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Natural Resource Stewardship and Science

Multi-Network Exotic Plant Monitoring Protocol

A Collaboration Among The Southern Plains, Sonoran Desert, and Chihuahuan Desert Networks

Narrative Version 1.00

Natural Resource Report NPS/SOPN/NRR—2016/1304



ON THE COVER

Cheatgrass Infestation
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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), non-native species have profound impacts worldwide on the environment, economies, and human health.

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). Non-native plants claim an estimated 4,600 acres per day on federal lands alone in the western United States, quadrupling their range from 1985-1995, claiming approximately 17 million acres (BLM 2011), significantly altering local flora. For example, in Great Smoky Mountains National Park, over ¼ of the plants (27%) are non-native species, and on the big island of Hawaii, 35% of the plants are non-native (Pimentel et al. 2005). Invasive plants infest an estimated 2.6 million acres of the 83 million acres managed by the NPS.

The most effective, economical, and ecologically sound method of managing weeds is to prevent their invasion in the first place. Proactive weed management relies on management of existing infestations, but with a strong focus on prevention or early detection of new invasions (Weed Center n.d., USDA 2001). Invasive exotic species most certainly will continue to be a management priority for the National Park Service 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 (2.47 acres; Rejmanek and Pitcairn 2002). Eradication of infestations larger than 100 hectares (247 acres) 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 non-native species problem in the United States, the U.S. 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

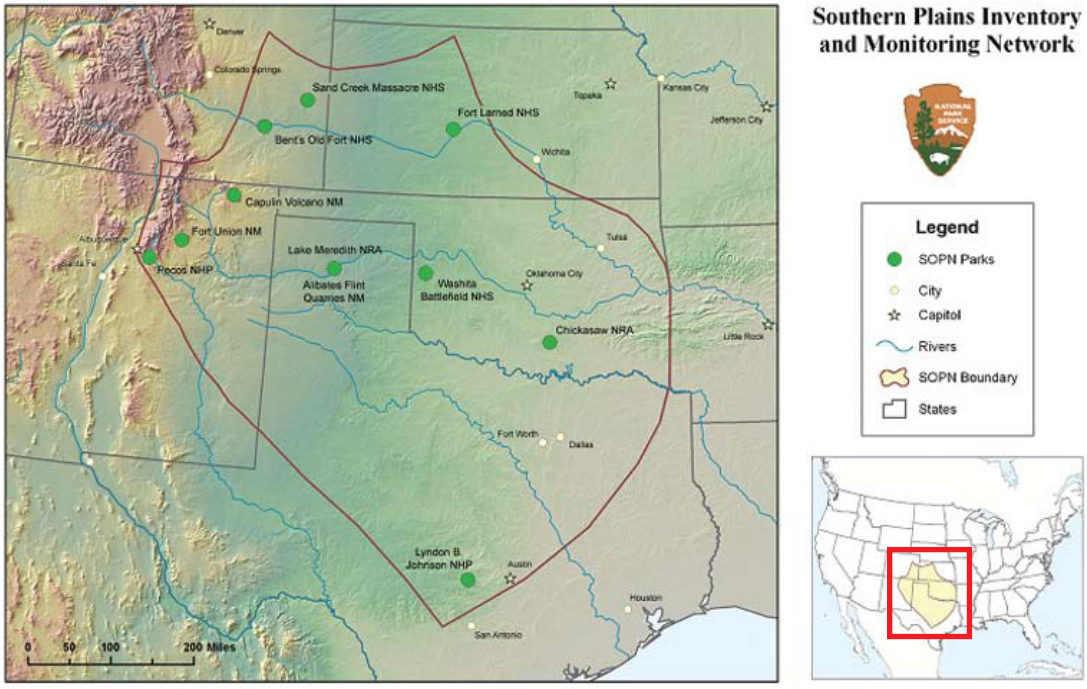


Figure 1.2.1. Parks in the Southern Plains Network.

detection monitoring to ensure 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).

1.2. Overview of Exotics and Monitoring at Network Parks

The 29 parks within the Southern Plains Network, Sonoroan Desert Network, and Chihuahaun Desert Network have recognized the need for better early detection and eradication of exotic plants. While there are many approaches to monitoring exotic plants, not all networks had need of an expanded detection protocol. This protocol has been designed to provide a uniform approach for all networks that addresses the most critical areas within our parks. Each network is free to add additional detection methods as needed.

1.2.1. Southern Plains Network

The Southern Plains Inventory and Monitoring Network (SOPN) is composed of 11 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 they range in size from 326 acres (WABA) to 46,349 acres (LAMR). CHIC, FOLS, LYJO, and WABA are in mixed grass prairie or savanna. 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 (see Appendix A for more detail).

1.2.2. Sonoran Desert Network

The Sonoran Desert Inventory and Monitoring Network (SODN) is 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

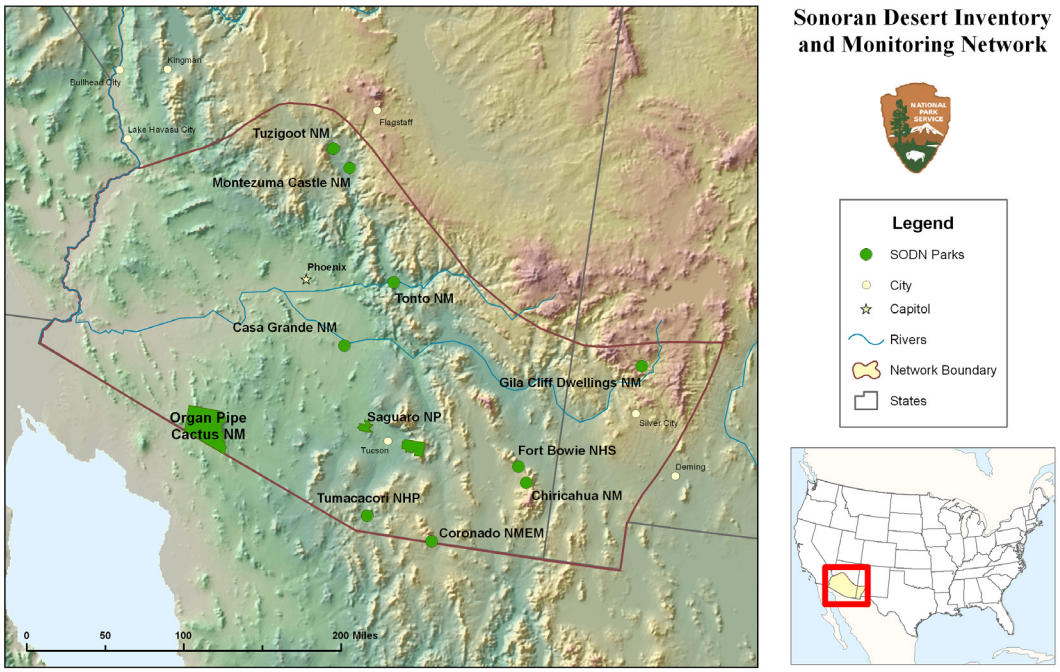


Figure 1.2.2. Parks in the Sonoran Desert Network.

histories, making each park a novel system for invasion susceptibility. Situated in the sky island region, Saguaro National Park (SAGU), Organ Pipe Cactus 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 (See Appendix B for more detail).

1.2.3. Chihuahuan Desert Network

The Chihuahuan Desert Inventory and Monitoring Network (CHDN) is composed of seven 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 (WHSA) (Figure 1.2.3). The parks vary in size from almost 200 ha (500 acres) at FODA to over 300,000 ha (800,000 acres) 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.

1.3. Measurable Objectives for the Exotic Plant Protocol

As a complement to the management strategy of early detection and rapid response, the networks have incorporated the following objectives into its monitoring plan for Exotic Plants:

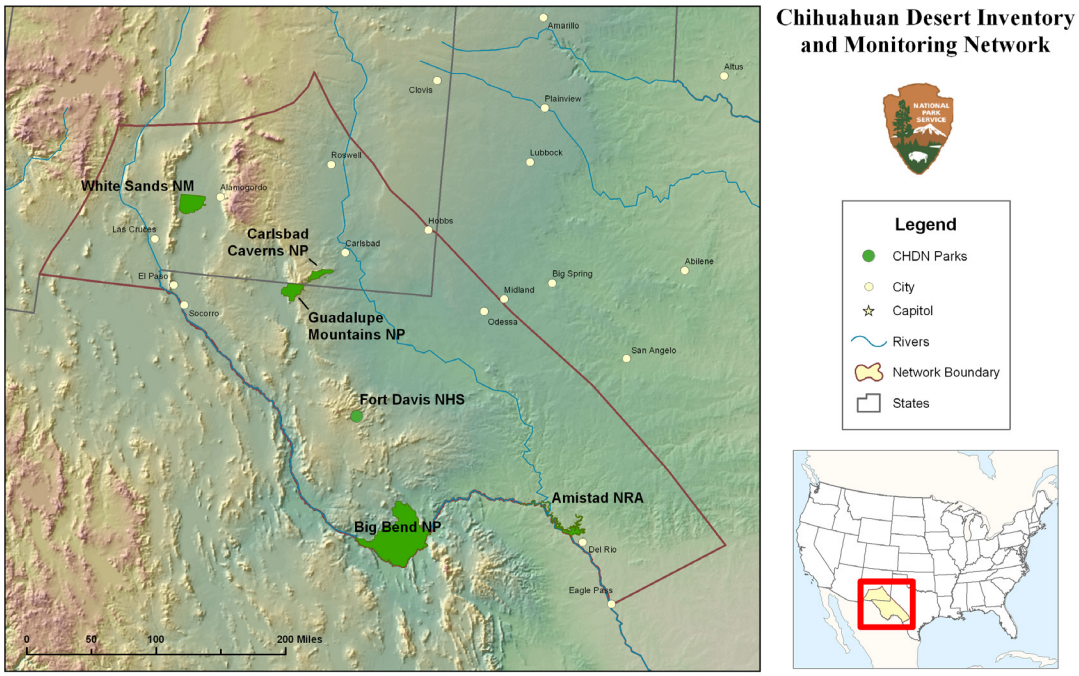


Figure 1.2.3. Parks in the Chihuahuan Desert Network.

- Detect the initial occurrence of invasive exotic species in park units in areas of both high and low invasion probability. Early detection will be implemented along high probability areas, while low probability areas can be assessed during data collection for other protocols.
- Determine changes in the status and trend (density, abundance or extent) of a subset of high priority species in selected areas. While all exotic species are monitored, special emphasis will be placed on species of major concern.
- Determine changes in invasive species composition in park units, taking into account any management treatments that occurred between sampling intervals. For example, is an eradicated exotic replaced by a native plant or another exotic?

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 integrated invasive plants monitoring into other protocols. Because of its high importance to network parks, SOPN, SODN, and CHDN 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 primarily along the highest risk invasion vectors (e.g., roads, trails, and waterways) of our parks. Areas of lower introduction probability (e.g., interior landscapes) can be monitored, when warranted, through an integrated approach with other protocols.

2.1. A Hierarchical Three-Tiered Approach

Our overall approach incorporates three different components (tiers) of sampling, each intended to complement the others (Table 2.1):

Tier 1. Systematic Rotating Panel Design for the Highest Risk Vectors
- Highest risk vectors (e.g., roads, trails, and waterways) would be monitored using a rapid sampling technique. This approach assigns each invasive exotic 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; the results can also be represented spatially, and quickly communicated to park management or Exotic Plant Management Teams (EPMTs).

Tier 2. Systematic Monitoring of Interior Sites as part of our Grassland, Riparian or Upland Monitoring
- Interior habitats away from high risk vectors are monitored in conjunction with other vegetation monitoring, when warranted.

Tier 3. Supplementary Monitoring of Lesser Risk Vectors using Same Field Methods as Tier 1
- A second set of lower risk vectors (e.g., interior landscapes) are identified for any supplementary monitoring by parks, citizen science groups, 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. Systematic Rotating Panel Design for the Highest Risk Vectors (Tier 1)

Preliminary pilot efforts in 2008 in SOPN indicated that we are able to sample approximately 160 blocks per day (see Chapter 3), eight linear kilometers for vectors with one side (e.g., park unit boundaries), or four linear kilometers for vectors with two sides (interior trails and roads). Thus, for most of the smaller parks (< 5,000 acres), this will enable all of the highest risk vectors to be

Table 2.1. The three 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 exotic species along the highest risk invasion vectors.	Each network
Systematic Monitoring of Interior Sites as part of our Grassland/ Riparian Monitoring	All exotic 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 science groups

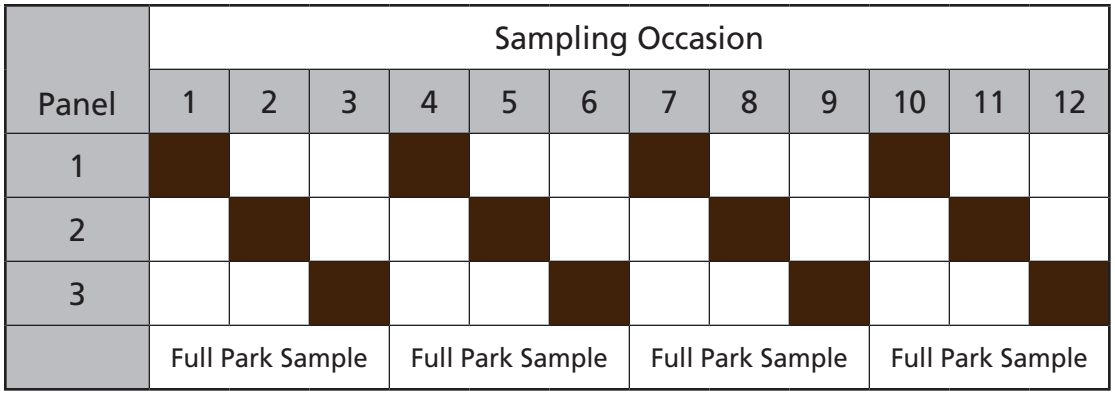


Figure 2.1.1. A basic three-year rotating panel revisit design where a full sample of each park is completed and repeated every three years.

sampled on a 3-year rotation (Figure 2.1.1). Larger parks will select their areas of most concern from a range of high-risk vectors. For example, CHDN and its parks identified vectors and sampling frequency, which range from a 6-month to a 3-year rotation (see Appendix C for park-specific details). Surveys occur in the spring and fall in CHDN parks to capture the phenology of warm- and cool-season species.

The networks will continue this effort in all parks. We 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 Appendix A, B or C (according to network). Also note that some additional details on the pilot sampling efforts in 2008 are described in Section 2.2

2.1.2. Design for Systematic Monitoring of Interior Sites as part of Grassland/ Riparian and Upland Monitoring (Tier 2)

The design for Tier 2 of this effort is described in detail elsewhere (Folts et al. 2009, Hubbard et al. 2012) as part of our other monitoring. All three networks involved in this protocol carry out vegetation monitoring in their parks using various methodologies appropriate for their habitats. In all cases, data collected during this monitoring includes the identification of exotic plants. This information can be provided in annual reporting to supplement data on the detection and distribution of these populations.

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., citizen science groups). As such, we might expect less consistency in effort among the networks and/or parks, which will need to be accounted for as part of any analysis.

2.2. Pilot Sampling Efforts

Piloting for this protocol began in the Southern Plains Network in 2008 and 2009 followed by pilots in the Chihuahuan and Sonoram Desert Networks. All parks were included in these pilot efforts. The basic methods presented in this protocol were used and refined as work proceeded in these various habitats. The sampling time/distance ratio improved as each crew became familiar with methodology and work flow, enabling greater sampling distances per visit in subsequent years. Species recognition, while a cumulative skill, has not been problematic, especially when one crew member is experienced in the protocol. Pictorial guides of less common species or potential species for the area has aided rapid detection and identification of these species. Revisits have proven to be easily repeatable. This protocol works best in open environments with good line-of-sight and may not be suitable for use in areas with tall, dense vegetation.

3. Field Methods

The following field methods have been developed to provide a basis for early detection and monitoring across multiple networks, parks, and habitats, to ensure a common approach to initial data collection. Additional detection methods can be customized to meet each network's needs for supplemental information, but are not considered in this protocol. Areas in the interior of each park with a relatively low probability of initial invasion by exotic plants are sampled in conjunction with other ongoing vegetation monitoring (Folts-Zettner et al. 2009, Hubbard et al, 2012). These areas are also potentially sampled through additional park efforts and opportunistic encounters by park staff or visitors.

The number of exotic species that are included in the search can be all known exotic species in the park, or a subset of these that are of most concern (for invasion). If a subset is chosen, it should be done in consultation with the park. Adequate plant ID resources should be provided to the crew for quick identification in the field.

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). This is accomplished by determing all potential vectors and prioritizing them in consultation with appropriate park staff. The extent of survey is dependent upon a realistic time budget for each visit and augmented by a multi-year rotating panel.

The primary sample units along these high risk vectors consist of blocks, 50 meters in length, along both sides (right [R] and left [L]) of the vector (except for park boundaries; Figure 3.1.). The transect (line walked by each observer) runs parallel to the vector and is 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 into the landscape from the vector edge. Exceptions to this rule are discussed in detail in Section 3.4.1

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 a greater area sampled 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 of the area for additional occurrences by park staff or EPMTs.

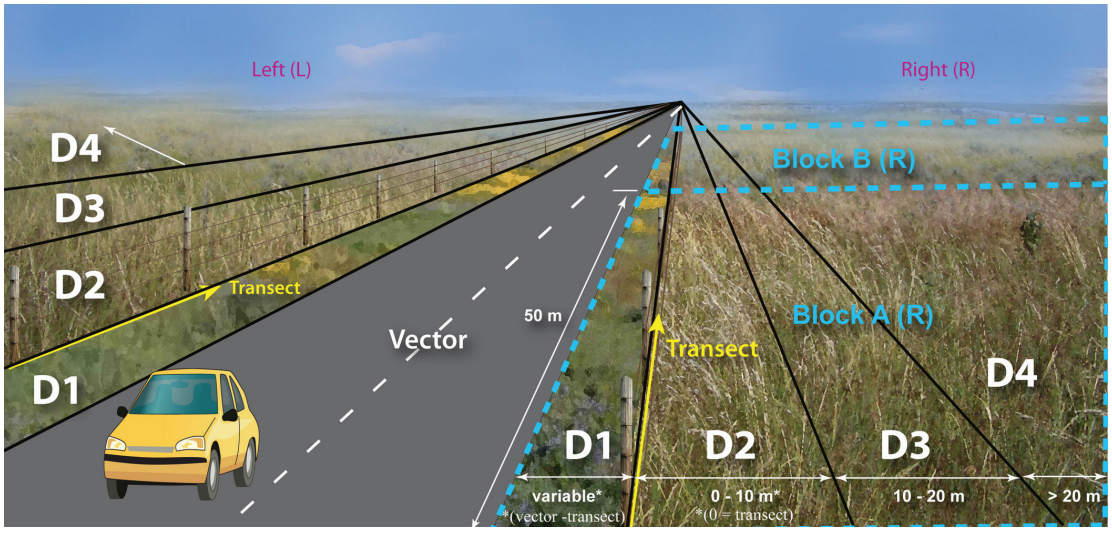


Figure 3.1. Fifty-meter blocks are sampled on each side of a vector (e.g., roads and trails) in each of four distance classes from the vector.

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 it tends to remain localized near the source of likely invasion. Some species, such as mullein (*Verbascum thapsus)*, appear equally likely to be found in all distance classes, indicating that they are 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 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 represent 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 the 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 the 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 Standard Operating Procedures (SOPs). It is important that each member of the field crew is thoroughly familiar with the elements of the design and SOPs 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. The tasks involved in preparing for a field sampling tour include:

- Annual sampling effort. Identification of all vectors and blocks to be sampled and preparation of spatial data and data collection equipment. Typically conducted by the PI or protocol lead.
- Scheduling of sampling dates and arranging logistics. This work is conducted prior to the start of each field season and should address timing for peak phenology, collection permits (where applicable) and location review for access issues.
- Plant identification training. Ample time should be set aside to compile the appropriate species lists and to familiarize crew members with the target species.

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 points in UTMs at the survey

pin during the initial sampling visit. This will enable GIS mapping of vectors 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. Refer to the specific manual for the GPS unit for instructions on marking a point.

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 of 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 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. Once data have been collected from the vector blocks, repeat the measurement process for the next set of blocks. GPS point readings will now be needed only 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, pointing in the direction of travel. The second photo should be taken from the center of the vector, pointing 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. Photos should be downloaded at the end of each sampling day and immediately renamed using approved naming conventions (see various SOPs).

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 (Figure 3.4.1). Only the park side of the boundary is sampled for various reasons (e.g., sometimes the view onto the adjacent land is obstructed; and NPS has no authority over the management of private land in the event that the source of invasion is coming from outside the park).

3.4.2. Prepare Data Collection Sheet

Prior to the beginning of the block sampling, two sets of data sheets are prepared (SOP #02), one set for each side of the vector. Park, vector type (paved, unpaved, trail, etc.), side of vector surveyed, width of mow strip or Distance Class 1, date, observer, and photo numbers are recorded. Each vector block monitored is assigned a consecutive number and beginning point UTMs, which, by default, are frequently the ending points of the previous vector block.

A digital data collection platform is being developed and, once complete, will be presented in a revision of the protocol. It is also possible to enter data directly into the database using a ruggedized notebook. See Section 4 – Data Management for more information.

3.4.3. Calibrate Distance 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

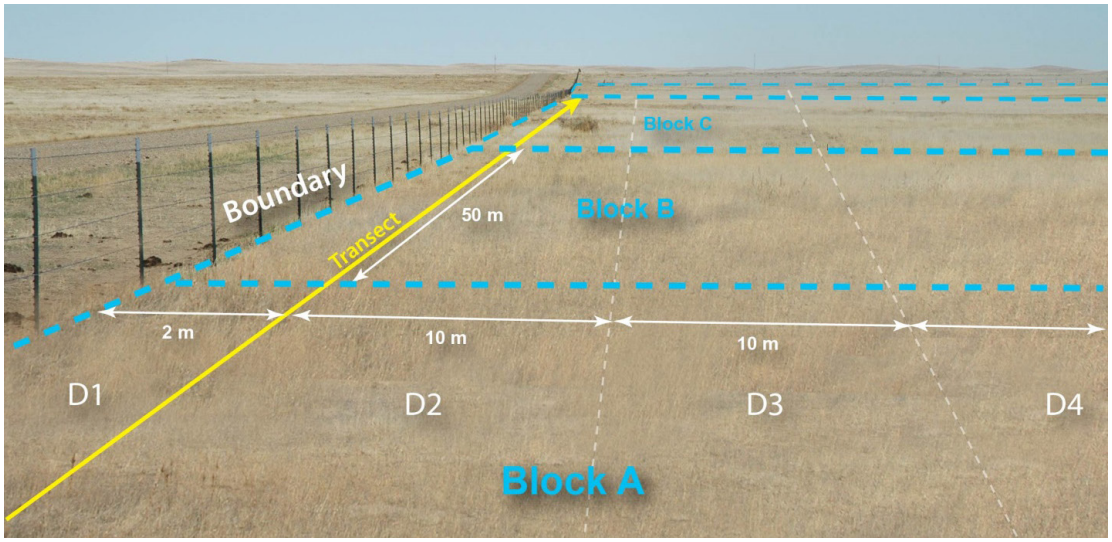


Figure 3.4.1. Alternate transect establishment for boundaries.

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 in any distance class. As a temporary reminder, a tick mark can be placed in the corner of each distance class in which a specific species is observed. Place an "X" in the appropriate distance class if topography, habitat, or structures preclude 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. Then set up the next block transect (see 3.3.1), and repeat the procedure. Note that the detection method discussed here is known to deteriorate with distance to/from the exotic plant(s) observed; however, this is taken into account in the analyses. Also, pattern recognition (e.g., for shape, color, form) assists observers in the identification of more distant plants.

When walking along the transect, there are situations in which sampling is precluded by vegetation or terrain. In such 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 to which seeds can adhere. 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. Specimens 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 #03). 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 the 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.

Regarding unknown species, note that field experience thus far (e.g., pilot data collection) has resulted in very few unknown plants, and most unknown plants are later identified.

3.6. End-of-Season Procedures

3.6.1. Equipment Maintenance

Use the Equipment List found in SOP#01 (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 for ensuring complete resolution of all unknown plants. Plants are identified to species level whenever possible, with genus or family levels as secondary options. If a plant is unable to be identified, the sample and notes are retained in the file in order to attempt identification and/or collection of a better sample during the following field season. The unknown is not used in the analysis because there is no confidence that it is an exotic plant species.

3.6.3. Data Management

The field crew leader is responsible for ensuring that all data sheets are completed properly, and that all digital photos are processed according to labeling and naming conventions (SOP #05).

3.6.4. New Species

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

3.6.5. Protocol Review Process

Prior to the departure of the field crew at the end of the season, 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 cyclical process that starts before field season begins and continues until the beginning of the field season the following year. The cycle is repeated every 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 #05 and 06.

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. An "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 (Visual Basic for Applications) 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.The database can be shared upon request.

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. Each network maintains its own database of all its parks, but one collaborative database containing all three networks' data is also maintained.

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 #06), 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 manually recorded on paper field data sheets, (2) data are entered directly into the project database on ruggedized field laptop computers, or 3) data are downloaded from handheld data loggers.

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 #05) and office (SOP #06) 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 data loggers are processed as specified in SOP #06.

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 can be 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 #06 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 #06 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/nrdata/tools/dme.cfm) and the ArcCatalog (ESRI, Inc.) metadata module in conjunction with the NPS Metadata Tools & Editor (http://science.nature.nps.gov/nrdata/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./nrdata/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 are 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.

A map of the individual vector blocks surveyed and their identifying number is also provided in annual summaries to facilitate (re) location of plant populations. Additionally, distribution and density maps of specific exotic species can be generated using annual data. Individual parks and the Invasive Plant Program (IPP) can request maps for specific species for use in their eradication programs.

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:

$$E(Yi) = \beta 0 + \beta 1X1 + \beta 2X2 \ldots \beta kXk$$

where E(Yi) is the expected value of Y at time i, β0 is the intercept, and βiXi is the explanatory effect βi of variable Xi. 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 - The 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). It should be noted that that these data, especially from vector blocks, are highly spatially autocorreltated, and we will be working with a statistician to determine the best means of accounting for correlation. The results from that effort will be presented in subsequent versions of this protocol.

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, in 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., α 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).

A 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 with only an 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 for individual parks will be hierarchical and intended for multiple audiences and media. A primary delivery systems for all reports will be the Integrated Resource Management Applications (IRMA) web portal, https://irma.nps.gov/Portal. IRMA is a on line web portal that houses information in mulitple formats (documetns, reports, publications, datasets and species-lists) related to National Park Service natural and cultural resources.

Another delivery system for all reports will be the Internet, via the Learning Center of the American Southwest (LCAS), http://www.soutwestlearning.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).

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

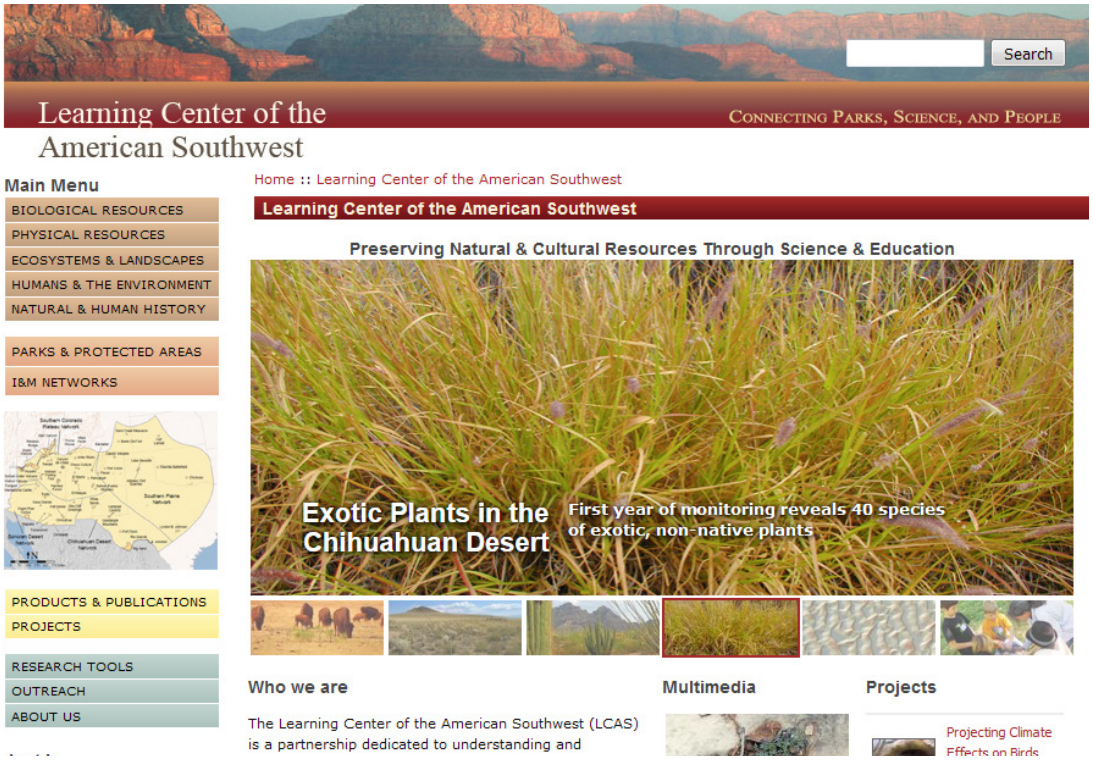


Figure 6.1. The home page of the Learning Center of the American Southwest enables navigation via a given resource or via a given park unit or network.

Table 6.1. Hierarchy of primary products produced for the Learning Center of the American Southwest.

Product	Primary Purpose/ Scope	Primary Target Audience(s)	Scale	Length	Frequency
Resource Brief	Status and trend of exotic plants.	Superintendents/ 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/ Science Community	Each network with individual park sections	Variable	Every 6 Years

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.

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, it will 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 be available quickly to park managers and/or 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 of the crew members. It is anticipated that there will be two crew members responsible for efficient data collection.

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 pattern search techniques, 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 calibrated 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.

7.2.1. Training Observers

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

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. User manuals for the specific GPS unit to be used should be thoroughly reviewed. Training sessions described below will require field crew members to exercise the use of a GPS.

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.

Table 7.1. Roles, responsibilities, and minimum qualifications of the primary positions of this project.

