
| Poaceae          | <i>Echinochloa colona</i>        | jungle ricegrass          | •    | •    | •    |
| Poaceae          | <i>Echinochloa crus-galli</i>    | barnyardgrass             | •    | •    | •    |
| Poaceae          | <i>Echinochloa muricata</i>      | rough barnyard grass      |      | •    |      |
| Elaeagnaceae     | <i>Elaeagnus angustifolia</i>    | Russian olive             | •    | •    | •    |
| Elaeagnaceae     | <i>Elaeagnus pungens</i>         | thorny olive              |      |      | •    |
| Poaceae          | <i>Eleusine indica</i>           | goose grass               |      | •    |      |
| Poaceae          | <i>Elymus repens</i>             | quackgrass                |      |      | •    |
| Poaceae          | <i>Enneapogon mollis</i>         | soft feather pappusgrass  | •    |      |      |
| Poaceae          | <i>Eragrostis barrelieri</i>     | Mediterranean lovegrass   | •    | •    | •    |
| Poaceae          | <i>Eragrostis cilianensis</i>    | stinkgrass                | •    | •    | •    |
| Poaceae          | <i>Eragrostis curvula</i>        | weeping lovegrass         | •    | •    | •    |
| Poaceae          | <i>Eragrostis echinochloidea</i> | African lovegrass         | •    |      |      |
| Poaceae          | <i>Eragrostis lehmanniana</i>    | Lehmann's lovegrass       | •    | •    |      |
| Poaceae          | <i>Eragrostis superba</i>        | Wilman lovegrass          | •    |      |      |
| Geraniaceae      | <i>Erodium cicutarium</i>        | redstem storksbill        | •    | •    | •    |
| Brassicaceae     | <i>Eruca vesicaria</i>           | rocketsalad               | •    | •    |      |
| Brassicaceae     | <i>Erysimum repandum</i>         | bushy wallflower          | •    |      | •    |
| Celastraceae     | <i>Euonymus japonica</i>         | Japanese spindletree      |      |      | •    |
| Euphorbiaceae    | <i>Euphorbia davidii</i>         | David's spurge            |      | •    | •    |
| Euphorbiaceae    | <i>Euphorbia dentata</i>         | toothed spurge            |      | •    | •    |
| Euphorbiaceae    | <i>Euphorbia esula</i>           | leafy spurge              | •    |      | •    |
| Asteraceae       | <i>Facelis retusa</i>            | annual trampweed          |      |      | •    |
| Moraceae         | <i>Fatoua villosa</i>            | hairy crabweed            |      |      | •    |
| Moraceae         | <i>Ficus carica</i>              | common fig                | •    | •    |      |
| Asteraceae       | <i>Galinsoga parviflora</i>      | gallant soldier           | •    |      |      |
| Rubiaceae        | <i>Galium divaricatum</i>        | Lamarck's bedstraw        |      |      | •    |
| Geraniaceae      | <i>Geranium pusillum</i>         | small-flower crane's-bill |      |      | •    |
| Verbenaceae      | <i>Glandularia peruviana</i>     | Peruvian mock vervain     |      | •    |      |
| Poaceae          | <i>Hemarthria altissima</i>      | African jointgrass        |      | •    |      |
| Liliaceae        | <i>Hemerocallis fulva</i>        | orange daylily            |      |      | •    |
| Caryophyllaceae  | <i>Herniaria hirsuta</i>         | hairy rupturewort         | •    |      |      |
| Malvaceae        | <i>Hibiscus trionum</i>          | flower-of-an-hour         |      |      | •    |
| Caryophyllaceae  | <i>Holosteum umbellatum</i>      | jagged chickweed          |      |      | •    |
| Poaceae          | <i>Hordeum marinum</i>           | seaside barley            | •    | •    |      |
| Poaceae          | <i>Hordeum murinum</i>           | mouse barley              | •    |      | •    |
| Poaceae          | <i>Hordeum vulgare</i>           | cereal barley             | •    |      | •    |
| Papaveraceae     | <i>Hunnemannia fumariifolia</i>  | Mexican tulip poppy       |      | •    |      |
| Hydrocharitaceae | <i>Hydrilla verticillata</i>     | hydrilla                  |      | •    |      |
