



Invasive Non-native Plant Inventory for Tumacácori National Historical Park

Natural Resource Technical Report NPS/SODN/NRTR—2009/219



ON THE COVER

San José de Tumacácori church ruins, Tumacácori National Historical Park. NPS photo.

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Acronyms

APRS	Alien Plants Ranking System
AZ-WIPWG	Arizona Wildlands Invasive Plant Working Group species list
ft	feet
GPS	global positioning systems
m	meters
NAWMA	North American Weed Management Association
NHP	National Historical Park
NPS	National Park Service
SODN	Sonoran Desert Network

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Abstract

Early detection and trend detection of invasive non-native plant species comprise two of the Sonoran Desert Network Inventory and Monitoring Program's vital signs. Baseline information on the presence, location, and abundance of invasive non-native plant species is necessary to accomplish two goals: (1) to identify which invasive non-native species are not yet present in the park (early detection monitoring); and (2) to map the spatial location, distribution, and abundance of those species that already occur in the park as the basis for future trend assessment.

The goals of this project were (1) to map the spatial location, abundance, and distribution of 74 invasive plant species on the Arizona Wildlands Invasive Plant Working Group species list (AZ-WIPWG), plus 5 additional species of interest/concern to Tumacácori National Historical Park (NHP) staff; and (2) to rank the recorded species based on ease of control, invasibility, and current extent using the Alien Plants Ranking System (APRSIT 2001).

An invasive non-native plant inventory was conducted at Tumacácori NHP during January and February 2006. The survey was conducted in cooperation between the National Park Service's Sonoran Desert Network (SODN) and the Sonoran Institute. Roaming surveys were performed with the intent of comprehensively covering the entirety of all three mission-site units. Additional randomly located plot-based surveys were performed in order to assess any observer bias and the accuracy of the roaming surveys.

Of the 79 target species, 14 were observed during roaming surveys at Tumacácori NHP units in 2006 (see Tables 4.1-1, 4.1-2, 4.1-3). Of these same 14 species, only 5 were recorded at the Calabazas and Guevavi units (these two sites were affected by the same suite of five species).

All of these species had been recorded previously at these units during either the 2003 biological inventory or during other projects (Powell et al. 2005). Of the 14 non-native species mapped, 5 are members of the grass family (*Poaceae*). Species recorded were: Palmer's amaranth (*Amaranthus palmeri*), stink grass (*Eragrostis cilianensis*), Lehmann lovegrass (*Eragrostis lehmanniana*), Russian thistle (*Salsola tragus*), Bermuda grass (*Cynodon dactylon*), tamarisk (*Tamarix chinensis*), Johnson grass (*Sorghum halepense*), horehound (*Marrubium vulgare*), poison hemlock (*Conium maculatum*), sowthistles (*Sonchus* spp.), tree of heaven (*Ailanthus altissima*), London rocket (*Sisymbrium irio*), cheese weed (*Malva parviflora*), and giant reed (*Arundo donax*).

Area infested was calculated as a measure of the actual land area infested by each target species. Infested area was calculated using polygon data by multiplying the cover-class midpoint by the polygon's area. For example, a 1.5-ha polygon estimated at 25–50% cover would represent 0.5625 ha ($1.5 \times 0.375 = 0.5625$) infested. In both calculations, points were estimated to represent 0.5 m².

Levels of infestation varied by species, with nine species infesting less than 1% of the total park area, three species infesting between 1% and 4% of the total area, and two species, Bermuda grass and amaranth, infesting 23% and 14% of the total area, respectively.

Area affected is a measure of plant distribution calculated directly from mapped polygon boundaries; this measure does not reflect the intensity of invasion. For example, a 1.5-ha polygon estimated at 25–50% cover would represent 1.5 ha affected. Affected-area value also varied substantially by species, with several species being widespread throughout the unit. Amaranth was mapped across 76% of the unit, Bermuda grass over 72%, Russian thistle over 61%, tamarisk across 42%, and Lehmann lovegrass and poison hemlock at 36 and 34%, respectively. All other species were mapped to be affecting between 1% and 10% of the unit.

Of the 79 target species, 9 were recorded within the circular plots (see Table 4.2). The circular plots were implemented to estimate spatial bias and accuracy of the roaming surveys. Stohlgren et al. (2003) suggested randomly locating these plots and comparing the foliar cover of target spe-

cies within the circular plots to the foliar cover of target species collected during the roaming surveys. Figure 4.2.1 depicts foliar cover of target species collected via circular plots plotted against foliar cover of target species collected via roaming surveys. Both datasets were transformed using the cube-root transformation. The relative abundance of target species is rather consistent between the two methods ($R^2 = 0.62$), indicating that roaming surveys performed well at estimating abundance of target species.

As a result of this survey, several distinctly infested areas have been identified and, as such, are addressed separately in the Discussion section of this report. In general, the old agricultural areas in the southern portion of Tumacácori still show signs of disturbance and are heavily infested with non-native invasive species. To a lesser extent, areas to the north of the fiesta grounds (also old agricultural fields) also have many invasive plants, but these occur in the open areas and the understory of the many trees and shrubs. The riparian corridor has several invasive species, most notably tamarisk, Bermuda grass, and poison hemlock. Some species mapped were only found sporadically or as individual plants, and do not pose a significant threat. The two smaller units, Calabazas and Guevavi, were both observed to have the same five species. These units are in relatively good shape but management should be considered in some of the worse-affected areas.