Position	Roles	Responsibilities	Minimum Qualifications
Principal 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	• Hire other staff members (crew leader and members) • Coordinate field schedules and availability of supplies with the crew leader • Participate in the creation of (and possibly lead) training for crew leader and members • Inform network staff and cooperators of the progress of monitoring and any areas where adjustments may be needed • Act as a direct channel of communication between this project and others of this nature, thus building relationships and cooperation among this and similar projects • 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 be available for any questions pertaining to the data	• Excellence in identifying (and explaining the id of) native and exotic plant species found in network parks • Experience hiring personnel • Experience managing projects and communicating results in a clear and concise manner to all interested parties through a variety of media • Experience collecting and quality checking reliable data • 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	• Participate in field training • Act as the primary coordinator with respect to field schedules and supplies • Serve as the party who is primarily responsible for the safety of crew members and to conduct safety training for crew members • Accompany crew members in the field • Act as a direct liaison between the project manager and the crew members • Enter and quality check all data before submitting for analysis	• Experience performing field work • Experience training, leading, and coordinating crews • Experience with data collection, entry and quality assurance • Experience communicating with a variety of audiences, • Experience with teaching outdoor safety and route finding • Experience in identifying (and explaining the id of) native and exotic plant species found in network parks • Experience using a GPS unit • Ability to hike long distances and carry a heavy backpack
Crew Members	• Serves as the back-bone of the field operation by performing all field work related to the monitoring project	• Participate in field training • Alert crew leader of any scheduling conflicts or needed supplies • Account for the safety of yourself and others at all times • Responsible for all loaned equipment and its proper use • 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 • Capability to learn safety and route finding • Capability to learn the use of a GPS unit and undergo training if necessary • Experience communicating and working with a variety of personalities in close settings under arduous conditions • Ability to hike long distances and carry a heavy backpack • Preferably have experience performing field work in vegetation measurements, have experience working with dichotomous keys and identifying species, and have extensive hiking/ backpacking experience

8. Continual Improvement

Quality assurance extends beyond data management and must be an integral component of all aspects of the monitoring program. The U.S. 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). 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.

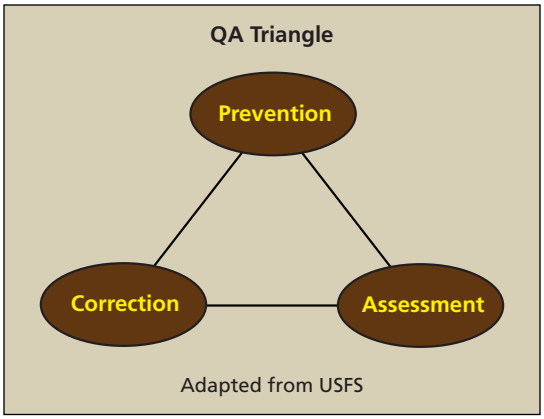


Figure 8. The quality assurance triangle. Adapted from the USFS.

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 (are) 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, which 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. Therefore, 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 fulfill information needs?

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 #07. 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 use 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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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 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 Invasive Plants Program, 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.

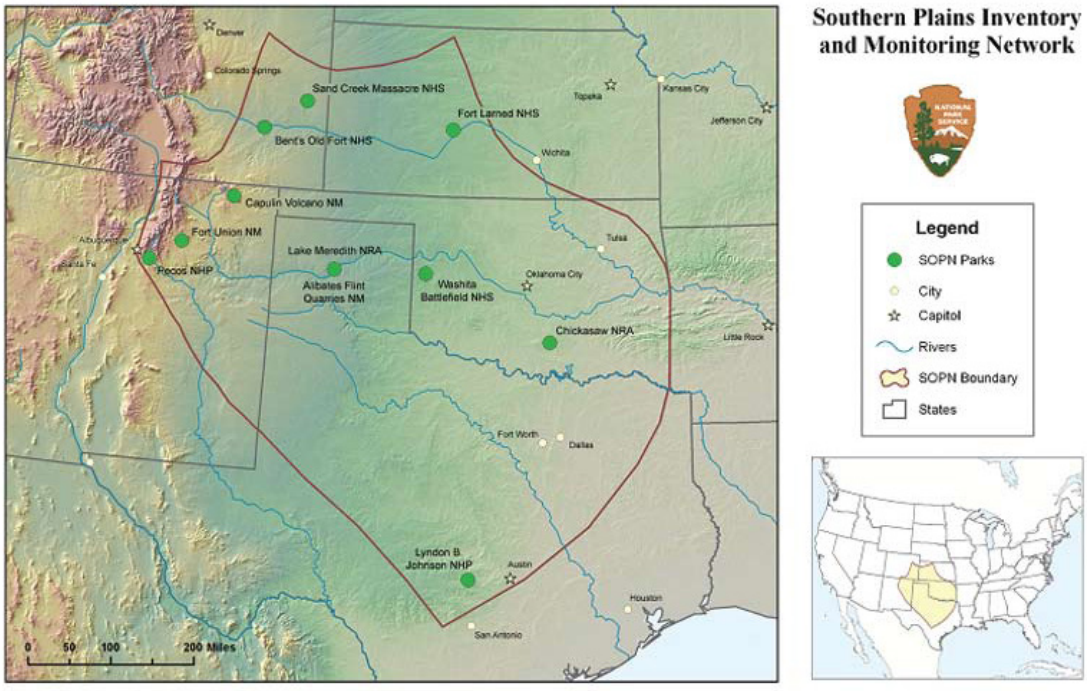


Figure A.1. Park location within the Southern Plains I&M Network.

A.1. 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 bristlegrass (*Setaria viridus)*, 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.

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.

Table A-1. Sampling frequency, panel ID, and length of exotics transects at BEOL.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
BEOL_EX_101	Main Maintenance / Oxbow Road	3 years	Panel Year 1	800
BEOL_EX_102	Path to Fort	3 years	Panel Year 1	250
BEOL_EX_103	Entrance Road	3 years	Panel Year 1	200
BEOL_EX_104	West Boundary	3 years	Panel Year 1	1800
BEOL_EX_201	Tamarisk Road - East	3 years	Panel Year 2	1000
BEOL_EX_202	East Road	3 years	Panel Year 2	1000
BEOL_EX_203	SE Oxbow Road - East	3 years	Panel Year 2	650
BEOL_EX_301	Hiking Trail	3 years	Panel Year 3	900
BEOL_EX_302	Oxbow Road - South	3 years	Panel Year 3	500
BEOL_EX_303	South Side Loop - Upper	3 years	Panel Year 3	900
BEOL_EX_304	Railroad	3 years	Panel Year 3	1500

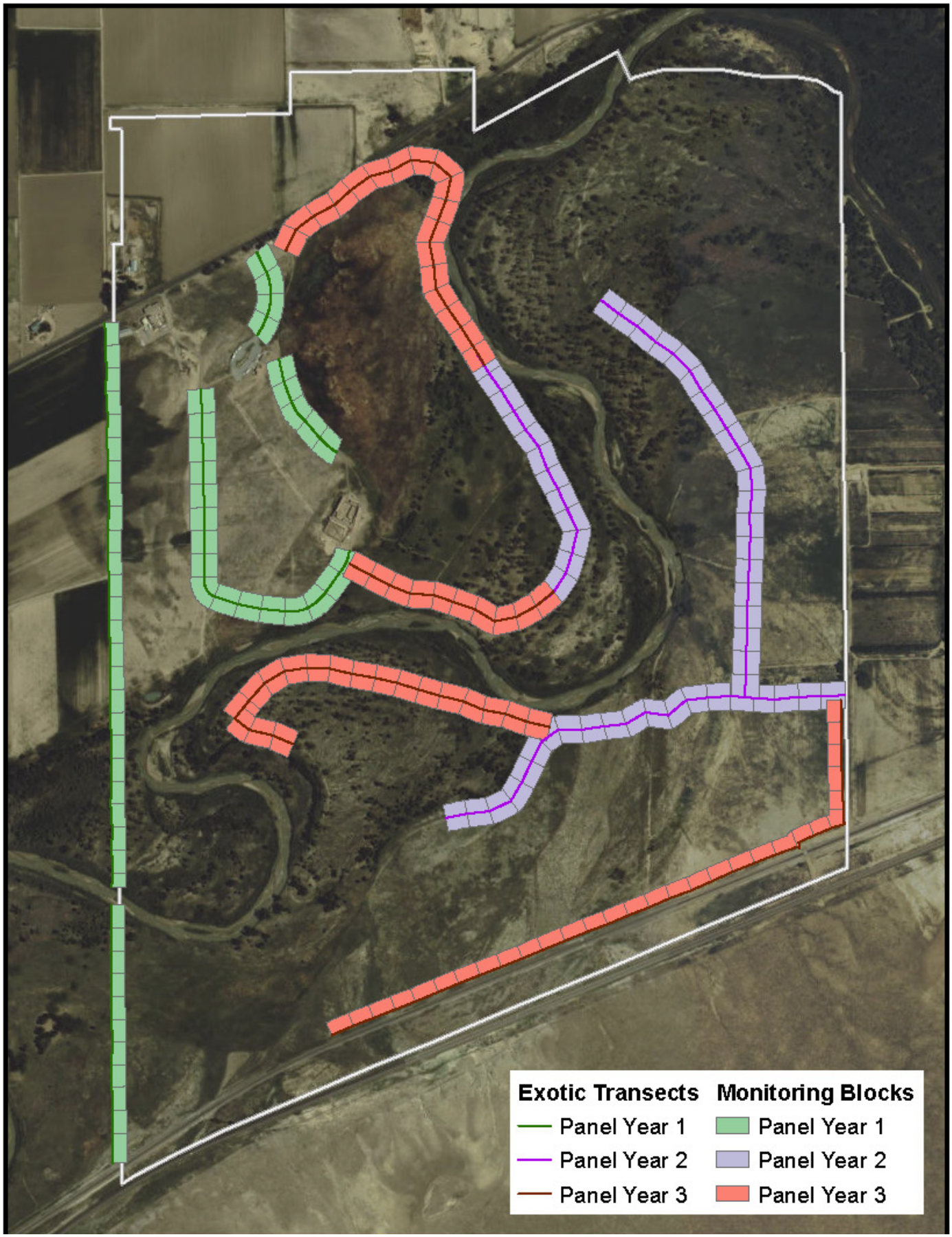


Figure A-2. Panel selection for BEOL

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)*, flixweed (*Descurainia sophia)*, kochia (*Kochia scoparia)*, Russian thistle (*Salsola tragus)*, yellow bristlegrass (*Setaria pumila)*, green bristlegrass (*Setaria viridus)* and mullein (*Verbascum thapsus)*.

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

Table A-2. Sampling frequency, panel ID, and length of exotics transects at CAVO.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
CAVO_EX_101	Boca Trail - South	3 years	Panel Year 1	250
CAVO_EX_102	Water Tank Road	3 years	Panel Year 1	200
CAVO_EX_103	Lava Flow Trail - North	3 years	Panel Year 1	650
CAVO_EX_104	Lava Flow Trail - West	3 years	Panel Year 1	200
CAVO_EX_105	East Boundary	3 years	Panel Year 1	1250
CAVO_EX_201	Crater Rim	3 years	Panel Year 2	450
CAVO_EX_202	Vent Trail	3 years	Panel Year 2	200
CAVO_EX_203	Main Road - West	3 years	Panel Year 2	700
CAVO_EX_301	Boca Trail - West	3 years	Panel Year 3	1200

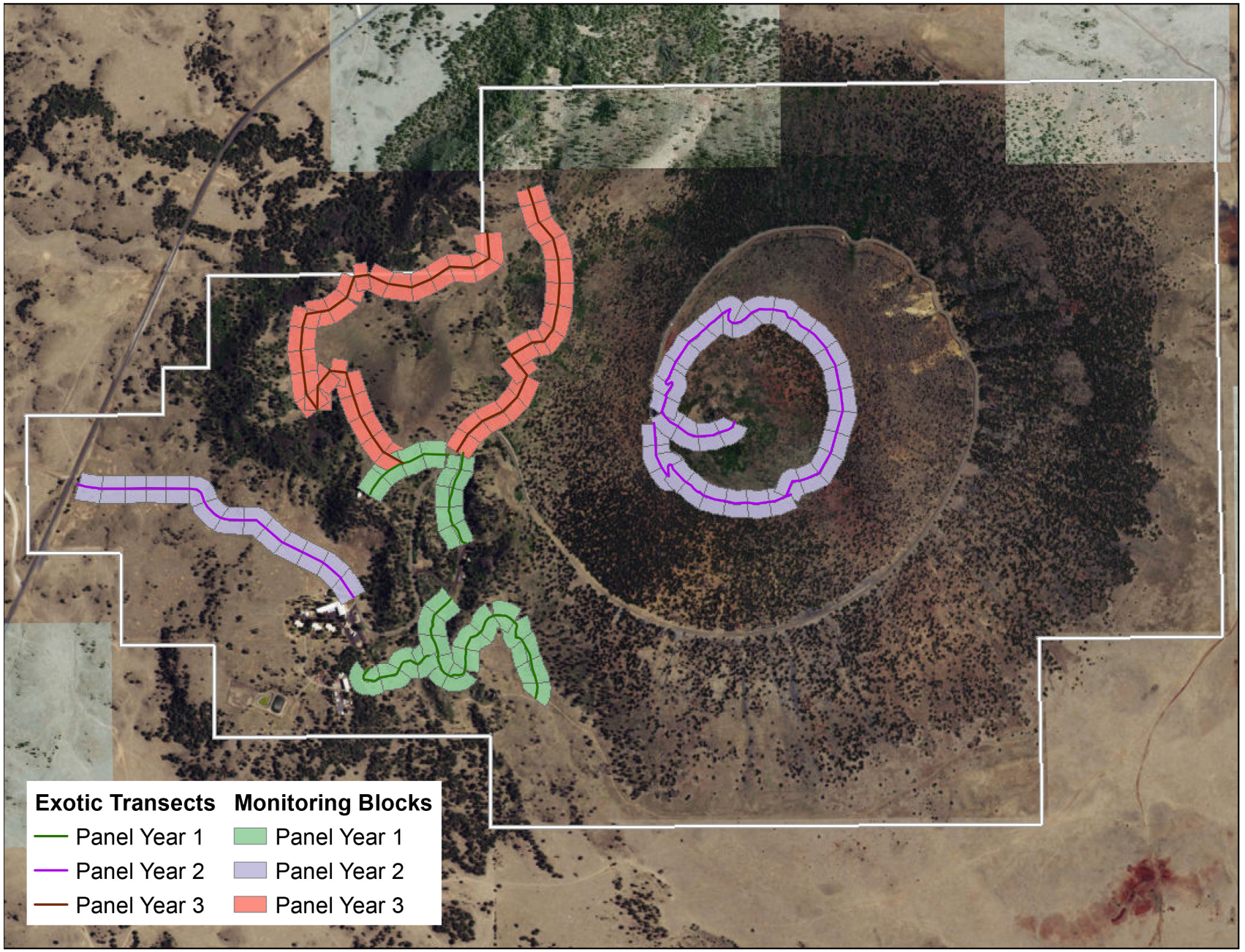


Figure A-3. Panel selection for CAVO.

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)*.

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).

Table A-3. Sampling frequency, panel ID, and length of exotics transects at CHIC.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
CHIC_EX_101	Buckhorn Road	3 years	Panel Year 1	1950
CHIC_EX_102	Cedar Blue Road	3 years	Panel Year 1	850
CHIC_EX_201	Trail 3	3 years	Panel Year 2	1000
CHIC_EX_202	Trail 1	3 years	Panel Year 2	1250
CHIC_EX_203	Trail Access Road	3 years	Panel Year 2	250
CHIC_EX_204	Sewage Treatment Road	3 years	Panel Year 2	700
CHIC_EX_301	East Guy Sandy	3 years	Panel Year 3	750
CHIC_EX_302	Breezy Point	3 years	Panel Year 3	450
CHIC_EX_303	West Guy Sandy	3 years	Panel Year 3	1050
CHIC_EX_304	E1750 ROAD	3 years	Panel Year 3	400
CHIC_EX_305	West Guy Sandy - Spur	3 years	Panel Year 3	550

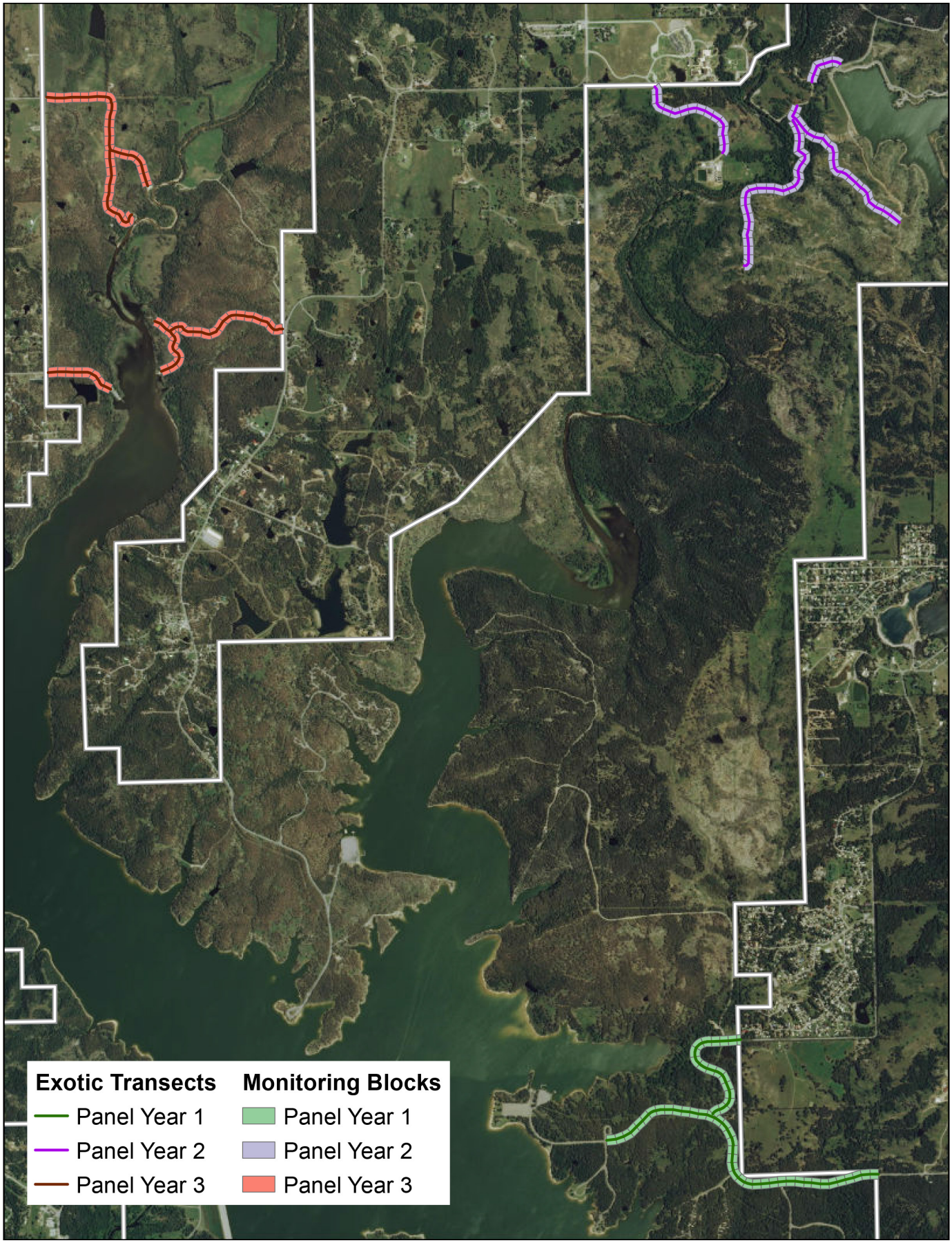


Figure A-4. Panel selection for CHIC.

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 abut 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.

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.

Table A-4. Sampling frequency, panel ID, and length of exotics transects at FOLS.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
FOLS_EX_101	Lower Trail	3 years	Panel Year 1	250
FOLS_EX_102	East Trail	3 years	Panel Year 1	1150
FOLS_EX_103	Rut Site	3 years	Panel Year 1	1800
FOLS_EX_201	Entrance Road / Trail	3 years	Panel Year 2	450
FOLS_EX_202	West Boundary	3 years	Panel Year 2	300
FOLS_EX_203	SW Corner Boundary	3 years	Panel Year 2	1050
FOLS_EX_301	Boundary - NW	3 years	Panel Year 3	1900
FOLS_EX_302	Boundary - S	3 years	Panel Year 3	3200

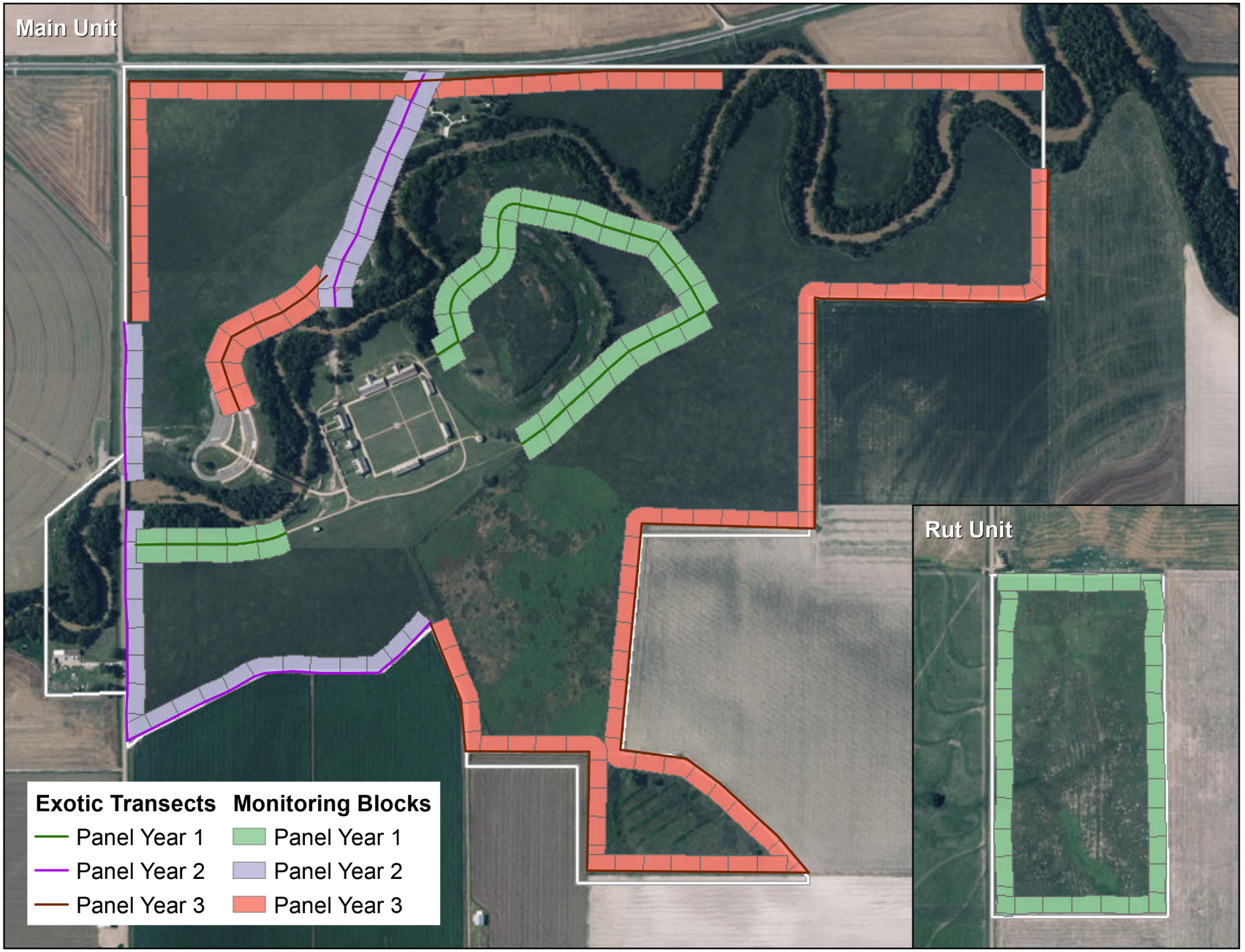


Figure A-5. Panel selection for FOLS.

A.6. Fort Union NM

Fort Union National Monument (FOUN) (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 FOUN 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.

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.

Table A-5. Sampling frequency, panel ID, and length of exotics transects at FOUN.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
FOUN_EX_101	Ruin Road	3 years	Panel Year 1	1700
FOUN_EX_102	West Spur	3 years	Panel Year 1	250
FOUN_EX_103	South Boundary	3 years	Panel Year 1	1800
FOUN_EX_201	Old Fort Trail	3 years	Panel Year 2	200
FOUN_EX_202	Old Fort Road	3 years	Panel Year 2	550
FOUN_EX_203	NE Dirt Road	3 years	Panel Year 2	900
FOUN_EX_204	Service Road	3 years	Panel Year 2	800
FOUN_EX_205	East Boundary	3 years	Panel Year 2	1600
FOUN_EX_301	Entrance Road	3 years	Panel Year 3	950
FOUN_EX_302	Service Road	3 years	Panel Year 3	750

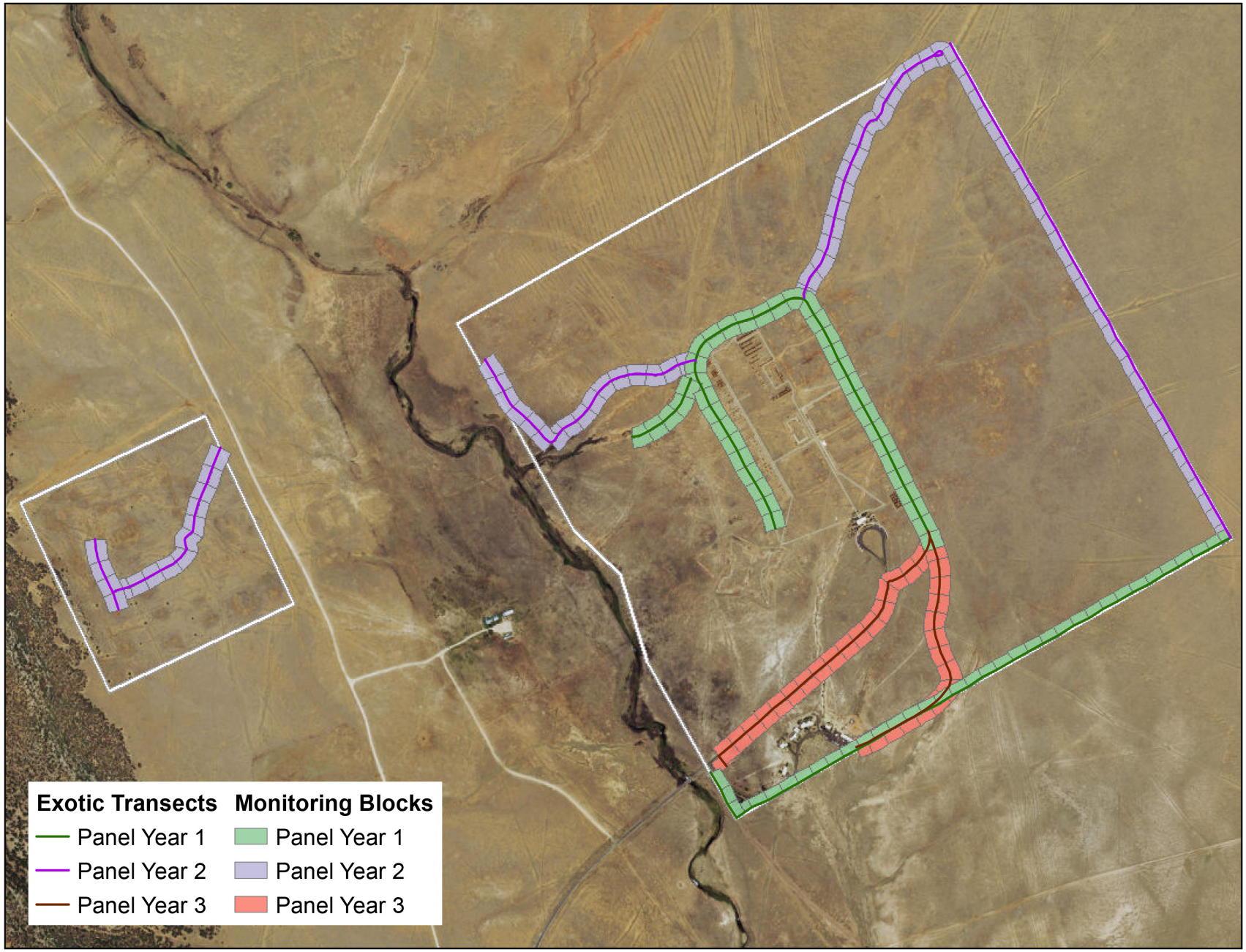


Figure A-6. Panel selection for FOUN.

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)*, flixweed (*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 viridus)*, Johnsongrass (*Sorghum halepense)*, tamarisk (*Tamarix* ssp.*.)*, 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.

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

Table A-6. Sampling frequency, panel ID, and length of exotics transects at LAMR.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
ALFL_EX_101	Alibates Road	3 years	Panel Year 1	2050
LAMR_EX_201	Sanford Yake Road	3 years	Panel Year 2	600
LAMR_EX_202	Cedar Canyon Road	3 years	Panel Year 2	850
LAMR_EX_203	Bugbee Road	3 years	Panel Year 2	750
LAMR_EX_301	Blue West Road - West	3 years	Panel Year 3	2600
LAMR_EX_302	Fritch Fortress Road	3 years	Panel Year 3	1350
LAMR_EX_303	Bates Canyon Road	3 years	Panel Year 3	850

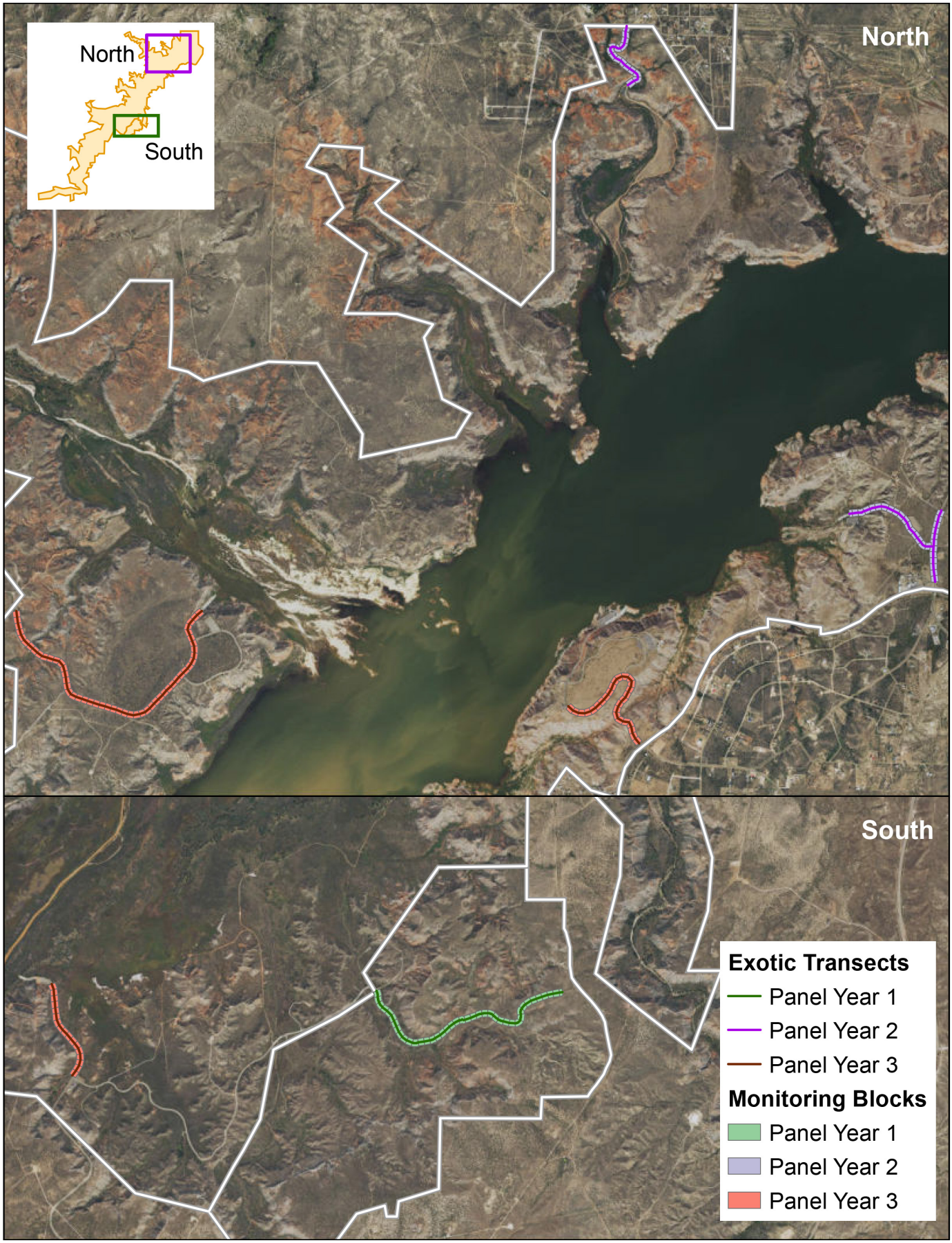


Figure A-7. Panel selection for LAMR and ALFL.