| Convolvulaceae   | <i>Ipomoea coccinea</i>          | Mexican morningglory      | •    |      |      |
| Convolvulaceae   | <i>Ipomoea hederacea</i>         | ivyleaf morningglory      | •    |      |      |
| Convolvulaceae   | <i>Ipomoea purpurea</i>          | common morningglory       | •    | •    | •    |
| Iridaceae        | <i>Iris germanica</i>            | German iris               |      |      | •    |
| Iridaceae        | <i>Iris lutescens</i>            | Crimean iris              |      |      | •    |
| Iridaceae        | <i>Iris sanguinea</i>            | Japanese iris             |      |      | •    |
| Oleaceae         | <i>Jasminum nudiflorum</i>       | winter jasmine            |      |      | •    |
| Euphorbiaceae    | <i>Jatropha spathula</i>         |                           | •    |      |      |
| Chenopodiaceae   | <i>Kochia scoparia</i>           | kochia                    | •    | •    | •    |
| Fabaceae         | <i>Kummerowia stipulacea</i>     | Korean lespedeza          |      |      | •    |
| Asteraceae       | <i>Lactuca saligna</i>           | willowleaf lettuce        | •    |      |      |
| Asteraceae       | <i>Lactuca serriola</i>          | prickly lettuce           | •    | •    | •    |
| Asteraceae       | <i>Lactuca tatarica</i>          | blue lettuce              |      |      | •    |

| Family           | Scientific Name                      | Common Names              | SODN | CHDN | SOPN |
|------------------|--------------------------------------|---------------------------|------|------|------|
| Poaceae          | <i>Lamarckia aurea</i>               | goldentop grass           | •    |      |      |
| Lamiaceae        | <i>Lamium amplexicaule</i>           | henbit                    | •    | •    | •    |
| Boraginaceae     | <i>Lappula squarrosa</i>             | bristly sheepburr         |      | •    |      |
| Fabaceae         | <i>Lathyrus hirsutus</i>             | singletary pea            |      |      | •    |
| Fabaceae         | <i>Lathyrus latifolius</i>           | everlasting peavine       |      |      | •    |
| Lamiaceae        | <i>Leonurus cardiaca</i>             | motherwort                |      |      | •    |
| Lamiaceae        | <i>Leonurus sibiricus</i>            | honeyweed                 |      |      | •    |
| Brassicaceae     | <i>Lepidium latifolium</i>           | broadleaf pepperweed      |      |      | •    |
| Fabaceae         | <i>Lespedeza cuneata</i>             | sericea lespedeza         |      |      | •    |
| Asteraceae       | <i>Leucanthemum vulgare</i>          | oxeye daisy               |      |      | •    |
| Oleaceae         | <i>Ligustrum japonicum</i>           | Japanese privet           |      |      | •    |
| Oleaceae         | <i>Ligustrum lucidum</i>             | glossy privet             |      |      | •    |
| Oleaceae         | <i>Ligustrum sinense</i>             | Chinese privet            |      |      | •    |
| Oleaceae         | <i>Ligustrum vulgare</i>             | European privet           |      |      | •    |
| Scrophulariaceae | <i>Linaria dalmatica</i>             | Dalmatian toadflax        | •    | •    |      |
| Scrophulariaceae | <i>Linaria vulgaris</i>              | yellow toadflax           |      |      | •    |
| Linaceae         | <i>Linum usitatissimum</i>           | cultivated flax           | •    | •    |      |
| Poaceae          | <i>Lolium arundinaceum</i>           | tall fescue               |      |      | •    |
| Poaceae          | <i>Lolium perenne</i>                | perennial ryegrass        | •    | •    | •    |
| Poaceae          | <i>Lolium pratense</i>               | meadow fescue             |      |      | •    |
| Poaceae          | <i>Lolium temulentum</i>             | Darnel ryegrass           |      |      | •    |
| Caprifoliaceae   | <i>Lonicera japonica</i>             | Japanese honeysuckle      | •    |      | •    |
| Caprifoliaceae   | <i>Lonicera maackii</i>              | Amur honeysuckle bush     |      |      | •    |