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Chapter 1

Introduction

1.1 Background

The Sonoran Desert Inventory & Monitoring Network (SODN), whose purpose is to inventory and monitor natural resources in 11 national parks in southern Arizona and New Mexico, has identified invasive exotic plant species as a significant threat to park resources. The SODN is currently developing methods for both early detection and long-term monitoring of 74 invasive non-native plant species in SODN park units. The first step in invasive non-native plant monitoring is establishing baseline data on the presence, distribution, and abundance of these target species in park units. The SODN has been working cooperatively with the Sonoran Institute's Adaptive Management Project to accomplish baseline invasive-plant inventories.

Non-native invasive species are a major threat to native species diversity and ecosystem function, causing economic impacts within the U.S. estimated at more than \$100 billion annually (Pimentel et al. 1999). In addition to competing with and displacing native species, these introduced species can hybridize with natives and alter conditions to promote the establishment and spread of other non-native species. Invasive species have been called the “single most formidable threat of natural disaster of the 21st century” (Schnase et al. 2002).

“Exotic species” are those species that occupy or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities (NPS 2006). Exotic species are also commonly referred to as non-native, alien, or invasive species. Because an exotic species did not evolve in concert with the species native to an area, the exotic species is not a natural component of the natural ecosystem at that location. According to the *NPS Management Policies* (NPS 2006), “(e)xotic species will not be allowed to displace native species if displacement can be prevented.” In addition, these policies state that “high priority will be given to managing exotic species that have, or potentially could have, a substantial impact on

park resources, and that can reasonably be expected to be successfully controllable.”

1.2 Project goals

The goals of this project were:

- 1) To map the spatial location, abundance, and distribution of 74 invasive plants on the Arizona Wildlands Invasive Plant Working Group's “List of Non-native Invasive Plants That Threaten Wildlands in Arizona” (AZ-WIPWG 2005), plus 5 additional species known by the facilities manager at Tumacácori National Historical Park to be or to have been recently present and of concern to park staff.
- 2) To rank the recorded exotic species based on ease of control, invasibility, and current extent using the Alien Plants Ranking System (APRSIT 2001). The results of this ranking will help park managers to prioritize control efforts.

1.3 Study area

Tumacácori National Historical Park (NHP) is located in the upper Santa Cruz River Valley of southern Arizona (Figure 1.3). 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.

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.

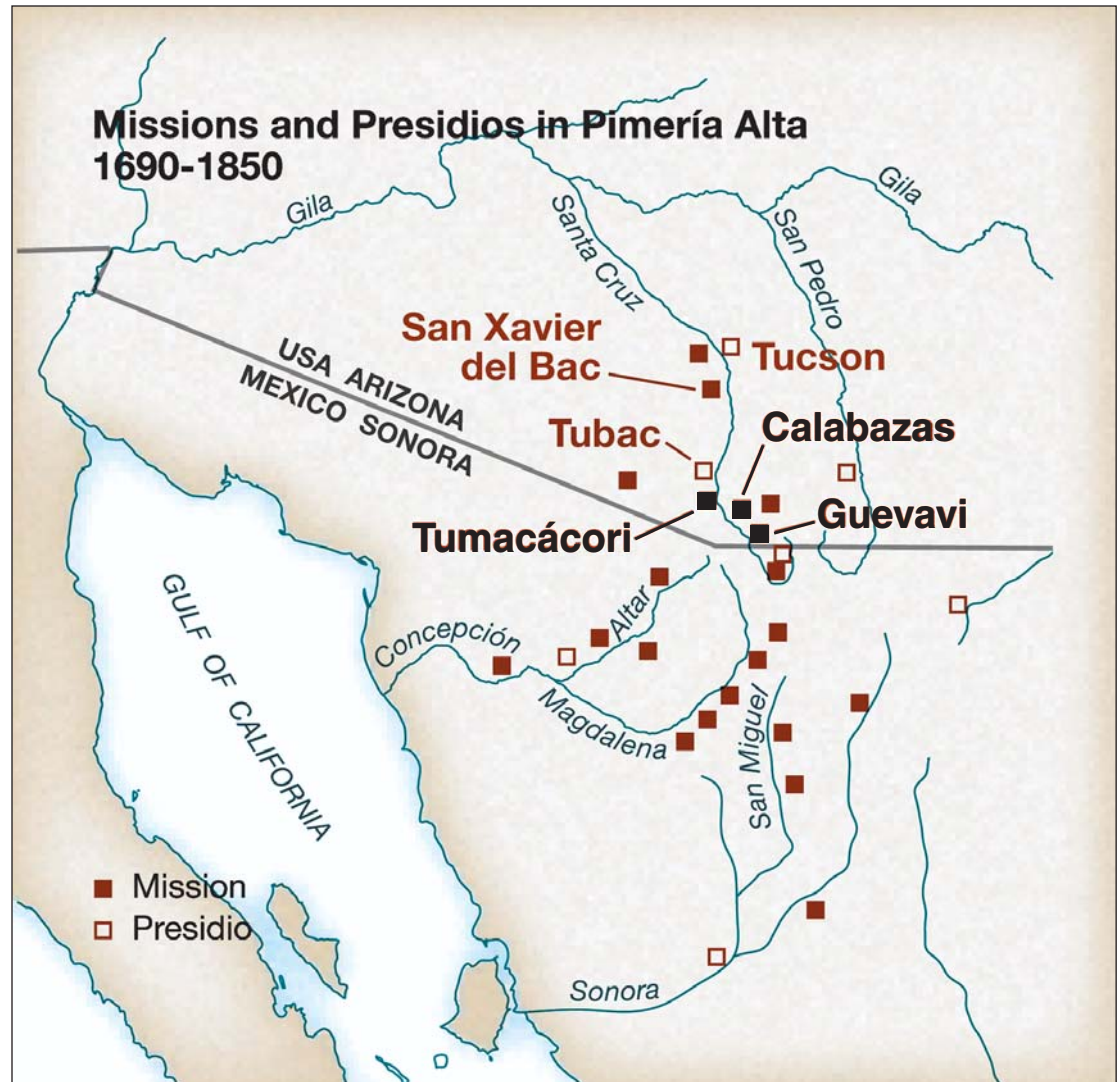


Figure 1.3. Location of Tumacácori NHP in southern Arizona.