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 36th 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)*.

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).

Table A-7. Sampling frequency, panel ID, and length of exotics transects at LYJO.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
LYJO_EX_101	Restoration Loop	Annual	Panel Year 1	800



Figure A-8. Panel selection for LYJO.

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 Gloriets 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 (*Onopordun 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 puse (*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 viridus)*, puncturevine (*Tribulus terrestris)*, and mullein (*Verbascum thapsus)*. One other species, horehound (*Marrubium vulagare)* is of park-specific concern.

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 Lightening Ranch house and adjacent ranch lands (Panels 2 & 3).

Table A-8. Sampling frequency, panel ID, and length of exotics transects at PECO.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
PECO_EX_101	Forked Lightning Road	3 years	Panel Year 1	1500
PECO_EX_102	Pasture 3 Access Rd	3 years	Panel Year 1	1050
PECO_EX_201	Well Road	3 years	Panel Year 2	2000
PECO_EX_301	Headquarters Road	3 years	Panel Year 3	500
PECO_EX_302	Ranch Roads	3 years	Panel Year 3	700
PECO_EX_303	Southwest Trail	3 years	Panel Year 3	1000

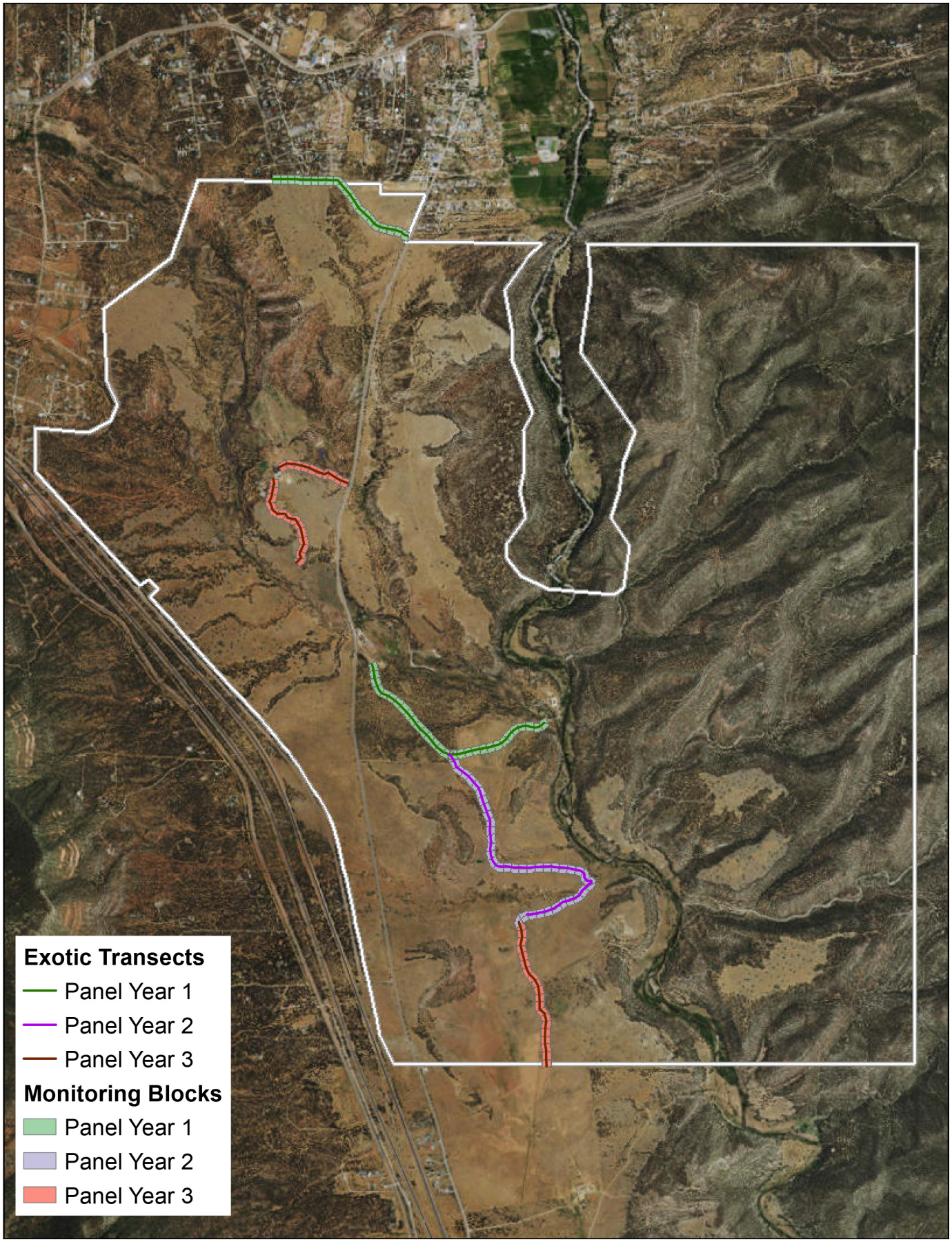


Figure A-9. Panel selection for PECO

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)*.

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

Table A-9. Sampling frequency, panel ID, and length of exotics transects at SAND.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
SAND_EX_101	Lower Monument Road	3 years	Panel Year 1	700
SAND_EX_102	Upper Ranch House Road	3 years	Panel Year 1	350
SAND_EX_103	Lower Ranch House Road	3 years	Panel Year 1	300
SAND_EX_104	Southeast Boundary	3 years	Panel Year 1	1600
SAND_EX_201	Ceremony Road	3 years	Panel Year 2	1250
SAND_EX_202	Cuttoff Road	3 years	Panel Year 2	1000
SAND_EX_203	County Road	3 years	Panel Year 2	800
SAND_EX_301	Interior Momument Road	3 years	Panel Year 3	2750

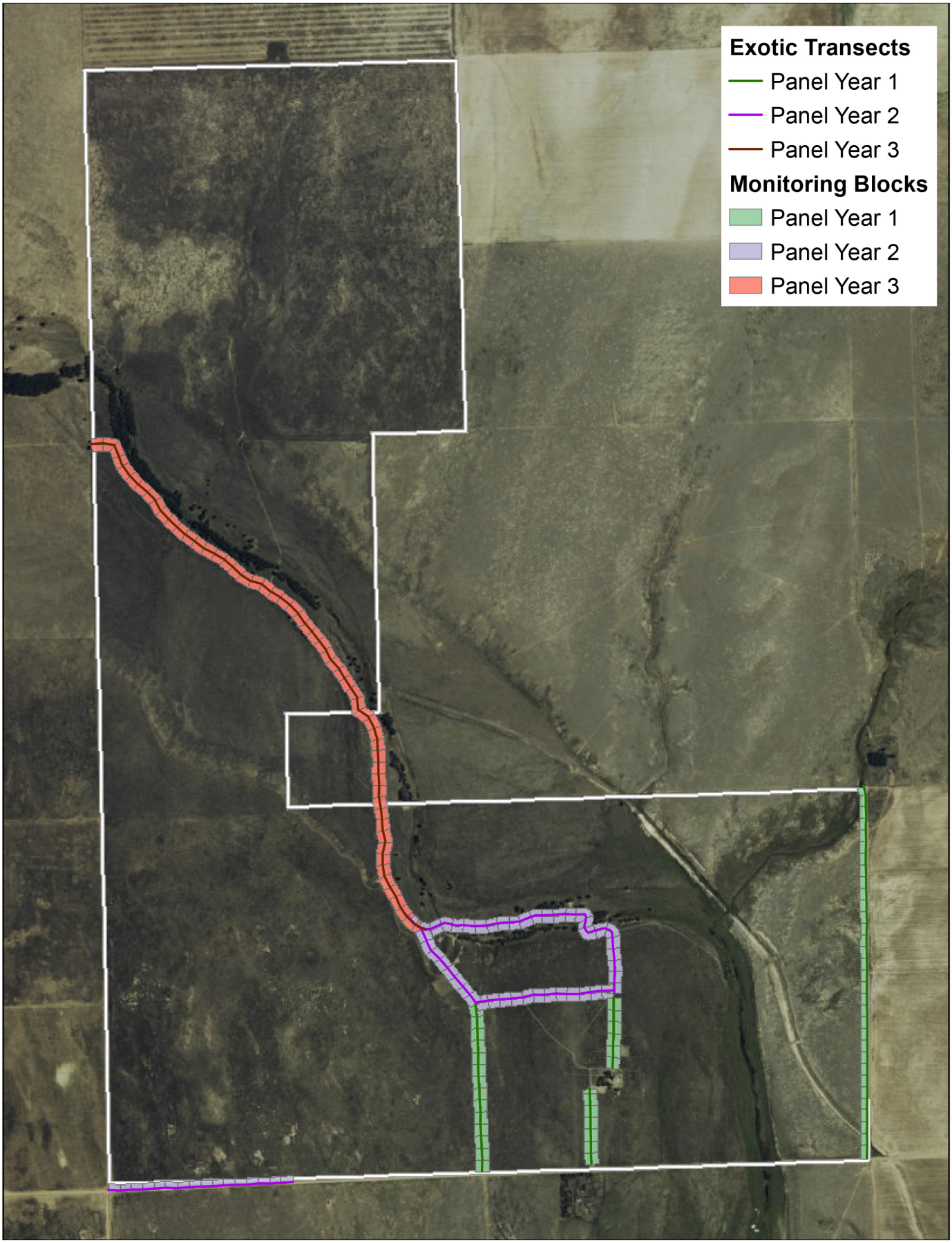


Figure A-10. Panel selection for SAND.

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.

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.

Table A-10. Sampling frequency, panel ID, and length of exotics transects at WABA.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
WABA_EX_101	South Loop Trail	3 years	Panel Year 1	1050
WABA_EX_102	North Loop Trail	3 years	Panel Year 1	1050
WABA_EX_201	South Loop Trail - West	3 years	Panel Year 2	200
WABA_EX_202	New Trail	3 years	Panel Year 2	700
WABA_EX_203	Dirt Road	3 years	Panel Year 2	850
WABA_EX_301	Boundary	3 years	Panel Year 3	3400

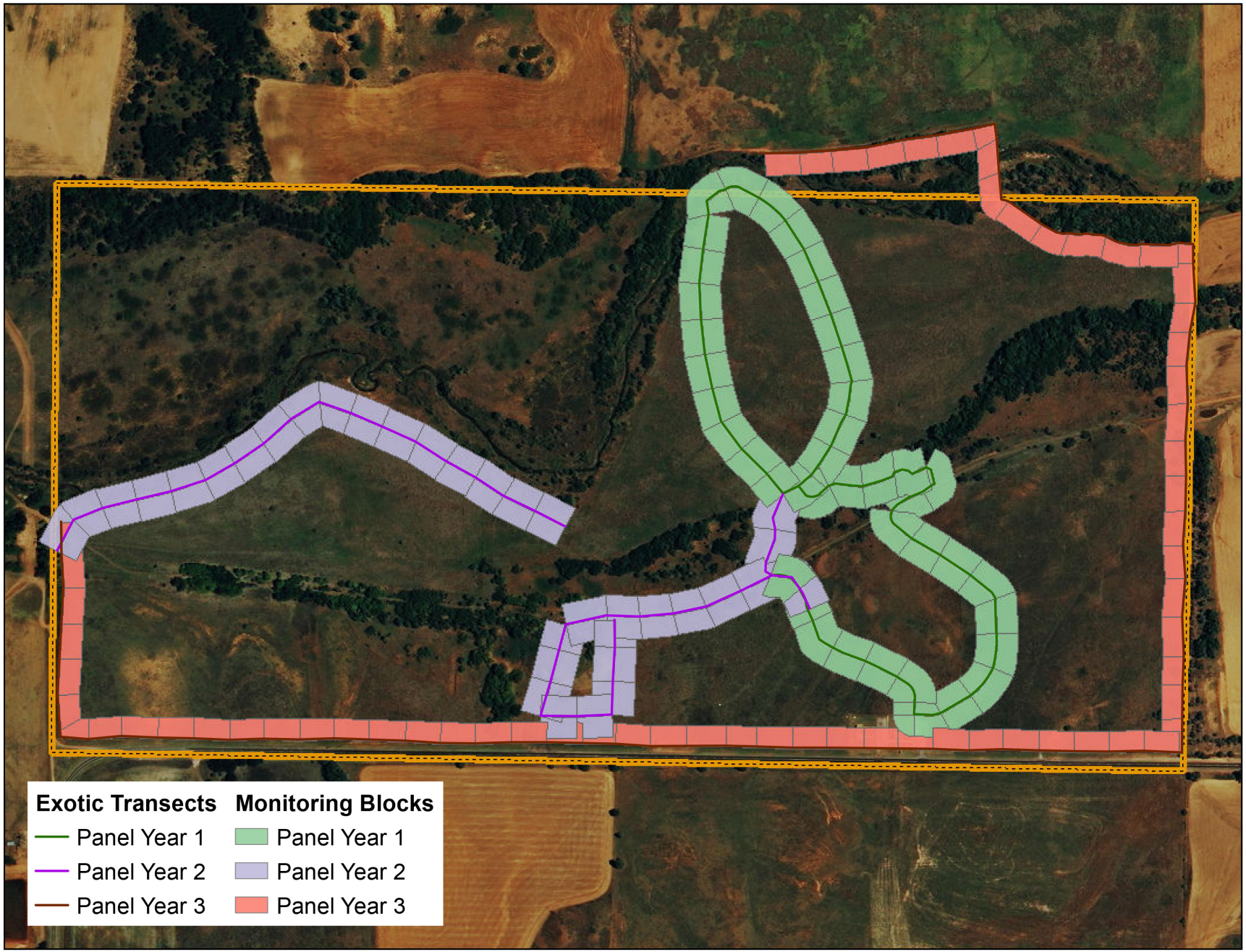


Figure A-11. Panel selection for WABA.

Table A-11. Exotic Plants Found In Southern Plains Parks

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

Table A-11. Exotic Plants Found In Southern Plains Parks (continued)

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

Table A-11. Exotic Plants Found In Southern Plains Parks (continued)

Family	Scientific Name	Common Names	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR/ ALFL	LYJO	PECO	SAND	WABA
Dipsacaceae	*Dipsacus fullonum*	Fuller's teasel	•							•	•	
Poaceae	*Echinochloa colona*	jungle ricegrass			•				•			
Poaceae	*Echinochloa crus-galli*	barnyardgrass	•	•	•	•		•	•			
Elaeagnaceae	*Elaeagnus angustifolia*	Russian olive				•		•		•		
Elaeagnaceae	*Elaeagnus pungens*	thorny olive							•			
Poaceae	*Elymus repens*	quackgrass								•	•	
Poaceae	*Eragrostis barrelieri*	Mediterranean lovegrass						•	•	•		
Poaceae	*Eragrostis cilianensis*	stinkgrass			•	•		•	•			
Poaceae	*Eragrostis curvula*	weeping lovegrass						•				
Geraniaceae	*Erodium cicutarium*	redstem storksbill			•		•	•	•	•		
Brassicaceae	*Erysimum repandum*	bushy wallflower			•			•				
Celastraceae	*Euonymus japonica*	Japanese spindletree							•			
Euphorbiaceae	*Euphorbia davidii*	David's spurge		•			•	•		•		
Euphorbiaceae	*Euphorbia dentata*	toothed spurge	•		•	•			•			•
Euphorbiaceae	*Euphorbia esula*	leafy spurge									•	
Asteraceae	*Facelis retusa*	annual trampweed							•			
Moraceae	*Fatoua villosa*	hairy crabweed							•			
Rubiaceae	*Galium divaricatum*	Lamarck's bedstraw							•			
Geraniaceae	*Geranium pusillum*	small-flower crane's-bill										•
Liliaceae	*Hemerocallis fulva*	orange daylily							•			
Malvaceae	*Hibiscus trionum*	flower-of-an-hour	•			•						
Caryophyllaceae	*Holosteum umbellatum*	jagged chickweed			•							
Poaceae	*Hordeum murinum*	mouse barley							•			
Poaceae	*Hordeum vulgare*	cereal barley							•			
Convolvulaceae	*Ipomoea purpurea*	common morningglory					•					
Iridaceae	*Iris germanica*	German iris			•				•			
Iridaceae	*Iris lutescens*	Crimean iris							•			•
Iridaceae	*Iris sanguinea*	Japanese iris			•							
Oleaceae	*Jasminum nudiflorum*	winter jasmine			•							•
Chenopodiaceae	*Kochia scoparia*	kochia	•	•		•	•	•		•	•	
Fabaceae	*Kummerowia stipulacea*	Korean lespedeza			•							
Asteraceae	*Lactuca serriola*	prickly lettuce	•	•	•	•	•	•	•	•	•	
Asteraceae	*Lactuca tatarica*	blue lettuce	•									
Lamiaceae	*Lamium amplexicaule*	henbit			•	•		•	•			

Table A-11. Exotic Plants Found In Southern Plains Parks (continued)

Family	Scientific Name	Common Names	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR/ ALFL	LYJO	PECO	SAND	WABA
Fabaceae	*Lathyrus hirsutus*	singletary pea			•				•			
Fabaceae	*Lathyrus latifolius*	everlasting peavine								•		
Lamiaceae	*Leonurus cardiaca*	motherwort	•									
Lamiaceae	*Leonurus sibiricus*	honeyweed							•			
Brassicaceae	*Lepidium latifolium*	broadleaf pepperweed	•									
Fabaceae	*Lespedeza cuneata*	sericea lespedeza			•							
Asteraceae	*Leucanthemum vulgare*	oxeye daisy							•	•		
Oleaceae	*Ligustrum japonicum*	Japanese privet							•			
Oleaceae	*Ligustrum lucidum*	glossy privet							•			
Oleaceae	*Ligustrum sinense*	Chinese privet							•			
Oleaceae	*Ligustrum vulgare*	European privet			•							
Scrophulariaceae	*Linaria vulgaris*	yellow toadflax									•	
Poaceae	*Lolium arundinaceum*	tall fescue				•		•	•	•		
Poaceae	*Lolium perenne*	perennial ryegrass			•	•		•	•	•		•
Poaceae	*Lolium pratense*	meadow fescue			•							
Poaceae	*Lolium temulentum*	Darnel ryegrass						•				
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle			•				•			
Caprifoliaceae	*Lonicera maackii*	Amur honeysuckle bush			•							•
Solanaceae	*Lycium barbarum*	matrimony vine			•							
Rosaceae	*Malus pumila*	paradise apple								•		
Rosaceae	*Malus sylvestris*	European crabapple								•		
Malvaceae	*Malva neglecta*	roundleaf mallow						•		•		•
Malvaceae	*Malva parviflora*	small-whorl mallow							•			
Lamiaceae	*Marrubium vulgare*	horehound		•	•		•	•	•	•		•
Fabaceae	*Medicago lupulina*	black medic clover			•	•	•	•	•	•		
Fabaceae	*Medicago minima*	little burclover			•			•	•			
Fabaceae	*Medicago polymorpha*	California burclover				•			•			•
Fabaceae	*Medicago sativa*	alfalfa			•			•		•		
Meliaceae	*Melia azedarach*	Chinaberry tree			•				•			
Fabaceae	*Melilotus alba*	white sweetclover				•					•	
Fabaceae	*Melilotus indicus*	annual yellow sweetclover						•		•		
Fabaceae	*Melilotus officinalis*	yellow sweetclover		•	•	•	•	•	•	•	•	
Lamiaceae	*Mentha spicata*	spearmint			•				•			

Table A-11. Exotic Plants Found In Southern Plains Parks (continued)

Family	Scientific Name	Common Names	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR/ ALFL	LYJO	PECO	SAND	WABA
Nyctaginaceae	*Mirabilis jalapa*	common four o'clock							•			•
Lamiaceae	*Moluccella laevis*	shellflower						•				
Moraceae	*Morus alba*	white mulberry				•		•	•			
Haloragaceae	*Myriophyllum spicatum*	Eurasian water-milfoil						•				
Berberidaceae	*Nandina domestica*	heavenly bamboo							•			•
Lamiaceae	*Nepeta cataria*	catnip			•	•				•		
Asteraceae	*Onopordum acanthium*	Scotch thistle								•		
Liliaceae	*Ornithogalum umbellatum*	Star-of-Bethlehem			•							
Poaceae	*Panicum coloratum*	klinegrass							•			•
Poaceae	*Panicum miliaceum*	proso millet						•				•
Asteraceae	*Parthenium hysterophorus*	ragweed parthenium			•							
Poaceae	*Paspalum dilatatum*	dallis grass			•				•			
Poaceae	*Paspalum urvillei*	Vasey grass							•			
Poaceae	*Pennisetum glaucum*	yellow foxtail			•	•						
Poaceae	*Phalaris arundinacea*	reed canarygrass	•							•		
Poaceae	*Phleum pratense*	common timothy								•		
Pinaceae	*Pinus nigra*	Australian pine				•						•
Plantaginaceae	*Plantago lanceolata*	buckhorn plaintain			•					•		
Poaceae	*Poa annua*	annual bluegrass			•		•		•			
Poaceae	*Poa compressa*	flat-stem blue grass								•		
Poaceae	*Poa pratensis*	Kentucky bluegrass		•	•	•	•	•		•	•	
Caryophyllaceae	*Polycarpon tetraphyllum*	fourleaf manyseed							•			
Polygonaceae	*Polygonum arenastrum*	prostrate knotweed				•		•				
Polygonaceae	*Polygonum aviculare*	yard knotweed						•		•		
Polygonaceae	*Polygonum convolvulus*	climbing buckwheat		•	•			•		•		
Polygonaceae	*Polygonum hydropiper*	annual smartweed			•							
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass	•					•	•		•	
Poaceae	*Polypogon viridis*	beardless rabbitsfoot grass						•				•
Salicaceae	*Populus alba*	white poplar	•									
Rosaceae	*Potentilla recta*	sulphur cinquefoil			•							•
Rosaceae	*Prunus mahaleb*	Mahaleb cherry			•							

Table A-11. Exotic Plants Found In Southern Plains Parks (continued)

Family	Scientific Name	Common Names	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR/ ALFL	LYJO	PECO	SAND	WABA
Poaceae	*Psathyrostachys juncea*	Russian wildrye								•		
Asteraceae	*Pseudognaphalium luteoalbum*	Jersey cudweed							•			
Rosaceae	*Pyrus communis*	common pear				•			•			
Ranunculaceae	*Ranunculus acris*	meadow buttercup								•		
Euphorbiaceae	*Ricinus communis*	castor bean							•			•
Brassicaceae	*Rorippa sylvestris*	creeping yellow cress								•		
Polygonaceae	*Rumex crispus*	curley dock	•		•	•		•		•	•	
Polygonaceae	*Rumex obtusifolius*	bluntleaf dock	•									•
Polygonaceae	*Rumex patientia*	patience dock				•						•
Polygonaceae	*Rumex pulcher*	fiddle dock			•				•			
Polygonaceae	*Rumex stenophyllus*	narrowleaf dock				•		•				•
Chenopodiaceae	*Salsola collina*	slender Russian thistle						•				
Chenopodiaceae	*Salsola kali*	prickly Russian thistle				•						•
Chenopodiaceae	*Salsola tragus*	prickly Russian thistle	•	•			•	•		•	•	
Lamiaceae	*Salvia uliginosa*	bog sage							•			•
Caryophyllaceae	*Saponaria officinalis*	bouncingbet			•							
Asteraceae	*Scorzonera laciniata*	cutleaf vipergrass						•		•		•
Poaceae	*Setaria pumila*	yellow bristlegrass		•		•		•				
Poaceae	*Setaria viridis*	green bristlegrass	•	•		•		•		•		
Rubiaceae	*Sherardia arvensis*	blue fieldmadder							•			
Malvaceae	*Sida abutifolia*	prostrate sida			•				•			
Brassicaceae	*Sinapis arvensis*	charlock mustard			•							
Brassicaceae	*Sisymbrium altissimum*	tumble mustard			•			•		•		
Brassicaceae	*Sisymbrium irio*	London rocket							•			
Brassicaceae	*Sisymbrium officinale*	hairypod hedgemustard							•			
Asteraceae	*Sonchus asper*	spiny sowthistle			•	•	•	•	•	•		
Asteraceae	*Sonchus oleraceus*	annual sowthistle							•			
Poaceae	*Sorghum halepense*	Johnsongrass	•		•	•		•	•			
Caryophyllaceae	*Stellaria media*	common chickweed			•	•			•			
Oleaceae	*Syringa vulgaris*	common lilac				•						
Tamaricaceae	*Tamarix chinensis*	Chinese tamarisk			•			•		•		
Tamaricaceae	*Tamarix gallica*	French tamarisk						•				
Tamaricaceae	*Tamarix ramosissima*	saltcedar	•					•				

Table A-11. Exotic Plants Found In Southern Plains Parks (continued)

Family	Scientific Name	Common Names	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR/ ALFL	LYJO	PECO	SAND	WABA
Asteraceae	*Taraxacum laevigatum*	red-seed dandelion		•								
Asteraceae	*Taraxacum officinale*	common dandelion			•	•	•	•	•	•		
Poaceae	*Thinopyrum intermedium*	intermediate wheatgrass	•							•		
Poaceae	*Thinopyrum ponticum*	rush wheatgrass	•							•		
Brassicaceae	*Thlaspi arvense*	field pennycress	•			•				•		
Apiaceae	*Torilis arvensis*	spreading hedgeparsley			•				•			
Apiaceae	*Torilis nodosa*	knotted hedgeparsley							•			
Asteraceae	*Tragopogon dubius*	western salsify	•	•	•	•		•		•	•	
Asteraceae	*Tragopogon pratensis*	meadow salsify		•			•			•		
Euphorbiaceae	*Triadica sebifera*	Chinese tallow tree							•			
Zygophyllaceae	*Tribulus terrestris*	puncturevine	•		•	•		•		•		
Fabaceae	*Trifolium campestre*	big-hop field clover			•							
Fabaceae	*Trifolium dubium*	small hop clover			•							
Fabaceae	*Trifolium pratense*	red clover								•		
Fabaceae	*Trifolium repens*	white clover				•		•	•	•		
Poaceae	*Triticum aestivum*	common wheat			•	•						•
Typhaceae	*Typha angustifolia*	narrowleaf cattail	•		•							
Ulmaceae	*Ulmus pumila*	Siberian elm				•	•	•		•		•
Urticaceae	*Urtica dioica*	stinging nettle					•					•
Scrophulariaceae	*Verbascum thapsus*	common mullein	•	•	•		•		•	•		
Verbenaceae	*Verbena brasiliensis*	Brazilian vervain							•			
Scrophulariaceae	*Veronica agrestis*	field speedwell			•							
Scrophulariaceae	*Veronica arvensis*	corn speedwell							•			
Fabaceae	*Vicia sativa*	narrowleaf vetch			•				•			
Fabaceae	*Vicia villosa*	hairy vetch							•			
Apocynaceae	*Vinca minor*	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 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.

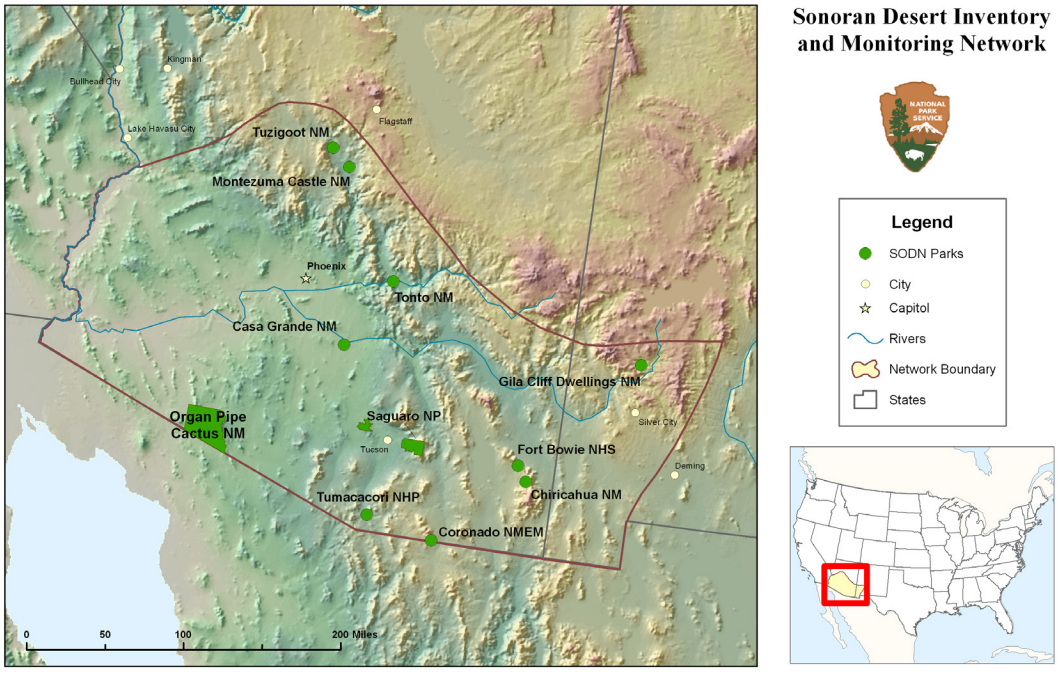


Figure B-1. Park locations within the Sonoran Desert I&M Network.

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 (Figure B-2).

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 (*Carnegia giganteus* & *Ferocactus wislizinii)* 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 al2004*)*; however three species formerly observed were not seen during this effort: African daisy (*Dimortheca)*, 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)*.

Table B-1. Sampling frequency, panel ID, and length of exotics transects at CAGR.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
CAGR_EX_ACR	Abandoned Canal Road	3 years	Panel 1	465
CAGR_EX_CBF	CAGR Boundary Fence	3 years	Panel 1	5579
CAGR_EX_MLR	Maintenance Loop Road	3 years	Panel 1	437
CAGR_EX_NVC	North Visitor Center	3 years	Panel 1	152
CAGR_EX_PER	Park Entrance Road	3 years	Panel 1	1364
CAGR_EX_SVC	South Visitor Center	3 years	Panel 1	379



Figure B-2. Panel selection 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 14th 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 (Figure 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 (*Carnegia gigantea)*, cholla and prickley 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.