| Fabaceae         | <i>Lotus corniculatus</i>            | birdfoot deervetch        | •    |      |      |
| Solanaceae       | <i>Lycium barbarum</i>               | matrimony vine            |      |      | •    |
| Fabaceae         | <i>Macroptilium gibbosifolium</i>    | variableleaf bushbean     | •    |      |      |
| Rosaceae         | <i>Malus pumila</i>                  | paradise apple            | •    | •    |      |
| Rosaceae         | <i>Malus sylvestris</i>              | European crabapple        |      | •    | •    |
| Malvaceae        | <i>Malva neglecta</i>                | roundleaf mallow          | •    |      | •    |
| Malvaceae        | <i>Malva parviflora</i>              | small-whorl mallow        | •    | •    | •    |
| Malvaceae        | <i>Malvastrum coromandelianum</i>    | threelobe false mallow    |      | •    |      |
| Lamiaceae        | <i>Marrubium vulgare</i>             | horehound                 | •    | •    | •    |
| Asteraceae       | <i>Matricaria discoidea</i>          | pineapple weed            | •    |      |      |
| Brassicaceae     | <i>Matthiola longipetala</i>         | night-scented stock       | •    |      |      |
| Fabaceae         | <i>Medicago arabica</i>              | spotted burclover         |      | •    |      |
| Fabaceae         | <i>Medicago lupulina</i>             | black medic clover        | •    | •    | •    |
| Fabaceae         | <i>Medicago minima</i>               | little burclover          | •    | •    | •    |
| Fabaceae         | <i>Medicago polymorpha</i>           | California burclover      | •    | •    | •    |
| Fabaceae         | <i>Medicago sativa</i>               | alfalfa                   | •    | •    | •    |
| Asteraceae       | <i>Melampodium sericeum</i>          | rough blackfoot           | •    |      |      |
| Meliaceae        | <i>Melia azedarach</i>               | Chinaberry tree           |      | •    | •    |
| Fabaceae         | <i>Melilotus alba</i>                | white sweetclover         | •    | •    | •    |
| Fabaceae         | <i>Melilotus indicus</i>             | annual yellow sweetclover | •    | •    | •    |
| Fabaceae         | <i>Melilotus officinalis</i>         | yellow sweetclover        | •    | •    | •    |
| Poaceae          | <i>Melinis repens</i>                | rose Natal grass          | •    |      |      |
| Lamiaceae        | <i>Mentha spicata</i>                | spearmint                 | •    | •    | •    |
| Lamiaceae        | <i>Mentha x piperita</i>             | peppermint                |      | •    |      |
| Aizoaceae        | <i>Mesembryanthemum crystallinum</i> | common iceplant           | •    |      |      |
| Aizoaceae        | <i>Mesembryanthemum nodiflorum</i>   | slenderleaf iceplant      | •    |      |      |
| Nyctaginaceae    | <i>Mirabilis jalapa</i>              | common four o'clock       |      |      | •    |
| Poaceae          | <i>Mnesithea granularis</i>          | pitscale grass            | •    |      |      |
| Molluginaceae    | <i>Mollugo cerviana</i>              | threadstem carpetweed     | •    | •    |      |
| Lamiaceae        | <i>Moluccella laevis</i>             | shellflower               |      |      | •    |
| Moraceae         | <i>Morus alba</i>                    | white mulberry            | •    | •    | •    |

| Family          | Scientific Name                 | Common Names                | SODN | CHDN | SOPN |
|-----------------|---------------------------------|-----------------------------|------|------|------|
| Moraceae        | <i>Morus celtidifolia</i>       |                             |      | •    |      |
| Haloragaceae    | <i>Myriophyllum spicatum</i>    | Eurasian water-milfoil      | •    |      | •    |
| Berberidaceae   | <i>Nandina domestica</i>        | heavenly bamboo             |      |      | •    |
| Lamiaceae       | <i>Nepeta cataria</i>           | catnip                      | •    |      | •    |