Chapter 2

Methods

The abundance and location of 79 exotic-plant target species were mapped at Tumacácori NHP following the North American Invasive Plant Mapping Standards (NAWMA 2002) and the “Beyond NAWMA” (North American Weed Management Association) guidelines suggested by researchers (Stohlgren et al. 2003). Because Tumacácori NHP is small (less than 150 ha), an intensive mapping method was both practical and desirable. Individual target plants were mapped as points and invaded regions were mapped as polygons using handheld computers equipped with global positioning systems (GPS) units.

2.1 Roaming surveys

Roaming surveys were conducted with the intent of covering the majority of the park unit accessible by foot, without biasing the surveys towards merely roads and trails. Surveyors walked throughout the park in a systematic way, utilizing handheld mapping units with GIS layers showing current spatial position and the areas already surveyed and mapped. Non-native plant species were mapped opportunistically as they were encountered. Target species for this effort included the 74 species currently on the AZ-WIPWG list (AZ-WIPWG 2005) and five other plants known to be problematic at Tumacácori NHP (see Appendix A).

Spatial location, distribution, and abundance of the species were recorded as ArcMap shapefiles (.shp) using the Dell Axim X30 handheld PC equipped with HGIS software and connected to Garmin 76S handheld GPS units. Two researchers identified and mapped species via walking surveys. Individual target plants were mapped as points, and areas more than 5 m in diameter were mapped as polygons. Up to five species could be recorded in each polygon, and for each species, a percent cover class was assigned. The cover classes were: <1%, 1–5%, 6–25%, 26–50%, 51–75%, 76–95%, and 96–100%.

Data collection took place on January 6, 11, 17, 23, 25, and 30, and February 1 and 6, 2006. An estimated 64 total person hours were required for data collection over these 8 days. Data were collected following the NAWMA (2002) standards and included the following fields: collection date, collection time, plant name, genus and species, aerial percent cover, and location (in Universal Transverse Mercator coordinates).

An additional visit was made one year later, in April 2007, and observations were taken throughout the park. Some point locations were recorded for new species occurrences; these will be addressed in the Discussion section of this report.

Data files were merged and then split to generate individual ArcMap shapefiles by species, with separate point and polygon files. Metadata was written for each shapefile. Separate maps were created for each species in each park unit (see Appendix B).

2.2 Circular plot sampling

In the “Beyond NAWMA” guidelines, Stohlgren et al. (2003) recommended supplementing roaming surveys with randomly located circular plot sampling to estimate spatial bias and accuracy. Approximately one-quarter of our field resources was used to perform these supplemental circular plot surveys, in which vegetation abundance and diversity were measured by way of ocular estimates of percent cover, by species, within three 1-m² quadrats. Point locations were randomly generated in ArcMap; from these, 11 circular plots were sampled within the Tumacácori unit and three each at the Calabazas and Guevavi units (Figures 2.2-1, 2.2-2). The circular plots were 7.32 m (24 ft) in radius, encompassing three 1-m² quadrats (Figure 2.2-3). The percent basal cover of all species was recorded within the 1-m² quadrats to the nearest 1%. All additional species present within the entire circular plot were also recorded. Data were recorded directly

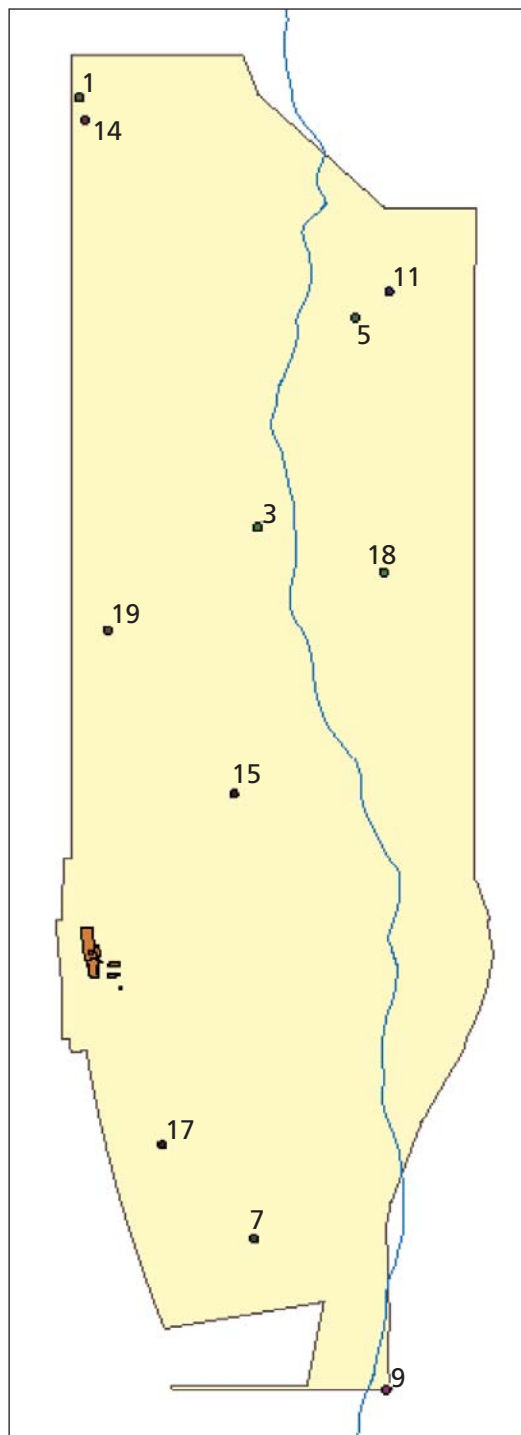


Figure 2.2-1. Circular plot locations at Tumacácori National Historical Park.