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, mulit-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

Table B-2. Sampling frequency, panel ID, and length of exotics transects at TONT.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
TONT_EX_CCW	CCW	3 years	Panel 1	86
TONT_EX_CPT	Cactus Patch Trail	3 years	Panel 1	153
TONT_EX_HWY	Hwy 188	3 years	Panel 1	1543
TONT_EX_LRT	LCD trail	3 years	Panel 1	669
TONT_EX_PER	Park Road	3 years	Panel 1	1543
TONT_EX_PRR	Administration Road	3 years	Panel 1	224
TONT_EX_URN	Unpaved Road North	3 years	Panel 1	812
TONT_EX_URT	UCD Trail	3 years	Panel 1	1811

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.

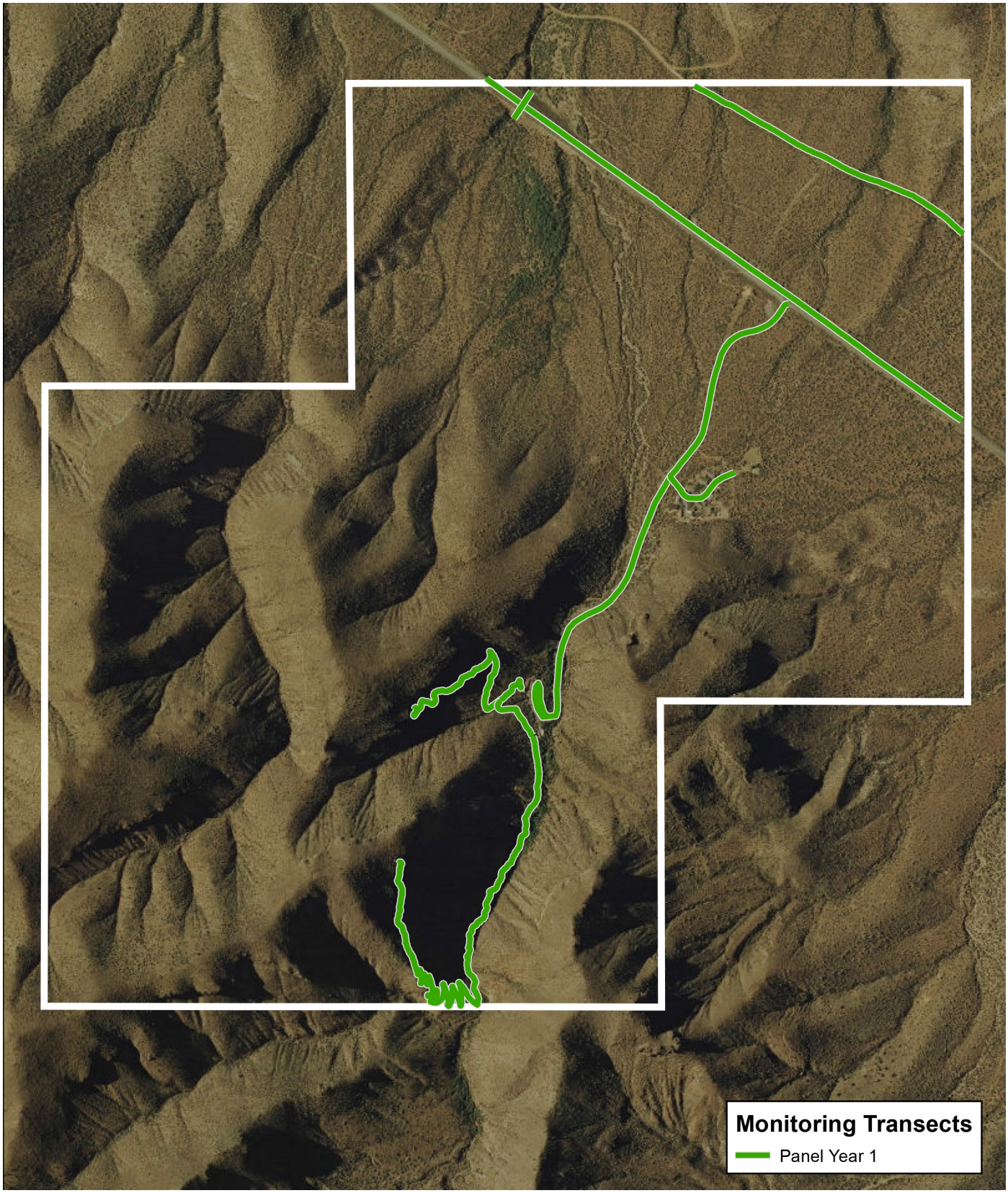


Figure B-3. Panel selection for TONT.

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) (Figure B-4), and the Well unit, both located along the perennial Beaver Creek. (Figure B-5) 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 (Figure B-6). 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 cicutarum)* are some of the herbaceous species that have extensive cover at the pasture-like areas at MOCA and MOWE.

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)*.

Table B-3. Sampling frequency, panel ID, and length of exotics transects at MOCA and TUZI.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
MOCA_EX_ADL	Administration Loop	3 years	Panel 1	384
MOCA_EX_ADR	Administration Road	3 years	Panel 1	132
MOCA_EX_MCR	Montezuma Castle Road	3 years	Panel 1	2058
MOCA_EX_MCT	Montezuma Castle Trail	3 years	Panel 1	602
MOWE_EX_ABR	Abandoned Road	3 years	Panel 1	1145
MOWE_EX_ADR	Administration Road	3 years	Panel 1	652
MOWE_EX_ MWM	Montezuma Well Main Trail	3 years	Panel 1	641
MOWE_EX_ MWS	Montezuma Well Side Trail	3 years	Panel 1	114
MOWE_EX_PER	Entrance Road	3 years	Panel 1	661
TUZI_EX_NRT	North Ruin Trail	3 years	Panel 1	531
TUZI_EX_PLR	Pecks Lake Road	3 years	Panel 1	1016
TUZI_EX_SRT	South Ruin Trail	3 years	Panel 1	392
TUZI_EX_TRE	Tuzigoot Road East	3 years	Panel 1	2927
TUZI_EX_URE	Unnamed Road East	3 years	Panel 1	926
TUZI_EX_UTN	Unnamed Trail North	3 years	Panel 1	168

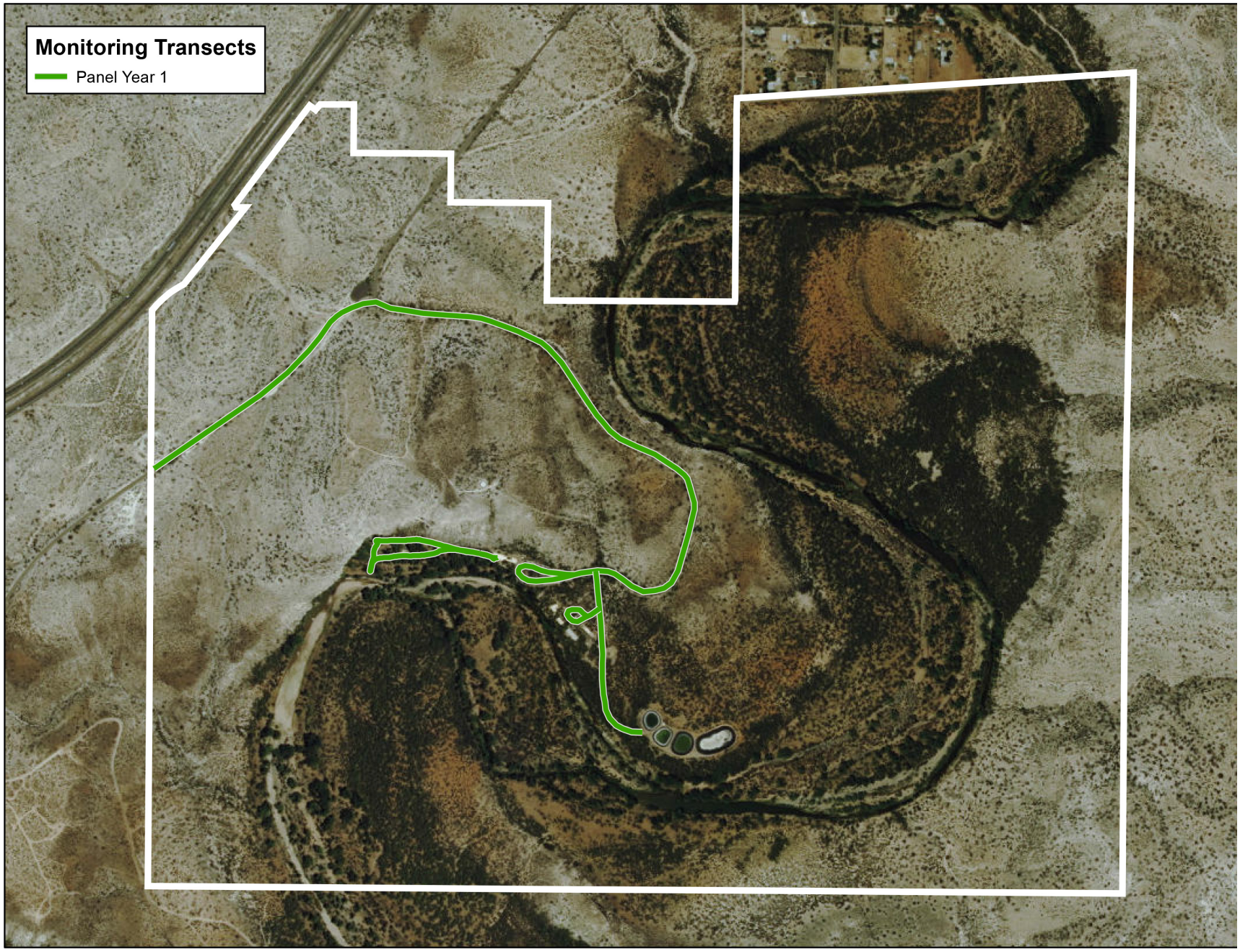


Figure B-4. Panel selection for MOCA (Castle Unit).

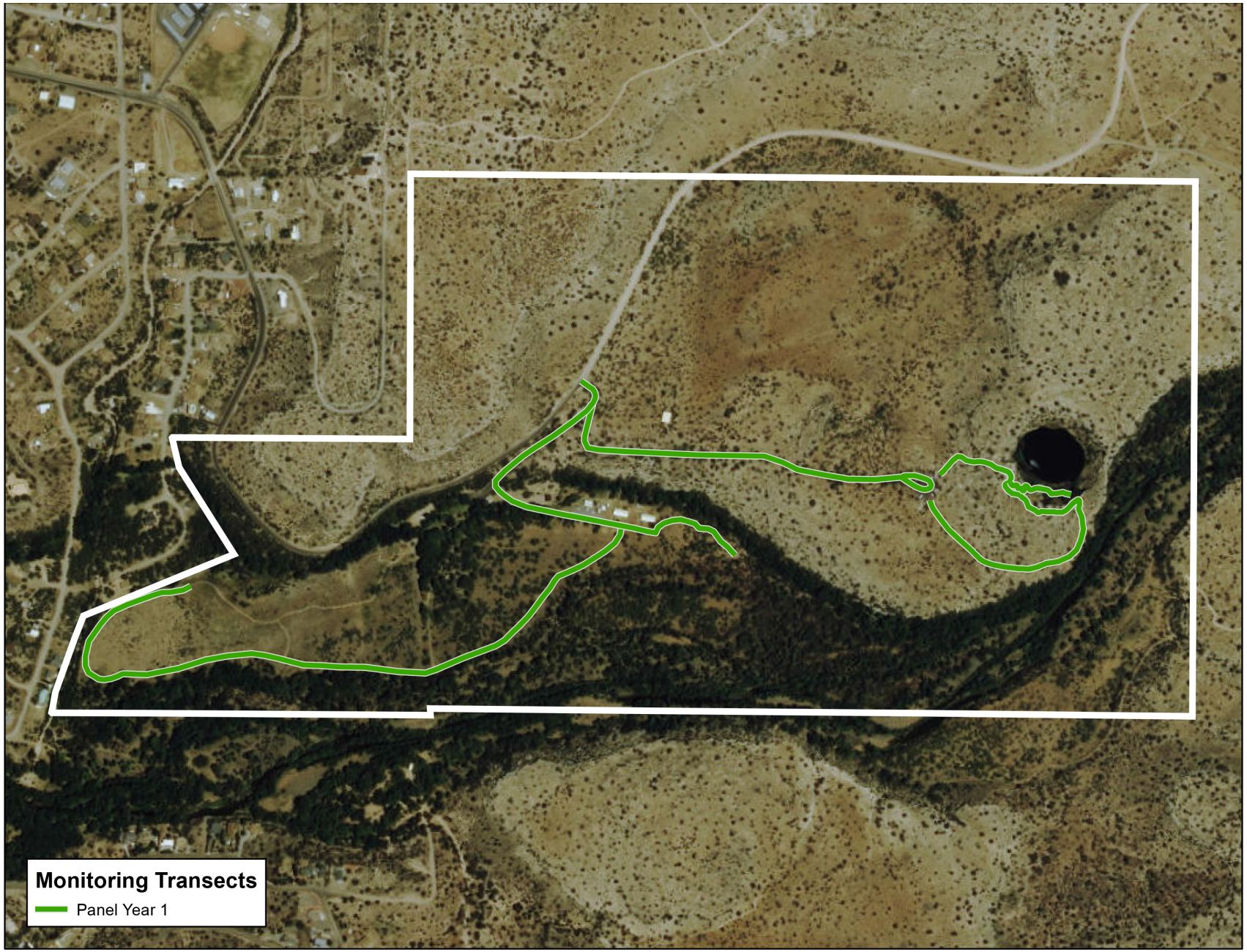


Figure B-5. Panel selection for MOCA (Well Unit).

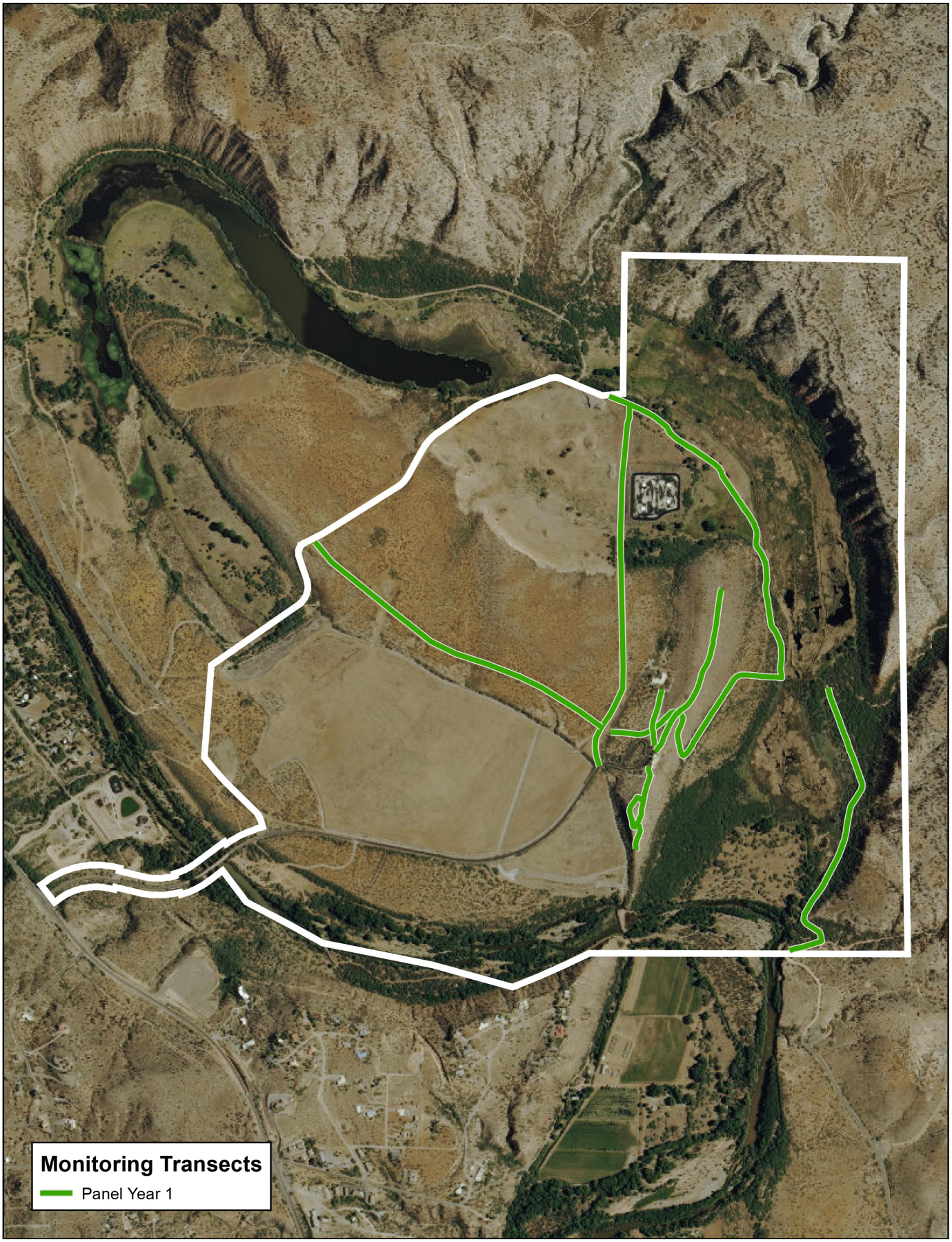


Figure B-6. Panel selection for TUZI..

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.

The monument has one main road that begins on the western boundary (Figure B-7), 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)*.

Table B-4. Sampling frequency, panel ID, and length of exotics transects at CHIR

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
CHIR_EX_ADR	Administration Road	3 years	Panel 1	881
CHIR_EX_BCR	Bonita Canyon Drive	3 years	Panel 1	3385
CHIR_EX_FRT	Faraway Ranch Trails	3 years	Panel 1	1698
CHIR_EX_KLM	King of Lead Mine Road	3 years	Panel 2	1521
CHIR_EX_LRT	Lower Rhyolite Trail	3 years	Panel 2	2350
CHIR_EX_MPR	Massai Point Road	3 years	Panel 1	909
CHIR_EX_NBT	Natural Bridge Trail	3 years	Panel 2	1078
CHIR_EX_SMT	Sugarloaf Lookout Trail	3 years	Panel 1	1461
CHIR_EX_SSR	Sugarloaf Road	3 years	Panel 1	944
CHIR_EX_URT	Upper Rhyolite Trail	3 years	Panel 2	1538
CHIR_EX_VCT	Visitor Campground Trail	3 years	Panel 1	669

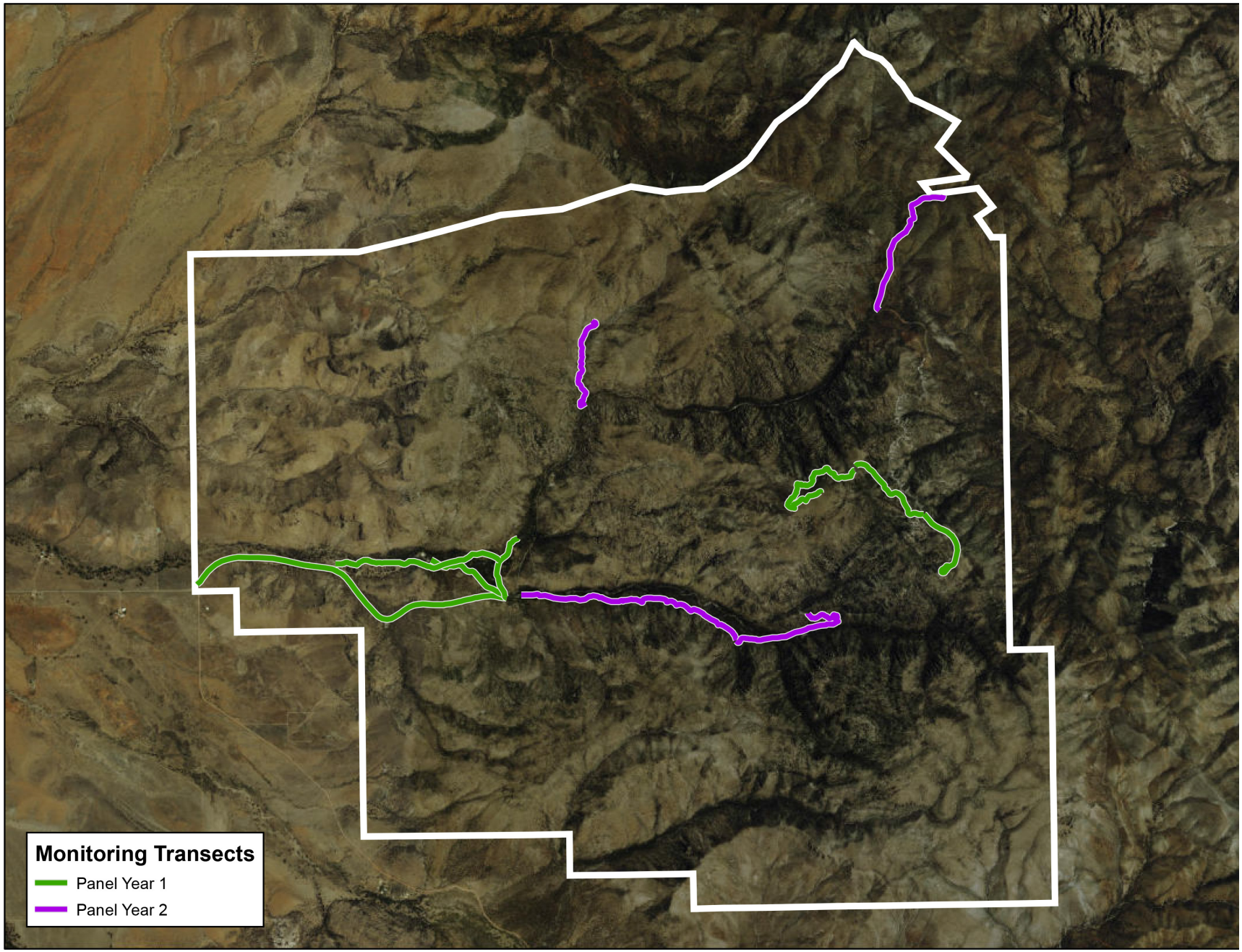


Figure B-7. Panel selection for CHIR.

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, (Figure B-8). 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 15th 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.

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.

Table B-5. Sampling frequency, panel ID, and length of exotics transects at GICL.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
GICL_EX_CDC	Cliff Dweller Canyon	3 years	Panel 1	901
GICL_EX_CDT	Cliff Dwelling Trail	3 years	Panel 1	1378
GICL_EX_GCR	GICL Copperas Road	3 years	Panel 1	833
GICL_EX_GMF	Gila Middle Fork	3 years	Panel 1	934
GICL_EX_THE	TJ Horsetrail East	3 years	Panel 1	999
GICL_EX_WFG	West Fork of Gila	3 years	Panel 1	931
GICL_EX_WFT	West Fork Trail	3 years	Panel 1	884

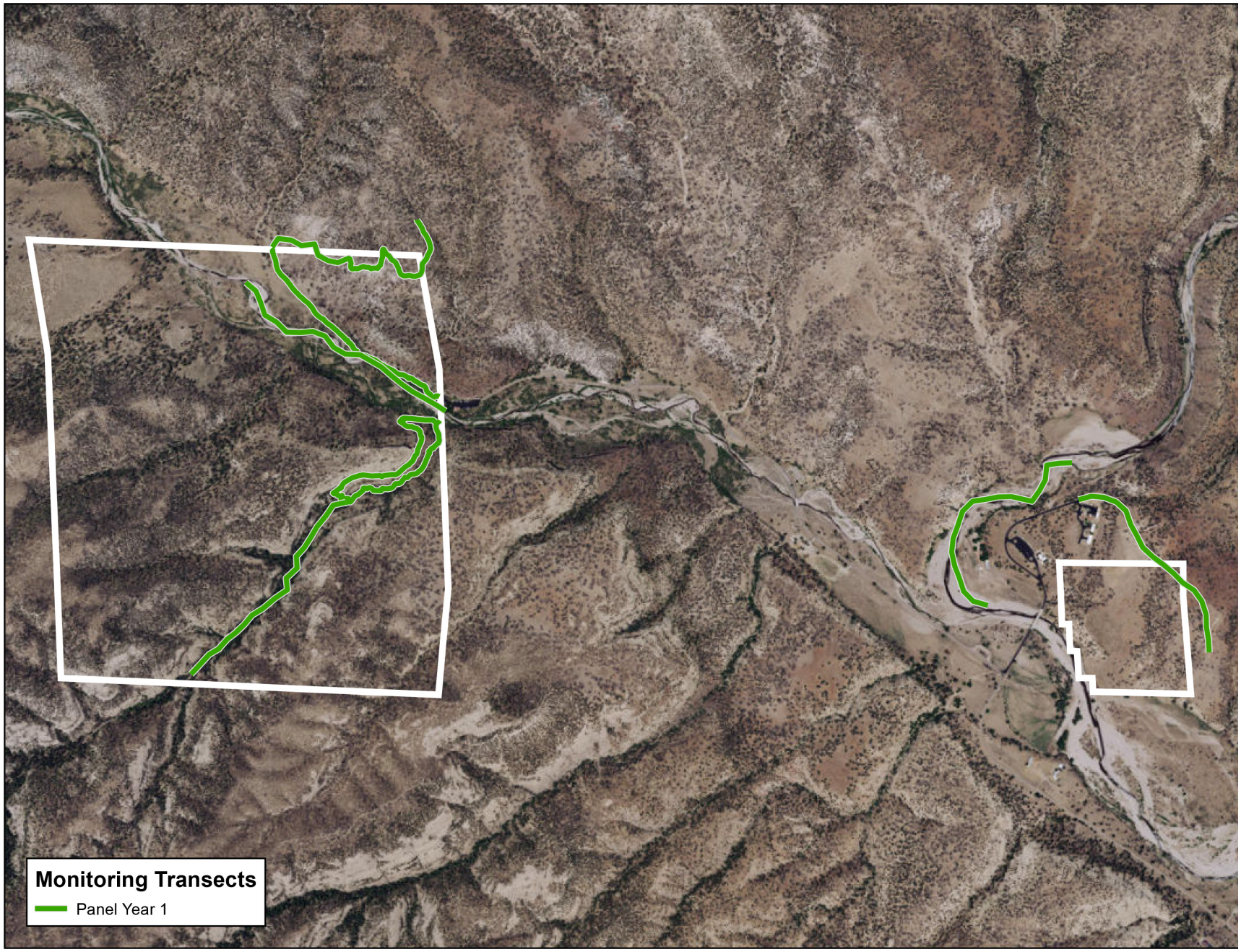


Figure B-8. Panel selection for GICL.

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 (Figure B-9). 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.

Table B-6 Sampling frequency, panel ID, and length of exotics transects at FOBO.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
FOBO_EX_ADT	Administration Trail	3 years	Panel 1	144
FOBO_EX_APE	Apache Pass Road East	3 years	Panel 1	584
FOBO_EX_APW	Apache Pass Road West	3 years	Panel 1	1466
FOBO_EX_FFT	First Fort Trail	3 years	Panel 1	394
FOBO_EX_RET	Return Trail	3 years	Panel 1	1879
FOBO_EX_VCT	Visitor Center Trail	3 years	Panel 1	2640

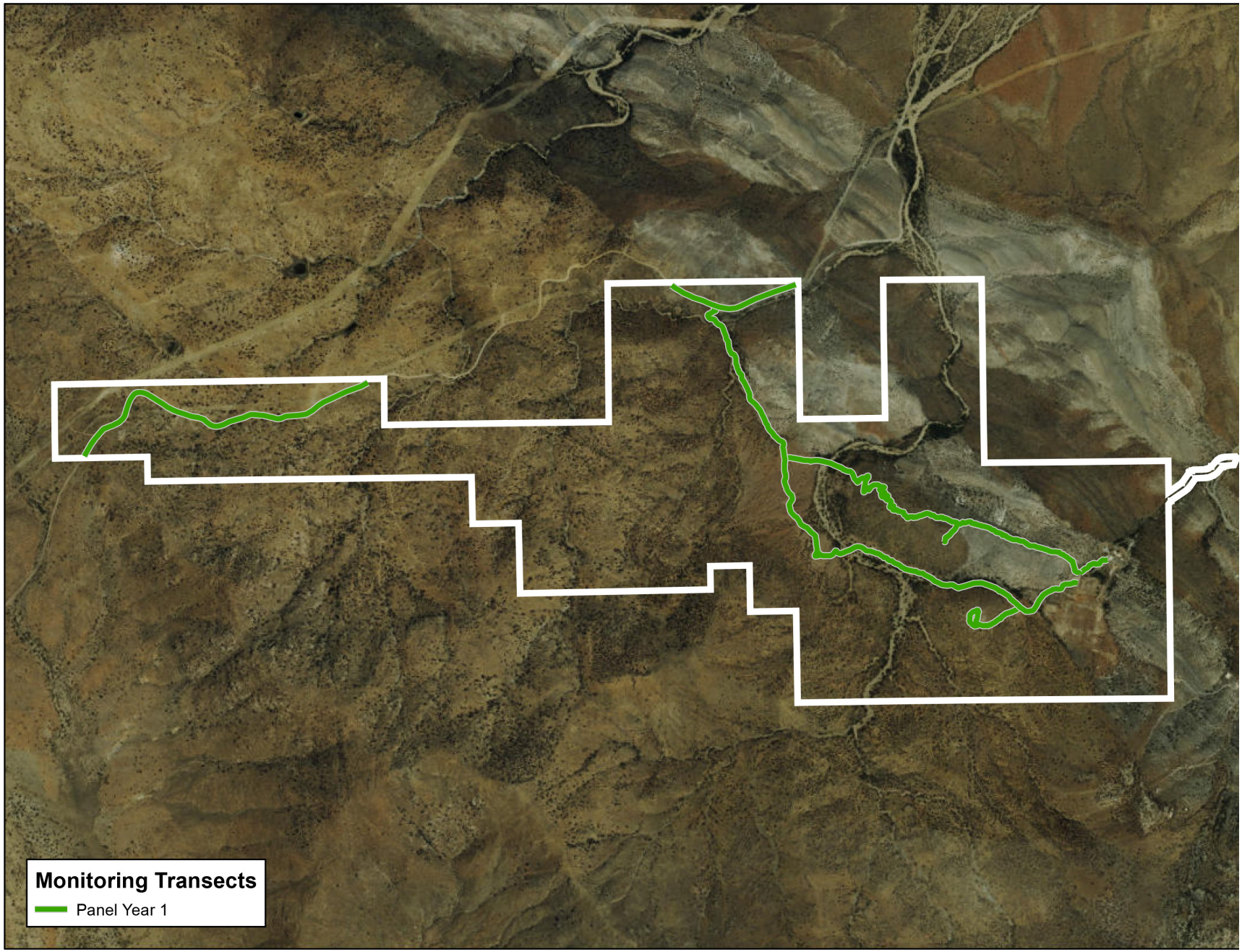


Figure B-9. Panel selection for FOBO.

B.7. Coronado NM

Coronado National Memorial (CORO) is situated on the Mexico/Arizona border approximately 20 miles south of Sierra Vista (Figure B-10). 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.*)*.