| Apocynaceae     | <i>Nerium oleander</i>          | oleander                    |      | •    |      |
| Solanaceae      | <i>Nicotiana glauca</i>         | tree tobacco                | •    | •    |      |
| Acanthaceae     | <i>Nomaphila stricta</i>        |                             |      | •    |      |
| Asteraceae      | <i>Oncosiphon piluliferum</i>   | stinknet                    | •    |      |      |
| Asteraceae      | <i>Onopordum acanthium</i>      | Scotch thistle              |      | •    | •    |
| Poaceae         | <i>Oplismenus hirtellus</i>     | bristle basketgrass         |      | •    |      |
| Cactaceae       | <i>Opuntia ficus-indica</i>     | Indian fig                  | •    | •    |      |
| Liliaceae       | <i>Ornithogalum umbellatum</i>  | Star-of-Bethlehem           |      |      | •    |
| Oxalidaceae     | <i>Oxalis corniculata</i>       | creeping oxalis             |      | •    |      |
| Poaceae         | <i>Panicum antidotale</i>       | blue panicgrass             | •    | •    |      |
| Poaceae         | <i>Panicum coloratum</i>        | klinegrass                  |      | •    | •    |
| Poaceae         | <i>Panicum miliaceum</i>        | proso millet                | •    | •    | •    |
| Papaveraceae    | <i>Papaver rhoeas</i>           | corn poppy                  | •    |      |      |
| Asteraceae      | <i>Parthenium hysterophorus</i> | ragweed parthenium          |      | •    | •    |
| Poaceae         | <i>Paspalum dilatatum</i>       | dallis grass                | •    | •    | •    |
| Poaceae         | <i>Paspalum urvillei</i>        | Vasey grass                 |      | •    | •    |
| Zygophyllaceae  | <i>Peganum harmala</i>          | African rue                 |      | •    |      |
| Poaceae         | <i>Pennisetum ciliare</i>       | buffelgrass                 |      | •    |      |
| Poaceae         | <i>Pennisetum glaucum</i>       | yellow foxtail              |      | •    | •    |
| Polygonaceae    | <i>Persicaria maculosa</i>      |                             | •    |      |      |
| Poaceae         | <i>Phalaris aquatica</i>        | bulbous canarygrass         | •    |      |      |
| Poaceae         | <i>Phalaris arundinacea</i>     | reed canarygrass            |      |      | •    |
| Poaceae         | <i>Phalaris canariensis</i>     | annual canarygrass          | •    | •    |      |
| Poaceae         | <i>Phalaris minor</i>           | littleseed canarygrass      | •    |      |      |
| Poaceae         | <i>Phalaris para</i>            |                             | •    |      |      |
| Poaceae         | <i>Phleum pratense</i>          | common timothy              | •    |      | •    |
| Arecaceae       | <i>Phoenix dactylifera</i>      | date palm                   |      | •    |      |
| Solanaceae      | <i>Physalis philadelphica</i>   | Mexican groundcherry        |      | •    |      |
| Asteraceae      | <i>Picris sprengeriana</i>      | bitterweed                  |      | •    |      |
| Pinaceae        | <i>Pinus nigra</i>              | Australian pine             |      |      | •    |
| Pinaceae        | <i>Pinus pinea</i>              | Italian stone pine          | •    |      |      |
| Plantaginaceae  | <i>Plantago lanceolata</i>      | buckhorn plaintain          | •    | •    | •    |
| Poaceae         | <i>Poa annua</i>                | annual bluegrass            | •    | •    | •    |
| Poaceae         | <i>Poa compressa</i>            | flat-stem blue grass        |      |      | •    |
| Poaceae         | <i>Poa pratensis</i>            | Kentucky bluegrass          |      |      | •    |
| Caryophyllaceae | <i>Polycarpon tetraphyllum</i>  | fourleaf manyseed           |      |      | •    |
| Polygonaceae    | <i>Polygonum arenastrum</i>     | prostrate knotweed          |      |      | •    |
| Polygonaceae    | <i>Polygonum argyrocoleon</i>   | silver sheath knotweed      | •    | •    |      |