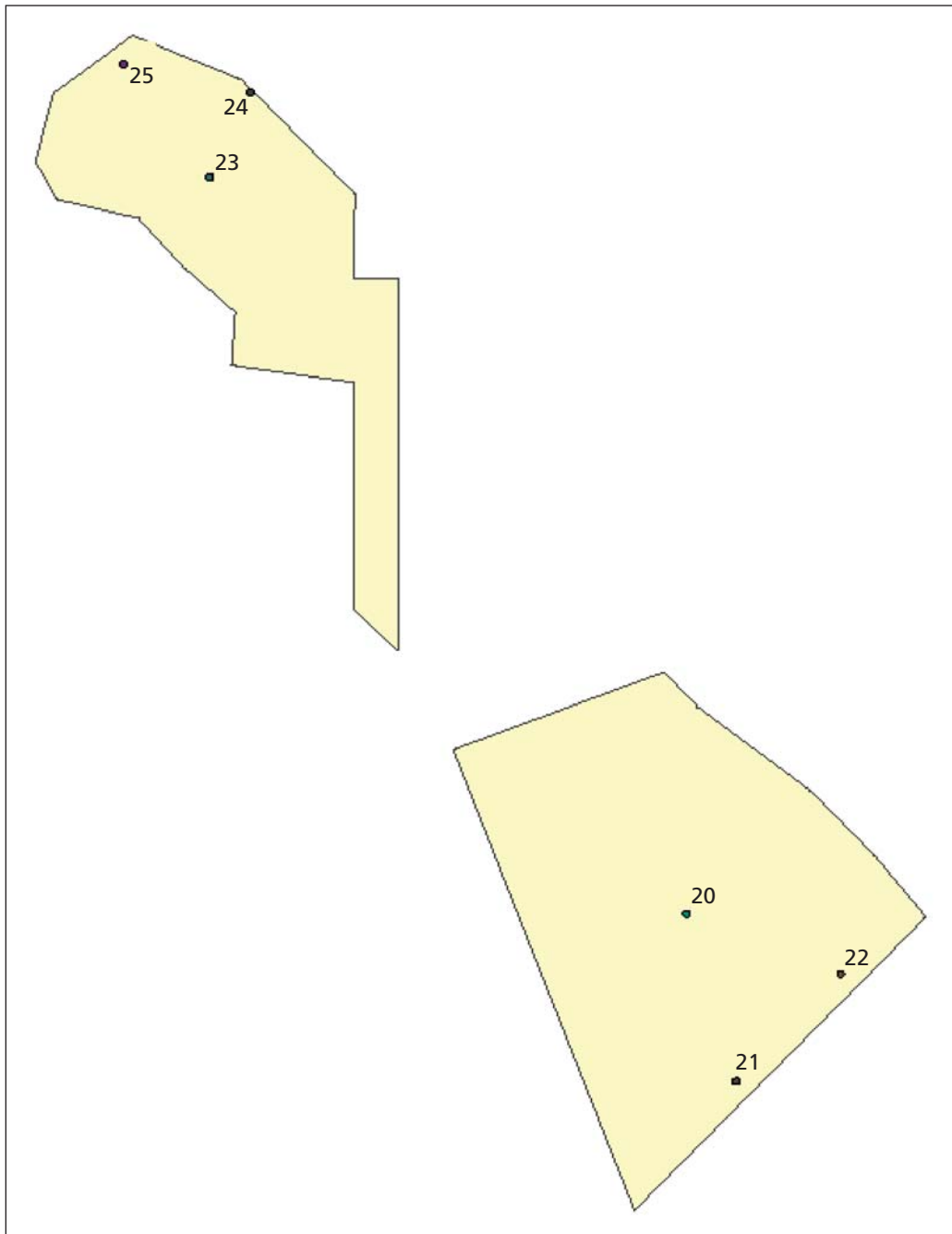


Figure 2.2-2. Circular plot locations at the Calabazas unit (above) and the Guevavi unit (below).

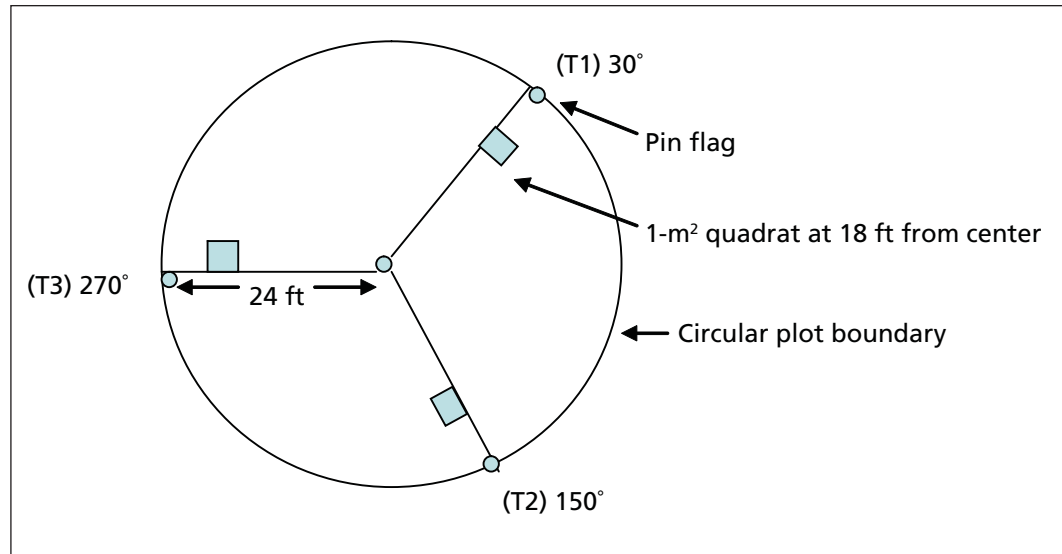


Figure 2.2-3. Circular plot diagram showing layout of 1-m² quadrats.