Table B-7. Sampling frequency, panel ID, and length of exotics transects at CORO.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
CORO_EX_BFR	Border Fence Road	3 years	Panel 3	2497
CORO_EX_CAT	Cave Trail	3 years	Panel 3	1171
CORO_EX_CPR	Coronado Picnic Road	3 years	Panel 2	445
CORO_EX_CPT	Coronado Peak Trail	3 years	Panel 1	602
CORO_EX_CRT	Crest Trail	3 years	Panel 3	3039
CORO_EX_EFL	East Forest Lane Road	3 years	Panel 1	1857
CORO_EX_JCE	Joe's Canyon Trail East	3 years	Panel 3	1990
CORO_EX_JCW	Joe's Canyon Trail West	3 years	Panel 1	2387
CORO_EX_JSR	Joes Spring Road	3 years	Panel 2	1723
CORO_EX_MCN	Montezuma Canyon North	3 years	Panel 2	432
CORO_EX_MCR	Montezuma Canyon Road	3 years	Panel 1	8003
CORO_EX_MPR	Montezuma Pass Road	3 years	Panel 1	533
CORO_EX_MRR	Montezuma Ranch Road	3 years	Panel 1	334
CORO_EX_MWE	Montezuma Wash East	3 years	Panel 2	1238
CORO_EX_MWW	Montezuma Wash West	3 years	Panel 2	2208
CORO_EX_MZP	Montezuma Pass Road Parking Lot	3 years	Panel 1	204
CORO_EX_PIT	Picnic Trail	3 years	Panel 2	144
CORO_EX_WTR	Water tower Road	3 years	Panel 2	240

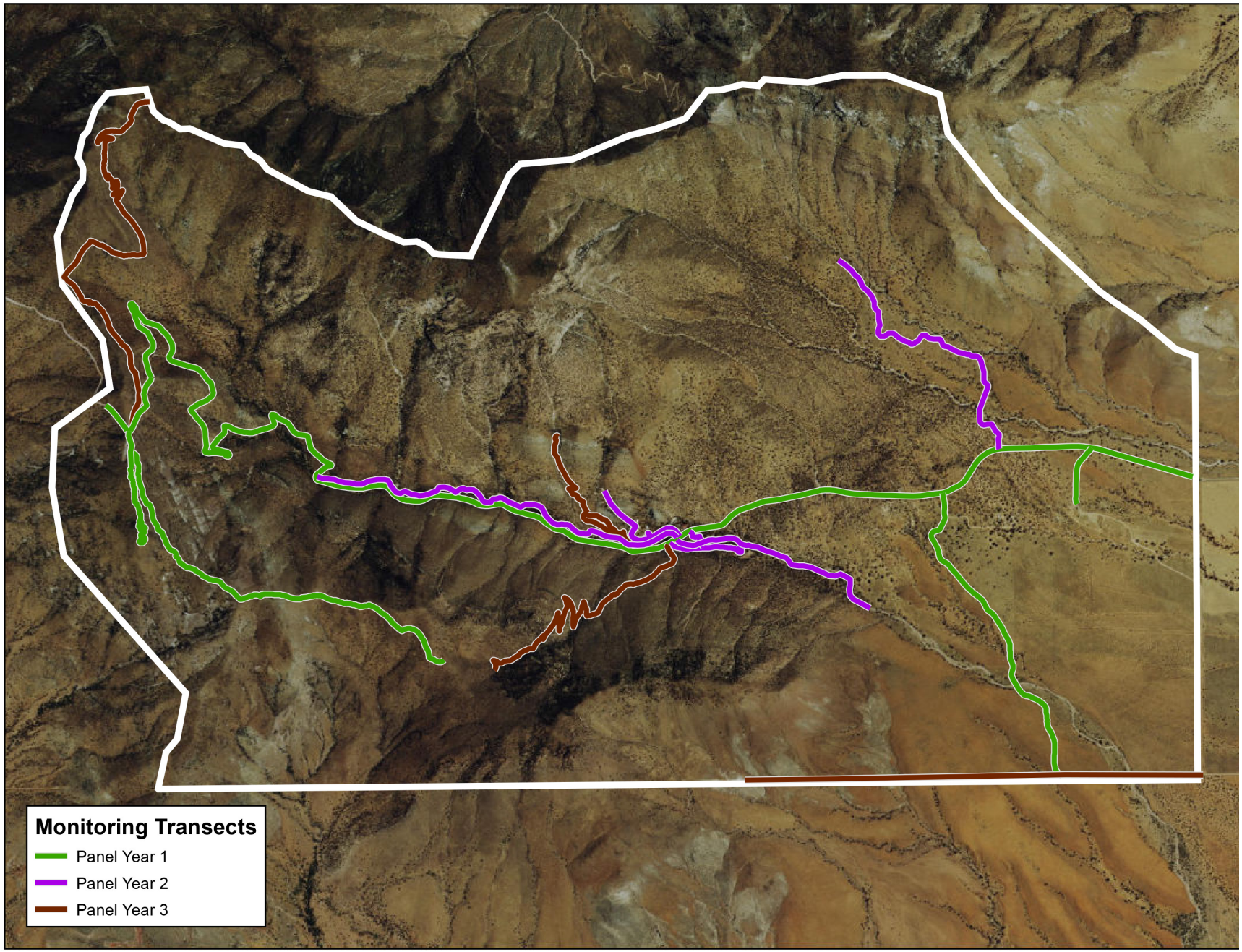


Figure B-10. Panel selection for CORO.

B.8. Tumacacori NHP

Tumacácori 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 Tumacácori 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). Tumacácori, with 131.5 ha (325 acres), is the largest unit; Calabazas is 11 ha (28 acres) and Guevavi 2.83 ha (7 acres). Tumacácori 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 Tumacácori, respectively. This exotic protocol will be implemented at the main unit (Figure B-11).

The Tumacácori 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 Tumacácori 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.

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*

Table B-8. Sampling frequency, panel ID, and length of exotics transects at TUMA.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
TUMC_EX_CVT	Calabazas Visitor Trail	3 years	Panel 1	317
TUMC_EX_GNT	Guevavi North Trail	3 years	Panel 1	76
TUMG_EX_GST	Guevavi South Trail	3 years	Panel 1	74
TUMG_EX_GVT	Guevavi Visitor Trail	3 years	Panel 1	133
TUMM_EX_DAT	De Anza Trail	3 years	Panel 2	2412
TUMM_EX_PHT	Public Horse Trail	3 years	Panel 1	245
TUMM_EX_SCR	Santa Cruz River	3 years	Panel 1	2218
TUMM_EX_TTR	TUMM Trail River	3 years	Panel 2	702

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.

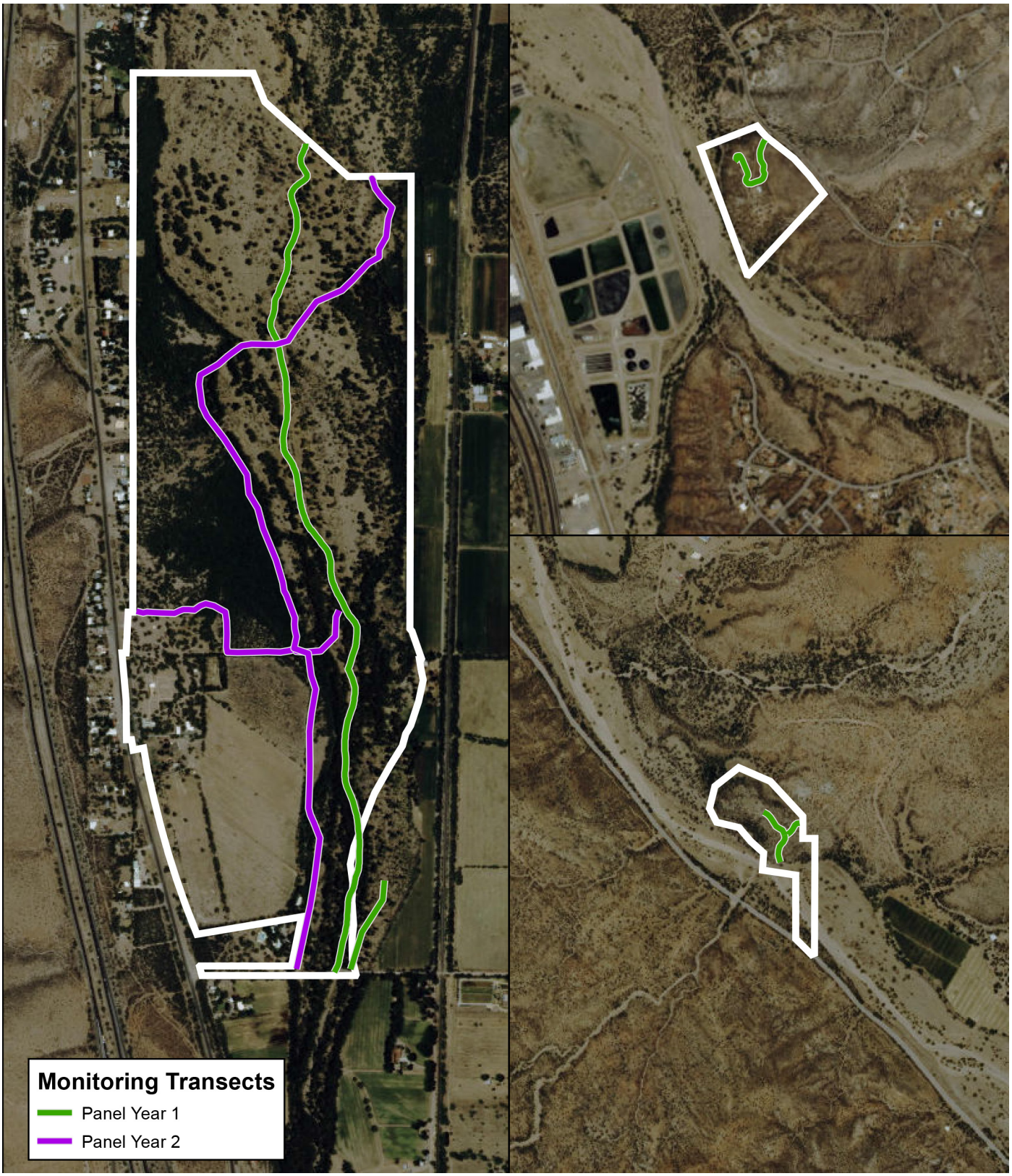


Figure B-11. Panel selection for TUMA.

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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Table B-9. Exotic Plants Found In Sonoran Desert Parks

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

Table B-9. Exotic Plants Found In Sonoran Desert Parks (continued)

Family	Scientific Name	Common Names	CAGR	CHIR	CORO	FOBO	GICL	MOCA	MOWE	ORPI	SAGE	SAGW	TONT	TUMA	TUZI
Asteraceae	*Carthamus tinctoris*	safflower								•		•			
Poaceae	*Cenchrus ciliaris*	buffelgrass	•				•			•	•	•			
Poaceae	*Cenchrus setaceous*									•	•	•	•		
Asteraceae	*Centaurea melitensis*	Malta starthistle	•	•				•	•	•	•	•	•		•
Asteraceae	*Centaurea solstitialis*	yellow starthistle									•				
Caryophyllaceae	*Cerastium fontanum*	big chickweed									•				
Caryophyllaceae	*Cerastium gracile*	slender chickweed									•				
Chenopodiaceae	*Chenopodium glaucum*	oakleaf goosefoot					•								
Chenopodiaceae	*Chenopodium murale*	nettleleaf goosefoot	•			•				•	•	•			
Brassicaceae	*Chorispora tenella*	blue mustard						•							•
Asteraceae	*Cichorium intybus*	chicory						•	•						•
Cleomaceae	*Cleome viscosa*	Asian spiderflower								•					
Apiaceae	*Conium maculatum*	poison hemlock					•							•	
Convolvulaceae	*Convolvulus arvensis*	field bindweed		•		•		•	•		•	•	•	•	•
Poaceae	*Cortaderia selloana*	pampas grass									•	•			
Apiaceae	*Cyclospermum leptophyllum*	marsh parsley								•		•		•	
Poaceae	*Cynodon dactylon*	Bermudagrass	•	•	•	•		•	•	•	•	•	•	•	•
Cyperaceae	*Cyperus rotundus*	purple nutsedge										•			
Poaceae	*Dactyloctenium aegyptium*	crowfoot grass								•	•			•	
Solanaceae	*Datura inoxia*	prickly datura													•
Solanaceae	*Datura stramonium*	jimsonweed			•										
Brassicaceae	*Descurainia sophia*	herb sophia	•	•	•	•	•		•		•	•		•	•
Asteraceae	*Dimorphotheca sinuata*	glandular Cape marigold	•								•	•			
Poaceae	*Echinochloa colona*	jungle ricegrass		•	•	•				•	•	•		•	
Poaceae	*Echinochloa crus-galli*	barnyardgrass		•		•	•	•	•	•	•			•	•
Elaeagnaceae	*Elaeagnus angustifolia*	Russian olive													•
Poaceae	*Enneapogon mollis*	soft feather pappusgrass								•		•			
Poaceae	*Eragrostis barrelieri*	Mediterranean lovegrass										•		•	
Poaceae	*Eragrostis cilianensis*	stinkgrass		•	•	•		•	•	•	•	•	•	•	•
Poaceae	*Eragrostis curvula*	weeping lovegrass		•	•	•	•	•	•		•	•	•	•	

Table B-9. Exotic Plants Found In Sonoran Desert Parks (continued)

Family	Scientific Name	Common Names	CAGR	CHIR	CORO	FOBO	GICL	MOCA	MOWE	ORPI	SAGE	SAGW	TONT	TUMA	TUZI
Poaceae	*Eragrostis echinochloidea*	African lovegrass									•	•			
Poaceae	*Eragrostis lehmanniana*	Lehmann's lovegrass	•	•	•	•		•	•	•	•	•	•	•	•
Poaceae	*Eragrostis superba*	Wilman lovegrass			•										
Geraniaceae	*Erodium cicutarium*	redstem storksbill	•	•	•	•	•	•	•	•	•	•	•	•	•
Brassicaceae	*Eruca vesicaria*	rocketsalad								•		•			
Brassicaceae	*Erysimum repandum*	bushy wallflower												•	
Euphorbiaceae	*Euphorbia esula*	leafy spurge					•								
Moraceae	*Ficus carica*	common fig								•					
Asteraceae	*Galinsoga parviflora*	gallant soldier									•				
Caryophyllaceae	*Herniaria hirsuta*	hairy rupturewort								•	•	•	•		
Poaceae	*Hordeum marinum*	seaside barley						•	•						•
Poaceae	*Hordeum murinum*	mouse barley	•	•	•	•		•	•	•	•	•	•	•	•
Poaceae	*Hordeum vulgare*	cereal barley	•								•		•	•	
Convolvulaceae	*Ipomoea coccinea*	Mexican morningglory		•	•	•	•			•	•		•	•	•
Convolvulaceae	*Ipomoea hederacea*	ivyleaf morningglory		•	•	•		•	•	•	•	•		•	
Convolvulaceae	*Ipomoea purpurea*	common morningglory		•	•	•	•				•			•	
Euphorbiaceae	*Jatropha spathula*									•					
Chenopodiaceae	*Kochia scoparia*	kochia													•
Asteraceae	*Lactuca saligna*	willowleaf lettuce						•	•						
Asteraceae	*Lactuca serriola*	prickly lettuce	•	•	•	•	•	•	•	•	•	•	•	•	•
Poaceae	*Lamarckia aurea*	goldentop grass									•	•	•		
Lamiaceae	*Lamium amplexicaule*	henbit				•		•	•			•		•	•
Scrophulariaceae	*Linaria dalmatica*	Dalmatian toadflax				•		•							
Linaceae	*Linum usitatissimum*	cultivated flax				•				•					
Poaceae	*Lolium perenne*	perennial ryegrass			•			•							
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle		•											
Fabaceae	*Lotus corniculatus*	birdfoot deervetch						•	•						
Fabaceae	*Macroptilium gibbosifolium*	variableleaf bushbean		•	•	•	•				•				
Rosaceae	*Malus pumila*	paradise apple													•
Malvaceae	*Malva neglecta*	roundleaf mallow						•	•						•
Malvaceae	*Malva parviflora*	small-whorl mallow	•		•					•	•	•	•	•	
Lamiaceae	*Marrubium vulgare*	horehound		•		•	•	•	•		•		•	•	•
Asteraceae	*Matricaria discoidea*	pineapple weed	•									•			

Table B-9. Exotic Plants Found In Sonoran Desert Parks (continued)

Family	Scientific Name	Common Names	CAGR	CHIR	CORO	FOBO	GICL	MOCA	MOWE	ORPI	SAGE	SAGW	TONT	TUMA	TUZI
Brassicaceae	*Matthiola longipetala*	night-scented stock						•		•	•				•
Fabaceae	*Medicago lupulina*	black medic clover			•		•								•
Fabaceae	*Medicago minima*	little burclover						•	•						•
Fabaceae	*Medicago polymorpha*	California burclover	•					•	•	•		•	•	•	•
Fabaceae	*Medicago sativa*	alfalfa		•				•	•			•			•
Asteraceae	*Melampodium sericeum*	rough blackfoot					•								
Fabaceae	*Melilotus alba*	white sweetclover					•	•							•
Fabaceae	*Melilotus indicus*	annual yellow sweetclover	•		•		•	•	•	•		•	•	•	•
Fabaceae	*Melilotus officinalis*	yellow sweetclover		•			•	•	•		•			•	•
Poaceae	*Melinis repens*	rose Natal grass									•				
Lamiaceae	*Mentha spicata*	spearmint						•	•						•
Aizoaceae	*Mesembryanthemum crystallinum*	common iceplant								•					
Aizoaceae	*Mesembryanthemum nodiflorum*	slenderleaf iceplant								•					
Poaceae	*Mnesithea granularis*	pitscale grass		•	•										
Molluginaceae	*Mollugo cerviana*	threadstem carpetweed								•	•	•			
Moraceae	*Morus alba*	white mulberry						•	•						•
Haloragaceae	*Myriophyllum spicatum*	Eurasian water-milfoil													•
Lamiaceae	*Nepeta cataria*	catnip		•											
Solanaceae	*Nicotiana glauca*	tree tobacco	•							•		•	•	•	
Asteraceae	*Oncosiphon piluliferum*	stinknet								•					
Cactaceae	*Opuntia ficus-indica*	Indian fig									•				
Poaceae	*Panicum antidotale*	blue panicgrass								•					
Poaceae	*Panicum miliaceum*	proso millet		•								•			
Papaveraceae	*Papaver rhoeas*	corn poppy										•		•	
Poaceae	*Paspalum dilatatum*	dallis grass						•	•		•			•	
Polygonaceae	*Persicaria maculosa*						•				•				
Poaceae	*Phalaris aquatica*	bulbous canarygrass													•
Poaceae	*Phalaris canariensis*	annual canarygrass											•		
Poaceae	*Phalaris minor*	littleseed canarygrass	•							•	•	•	•		
Poaceae	*Phalaris para*												•		
Poaceae	*Phleum pratense*	common timothy									•				
Pinaceae	*Pinus pinea*	Italian stone pine			•										

Table B-9. Exotic Plants Found In Sonoran Desert Parks (continued)

Family	Scientific Name	Common Names	CAGR	CHIR	CORO	FOBO	GICL	MOCA	MOWE	ORPI	SAGE	SAGW	TONT	TUMA	TUZI
Plantaginaceae	*Plantago lanceolata*	buckhorn plaintain						•	•						•
Poaceae	*Poa annua*	annual bluegrass				•				•	•				
Polygonaceae	*Polygonum argyrocoleon*	silver sheath knotweed	•							•				•	
Polygonaceae	*Polygonum aviculare*	yard knotweed	•	•	•			•	•		•				•
Polygonaceae	*Polygonum convolvulus*	climbing buckwheat				•	•								
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass		•	•			•	•	•	•	•	•	•	•
Poaceae	*Polypogon viridis*	beardless rabbitsfoot grass		•		•		•	•	•	•				
Portulacaceae	*Portulaca oleracea*	common purslane		•	•	•	•	•		•	•	•		•	
Lythraceae	*Punica granatum*	pomegranate								•					
Rosaceae	*Pyracantha koizumii*	Formosa firethorn			•										
Brassicaceae	*Rorippa microphyllum*	onerow yellowcress								•					
Rosaceae	*Rubus rigidus*							•	•						
Polygonaceae	*Rumex acetosella*	common sheep sorrel					•				•				
Polygonaceae	*Rumex crispus*	curley dock		•		•	•	•	•		•			•	•
Chenopodiaceae	*Salsola kali*	prickly Russian thistle		•	•	•					•	•	•	•	•
Chenopodiaceae	*Salsola tragus*	prickly Russian thistle	•		•	•		•	•	•	•	•			•
Adoxaceae	*Sambucus nigra*	European black alder			•					•			•		•
Poaceae	*Schedonorus pratensis*							•	•						
Anacardiaceae	*Schinus molle*	American pepper												•	
Poaceae	*Schismus arabicus*	Arabian schismus	•							•	•	•		•	•
Poaceae	*Schismus barbatus*	common Mediterranean grass	•					•	•	•	•	•	•	•	•
Poaceae	*Setaria pumila*	yellow bristlegrass												•	
Poaceae	*Setaria viridis*	green bristlegrass		•				•	•		•			•	•
Malvaceae	*Sida abutifolia*	prostrate sida		•	•	•		•	•	•	•	•		•	
Brassicaceae	*Sisymbrium altissimum*	tumble mustard					•						•		•
Brassicaceae	*Sisymbrium irio*	London rocket	•	•	•	•		•	•	•	•	•	•	•	•
Brassicaceae	*Sisymbrium orientale*	Indian hedgemustard								•		•	•		
Asteraceae	*Sonchus asper*	spiny sowthistle	•	•	•		•	•			•	•	•	•	•
Asteraceae	*Sonchus oleraceus*	annual sowthistle	•	•	•	•				•	•	•	•		
Poaceae	*Sorghum bicolor*	broomcorn												•	
Poaceae	*Sorghum halepense*	Johnsongrass	•	•	•	•		•	•	•	•	•	•	•	•

Table B-9. Exotic Plants Found In Sonoran Desert Parks (continued)

Family	Scientific Name	Common Names	CAGR	CHIR	CORO	FOBO	GICL	MOCA	MOWE	ORPI	SAGE	SAGW	TONT	TUMA	TUZI
Caryophyllaceae	*Stellaria media*	common chickweed											•		
Asteraceae	*Tagetes minuta*	wild marigold												•	
Tamaricaceae	*Tamarix aphylla*	Athel tamarisk								•					
Tamaricaceae	*Tamarix aralensis*	Russian tamarisk									•				
Tamaricaceae	*Tamarix chinensis*	Chinese tamarisk	•									•			•
Tamaricaceae	*Tamarix ramosissima*	saltcedar						•	•	•	•			•	•
Asteraceae	*Taraxacum laevigatum*	red-seed dandelion					•	•	•		•				•
Asteraceae	*Taraxacum palustre*	marsh dandelion													•
Brassicaceae	*Thlaspi arvense*	field pennycress					•			•					
Asteraceae	*Tragopogon dubius*	western salsify					•	•	•						•
Asteraceae	*Tragopogon pratensis*	meadow salsify					•								
Zygophyllaceae	*Tribulus terrestris*	puncturevine	•	•	•	•	•	•	•	•	•	•		•	•
Fabaceae	*Trifolium repens*	white clover		•				•	•						•
Poaceae	*Triticum aestivum*	common wheat			•					•		•	•		
Scrophulariaceae	*Verbascum blattaria*	moth mullein		•											
Scrophulariaceae	*Verbascum thapsus*	common mullein		•			•	•	•		•				•
Scrophulariaceae	*Verbascum virgatum*	wand mullein		•		•									
Verbenaceae	*Verbena officinalis*	herb of the cross								•					
Apocynaceae	*Vinca major*	giant periwinkle						•	•						•
Poaceae	*Vulpia myuros*	rattail fescue									•	•	•		
Asteraceae	*Zinnia peruviana*	Peruvian zinnia			•									•	

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 (WHSA)(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.

The Chihuahuan Desert Network implements the exotics 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 were 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 was 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 have in some instances been 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. Surveys occur in

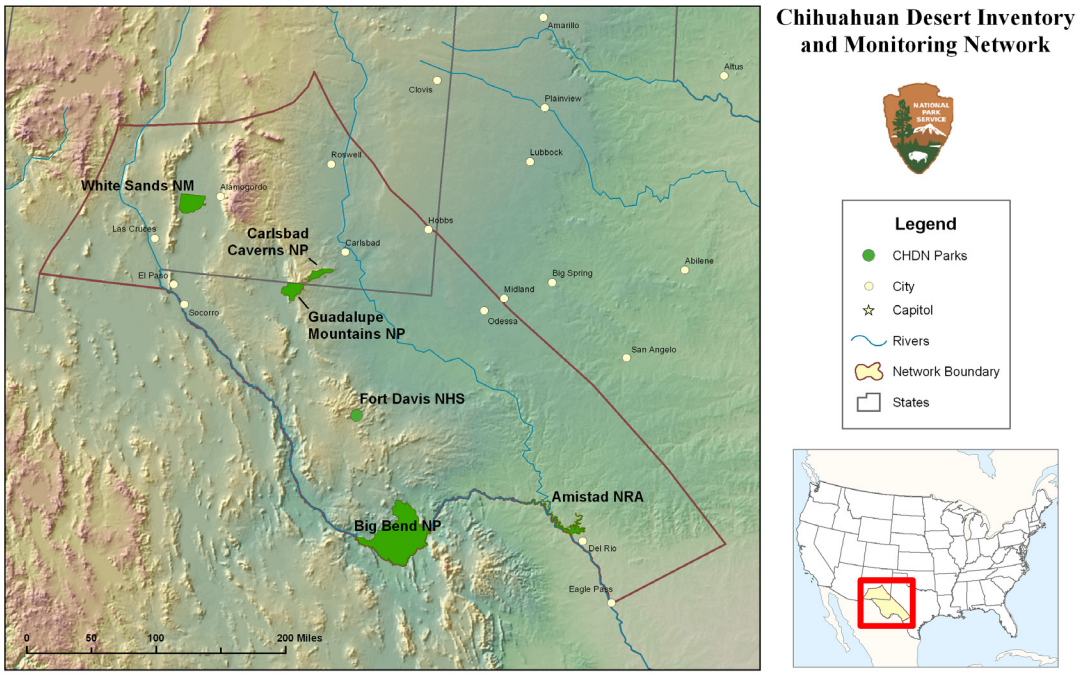


Figure C-1. Park locations within the Chihuahuan Desert I&M Network.

the spring and fall to best capture the exotic flora's phenological window and to nest within CHDN's other monitoring schedules. At this time, no exotic monitoring will take place at WHSA at the parks request. Yearly monitoring of all vectors of concern will take place at AMIS and FODA and of high priority areas of BIBE, CAVE and GUMO. Park-specific sampling frequencies are described below.

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 (accessed 2011) 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*.)*.

Exotics transects at AMIS are sampled yearly and are monitored in the opposite season of the last effort (Table C-1 and Figure C-2). For example, if a transect is monitored in spring of Year 1, it would be sampled next in fall of Year 2.

Table C-1. Sampling frequency, panel ID, and length of exotics transects at AMIS.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
AMIS_EX_014	Marina Access Road	Annually	12-a	1000
AMIS_EX_015	Marina Access Road	Annually	12-a	1000
AMIS_EX_016	Marina Access Road	Annually	12-a	250
AMIS_EX_017	Governors Landing	Annually	12-b	1000
AMIS_EX_018	Governors Landing	Annually	12-a	1000
AMIS_EX_019	Governors Landing	Annually	12-a	300
AMIS_EX_020	Marina Trails	Annually	12-b	350
AMIS_EX_021	Marina Trails	Annually	12-b	450
AMIS_EX_022	Marina Trails	Annually	12-b	805
AMIS_EX_023	Marina Trails	Annually	12-b	250
AMIS_EX_024	Marina Trails	Annually	12-b	200
AMIS_EX_025	Marina Trails	Annually	12-b	150
AMIS_EX_026	Diablo East	Annually	12-a	1000
AMIS_EX_027	Diablo East	Annually	12-a	200
AMIS_EX_028	Diablo East	Annually	12-b	1000
AMIS_EX_029	Diablo East	Annually	12-b	1000
AMIS_EX_030	Diablo East	Annually	12-b	300
AMIS_EX_031	Diablo East	Annually	12-b	450
AMIS_EX_032	Diablo East	Annually	12-b	400
AMIS_EX_033	Diablo East	Annually	12-a	200
AMIS_EX_034	Diablo East	Annually	12-a	300
AMIS_EX_035	Spur 454	Annually	12-b	1044
AMIS_EX_036	San Pedro	Annually	12-a	1000
AMIS_EX_037	San Pedro	Annually	12-a	1000
AMIS_EX_038	San Pedro	Annually	12-a	741
AMIS_EX_039	San Pedro	Annually	12-a	306
AMIS_EX_041	277 South	Annually	12-a	1000
AMIS_EX_044	277 North	Annually	12-b	610
AMIS_EX_045	Rough Canyon	Annually	12-a	300
AMIS_EX_046	Rough Canyon	Annually	12-a	100
AMIS_EX_047	Rough Canyon	Annually	12-a	300
AMIS_EX_048	Rough Canyon	Annually	12-a	300
AMIS_EX_049	Rough Canyon	Annually	12-a	150
AMIS_EX_050	Spur 406	Annually	12-b	1000
AMIS_EX_051	Spur 406	Annually	12-b	1000
AMIS_EX_052	Spur 406	Annually	12-b	292
AMIS_EX_055	Sunrise Trail	Annually	12-b	850
AMIS_EX_058	ADA at Diablo East	Annually	12-a	1000
AMIS_EX_059	ADA at Diablo East	Annually	12-a	1000
AMIS_EX_060	ADA at Diablo East	Annually	12-a	1000
AMIS_EX_061	Nature Trail	Annually	12-a	400



Figure C-2. Panel selection for AMIS (Governors Landing area).