| Polygonaceae    | <i>Polygonum aviculare</i>      | yard knotweed               | •    |      | •    |
| Polygonaceae    | <i>Polygonum convolvulus</i>    | climbing buckwheat          | •    | •    | •    |
| Polygonaceae    | <i>Polygonum hydropiper</i>     | annual smartweed            |      |      | •    |
| Polygonaceae    | <i>Polygonum lapathifolium</i>  | curlytop knotweed           |      | •    |      |
| Polygonaceae    | <i>Polygonum persicaria</i>     | ladysthumb smartweed        |      | •    |      |
| Poaceae         | <i>Polypogon monspeliensis</i>  | annual rabbitsfoot grass    | •    | •    | •    |
| Poaceae         | <i>Polypogon viridis</i>        | beardless rabbitsfoot grass | •    | •    | •    |
| Salicaceae      | <i>Populus alba</i>             | white poplar                |      |      | •    |
| Salicaceae      | <i>Populus nigra</i>            | black cottonwood            |      | •    |      |
| Portulacaceae   | <i>Portulaca oleracea</i>       | common purslane             | •    |      |      |
| Rosaceae        | <i>Potentilla recta</i>         | sulphur cinquefoil          |      |      | •    |
| Rosaceae        | <i>Prunus armeniaca</i>         | apricot                     |      | •    |      |

| Family          | Scientific Name                    | Common Names               | SODN | CHDN | SOPN |
|-----------------|------------------------------------|----------------------------|------|------|------|
| Rosaceae        | <i>Prunus cerasus</i>              | sour cherry                |      | •    |      |
| Rosaceae        | <i>Prunus domestica</i>            | European plum              |      | •    |      |
| Rosaceae        | <i>Prunus mahaleb</i>              | Mahaleb cherry             |      |      | •    |
| Rosaceae        | <i>Prunus persica</i>              | peach                      |      | •    |      |
| Poaceae         | <i>Psathyrostachys juncea</i>      | Russian wildrye            |      |      | •    |
| Asteraceae      | <i>Pseudognaphalium luteoalbum</i> | Jersey cudweed             |      | •    | •    |
| Lythraceae      | <i>Punica granatum</i>             | pomegranate                | •    |      |      |
| Rosaceae        | <i>Pyracantha koizumii</i>         | Formosa firethorn          | •    |      |      |
| Rosaceae        | <i>Pyrus communis</i>              | common pear                |      |      | •    |
| Ranunculaceae   | <i>Ranunculus acris</i>            | meadow buttercup           |      |      | •    |
| Euphorbiaceae   | <i>Ricinus communis</i>            | castor bean                |      | •    | •    |
| Brassicaceae    | <i>Rorippa microphyllum</i>        | onerow yellowcress         | •    |      |      |
| Brassicaceae    | <i>Rorippa sylvestris</i>          | creeping yellow cress      |      |      | •    |
| Rosaceae        | <i>Rubus rigidus</i>               |                            | •    |      |      |
| Polygonaceae    | <i>Rumex acetosella</i>            | common sheep sorrel        | •    |      |      |
| Polygonaceae    | <i>Rumex crispus</i>               | curley dock                | •    | •    | •    |
| Polygonaceae    | <i>Rumex obtusifolius</i>          | bluntleaf dock             |      |      | •    |
| Polygonaceae    | <i>Rumex patientia</i>             | patience dock              |      |      | •    |
| Polygonaceae    | <i>Rumex pulcher</i>               | fiddle dock                |      |      | •    |
| Polygonaceae    | <i>Rumex stenophyllus</i>          | narrowleaf dock            |      | •    | •    |
| Salicaceae      | <i>Salix X sepulcralis</i>         | weeping willow             |      | •    |      |
| Chenopodiaceae  | <i>Salsola collina</i>             | slender Russian thistle    |      |      | •    |
| Chenopodiaceae  | <i>Salsola kali</i>                | prickly Russian thistle    | •    | •    | •    |
| Chenopodiaceae  | <i>Salsola tragus</i>              | prickly Russian thistle    | •    | •    | •    |