into an Excel spreadsheet on the handheld PC. Excel spreadsheets were downloaded onto a computer each day and subsequently imported into an Access database for further analysis.2.3 ARPS prioritization

Target species were prioritized for treatment using the Alien Plants Ranking System (APRS) v7.1 (APRSIT 2001). Information regarding each species' distribution and abundance, phenology, and morphology were collected through fieldwork and extensive literature review. This information was then entered into the APRS database for ranking. The APRS is divided into two main sections: signifi-

cance of impact and feasibility of control or management. The impact category is further divided into two subcategories, significance of impact and innate ability to become a pest (see Figures 4.3-1, 4.3-2). Each plant is ranked based on criteria that fit into these three categories (impact, pest, and control) on a scale of 100 points. The resulting ranks can be used to help managers make decisions on the urgency of action (see Table 4.3). The information gained through this ranking system will enable a prioritization of invasive plant management efforts within Tumacácori NHP.

Chapter 3

Results

In this report, each of the three Tumacácori NHP units will be discussed separately. The Tumacácori unit is far larger and has many more invasive non-native species than the other two, smaller units; it also contains a broad range of different vegetative communities, each with a unique land-use history.

Within each park unit, polygons were defined either to encompass an entire management area (such as a bounded field, similar vegetative community) to delineate a specific infestation precisely, or a combination of both. This is reflected on the individual species maps in Appendix B. Areas shown approximate, as closely as possible, the extents of each species' range, with an estimated percent cover for that area.

3.1 Tumacácori unit

3.1.1 Mission grounds and former National Park Service offices

The Tumacácori unit is the largest site, encompassing the Tumacácori mission ruins and grounds. It can be split up into several distinct sections that both prove useful for discussion and reflect vegetative similarities or natural boundaries (Figure 3.1). This unit is adjacent to the visitor center and main roadway, and is by far the most-visited portion of the park. The main grounds have well-spaced, mature mesquite (*Prosopis* spp.) trees but little ground cover or perennial understory vegetation. Much of this is presumably due to the constant disturbance of visitors walking freely between structures and also to occasional mowing. To the north of the mission ruins are the fiesta grounds, a large open space with mature trees that is used a few times a year to host celebratory fetes and other events. Other buildings include former staff offices, storage areas for cars and machinery, and a house with stables and paddock. Roads (for staff use only) and pathways (public use) wind throughout this area, all of which is fenced or walled in. On and around these access roads and maintenance buildings, the vegetation

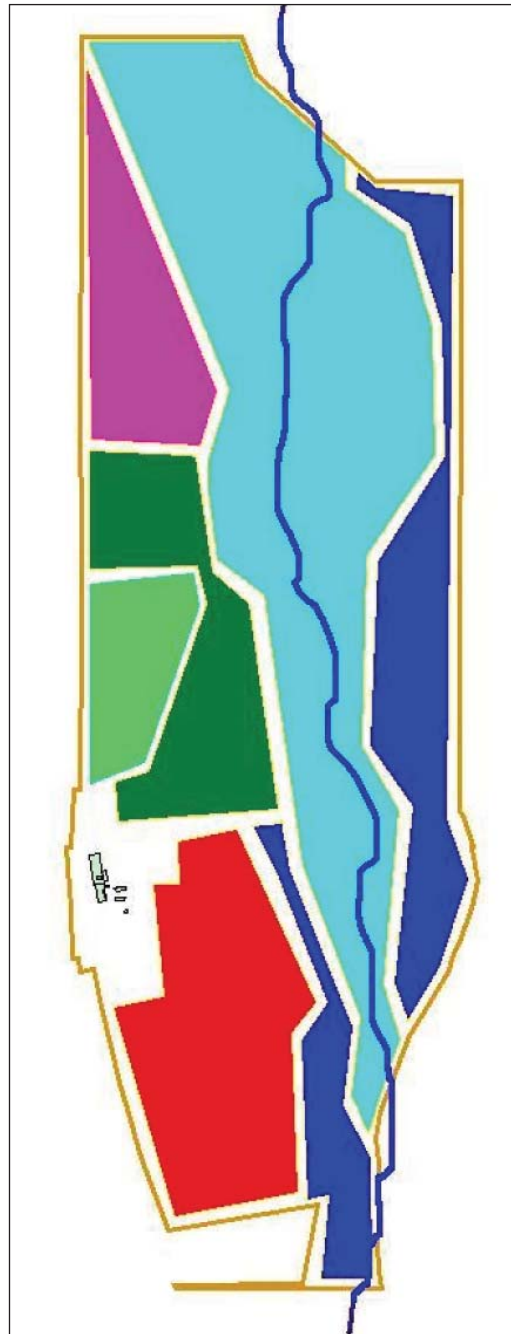


Figure 3.1.
San José de
Tumacácori unit,
divided according
to vegetative
similarities
or natural
boundaries.