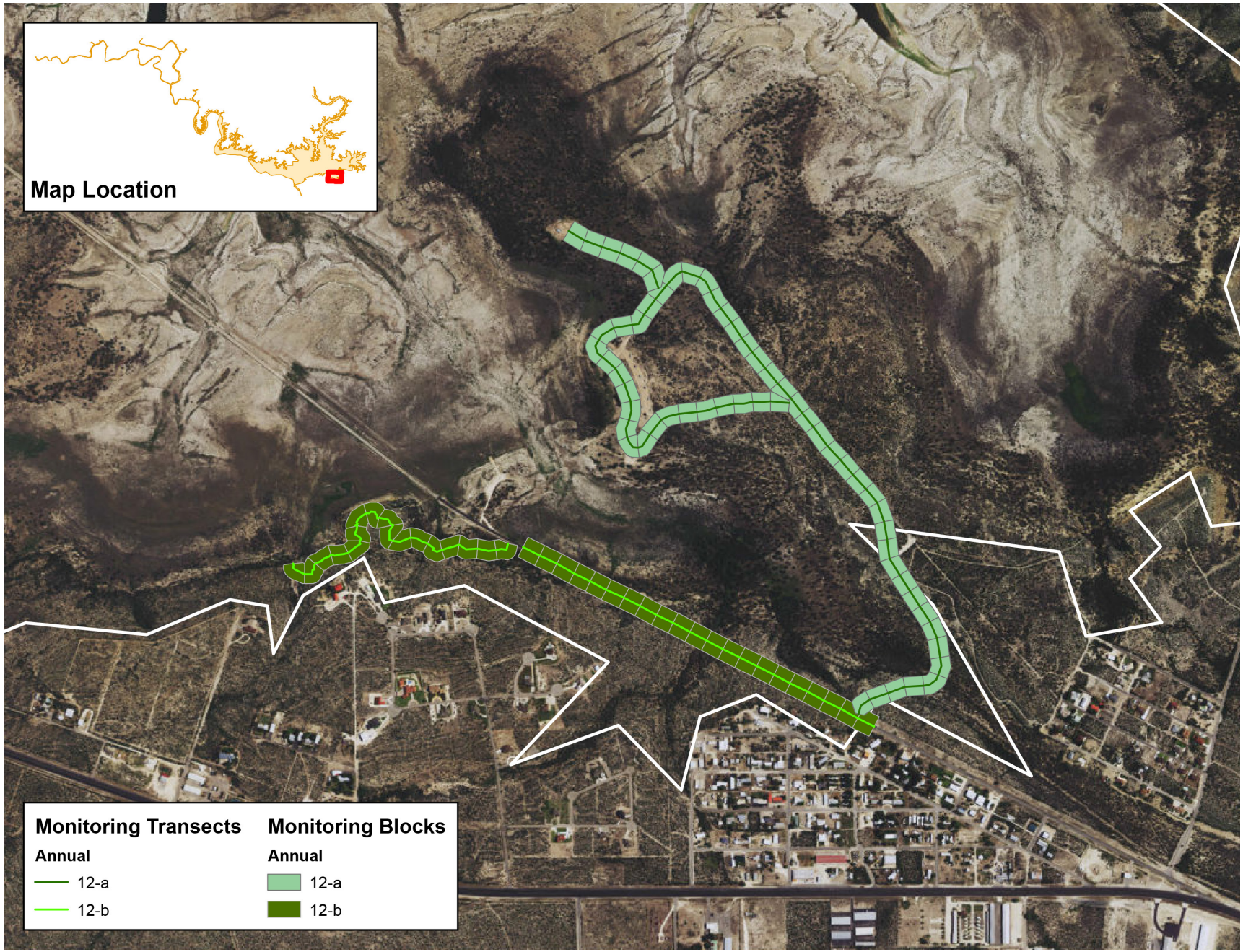


Figure C-3. Panel selection for AMIS (San Pedro area).



Figure C-4. Panel selection for AMIS (227 North and South boat launches).

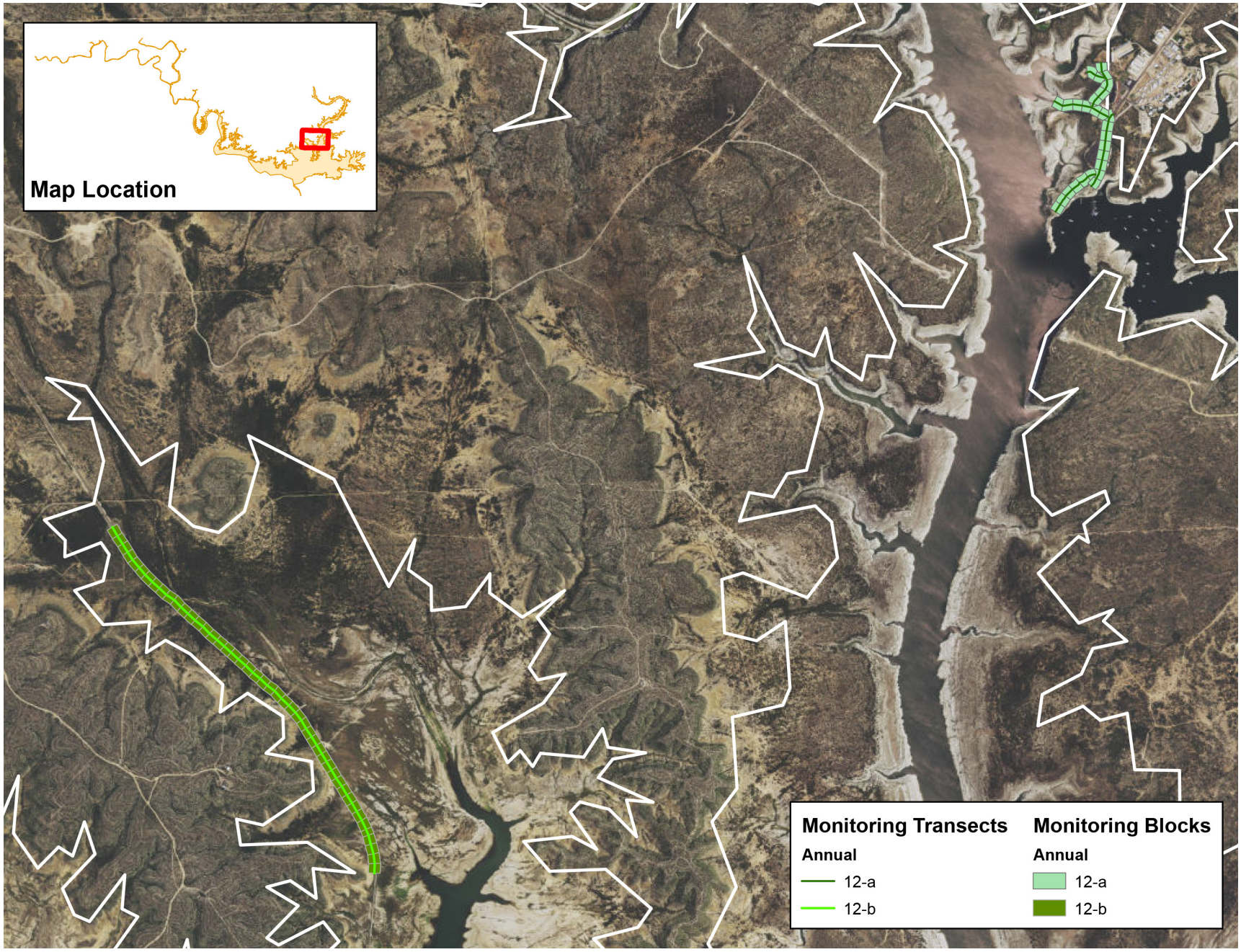


Figure C-5. Panel selection for AMIS (Spur 406 on left and Rough Canyon on right).

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* spp.), 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 (accessed in 2011) lists 86 non-native plant species present in BIBE and RIGR. Non-native plants that prove the greatest threat include saltcedar (*Tamarix* spp.), buffelgrass (*Pennisteum 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.

Due to the size of BIBE and the associated logistical and monetary constraints, transects at BIBE are assigned to 12 month, 24 month, and 36 month panels (Table C-2 and Figures C-6, -7, -8, -9 and -10). In areas where visitor use is highest and therefore the likelihood of introduction is highest, such as the Chisos Basin and around entrance stations, transects are assigned to the 12 month panel and are monitored primarily in the fall. Popular trails are assigned to a 24 month panel and are monitored on average every two years in the opposite season of the last effort. Busy roads are assigned to a 36 month panel and are monitored in the fall.

Table C-2. Sampling frequency, panel ID, and length of exotics transects at BIBE.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
BIBE_EX_001	Amphitheater Trail	Annually	12-F	300
BIBE_EX_002	Amphitheater Trail	Annually	12-F	700
BIBE_EX_003	Basin Sewer Plant Road	Annually	12-F	750
BIBE_EX_004	Campground	Annually	12-F	750
BIBE_EX_005	North Campground Road	Annually	12-F	300
BIBE_EX_006	Chisos Basin Group Campground Road	Annually	12-F	650
BIBE_EX_007	Chisos Basin Loop	Annually	12-F	850
BIBE_EX_008	Chisos Basin Road	2 years	24-2d	1000
BIBE_EX_009	Juniper Canyon	2 years	24-1c	1000
BIBE_EX_010	Juniper Canyon	2 years	24-1c	1000
BIBE_EX_011	Juniper Canyon	2 years	24-1c	1000
BIBE_EX_012	Juniper Canyon	2 years	24-1c	1000
BIBE_EX_013	Juniper Canyon	2 years	24-1c	1000
BIBE_EX_014	Laguna Meadow	2 years	24-2d	1000
BIBE_EX_015	Chisos Lodge Perimeter	Annually	12-F	475
BIBE_EX_016	Lower Basin Road	2 years	24-1d	1025
BIBE_EX_017	Old Warehouse Road	Annually	12-F	311
BIBE_EX_018	Persimmon Gap Road	Annually	12-a	1000
BIBE_EX_019	Persimmon Gap Road	Annually	12-a	1000
BIBE_EX_020	Persimmon Gap Road	Annually	12-a	1000
BIBE_EX_021	Persimmon Gap Road	Annually	12-a	1000
BIBE_EX_022	Persimmon Gap Road	Annually	12-a	1000
BIBE_EX_023	Pine Canyon	2 years	24-2c	1000
BIBE_EX_024	Pine Canyon	2 years	24-2c	1000
BIBE_EX_025	Pine Canyon	2 years	24-2c	1000
BIBE_EX_026	Pine Canyon	2 years	24-2c	201
BIBE_EX_027	Pinnacles	2 years	24-2d	1000
BIBE_EX_028	Pinnacles/Laguna Meadow	2 years	24-2d	428
BIBE_EX_029	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_030	Rio Grande Village Road	3 years	36-1F	925
BIBE_EX_031	Rio Grande Village Road	3 years	36-1F	675
BIBE_EX_032	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_033	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_034	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_035	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_036	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_037	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_038	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_039	Rio Grande Village Road	3 years	36-1F	1000
BIBE_EX_040	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_041	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_042	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_043	Rio Grande Village Road	3 years	36-2F	1000

Table C-2. Sampling frequency, panel ID, and length of exotics transects at BIBE (continued).

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
BIBE_EX_044	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_045	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_046	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_047	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_048	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_049	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_050	Rio Grande Village Road	3 years	36-2F	1000
BIBE_EX_051	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_052	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_053	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_054	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_055	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_056	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_057	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_058	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_059	Rio Grande Village Road	3 years	36-3F	1716
BIBE_EX_060	Rio Grande Village Road	3 years	36-3F	1000
BIBE_EX_061	Stone Cottage Road	Annually	12-F	275
BIBE_EX_062	West Entrance Road	Annually	12-b	1000
BIBE_EX_063	West Entrance Road	Annually	12-b	1000
BIBE_EX_064	West Entrance Road	Annually	12-b	1000
BIBE_EX_065	West Entrance Road	Annually	12-b	1000
BIBE_EX_066	West Entrance Road	Annually	12-b	1000
BIBE_EX_067	Window	2 years	24-1d	1000
BIBE_EX_068	Window Trail	2 years	24-1d	1000
BIBE_EX_069	Window Trail	2 years	24-1d	921
BIBE_EX_070	Window View Trail	Annually	12-F	400
BIBE_EX_071	Chisos Store	Annually	12-F	25
BIBE_EX_072	VC East	Annually	12-F	25
BIBE_EX_073	Restaurant Culdesac	Annually	12-F	25
BIBE_EX_074	Motel NE	Annually	12-F	25
BIBE_EX_075	Motel NW	Annually	12-F	25
BIBE_EX_076	Motel SW	Annually	12-F	25
BIBE_EX_077	Parking Median	Annually	12-F	25
BIBE_EX_078	Seating Area	Annually	12-F	25
BIBE_EX_079	Lodge A AND B	Annually	12-F	25
BIBE_EX_080	Lodge C	Annually	12-F	25
BIBE_EX_081	Lodge D	Annually	12-F	25
BIBE_EX_082	Rio Grande Village Road	3 Years	36-3F	1000

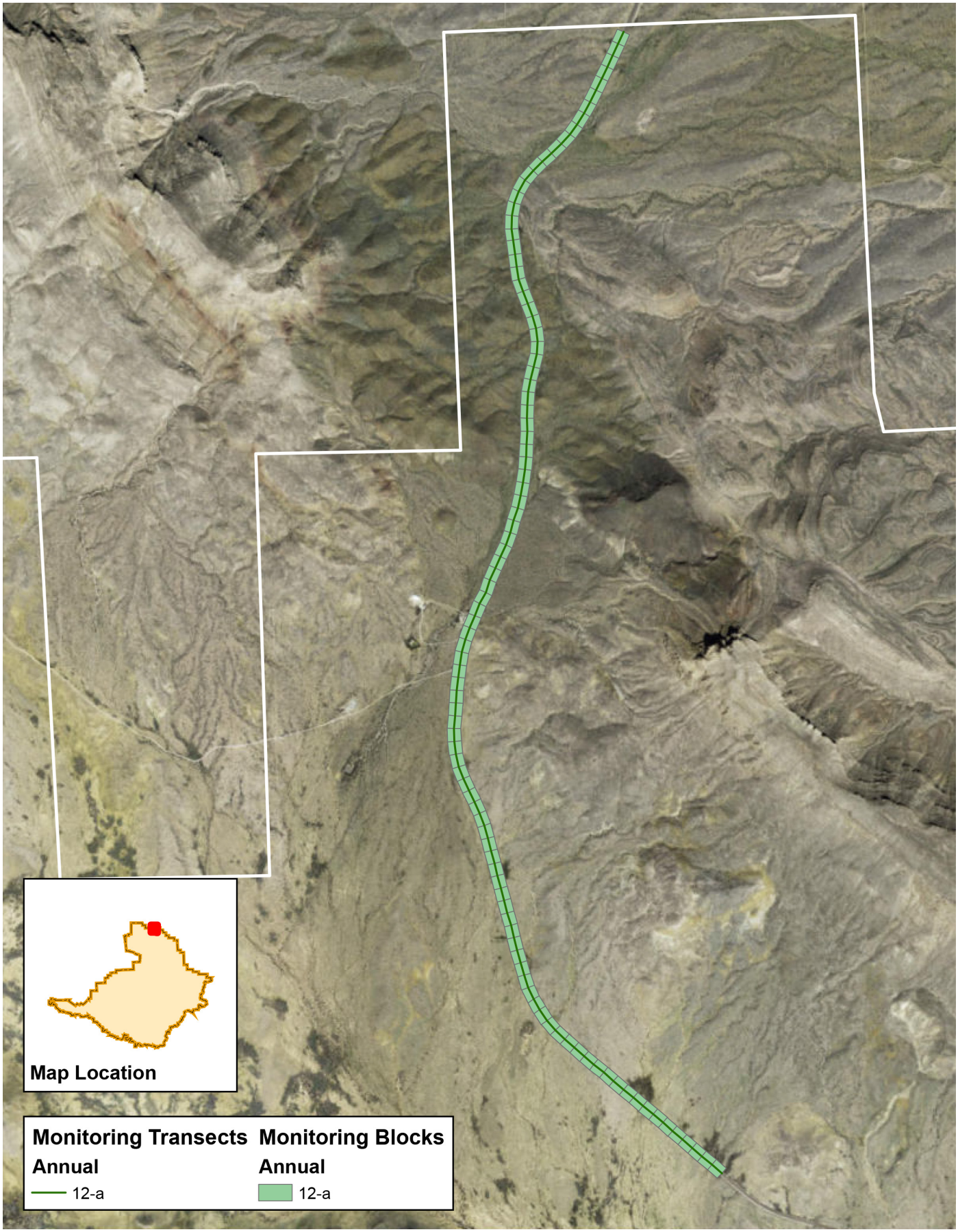


Figure C-6. Panel selection for BIBE (Persimmon Gap Road)..

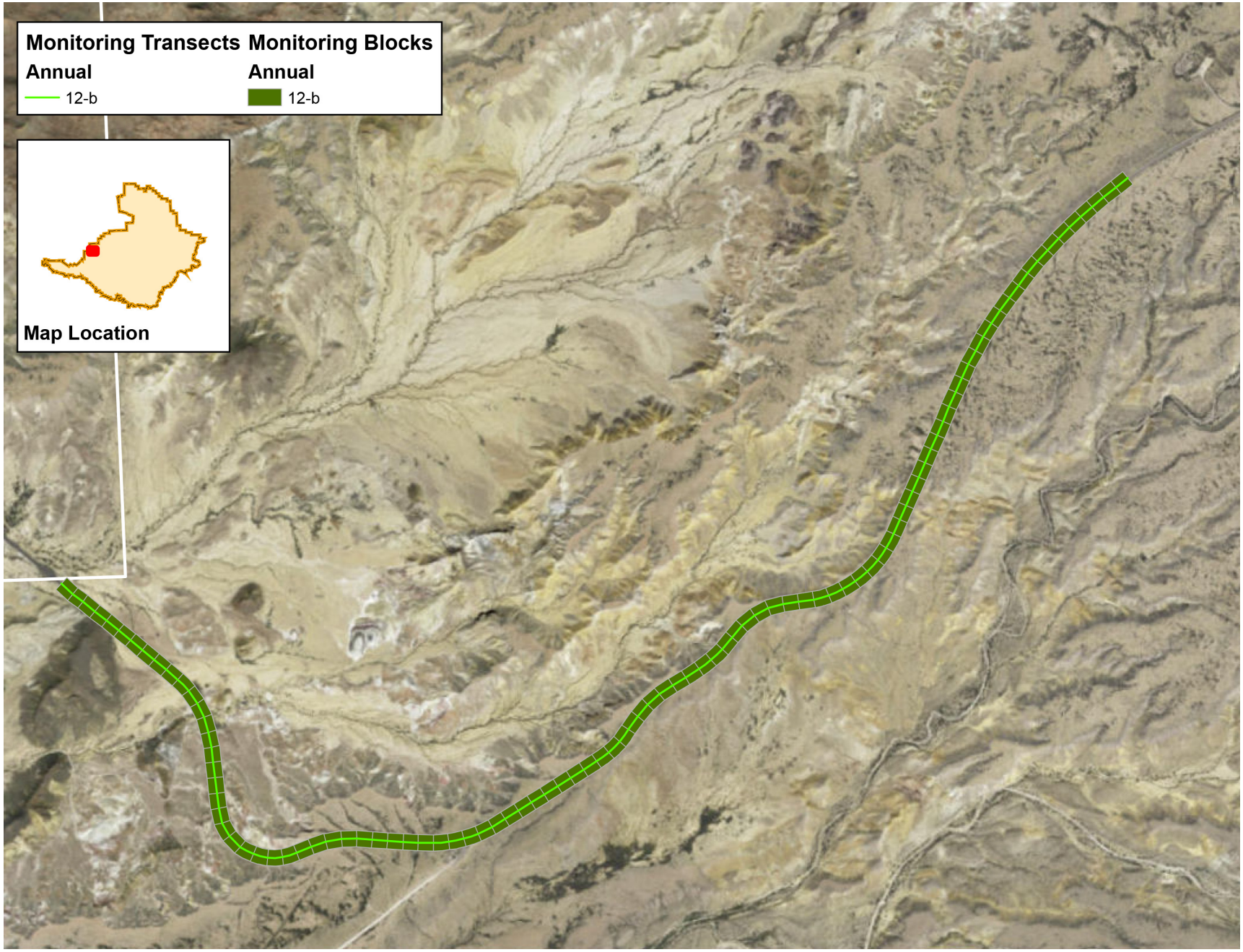


Figure C-7. Panel selection for BIBE (West Entrance Road).

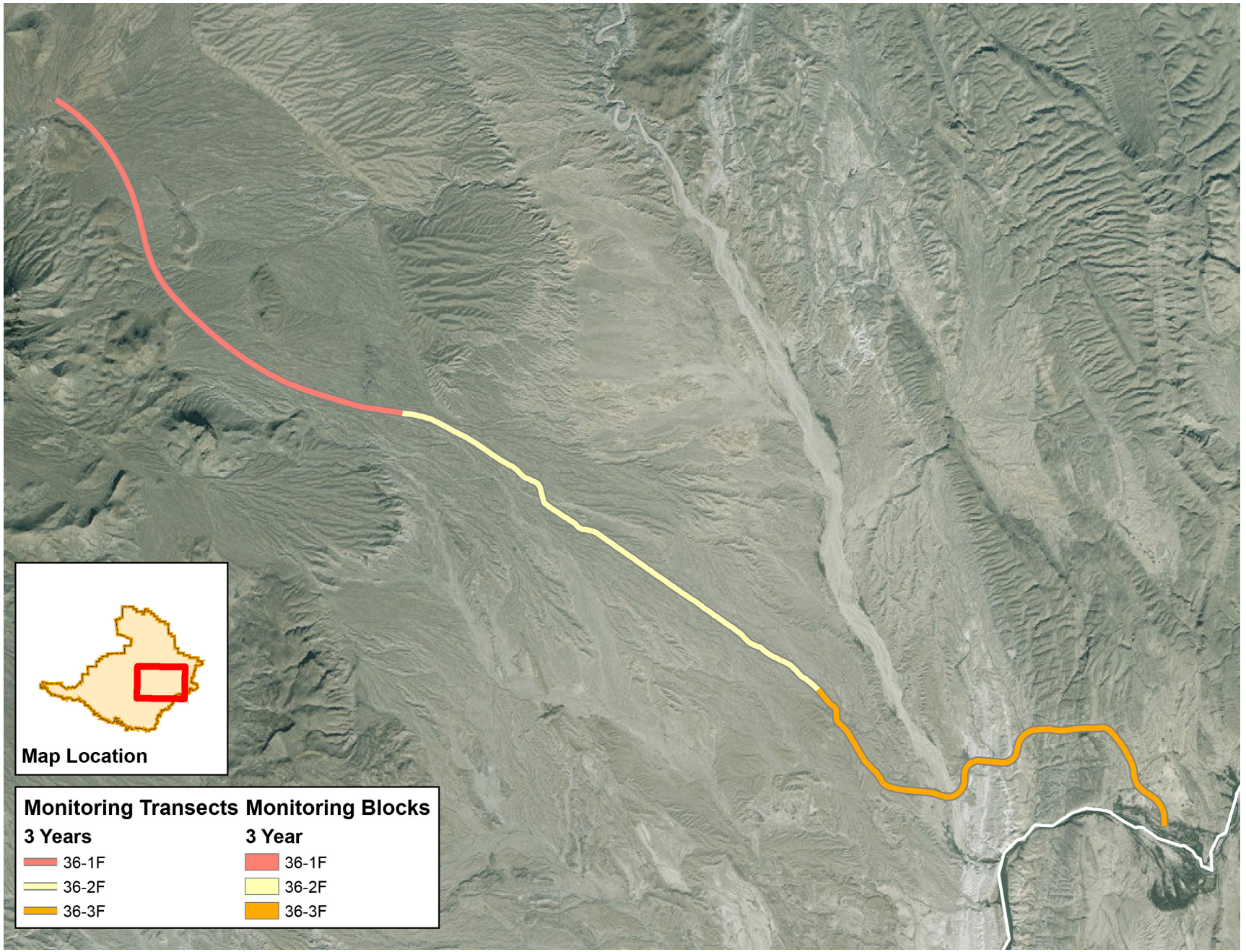


Figure C-8. Panel selection for BIBE (Rio Grande Road).

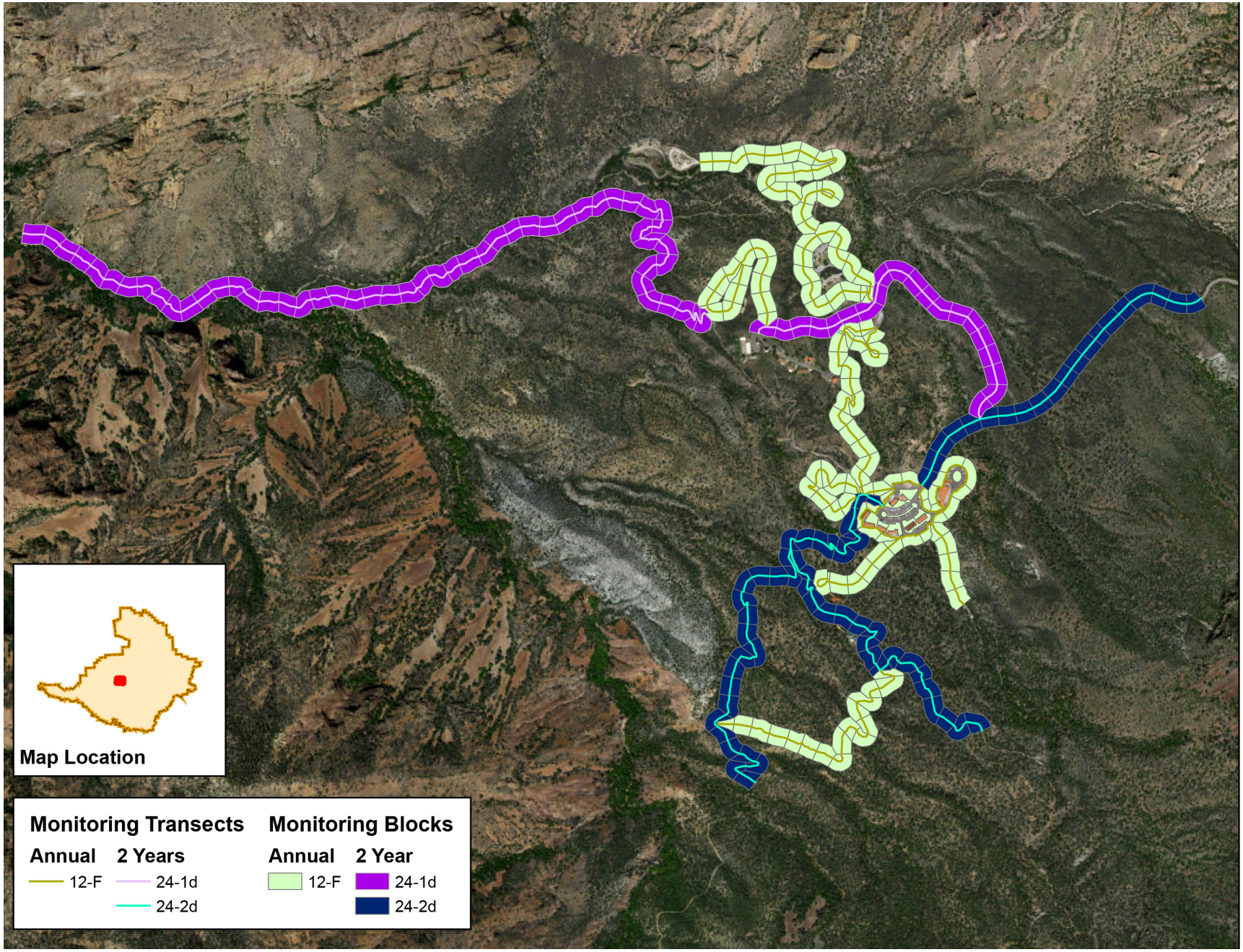


Figure C-9. Panel selection for BIBE (Chisos Basin area).

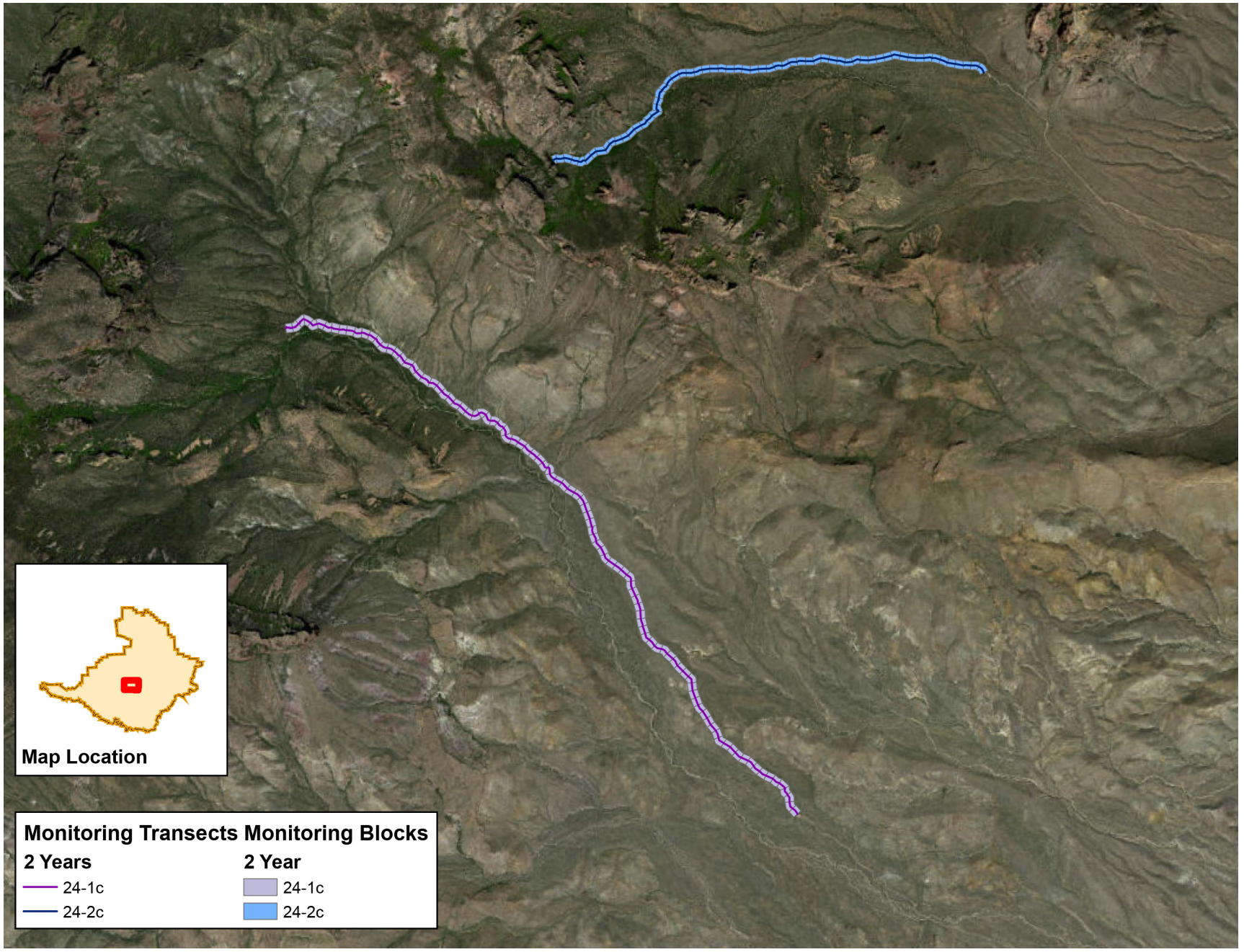


Figure C-10. Panel selection for BIBE (upper transect: Pine Canyon Trail, lower transect: Juniper Canyon Trail).

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. 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 (accessed 2011) 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 (*Elaegnus angustifolia)* and Johnsongrass (*Sorghum halapense)*, 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. Species on the New Mexico Noxious Weed list include: tree of heaven, Malta starthistle, yellow starthistle (*C. solstitialis)*, Russian olive, scotch thistle (*Onopordum acanthium)*, African Rue (*Peganum harmal)*, saltcedar (*Tamarix* spp.*)*, and Siberian elm (*Ulmus pumila)*.

Transects at CAVE are assigned to either the 12 month or 24 month panel (Table C-3 and Figures C-11, -12 and -13). For each panel transects are monitored in the opposite season of the last effort (e.g., transects surveyed in the fall one year are surveyed in the spring in the following year).