| Lamiaceae       | <i>Salvia uliginosa</i>            | bog sage                   |      |      | •    |
| Adoxaceae       | <i>Sambucus nigra</i>              | European black alder       | •    |      |      |
| Primulaceae     | <i>Samolus valerandi</i>           | seaside brookweed          |      | •    |      |
| Asteraceae      | <i>Sanvitalia procumbens</i>       | Mexican creeping zinnia    |      | •    |      |
| Caryophyllaceae | <i>Saponaria officinalis</i>       | bouncingbet                |      |      | •    |
| Poaceae         | <i>Schedonorus pratensis</i>       |                            | •    |      |      |
| Anacardiaceae   | <i>Schinus molle</i>               | American pepper            | •    |      |      |
| Poaceae         | <i>Schismus arabicus</i>           | Arabian schismus           | •    |      |      |
| Poaceae         | <i>Schismus barbatus</i>           | common Mediterranean grass | •    |      |      |
| Asteraceae      | <i>Scorzonera laciniata</i>        | cutleaf vipergrass         |      |      | •    |
| Poaceae         | <i>Setaria adhaerens</i>           | burr bristlegrass          |      | •    |      |
| Poaceae         | <i>Setaria italica</i>             | Italian bristle grass      |      | •    |      |
| Poaceae         | <i>Setaria pumila</i>              | yellow bristlegrass        | •    | •    | •    |
| Poaceae         | <i>Setaria verticillata</i>        | hooked bristlegrass        |      | •    |      |
| Poaceae         | <i>Setaria viridis</i>             | green bristlegrass         | •    | •    | •    |
| Rubiaceae       | <i>Sherardia arvensis</i>          | blue fieldmadder           |      |      | •    |
| Malvaceae       | <i>Sida abutilifolia</i>           | prostrate sida             | •    | •    | •    |
| Caryophyllaceae | <i>Silene gallica</i>              | windmill catchfly          |      | •    |      |
| Brassicaceae    | <i>Sinapis arvensis</i>            | charlock mustard           |      | •    | •    |
| Brassicaceae    | <i>Sisymbrium altissimum</i>       | tumble mustard             | •    | •    | •    |
| Brassicaceae    | <i>Sisymbrium irio</i>             | London rocket              | •    | •    | •    |
| Brassicaceae    | <i>Sisymbrium officinale</i>       | hairypod hedgemustard      |      |      | •    |
| Brassicaceae    | <i>Sisymbrium orientale</i>        | Indian hedgemustard        | •    |      |      |
| Solanaceae      | <i>Solanum sisymbriifolium</i>     | sticky nightshade          |      | •    |      |
| Solanaceae      | <i>Solanum villosum</i>            |                            |      | •    |      |
| Asteraceae      | <i>Sonchus asper</i>               | spiny sowthistle           | •    | •    | •    |
| Asteraceae      | <i>Sonchus oleraceus</i>           | annual sowthistle          | •    | •    | •    |
| Poaceae         | <i>Sorghum bicolor</i>             | broomcorn                  | •    | •    |      |
| Poaceae         | <i>Sorghum halepense</i>           | Johnsongrass               | •    | •    | •    |
| Caryophyllaceae | <i>Stellaria media</i>             | common chickweed           | •    |      | •    |

| Family           | Scientific Name               | Common Names            | SODN | CHDN | SOPN |
|------------------|-------------------------------|-------------------------|------|------|------|
| Oleaceae         | <i>Syringa vulgaris</i>       | common lilac            |      |      | •    |
| Asteraceae       | <i>Tagetes minuta</i>         | wild marigold           | •    |      |      |
| Tamaricaceae     | <i>Tamarix aphylla</i>        | Athel tamarisk          | •    | •    |      |
| Tamaricaceae     | <i>Tamarix aralensis</i>      | Russian tamarisk        | •    |      |      |
| Tamaricaceae     | <i>Tamarix chinensis</i>      | Chinese tamarisk        | •    | •    | •    |
| Tamaricaceae     | <i>Tamarix gallica</i>        | French tamarisk         |      | •    | •    |