White: mission
grounds
Red: abandoned
agricultural fields
Dark green:
mesquite bosque
Light green:
desert scrub
Light blue: flood
plain
Dark blue:
riparian scrub
Pink: cow
pasture/corral

grows thick with several weedy species, both native and non-native, and these rights of way appear to be kept mowed throughout the year. Exceptions are areas seen to be very dense with amaranth and Russian thistle.

Tumacácori unit mission grounds and former National Park Service offices.



Exotic species mapped in this area included Palmer's amaranth (*Amaranthus palmeri*), tree of heaven (*Ailanthus altissima*; only one point location recorded), Russian thistle (*Salsola* spp.), Johnson grass (*Sorghum halepense*), Bermuda grass (*Cynodon dactylon*), Lehmann lovegrass (*Eragrostis lehmanniana*), stink grass (*Eragrostis cilianensis*), and cheese weed (*Malva parviflora*). The amaranth was extremely prevalent in 2006, presumably due to high precipitation. This is a native species but it can invade disturbed areas rapidly, often forming extensive thickets. The plants are unsightly after they have died, and their large size reduces visibility and mobility in areas where they are established. Bermuda grass was mapped at 1–5% cover for the area as a whole but really dominated beneath the elderberry (*Sambucus nigra*) and mesquite trees and in areas with less foot traffic, whereas other areas which were mostly open were observed to still have a good mix of native annuals. Both the Johnson grass and Russian thistle were recorded at less than 5% cover and occurred mostly in small areas bordering the roadways.

Old agricultural areas.

3.1.2 Old agricultural areas

As can be seen from the individual species maps (for example, Map T-2, Appendix B), there are eight distinct old agricultural fields in the southern portion of Tumacácori; four larger fields running almost east–west and four smaller fields running north–south. All fields are still fenced, and the larger four, just west of the riparian area, show signs of frequent mowing. All of the fields had the same suite of non-natives present, varying only in their densities and species combinations. Other significant disturbance was apparent, such as rodent burrowing and vehicle tracks over old, yet visible, access roads. Each of the fields had low-growing, scattered mesquites averaging between 1 and 5 feet tall. It is presumed that should these fields not be mowed or plowed, they would eventually succeed into mesquite shrublands or shrub-savannas.

Invasive non-native species mapped in these fields included Russian thistle, Johnson grass, Bermuda grass, Lehmann lovegrass, stink grass, Palmer's amaranth, and horehound (*Marrubium vulgare*). Some additional species that were not observed during the 2006 survey were observed during a subsequent visit in March



2007. Many of these were native species, with three new non-native species: wild oats (*Avena fatua*), rescue brome (*Bromus catharticus*) and field bind weed (*Convolvulus arvensis*). Both the wild oats and bind weed had very low abundance and distribution (2 or 3 points each) and, while their locations were recorded, no maps were created. The rescue grass appeared well-distributed, seen growing from the agricultural fields north to the upper flood plain. However, it was only seen growing individually or in small clumps.

Bermuda grass was found in all of the fields, in densities at least 26% or greater and, as such, would be nearly impossible to control, even with major and repeated herbicide applications. Mechanical removal typically serves only to promote this species, as it can root and shoot from any fragment of the parent plant. Amaranth and Russian thistle were also found throughout, in densities varying from 1–5% to 51–75%. Stink grass was observed to have a wide distribution but a consistently low abundance of 1–5%. A small horehound infestation was localized in the southern-most large field at less than 1% cover, which may make management reasonably easy and worthwhile. It will not persist under cultivation, so hoeing or hand-pulling before seed-set often works well for control.

3.1.3 Mesquite bosque

Just north of the fiesta grounds, public access can be gained to the newly acquired expansion lands via the de Anza Trail, which winds down to the river and then runs north to the park boundary and beyond. Alternatively, this same trail can be accessed by walking along the Santa Cruz River from Santa Gertrudis Lane to the south of the park. Several other “social trails” exist throughout the park, one of which runs beside and through the mesquite bosque after branching off from the de Anza Trail. During this inventory it was observed that this particular trail was used frequently by horseback riders, runners, and people walking their dogs and, as can be seen in the picture above (top), it was quite wide, bare, and well-used.

The bosque was characterized by abundant velvet mesquite (*Prosopis velutina*) and elderberry, and classified as woodland. The understory consisted of herbaceous species with



Mesquite bosque.



a small percentage of shrubs or small trees. Morning glory (*Ipomoea* spp.) vines were prolific here, twining throughout trees and most shrubs. Six non-natives were mapped: London rocket (*Sisymbrium irio*), horehound, Russian thistle (*Salsola tragus*), Bermuda grass, poison hemlock (*Conium maculatum*) and Palmer’s amaranth. The hemlock and Bermuda grass occurred only at the edges of the woodland adjacent to the trail or in small patches in the interior, whereas the other species were scattered throughout at between less than 1% and 1–5% cover. Horehound growing under the woodland canopy was well-established, often seen growing in continuous stretches. This species was only observed to grow in this area and in the abandoned fields mentioned above. The shady environment and litter layer may provide some protection from intense infestation by species preferring open areas and more sun. Overall, this woodland was fairly intact with manageable infestations of moderately impacting species.

3.1.4 Desert scrub

On the west side of the park, north of the fiesta grounds and west of the mesquite bosque, is a

Desert scrub.



large area best described as wooded shrubland. The western boundary here is adjacent to private residences that continue the entire length of the boundary to the north. On all other sides, this area is surrounded by mesquite woodland. The dominant species here was mesquite, with interspersed wolfberry (*Lycium* sp.), catclaw (*Acacia greggii*), and occasional desert broom (*Baccharis sarothroides*). Isolated damp depressions were highly infested with Bermuda grass and most shrubs were harboring Russian thistle in great numbers. Interestingly, parts of this area were open with sparse vegetation. An old concrete irrigation channel runs through here, stretching east–west and north–south (photo above, top), a remnant from when this area was used for agriculture. Past this channel to the north, Russian thistle was observed to suddenly occur in far greater abundance than before, recorded at 6–25%. Several old brush piles were noted (photo above, bottom) as were many trails, presumably created by roaming cattle. Lehmann lovegrass and stink grass were recorded in low abundance and low frequency. Amaranth was again dispersed throughout at abundances of between 6–25% and 26–50% cover.