Table C-3. Sampling frequency, panel ID, and length of exotics transects at CAVE.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
CAVE_EX_001	Carlsbad Cavern Highway	2 years	24-2d	1000
CAVE_EX_002	Carlsbad Cavern Highway	2 years	24-2d	1000
CAVE_EX_003	Carlsbad Cavern Highway	2 years	24-2d	1000
CAVE_EX_004	Carlsbad Cavern Highway	2 years	24-2c	1000
CAVE_EX_005	Carlsbad Cavern Highway	2 years	24-2c	1000
CAVE_EX_006	Carlsbad Cavern Highway	2 years	24-2c	1000
CAVE_EX_007	Carlsbad Cavern Highway	2 years	24-1d	1025
CAVE_EX_008	Carlsbad Cavern Highway	2 years	24-1d	400
CAVE_EX_009	Carlsbad Cavern Highway	2 years	24-1d	450
CAVE_EX_010	Carlsbad Cavern Highway	2 years	24-1c	1000
CAVE_EX_011	Carlsbad Cavern Highway	2 years	24-1c	815
CAVE_EX_012	Sewage Treatment Road	Annually	12-a	1000
CAVE_EX_013	Sewage Treatment Road	Annually	12-a	1000
CAVE_EX_014	Sewage Treatment Road	Annually	12-a	1000
CAVE_EX_015	Sewage Treatment Road	Annually	12-b	1000
CAVE_EX_016	Sewage Treatment Road	Annually	12-b	1000
CAVE_EX_017	Sewage Treatment Road	Annually	12-b	625
CAVE_EX_019	Rattlesnake Canyon Trail	2 years	24-1c	1025
CAVE_EX_020	Rattlesnake Canyon Trail	2 years	24-1c	1000
CAVE_EX_021	Upper Rattlesnake Trail	2 years	24-1c	1000
CAVE_EX_022	Slaughter Canyon Cave Trail	2 years	24-2d	875
CAVE_EX_023	Slaughter Canyon Trail	2 years	24-2d	1025
CAVE_EX_024	Slaughter Canyon Road	2 years	24-2c	1000
CAVE_EX_025	Slaughter Canyon Road	2 years	24-2c	950
CAVE_EX_026	YUCCA TRAIL	2 years	24-1d	1000
CAVE_EX_027	Yucca Canyon Trail	2 years	24-1d	1000
CAVE_EX_028	Yucca Canyon Trail	2 years	24-1d	1000
CAVE_EX_029	Loop Road	Annually	12-a	1000
CAVE_EX_035	Loop Road	Annually	12-b	1000
CAVE_EX_036	Loop Road	Annually	12-b	550
CAVE_EX_037	Loop Road	Annually	12-a	1000
CAVE_EX_038	Loop Road	Annually	12-a	1000
CAVE_EX_039	Loop Road	Annually	12-a	1000
CAVE_EX_045	Guano Trail East	Annually	12-a	1000
CAVE_EX_046	Guano Trail East	Annually	12-a	1000
CAVE_EX_047	Guano Trail West	Annually	12-b	1000
CAVE_EX_048	Guano Trail West	Annually	12-b	1000

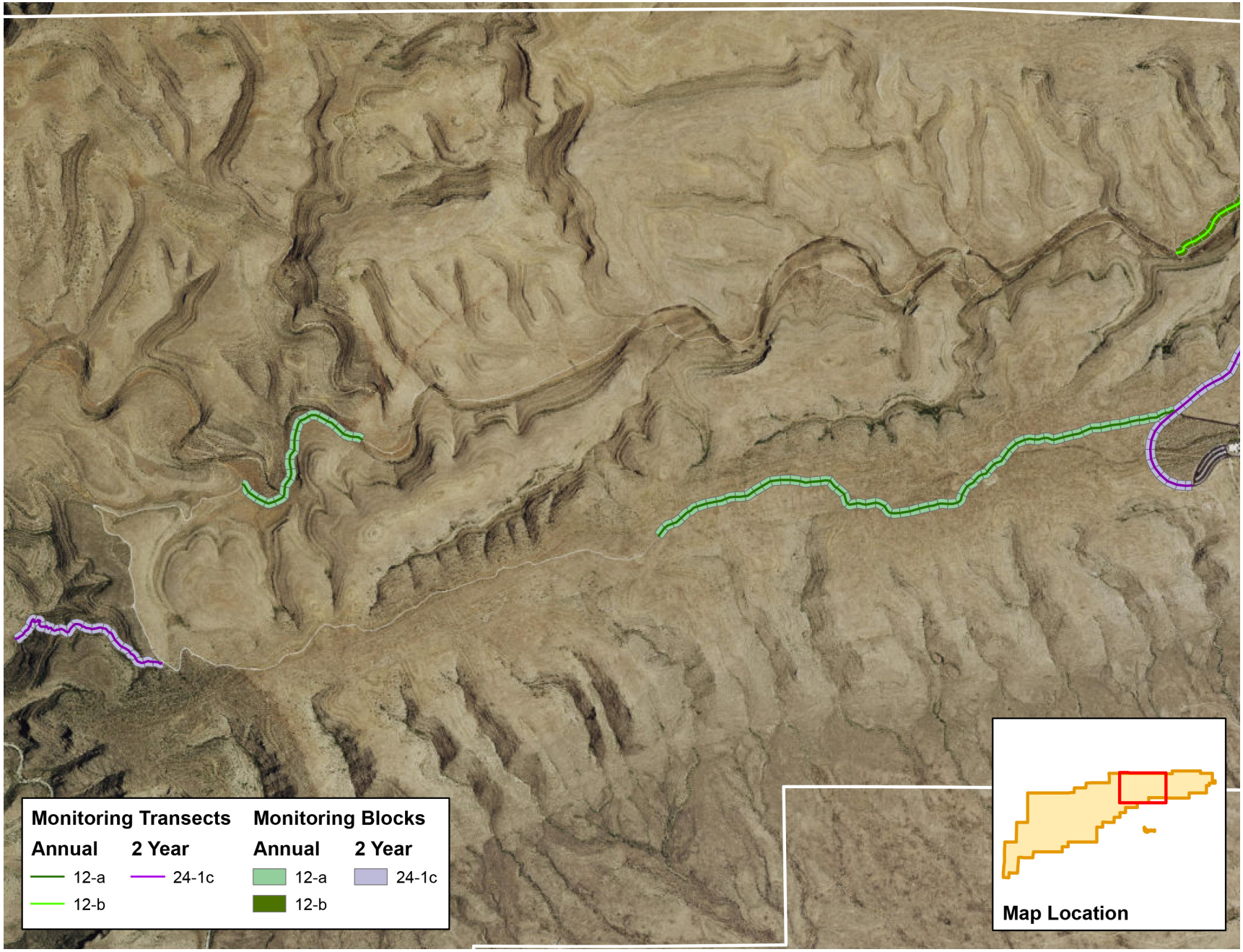


Figure C-11. Panel selection for CAVE (along the loop road).

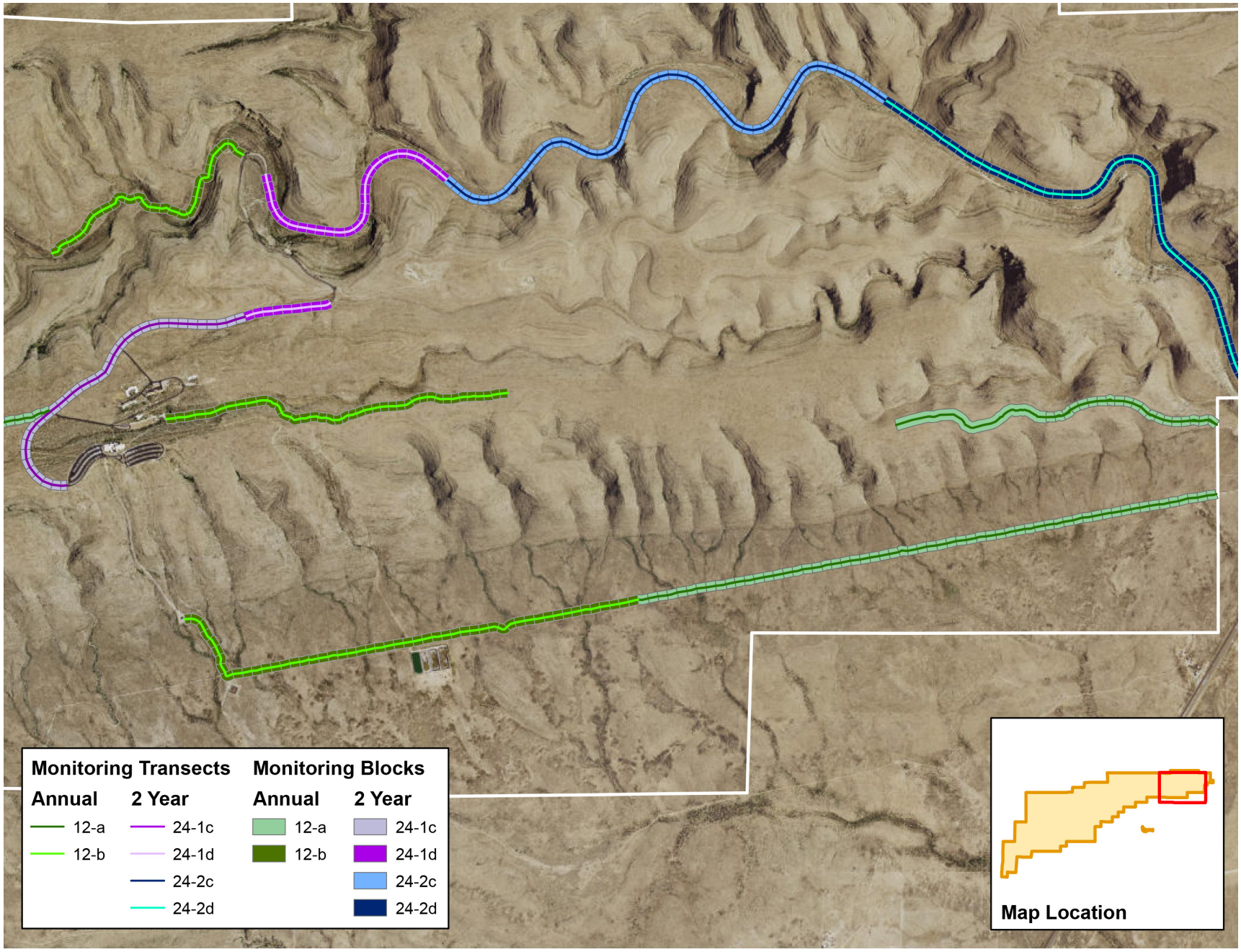


Figure C-12. Panel selection for CAVE (Visitor Center, entrance area and sewage treatment road).

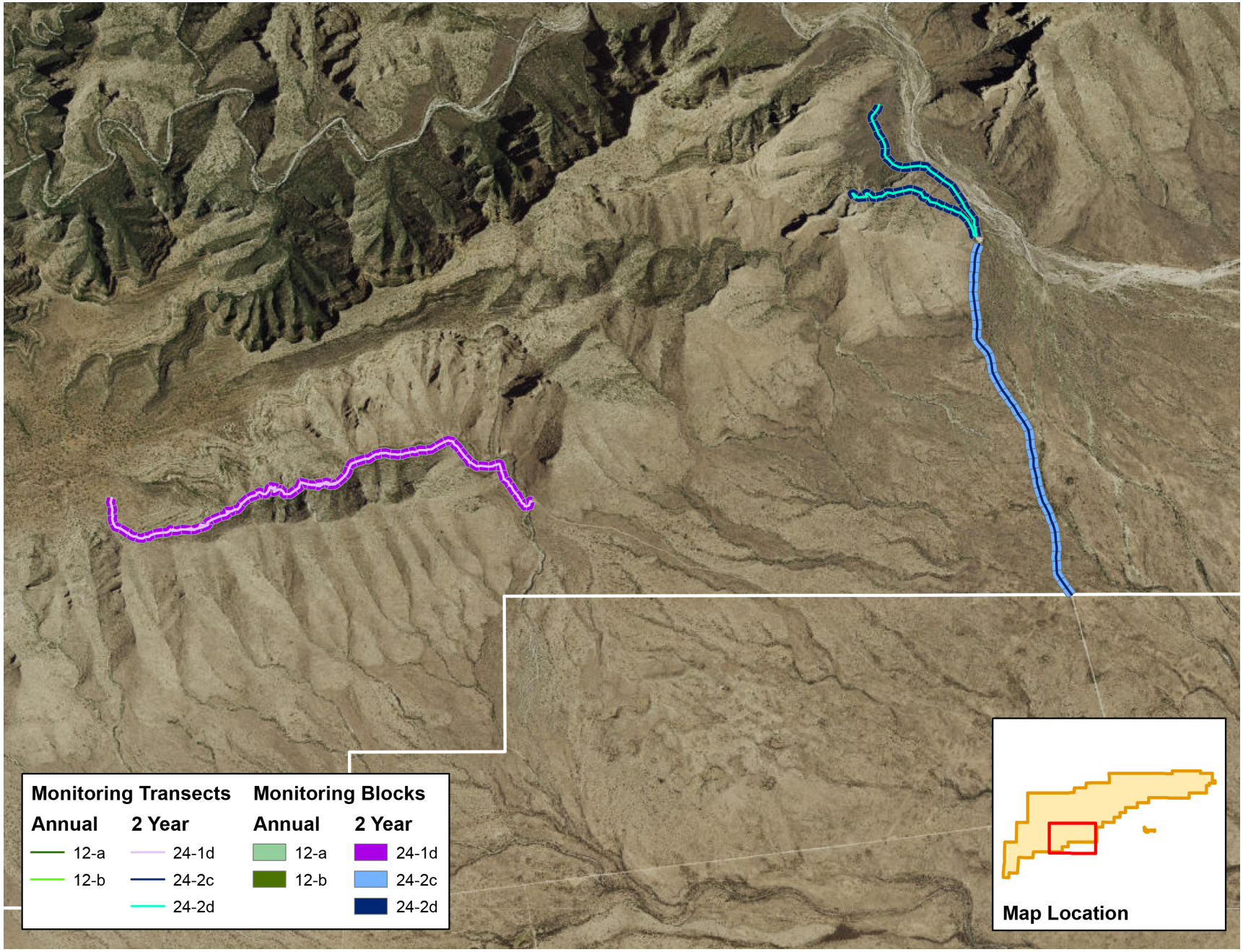


Figure C-13. Panel selection for CAVE (Yucca Canyon Trail on left, Slaughter Canyon Road and Trail on right).

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 (accessed 2011) 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.

Given the small size of FODA, all transects at FODA are monitored every 6 months (Table C-4 and Figure C-14).

Table C-4. Sampling frequency, panel ID, and length of exotics transects at FODA.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
FODA_EX_001	Old El Paso-San Antonio Road	Seasonally (every spring and fall)	6	750
FODA_EX_002	Hospital Canyon Road	Seasonally (every spring and fall)	6	1350
FODA_EX_003	Entrance Road	Seasonally (every spring and fall)	6	550
FODA_EX_004	Tallgrass Trail	Seasonally (every spring and fall)	6	700
FODA_EX501	Hospital Canyon Trail	Seasonally (every spring and fall)	6	750
FODA_EX502	North Ridge Trail	Seasonally (every spring and fall)	6	550
FODA_EX504	Tallgrass Trail West	Seasonally (every spring and fall)	6	600

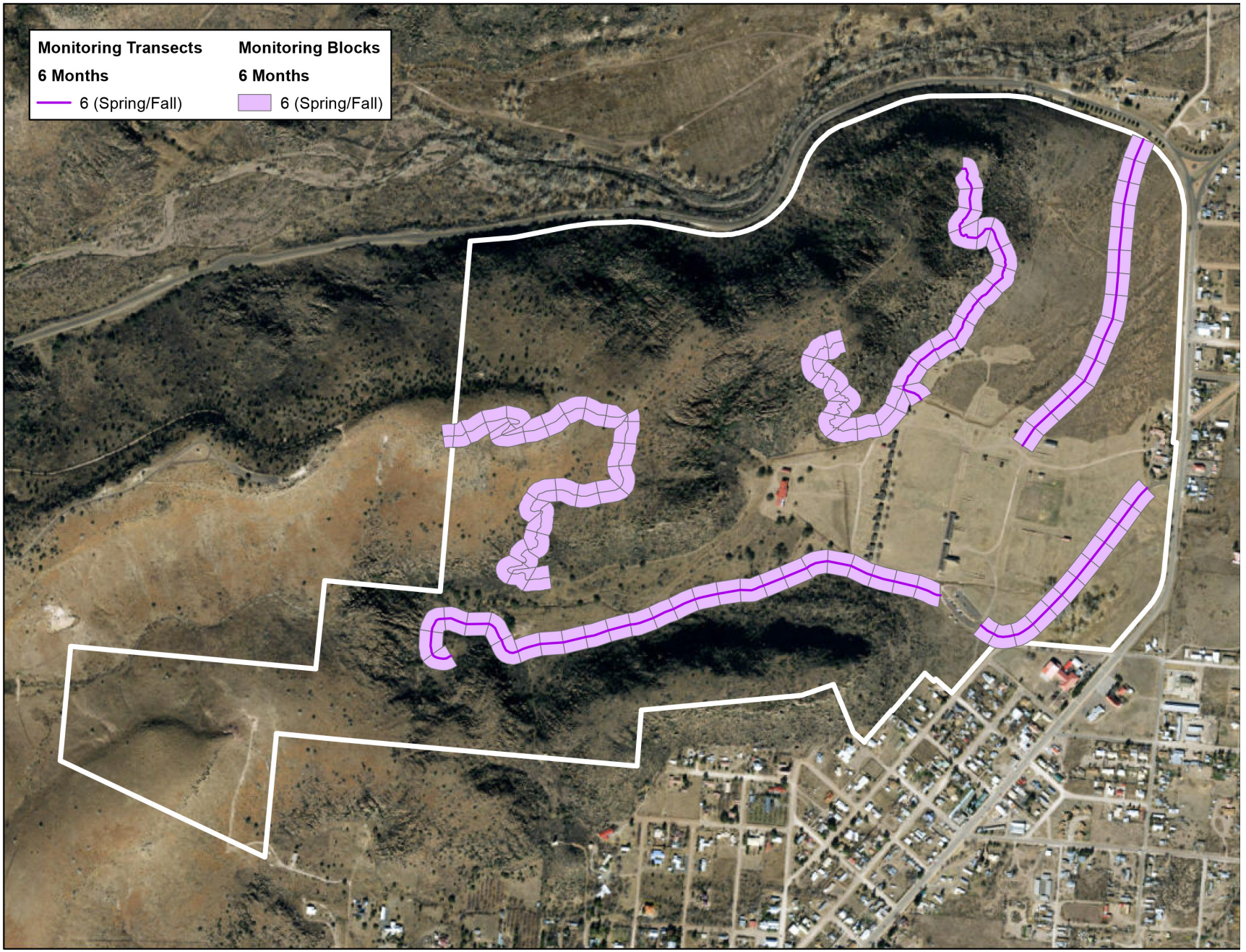


Figure C-14. Panel selection for FODA.

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.

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 (accessed 2011) lists 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.*)*.

Transects at GUMO are assigned a 18 month panel, where transects are monitored in the opposite season of the last effort (e.g., transects monitored in the spring of one year are monitored in the fall of the following year) (Table C-6 and Figures C-15, -16 and -17).

Table C-5. Sampling frequency, panel ID, and length of exotics transects at GUMO.

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
GUMO_EX_008	Pine Camp Loop	1.5 Years	18-Y	300
GUMO_EX_009	Employee Road	1.5 Years	18-X	1100
GUMO_EX_010	Frijole Ranch Road	1.5 Years	18-X	1050
GUMO_EX_011	Dog Canyon Road	1.5 Years	18-Z	800
GUMO_EX_012	Tejas Trail - Dog Canyon	1.5 Years	18-Z	1000
GUMO_EX_013	Tejas Trail - Dog Canyon	1.5 Years	18-Z	1000
GUMO_EX_015	New Corral Road	1.5 Years	18-X	800
GUMO_EX_016	McKittrick Canyon Road	1.5 Years	18-X	1000
GUMO_EX_017	McKittrick Canyon Road	1.5 Years	18-X	1000
GUMO_EX_018	McKittrick Canyon Road	1.5 Years	18-X	1000
GUMO_EX_019	McKittrick Canyon Road	1.5 Years	18-Y	1000
GUMO_EX_020	McKittrick Canyon Road	1.5 Years	18-Y	1000
GUMO_EX_021	McKittrick Canyon Road	1.5 Years	18-Z	1000

Table C-5. Sampling frequency, panel ID, and length of exotics transects at GUMO (continued).

Transect	Road/Trail Name	Sampling Frequency	Panel ID	Length (m)
GUMO_EX_022	McKittrick Canyon Road	1.5 Years	18-Z	760
GUMO_EX_023	McKittrick Canyon Nature Trail	1.5 Years	18-Z	1320
GUMO_EX_024	McKittrick Canyon Trail	1.5 Years	18-X	1000
GUMO_EX_025	McKittrick Canyon Trail	1.5 Years	18-X	1000
GUMO_EX_028	McKittrick Canyon Trail	1.5 Years	18-X	1000
GUMO_EX_029	McKittrick Canyon Trail	1.5 Years	18-X	500
GUMO_EX_030	El Capitan Trail	1.5 Years	18-X	1000
GUMO_EX_031	El Capitan Trail	1.5 Years	18-X	1000
GUMO_EX_032	Guadalupe Peak Horse Trail	1.5 Years	18-Z	1000
GUMO_EX_033	Guadalupe Peak Horse Trail	1.5 Years	18-Z	1000
GUMO_EX_034	Guadalupe Peak Trail	1.5 Years	18-Y	1000
GUMO_EX_036	Tejas Trail - VC	1.5 Years	18-Y	1000
GUMO_EX_037	Tejas Trail - VC	1.5 Years	18-Y	1000
GUMO_EX_038	Frijole Trail	1.5 Years	18-X	1000
GUMO_EX_039	Frijole Trail	1.5 Years	18-X	1000
GUMO_EX_040	Foothills Trail	1.5 Years	18-Z	1000
GUMO_EX_041	Foothills Trail	1.5 Years	18-Z	1000
GUMO_EX_042	Foothills Trail	1.5 Years	18-Z	1000
GUMO_EX_043	Smith Spring E	1.5 Years	18-Z	1000
GUMO_EX_044	Smith Spring W	1.5 Years	18-X	1000
GUMO_EX_045	Bush Mountain Trail	1.5 Years	18-Z	1000
GUMO_EX_046	Bush Mountain Trail	1.5 Years	18-Z	1000
GUMO_EX_047	Dune Road	1.5 Years	18-Y	1000
GUMO_EX_048	Dune Road	1.5 Years	18-Y	1000
GUMO_EX_049	Dune Road	1.5 Years	18-Y	1000
GUMO_EX_050	Dune Road	1.5 Years	18-Y	1000
GUMO_EX_051	Williams Ranch Road	1.5 Years	18-Y	1000
GUMO_EX_052	Williams Ranch Road	1.5 Years	18-Y	1000
GUMO_EX_053	VC/Campground road	1.5 Years	18-Y	1000
GUMO_EX_054	Permian Geology Trail & Loop	1.5 Years	18-Y	1050
GUMO_EX_055	Permian Geology Trail	1.5 Years	18-X	1000
GUMO_EX_056	RV Camp Loop	1.5 Years	18-Y	150

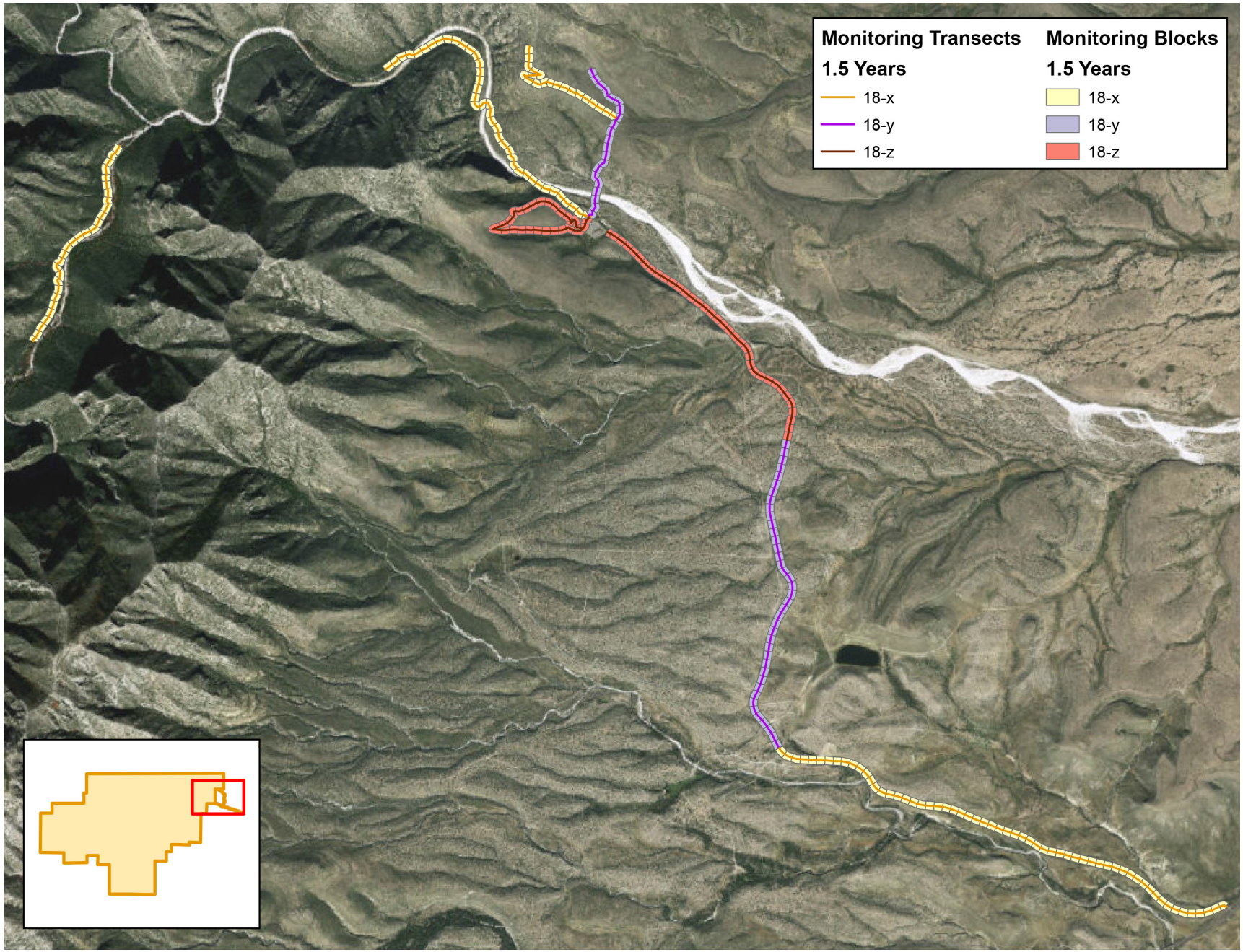


Figure C-15. Panel selection for GUMO (McKittrick Canyon Area).

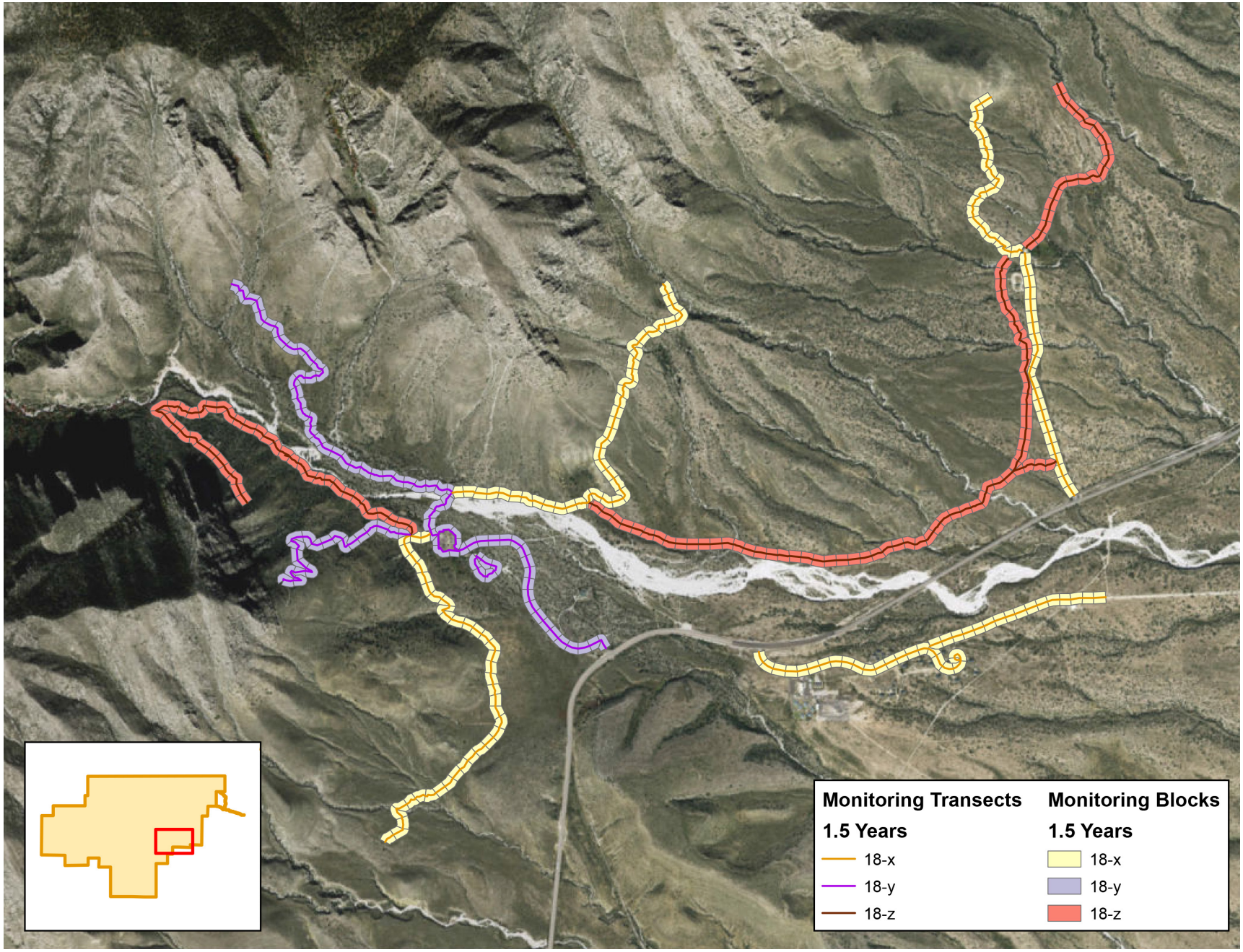


Figure C-16. Panel selection for GUMO (Visitor Center area).