| Tamaricaceae     | <i>Tamarix ramosissima</i>    | saltcedar               | •    | •    | •    |
| Asteraceae       | <i>Taraxacum laevigatum</i>   | red-seed dandelion      | •    |      | •    |
| Asteraceae       | <i>Taraxacum officinale</i>   | common dandelion        |      | •    | •    |
| Asteraceae       | <i>Taraxacum palustre</i>     | marsh dandelion         | •    |      |      |
| Poaceae          | <i>Thinopyrum intermedium</i> | intermediate wheatgrass |      |      | •    |
| Poaceae          | <i>Thinopyrum ponticum</i>    | rush wheatgrass         |      |      | •    |
| Poaceae          | <i>Thinopyrum pycnanthum</i>  | tick quackgrass         |      | •    |      |
| Brassicaceae     | <i>Thlaspi arvense</i>        | field pennycress        | •    | •    | •    |
| Apiaceae         | <i>Torilis arvensis</i>       | spreading hedgeparsley  |      | •    | •    |
| Apiaceae         | <i>Torilis nodosa</i>         | knotted hedgeparsley    |      |      | •    |
| Commelinaceae    | <i>Tradescantia wrightii</i>  | Wright's spiderwort     |      | •    |      |
| Asteraceae       | <i>Tragopogon dubius</i>      | western salsify         | •    | •    | •    |
| Asteraceae       | <i>Tragopogon porrifolius</i> | purple salsify          |      | •    |      |
| Asteraceae       | <i>Tragopogon pratensis</i>   | meadow salsify          | •    |      | •    |
| Euphorbiaceae    | <i>Triadica sebifera</i>      | Chinese tallow tree     |      | •    | •    |
| Zygophyllaceae   | <i>Tribulus terrestris</i>    | puncturevine            | •    | •    | •    |
| Fabaceae         | <i>Trifolium campestre</i>    | big-hop field clover    |      |      | •    |
| Fabaceae         | <i>Trifolium dubium</i>       | small hop clover        |      | •    | •    |
| Fabaceae         | <i>Trifolium pratense</i>     | red clover              |      |      | •    |
| Fabaceae         | <i>Trifolium repens</i>       | white clover            | •    |      | •    |
| Poaceae          | <i>Triticum aestivum</i>      | common wheat            | •    | •    | •    |
| Typhaceae        | <i>Typha angustifolia</i>     | narrowleaf cattail      |      | •    | •    |
| Ulmaceae         | <i>Ulmus pumila</i>           | Siberian elm            |      | •    | •    |
| Urticaceae       | <i>Urtica dioica</i>          | stinging nettle         |      |      | •    |
| Scrophulariaceae | <i>Verbascum blattaria</i>    | moth mullein            | •    |      |      |
| Scrophulariaceae | <i>Verbascum thapsus</i>      | common mullein          | •    | •    | •    |
| Scrophulariaceae | <i>Verbascum virgatum</i>     | wand mullein            | •    |      |      |
| Verbenaceae      | <i>Verbena brasiliensis</i>   | Brazilian vervain       |      | •    | •    |
| Verbenaceae      | <i>Verbena officinalis</i>    | herb of the cross       | •    |      |      |
| Scrophulariaceae | <i>Veronica agrestis</i>      | field speedwell         |      |      | •    |
| Scrophulariaceae | <i>Veronica arvensis</i>      | corn speedwell          |      |      | •    |
| Fabaceae         | <i>Vicia sativa</i>           | narrowleaf vetch        |      |      | •    |
| Fabaceae         | <i>Vicia villosa</i>          | hairy vetch             |      |      | •    |
| Apocynaceae      | <i>Vinca major</i>            | giant periwinkle        | •    |      |      |
| Apocynaceae      | <i>Vinca minor</i>            | lesser periwinkle       |      |      | •    |
| Verbenaceae      | <i>Vitex agnus-castus</i>     | chaste tree             |      | •    |      |
| Poaceae          | <i>Vulpia myuros</i>          | rattail fescue          | •    |      |      |
| Asteraceae       | <i>Xanthium spinosum</i>      | spiny cocklebur         |      | •    |      |
| Asteraceae       | <i>Zinnia peruviana</i>       | Peruvian zinnia         | •    |      |      |
| Rhamnaceae       | <i>Ziziphus mauritiana</i>    | Indian jujube           |      | •    |      |