3.1.5 Flood plain and riparian area

This area contains the bulk of the land recently acquired through the park expansion. The Santa Cruz River runs the entire length of this section and has a wide, flat flood plain, with riparian species extending up to several hundred meters beyond the current river channel. Disturbance along this corridor has been fairly constant, as it was grazed for several years and also contains both the de Anza Trail and many social trails used by birders, horse riders, and occasional immigrant traffic. While attempts have been made to completely fence the park boundaries, cattle were still frequently seen along the river as of April 2007. Overall, the flood plain included a good representation of native cover in all height classes, with abundant cottonwood (*Populus* spp.), willow (*Salix* spp.), hackberry (*Celtis* spp.), elderberry, saltbush (*Atriplex* spp.), and native grasses and forbs. Non-native plants established here co-exist among the natives and have only become dominant in a few cases and areas. Most of the exotic species mapped close to the river were also found throughout the extended flood plain/riparian corridor. Densities were higher closer to the river, likely due to the increased availability of water. Poison hemlock, giant reed, and saltcedar (*Tamarix* spp.) were only found within this part of the park.

Giant reed (*Arundo donax*) was found in one location just outside the official park boundary (Map T-14, Appendix B). Following the de Anza Trail from the south entrance, one crosses from private to park property within meters, and so this location was mapped as relevant to this inventory. This plant had 19 stems and was spread over approximately a 3-m radius. This species was first recorded as present in one modular plot in the park during a 2002–2003 biological inventory (Powell et al. 2005).

Tamarisk (*Tamarix chinensis*) (Map T-12, Appendix B) was well-established throughout the flood plain. Its total range covered 43% of the total park area, with an average cover estimate of 1–5%. These trees varied in size and age, some of them 2 m tall with little secondary growth, up to mature trees approximately 3–4 m tall in small groupings. As with other areas in the park, large polygons were described around areas similar in species composition, topography, or disturbance history. As a result of this, cover

estimates can be lower in these large areas for some species than if smaller areas were considered alone. Therefore, there are probably some areas that could be identified as higher-priority (i.e., higher-density) for any planned removal or treatment efforts. The maps in Appendix B show the entire broad areas over which the species is spread.

Almost the entire length of the river bank and edges were recorded to have between 1 and 25% cover of poison hemlock. This species is poisonous to both humans and livestock and its presence is thought to degrade habitat (Blele 2006). In general, this species will spread downstream and then move into drier upland areas. It was mapped at higher densities in the southern portion of the park (Map T-6, Appendix B), where the riparian corridor narrows, and was sparser to the north, where there is less tree cover and a wider open channel. It can act as both a biennial and winter annual, and while dependent on reproduction from seed, has a very high germination rate, especially in areas where other vegetative cover is limited.

Bermuda grass was also well-established here, occurring in densities between 6 and 75% cover along the river corridor (Map T-2, Appendix B). It pervaded the understory in the woodland and was also common on the exposed river banks. It readily sprouts from offshoots and will root at the nodes of stolons, and can therefore spread rapidly. Removal or treatment would be extremely expensive, time-consuming, and unlikely to succeed without years of follow-up treatment.

Lehmann lovegrass was scattered throughout the park but occurs in its greatest abundance in this area. Cover was estimated to be <1% in most polygons mapped (Map T-4, Appendix B). Again, this species requires intensive treatment and follow-up treatment if removal is to be successful.

Other species recorded in this area included Palmer's amaranth, tree of heaven, Russian thistle (*Salsola* sp.), London rocket, and sowthistles (*Sonchus* sp.). Tree of heaven was recorded at a total of three locations within the park unit (Map T-13, Appendix B), although more may exist but were missed by this inventory. Surveys were completed in the winter, when most leaves and branches had fallen. This

species can be identified by bark characteristics and distinct leaf scars; the trees do not, however, stand out from a distance when they are leafless. Sowthistles and London rocket were recognized mostly by their rosettes, which had just begun emerging; both of these were likely somewhat more abundant later in the season. Both Russian thistle and amaranth occurred throughout the riparian corridor. Most of these plants were dead but still rooted at the time the mapping occurred. Palmer's amaranth is a native species but considered "weedy" and unsightly, and can be a highly aggressive competitor. Cover along the riparian corridor was estimated to vary from 6% to 50% (Map T-1, Appendix B).

The northern end of the riparian flood plain narrows and gives way to a wider, dry wash area containing at least one or more intermittent/old channel. Here, tamarisk was seen in denser infestations, like a thicket, especially close to the northern boundary fence. Several mature trees were found in this more-open area, possibly due to less competition from other riparian tree species, like cottonwood and hackberry, which were growing closer to the river channel. Bermuda grass and amaranth still dominated in



Flood plain and riparian area.

the understory, with scattered occurrences of Lehmann lovegrass and stink grass. There was evidence of heavy flows throughout the riparian corridor, with large amounts of debris and sediment washed up against trees and shrubs. These heavy flows likely account for much seed dispersal and ensure a level of disturbance necessary for some of these species to establish and thrive.