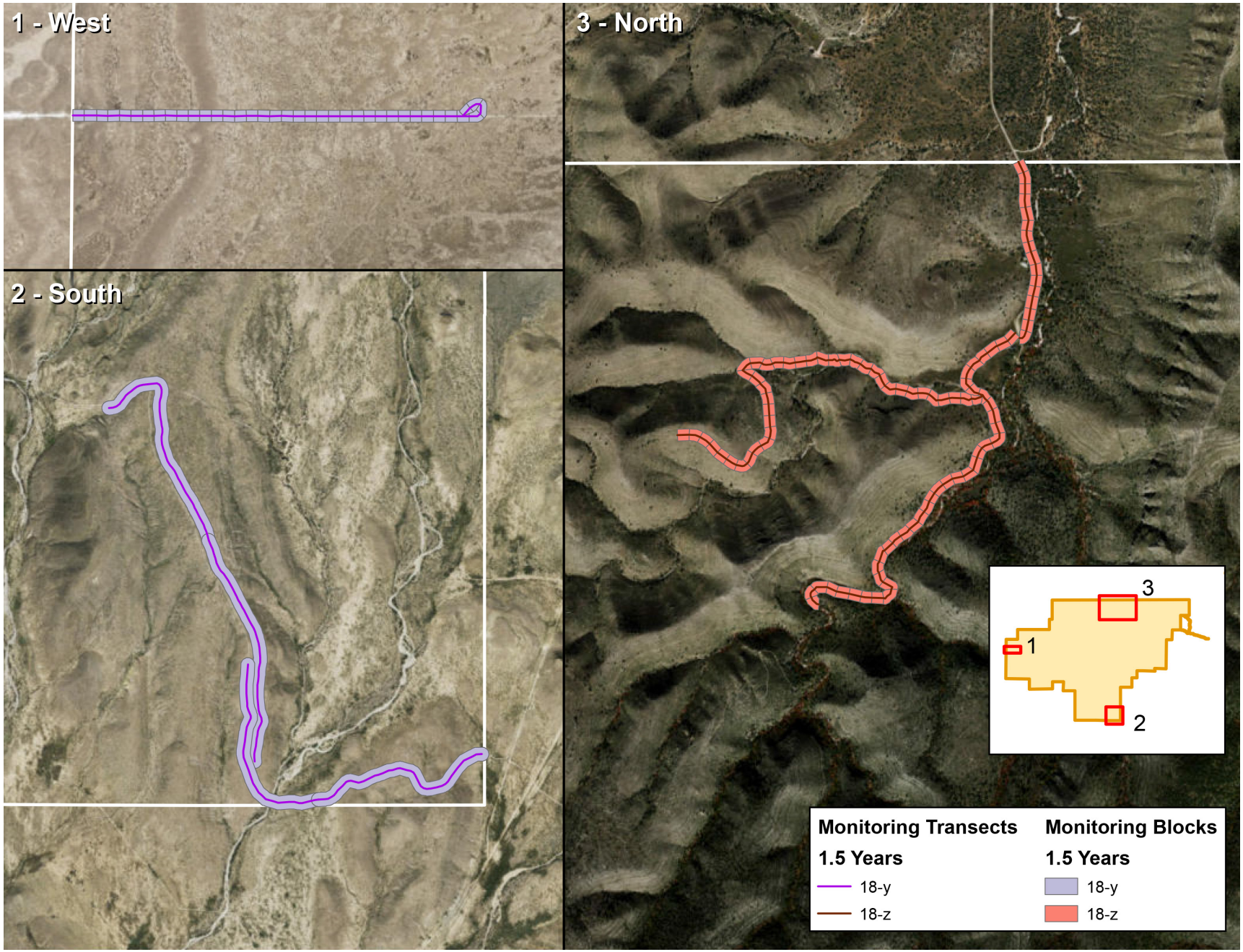


Figure C-17. Panel selection for GUMO (Dune Road on west frame, Williams Ranch Road on south frame, Dog Canyon Road and Tejas Trail in north frame).

C.6. White Sands National Monument

White Sands National Monument (WHSA) is located in south-central New Mexico. WHSA 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. WHSA 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. NPSpecies (accessed 2011) indicates 300 plant species, 16 of which are non-native, occur in WHSA. Those on the New Mexico Noxious Weed list include: Russian knapweed (*Acroptilon repens)*, Malta starthistle (*Centaurea melitensis)*, Russian olive (*Elaeagnus angustifolia)*, African Rue (*Peganum harmal)*, Dalmatian toadflax (*Linaria dalmatica)*, and saltcedar (*Tamarix* spp.*)*.

No exotic monitoring will take place at WHSA at the parks request to instead focus on salt cedar (Tamarisk sp.) surveys. If sampling occurs at WHSA in the future, CHDN and the park will develop the sampling scheme at that time.

C.7. References

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Table C-6. Exotic Plants Found In Chihuahuan Desert Parks

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

Table C-6. Exotic Plants Found In Chihuahuan Desert Parks (continued)

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

Table C-6. Exotic Plants Found In Chihuahuan Desert Parks (continued)

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

Table C-6. Exotic Plants Found In Chihuahuan Desert Parks (continued)

Family	Scientific Name	Common Names	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Poaceae	*Pennisetum glaucum*	yellow foxtail				•		
Poaceae	*Phalaris canariensis*	annual canarygrass			•			
Arecaceae	*Phoenix dactylifera*	date palm		•				
Solanaceae	*Physalis philadelphica*	Mexican groundcherry		•				
Asteraceae	*Picris sprengeriana*	bitterweed				•		
Plantaginaceae	*Plantago lanceolata*	buckhorn plaintain			•		•	
Poaceae	*Poa annua*	annual bluegrass	•X		•		•	
Polygonaceae	*Polygonum argyrocoleon*	silver sheath knotweed				•		
Polygonaceae	*Polygonum convolvulus*	climbing buckwheat		•				
Polygonaceae	*Polygonum lapathifolium*	curlytop knotweed		•				
Polygonaceae	*Polygonum persicaria*	ladysthumb smartweed	•	•				
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass	•	•	•		•	
Poaceae	*Polypogon viridis*	beardless rabbitsfoot grass	•	•	•		•	
Salicaceae	*Populus nigra*	black cottonwood			•			
Rosaceae	*Prunus armeniaca*	apricot			•			
Rosaceae	*Prunus cerasus*	sour cherry			•			
Rosaceae	*Prunus domestica*	European plum			•			
Rosaceae	*Prunus persica*	peach		•				
Asteraceae	*Pseudognaphalium luteoalbum*	Jersey cudweed	•					
Euphorbiaceae	*Ricinus communis*	castor bean	•					
Polygonaceae	*Rumex crispus*	curley dock	•	•	•			
Polygonaceae	*Rumex stenophyllus*	narrowleaf dock	•					
Salicaceae	*Salix X sepulcralis*	weeping willow			•			
Chenopodiaceae	*Salsola kali*	prickly Russian thistle		•	•	•		•
Chenopodiaceae	*Salsola tragus*	prickly Russian thistle	•	•	•		•	•
Primulaceae	*Samolus valerandi*	seaside brookweed	•					
Asteraceae	*Sanvitalia procumbens*	Mexican creeping zinnia		•				
Poaceae	*Setaria adhaerens*	burr bristlegrass		•				
Poaceae	*Setaria italica*	Italian bristle grass		•				
Poaceae	*Setaria pumila*	yellow bristlegrass	•			•	•	
Poaceae	*Setaria verticillata*	hooked bristlegrass	•?					
Poaceae	*Setaria viridis*	green bristlegrass	•	•	•		•	
Malvaceae	*Sida abutifolia*	prostrate sida	•	•	•	•	•	
Caryophyllaceae	*Silene gallica*	windmill catchfly					•	
Brassicaceae	*Sinapis arvensis*	charlock mustard		•				

Table C-6. Exotic Plants Found In Chihuahuan Desert Parks (continued)

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

Appendix D. Comparison Of Exotic Species Across All Networks

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Malvaceae	*Abutilon theophrasti*	velvetleaf Indian mallow			•
Asteraceae	*Achillea millefolium*	western yarrow		•	•
Asteraceae	*Acroptilon repens*	Russian knapweed	•	•	•
Poaceae	*Aegilops cylindrica*	jointed goatgrass			•
Poaceae	*Agropyron cristatum*	crested wheatgrass			•
Poaceae	*Agropyron desertorum*	clustered wheatgrass			•
Poaceae	*Agrostis gigantea*	redtop bentgrass	•		•
Simaroubaceae	*Ailanthus altissima*	tree if heaven	•	•	
Fabaceae	*Albizia julibrissin*	mimosa			•
Brassicaceae	*Alliaria petiolata*	garlic mustard			•
Liliaceae	*Allium ampeloprasum*	broadleaf wild leak			•
Brassicaceae	*Alyssum minus*	European alyssum			•
Amaranthaceae	*Amaranthus blitoides*	prostrate pigweed	•	•	•
Amaranthaceae	*Amaranthus crassipes*	spreading amaranth	•		
Amaranthaceae	*Amaranthus retroflexus*	redroot pigweed		•	•
Apiaceae	*Ammi visnaga*	toothpickweed		•	
Primulaceae	*Anagallis arvensis*	scarlet pimpernel	•	•	
Apiaceae	*Apium graveolens*	wild celery		•	
Brassicaceae	*Arabis hirsuta*	hairy rockcress			•
Asteraceae	*Arctium minus*	lesser burdock			•
Caryophyllaceae	*Arenaria serpyllifolia*	thymeleaf sandwort			•
Poaceae	*Arundo donax*	giant reed	•	•	•
Liliaceae	*Asparagus officinalis*	garden asparagus	•	•	•
Chenopodiaceae	*Atriplex rosea*	redscale saltbush		•	
Poaceae	*Avena fatua*	wild oats	•	•	
Poaceae	*Avena sativa*	common oat	•		•
Brassicaceae	*Barbarea vulgaris*	yellow rocket	•		•
Chenopodiaceae	*Bassia hyssopifolia*	fivehook bassia	•	•	
Asteraceae	*Bidens pilosa*	beggar's ticks	•		
Bignoniaceae	*Bignonia capreolata*	cross vine			•
Poaceae	*Bothriochloa bladhii*	Australian beardgrass			•
Poaceae	*Bothriochloa ischaemum*	Turkestan beardgrass	•	•	•
Brassicaceae	*Brassica juncea*	India mustard		•	
Brassicaceae	*Brassica nigra*	black mustard	•		•
Brassicaceae	*Brassica rapa*	birdrape	•	•	
Brassicaceae	*Brassica tournefortii*	African mustard	•		
Poaceae	*Bromus berteroanus*		•		
Poaceae	*Bromus arvensis*	field brome	•		•
Poaceae	*Bromus catharticus*	rescue brome	•	•	•
Poaceae	*Bromus commutatus*	meadow brome			•
Poaceae	*Bromus diandrus*	ripgut brome	•		
Poaceae	*Bromus hordeaceus*	soft brome	•		
Poaceae	*Bromus japonicus*	Japanese brome	•	•	•
Poaceae	*Bromus lanceolatus*	Mediterranean brome			•
Poaceae	*Bromus madritensis*	compact brome	•		

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Poaceae	*Bromus rubens*	red brome	•	•	
Poaceae	*Bromus tectorum*	cheatgrass	•	•	•
Moraceae	*Broussonetia papyrifera*	paper mulberry			•
Boraginaceae	*Buglossoides arvensis*	corn gromwell			•
Fabaceae	*Caesalpinia gilliesii*	Mexican bird of paradise	•	•	
Asteraceae	*Calyptocarpus vialis*	straggler daisy		•	•
Convolvulaceae	*Calystegia sepium*	hedge bindweed			•
Brassicaceae	*Camelina microcarpa*	smallseed false flax			•
Fabaceae	*Canavalia ensiformis*	wonderbean	•		
Cannabaceae	*Cannabis sativa*	hemp			•
Brassicaceae	*Capsella bursa-pastoris*	shepard's purse	•		•
Solanaceae	*Capsicum anuum var. glabriusculum*	chilipequin	•		
Brassicaceae	*Cardaria draba*	whitetop			•
Asteraceae	*Carduus nutans*	musk thistle			•
Asteraceae	*Carduus tenuiflorus*	Itlaian thistle		•	•
Cyperaceae	*Carex bonplandii*	Bonpland's sedge	•		
Cyperaceae	*Carex muricata*	rough sedge		•	
Asteraceae	*Carphochaete bigelovii*	Bigelow's bristlehead	•		
Asteraceae	*Carthamus tinctoris*	safflower	•		
Poaceae	*Cenchrus ciliaris*	buffelgrass	•		
Poaceae	*Cenchrus setaceous*		•		
Asteraceae	*Centaurea melitensis*	Malta starthistle	•	•	•
Asteraceae	*Centaurea solstitialis*	yellow starthistle	•	•	
Caryophyllaceae	*Cerastium fontanum*	big chickweed	•		
Caryophyllaceae	*Cerastium glomeratum*	sticky chickweed		•	•
Caryophyllaceae	*Cerastium gracile*	slender chickweed	•		
Chenopodiaceae	*Chenopodium album*	common lambsquarters		•	•
Chenopodiaceae	*Chenopodium ambrosioides*	Mexican tea		•	•
Chenopodiaceae	*Chenopodium glaucum*	oakleaf goosefoot	•		•
Chenopodiaceae	*Chenopodium murale*	nettleleaf goosefoot	•	•	
Brassicaceae	*Chorispora tenella*	blue mustard	•		•
Asteraceae	*Cichorium intybus*	chicory	•		•
Apiaceae	*Ciclospermum leptophyllum*	marsh parsley		•	
Asteraceae	*Cirsium arvense*	Canada thistle			•
Asteraceae	*Cirsium vulgare*	bull thistle			•
Cucurbitaceae	*Citrullus lanatus*	watermelon			•
Ranunculaceae	*Clematis terniflora*	sweet autumn clematis			•
Cleomaceae	*Cleome viscosa*	Asian spiderflower	•		
Apiaceae	*Conium maculatum*	poison hemlock	•		•
Ranunculaceae	*Consolida ajacis*	rocket larkspur		•	
Convolvulaceae	*Convolvulus arvensis*	field bindweed	•	•	•
Chenopodiaceae	*Corispermum nitidum*	shiny bugseed		•	
Fabaceae	*Coronilla varia*	crownvetch			•
Poaceae	*Cortaderia selloana*	pampas grass	•		
Cucurbitaceae	*Cucurbita pepo*	field pumpkin		•	
Apiaceae	*Cyclospermum leptophyllum*	marsh parsley	•		

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Poaceae	*Cynodon dactylon*	Bermudagrass	•	•	•
Boraginaceae	*Cynoglossum officinale*	houndstongue			•
Cyperaceae	*Cyperus esculentus*	yellow nutsedge		•	•
Cyperaceae	*Cyperus rotundus*	purple nutsedge	•		•
Poaceae	*Dactylis glomerata*	orchardgrass			•
Poaceae	*Dactyloctenium aegyptium*	crowfoot grass	•		
Solanaceae	*Datura inoxia*	prickly datura	•	•	
Solanaceae	*Datura quercifolia*	Chinese thornapple		•	
Solanaceae	*Datura stramonium*	jimsonweed	•		•
Apiaceae	*Daucus carota*	Queen Anne's lace			•
Brassicaceae	*Descurainia sophia*	herb sophia	•	•	•
Poaceae	*Desmazeria rigida*	ferngrass			•
Caryophyllaceae	*Dianthus chinensis*	rainbow pink			•
Poaceae	*Dichanthelium scabriusculum*	woolly rosette grass		•	
Poaceae	*Dichanthium annulatum*	Kleburg bluestem		•	•
Poaceae	*Digitaria ciliaris*	southern crabgrass			•
Poaceae	*Digitaria sanguinalis*	large crabgrass		•	•
Asteraceae	*Dimorphotheca sinuata*	glandular Cape marigold	•		
Brassicaceae	*Diplotaxis tenuifolia*	perennial wallrocket		•	
Dipsacaceae	*Dipsacus fullonum*	Fuller's teasel			•
Poaceae	*Echinochloa colona*	jungle ricegrass	•	•	•
Poaceae	*Echinochloa crus-galli*	barnyardgrass	•	•	•
Poaceae	*Echinochloa muricata*	rough barnyard grass		•	
Elaeagnaceae	*Elaeagnus angustifolia*	Russian olive	•	•	•
Elaeagnaceae	*Elaeagnus pungens*	thorny olive			•
Poaceae	*Eleusine indica*	goose grass		•	
Poaceae	*Elymus repens*	quackgrass			•
Poaceae	*Enneapogon mollis*	soft feather pappusgrass	•		
Poaceae	*Eragrostis barrelieri*	Mediterranean lovegrass	•	•	•
Poaceae	*Eragrostis cilianensis*	stinkgrass	•	•	•
Poaceae	*Eragrostis curvula*	weeping lovegrass	•	•	•
Poaceae	*Eragrostis echinochloidea*	African lovegrass	•		
Poaceae	*Eragrostis lehmanniana*	Lehmann's lovegrass	•	•	
Poaceae	*Eragrostis superba*	Wilman lovegrass	•		
Geraniaceae	*Erodium cicutarium*	redstem storksbill	•	•	•
Brassicaceae	*Eruca vesicaria*	rocketsalad	•	•	
Brassicaceae	*Erysimum repandum*	bushy wallflower	•		•
Celastraceae	*Euonymus japonica*	Japanese spindletree			•
Euphorbiaceae	*Euphorbia davidii*	David's spurge		•	•
Euphorbiaceae	*Euphorbia dentata*	toothed spurge		•	•
Euphorbiaceae	*Euphorbia esula*	leafy spurge	•		•
Asteraceae	*Facelis retusa*	annual trampweed			•
Moraceae	*Fatoua villosa*	hairy crabweed			•
Moraceae	*Ficus carica*	common fig	•	•	
Asteraceae	*Galinsoga parviflora*	gallant soldier	•		
Rubiaceae	*Galium divaricatum*	Lamarck's bedstraw			•
Geraniaceae	*Geranium pusillum*	small-flower crane's-bill			•
Verbenaceae	*Glandularia peruviana*	Peruvian mock vervain		•	

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Poaceae	*Hemarthria altissima*	African jointgrass		•	
Liliaceae	*Hemerocallis fulva*	orange daylily			•
Caryophyllaceae	*Herniaria hirsuta*	hairy rupturewort	•		
Malvaceae	*Hibiscus trionum*	flower-of-an-hour			•
Caryophyllaceae	*Holosteum umbellatum*	jagged chickweed			•
Poaceae	*Hordeum marinum*	seaside barley	•	•	
Poaceae	*Hordeum murinum*	mouse barley	•		•
Poaceae	*Hordeum vulgare*	cereal barley	•		•
Papaveraceae	*Hunnemannia fumariifolia*	Mexican tulip poppy		•	
Hydrocharitaceae	*Hydrilla verticillata*	hydrilla		•	
Convolvulaceae	*Ipomoea coccinea*	Mexican morningglory	•		
Convolvulaceae	*Ipomoea hederacea*	ivyleaf morningglory	•		
Convolvulaceae	*Ipomoea purpurea*	common morningglory	•	•	•
Iridaceae	*Iris germanica*	German iris			•
Iridaceae	*Iris lutescens*	Crimean iris			•
Iridaceae	*Iris sanguinea*	Japanese iris			•
Oleaceae	*Jasminum nudiflorum*	winter jasmine			•
Euphorbiaceae	*Jatropha spathula*		•		
Chenopodiaceae	*Kochia scoparia*	kochia	•	•	•
Fabaceae	*Kummerowia stipulacea*	Korean lespedeza			•
Asteraceae	*Lactuca saligna*	willowleaf lettuce	•		
Asteraceae	*Lactuca serriola*	prickly lettuce	•	•	•
Asteraceae	*Lactuca tatarica*	blue lettuce			•
Poaceae	*Lamarckia aurea*	goldentop grass	•		
Lamiaceae	*Lamium amplexicaule*	henbit	•	•	•
Boraginaceae	*Lappula squarrosa*	bristly sheepburr		•	
Fabaceae	*Lathyrus hirsutus*	singletary pea			•
Fabaceae	*Lathyrus latifolius*	everlasting peavine			•
Lamiaceae	*Leonurus cardiaca*	motherwort			•
Lamiaceae	*Leonurus sibiricus*	honeyweed			•
Brassicaceae	*Lepidium latifolium*	broadleaf pepperweed			•
Fabaceae	*Lespedeza cuneata*	sericea lespedeza			•
Asteraceae	*Leucanthemum vulgare*	oxeye daisy			•
Oleaceae	*Ligustrum japonicum*	Japanese privet			•
Oleaceae	*Ligustrum lucidum*	glossy privet			•
Oleaceae	*Ligustrum sinense*	Chinese privet			•
Oleaceae	*Ligustrum vulgare*	European privet			•
Scrophulariaceae	*Linaria dalmatica*	Dalmatian toadflax	•	•	
Scrophulariaceae	*Linaria vulgaris*	yellow toadflax			•
Linaceae	*Linum usitatissimum*	cultivated flax	•	•	
Poaceae	*Lolium arundinaceum*	tall fescue			•
Poaceae	*Lolium perenne*	perennial ryegrass	•	•	•
Poaceae	*Lolium pratense*	meadow fescue			•
Poaceae	*Lolium temulentum*	Darnel ryegrass			•
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	•		•
Caprifoliaceae	*Lonicera maackii*	Amur honeysuckle bush			•
Fabaceae	*Lotus corniculatus*	birdfoot deervetch	•		
Solanaceae	*Lycium barbarum*	matrimony vine			•

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Fabaceae	*Macroptilium gibbosifolium*	variableleaf bushbean	•		
Rosaceae	*Malus pumila*	paradise apple	•	•	
Rosaceae	*Malus sylvestris*	European crabapple		•	•
Malvaceae	*Malva neglecta*	roundleaf mallow	•		•
Malvaceae	*Malva parviflora*	small-whorl mallow	•	•	•
Malvaceae	*Malvastrum coromandelianum*	threelobe false mallow		•	
Lamiaceae	*Marrubium vulgare*	horehound	•	•	•
Asteraceae	*Matricaria discoidea*	pineapple weed	•		
Brassicaceae	*Matthiola longipetala*	night-scented stock	•		
Fabaceae	*Medicago arabica*	spotted burclover		•	
Fabaceae	*Medicago lupulina*	black medic clover	•	•	•
Fabaceae	*Medicago minima*	little burclover	•	•	•
Fabaceae	*Medicago polymorpha*	California burclover	•	•	•
Fabaceae	*Medicago sativa*	alfalfa	•	•	•
Asteraceae	*Melampodium sericeum*	rough blackfoot	•		
Meliaceae	*Melia azedarach*	Chinaberry tree		•	•
Fabaceae	*Melilotus alba*	white sweetclover	•	•	•
Fabaceae	*Melilotus indicus*	annual yellow sweetclover	•	•	•
Fabaceae	*Melilotus officinalis*	yellow sweetclover	•	•	•
Poaceae	*Melinis repens*	rose Natal grass	•		
Lamiaceae	*Mentha spicata*	spearmint	•	•	•
Lamiaceae	*Mentha x piperita*	peppermint		•	
Aizoaceae	*Mesembryanthemum crystallinum*	common iceplant	•		
Aizoaceae	*Mesembryanthemum nodiflorum*	slenderleaf iceplant	•		
Nyctaginaceae	*Mirabilis jalapa*	common four o'clock			•
Poaceae	*Mnesithea granularis*	pitscale grass	•		
Molluginaceae	*Mollugo cerviana*	threadstem carpetweed	•	•	
Lamiaceae	*Moluccella laevis*	shellflower			•
Moraceae	*Morus alba*	white mulberry	•	•	•
Moraceae	*Morus celtidifolia*			•	
Haloragaceae	*Myriophyllum spicatum*	Eurasian water-milfoil	•		•
Berberidaceae	*Nandina domestica*	heavenly bamboo			•
Lamiaceae	*Nepeta cataria*	catnip	•		•
Apocynaceae	*Nerium oleander*	oleander		•	
Solanaceae	*Nicotiana glauca*	tree tobacco	•	•	
Acanthaceae	*Nomaphila stricta*			•	
Asteraceae	*Oncosiphon piluliferum*	stinknet	•		
Asteraceae	*Onopordum acanthium*	Scotch thistle		•	•
Poaceae	*Oplismenus hirtellus*	bristle basketgrass		•	
Cactaceae	*Opuntia ficus-indica*	Indian fig	•	•	
Liliaceae	*Ornithogalum umbellatum*	Star-of-Bethlehem			•
Oxalidaceae	*Oxalis corniculata*	creeping oxalis		•	
Poaceae	*Panicum antidotale*	blue panicgrass	•	•	
Poaceae	*Panicum coloratum*	klinegrass		•	•
Poaceae	*Panicum miliaceum*	proso millet	•	•	•
Papaveraceae	*Papaver rhoeas*	corn poppy	•		

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Asteraceae	*Parthenium hysterophorus*	ragweed parthenium		•	•
Poaceae	*Paspalum dilatatum*	dallis grass	•	•	•
Poaceae	*Paspalum urvillei*	Vasey grass		•	•
Zygophyllaceae	*Peganum harmala*	African rue		•	
Poaceae	*Pennisetum ciliare*	buffelgrass		•	
Poaceae	*Pennisetum glaucum*	yellow foxtail		•	•
Polygonaceae	*Persicaria maculosa*		•		
Poaceae	*Phalaris aquatica*	bulbous canarygrass	•		
Poaceae	*Phalaris arundinacea*	reed canarygrass			•
Poaceae	*Phalaris canariensis*	annual canarygrass	•	•	
Poaceae	*Phalaris minor*	littleseed canarygrass	•		
Poaceae	*Phalaris para*		•		
Poaceae	*Phleum pratense*	common timothy	•		•
Arecaceae	*Phoenix dactylifera*	date palm		•	
Solanaceae	*Physalis philadelphica*	Mexican groundcherry		•	
Asteraceae	*Picris sprengeriana*	bitterweed		•	
Pinaceae	*Pinus nigra*	Australian pine			•
Pinaceae	*Pinus pinea*	Italian stone pine	•		
Plantaginaceae	*Plantago lanceolata*	buckhorn plaintain	•	•	•
Poaceae	*Poa annua*	annual bluegrass	•	•	•
Poaceae	*Poa compressa*	flat-stem blue grass			•
Poaceae	*Poa pratensis*	Kentucky bluegrass			•
Caryophyllaceae	*Polycarpon tetraphyllum*	fourleaf manyseed			•
Polygonaceae	*Polygonum arenastrum*	prostrate knotweed			•
Polygonaceae	*Polygonum argyrocoleon*	silver sheath knotweed	•	•	
Polygonaceae	*Polygonum aviculare*	yard knotweed	•		•
Polygonaceae	*Polygonum convolvulus*	climbing buckwheat	•	•	•
Polygonaceae	*Polygonum hydropiper*	annual smartweed			•
Polygonaceae	*Polygonum lapathifolium*	curlytop knotweed		•	
Polygonaceae	*Polygonum persicaria*	ladysthumb smartweed		•	
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass	•	•	•
Poaceae	*Polypogon viridis*	beardless rabbitsfoot grass	•	•	•
Salicaceae	*Populus alba*	white poplar			•
Salicaceae	*Populus nigra*	black cottonwood		•	
Portulacaceae	*Portulaca oleracea*	common purslane	•		
Rosaceae	*Potentilla recta*	sulphur cinquefoil			•
Rosaceae	*Prunus armeniaca*	apricot		•	
Rosaceae	*Prunus cerasus*	sour cherry		•	
Rosaceae	*Prunus domestica*	European plum		•	
Rosaceae	*Prunus mahaleb*	Mahaleb cherry			•
Rosaceae	*Prunus persica*	peach		•	
Poaceae	*Psathyrostachys juncea*	Russian wildrye			•
Asteraceae	*Pseudognaphalium luteoalbum*	Jersey cudweed		•	•
Lythraceae	*Punica granatum*	pomegranate	•		
Rosaceae	*Pyracantha koizumii*	Formosa firethorn	•		
Rosaceae	*Pyrus communis*	common pear			•
Ranunculaceae	*Ranunculus acris*	meadow buttercup			•
Euphorbiaceae	*Ricinus communis*	castor bean		•	•

Family	Scientific Name	Common Names	SODN	CHDN	SOPN
Brassicaceae	*Rorippa microphyllum*	onerow yellowcress	•		
Brassicaceae	*Rorippa sylvestris*	creeping yellow cress			•
Rosaceae	*Rubus rigidus*		•		
Polygonaceae	*Rumex acetosella*	common sheep sorrel	•		
Polygonaceae	*Rumex crispus*	curley dock	•	•	•
Polygonaceae	*Rumex obtusifolius*	bluntleaf dock			•
Polygonaceae	*Rumex patientia*	patience dock			•
Polygonaceae	*Rumex pulcher*	fiddle dock			•
Polygonaceae	*Rumex stenophyllus*	narrowleaf dock		•	•
Salicaceae	*Salix X sepulcralis*	weeping willow		•	
Chenopodiaceae	*Salsola collina*	slender Russian thistle			•
Chenopodiaceae	*Salsola kali*	prickly Russian thistle	•	•	•
Chenopodiaceae	*Salsola tragus*	prickly Russian thistle	•	•	•
Lamiaceae	*Salvia uliginosa*	bog sage			•
Adoxaceae	*Sambucus nigra*	European black alder	•		
Primulaceae	*Samolus valerandi*	seaside brookweed		•	
Asteraceae	*Sanvitalia procumbens*	Mexican creeping zinnia		•	
Caryophyllaceae	*Saponaria officinalis*	bouncingbet			•
Poaceae	*Schedonorus pratensis*		•		
Anacardiaceae	*Schinus molle*	American pepper	•		
Poaceae	*Schismus arabicus*	Arabian schismus	•		
Poaceae	*Schismus barbatus*	common Mediterranean grass	•		
Asteraceae	*Scorzonera laciniata*	cutleaf vipergrass			•
Poaceae	*Setaria adhaerens*	burr bristlegrass		•	
Poaceae	*Setaria italica*	Italian bristle grass		•	
Poaceae	*Setaria pumila*	yellow bristlegrass	•	•	•
Poaceae	*Setaria verticillata*	hooked bristlegrass		•	
Poaceae	*Setaria viridis*	green bristlegrass	•	•	•
Rubiaceae	*Sherardia arvensis*	blue fieldmadder			•
Malvaceae	*Sida abutifolia*	prostrate sida	•	•	•
Caryophyllaceae	*Silene gallica*	windmill catchfly		•	
Brassicaceae	*Sinapis arvensis*	charlock mustard		•	•
Brassicaceae	*Sisymbrium altissimum*	tumble mustard	•	•	•
Brassicaceae	*Sisymbrium irio*	London rocket	•	•	•
Brassicaceae	*Sisymbrium officinale*	hairypod hedgemustard			•
Brassicaceae	*Sisymbrium orientale*	Indian hedgemustard	•		
Solanaceae	*Solanum sisymbriifolium*	sticky nightshade		•	
Solanaceae	*Solanum villosum*			•	
Asteraceae	*Sonchus asper*	spiny sowthistle	•	•	•
Asteraceae	*Sonchus oleraceus*	annual sowthistle	•	•	•
Poaceae	*Sorghum bicolor*	broomcorn	•	•	
Poaceae	*Sorghum halepense*	Johnsongrass	•	•	•
Caryophyllaceae	*Stellaria media*	common chickweed	•		•
Oleaceae	*Syringa vulgaris*	common lilac			•
Asteraceae	*Tagetes minuta*	wild marigold	•		
Tamaricaceae	*Tamarix aphylla*	Athel tamarisk	•	•	
Tamaricaceae	*Tamarix aralensis*	Russian tamarisk	•		
Tamaricaceae	*Tamarix chinensis*	Chinese tamarisk	•	•	•

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

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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