3.1.6 Riparian scrub/Woodland

Many of the same exotic species found in the flood plain proliferated throughout the riparian scrub. The riparian scrub zone was characterized by hackberry, graythorn (*Ziziphus obtusifolia*), willow, Fremont cottonwood (*Populus fremontii*), and vines. The understory was typically dominated by Bermuda grass, amaranth, Russian thistle, and many different native herbaceous species. Occasional sightings of sandbur (*Cenchrus* spp.), a native grass, were observed but not mapped; the presence and abundance of this grass was of interest to park staff due to the obnoxious character of the seeds. Because of the season, this species was hard to identify, as most of the characteristic seeds had already fallen.

Poison hemlock was occasional in this area, mostly in the damper microclimates, and scattered sowthistles were seen to be emerging, along with London rocket. It was also of interest to park staff to know if tree tobacco (*Nicotiana glauca*) was present in the woodland and scrub areas, and in what abundance. A scattering of young plants was seen emerging from the litter layer in open woodland understory but none were observed on a return visit one year later. No mature plants were observed at any time.

3.1.7 Cow pasture/Corral

The pasture is situated at the northwest end of the park unit and has a distinct triangular shape. On the east side of the pasture runs an old, sandy river channel, the banks of which were heavily infested with Lehmann lovegrass. This species is enjoyed by cattle and, as such, probably has been propagated here by way of ingestion and subsequent distribution. Since the time of this inventory, grazing of this area has ceased and most of the fencing has been removed. Previously, approximately 15–20 cows were fenced into this area. The vegetation in this area consisted of mature mesquite trees, catclaw, and many small (possibly old,

Riparian scrub/
woodland (left
column).

Cow pasture/
corral (right
column).



yet suppressed) shrub mesquites. The majority of the ground was bare, clearly having been impacted by the animals grazing and disturbing the ground. Amaranth, London rocket, Russian thistle, Mediterranean grass (*Schismus* spp.), Lehmann lovegrass, and stink grass were recorded with most frequency at the edge, woody zones, rather than in the open, bare zones. In time, it appears that this area will likely revert to a bosque, especially given the presence of the numerous small mesquite shrubs. The upper portion of this polygon, toward the private residences to the north, is a shady woodland area with medium-sized mesquites and elderberry as well as a lush understory of herbaceous species. Only occasional non-natives were observed in the interior of the pasture.

During the visit in 2007, a large horse-manure dump, approximately 40×15 feet across, was located at the northern tip of this pasture area. It appears to be within the new park boundary, but very close to a private residence with stables.

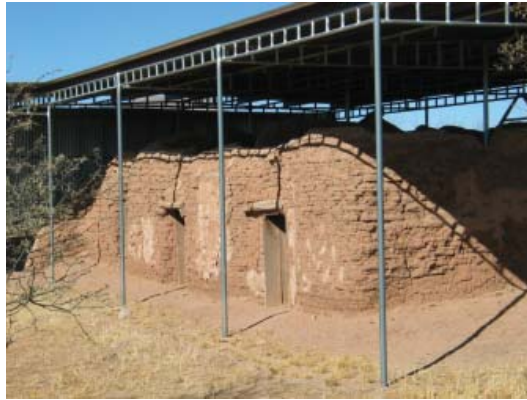
3.2 San Cayetano de Calabazas unit

The Calabazas park unit is located 15 km SSE of Tumacácori, and measures 11 ha (28 acres). Five exotic plant species were recorded here during the mapping effort in 2006. All of these species had been recorded previously at this unit, either during the 2003 biological inventory or during other projects (Powell et al. 2005). Species recorded were Palmer's amaranth, stink grass, Lehmann lovegrass, Russian thistle, and Bermuda grass.

The unit is broadly separated into two major areas: an upland portion, where the ruins are located, and lowland drainages to the northwest and southeast that flow into the river channel to the west, part of which is within the park boundary. As these drainages have distinct vegetation characteristics, they are considered separately here.

3.2.1 Mission site

The ruins are enclosed by a chain-link fence measuring approximately 55 m on each side, essentially creating a small compound. The interior of this compound was less vegetated than



San Cayetano de Calabazas unit.

the hilltop area outside the fence; only a handful of mesquite trees, for example, were established within the fenced site, while outside it they formed a formidable thicket. A roof over the ruins provided an unusually shady area around the walls of the mission, but human maintenance has precluded any plants from exploiting this microhabitat.

Amaranth was the most abundant species here, with a cover from 6–25% to 26–50%. Native grasses were more common than exotics, but a small patch of Bermuda grass had become established under a mesquite tree, and stink grass was present at 1–5% cover. Russian thistle was present in patches of 1–5% cover, and some uprooted plants had gathered against the more neglected ruin walls.

3.2.2 Hilltop

This upland area surrounds the mission site on all sides and is itself surrounded on most sides by steep slopes, in some places highly eroded. Disturbance was varied in this area; an eroded road and cleared ground around the mission fence were characterized by encroaching native species, while other sections, especially

where mesquite trees form thick stands, appeared relatively unimpacted. The most common invasive plant was amaranth, present at densities ranging from 1–5% to 51–75% cover. The densest populations of these plants were found in the area just outside the mission fence and on a deeply eroded hillslope, southwest of the mission site. Native grasses were common, although both Lehmann lovegrass and stink grass were represented at 1–5% cover. Russian thistle was present between <1% and 5–25% cover, with the heaviest concentration directly north of the mission site on a relatively bare, possibly disturbed, patch of ground.

3.2.3 East corner

This is a steep, rocky area, sloping into the south drainage and characterized by a relatively dense patch of Lehmann lovegrass at 6–25% cover. Other exotic plants found were Russian thistle at <1% cover and amaranth at 6–25% cover.

3.2.4 South drainage

This area of the park is a large wash flowing southwest to the main river channel, separated from the hilltop by steep slopes. Mesquite and dropseed (*Sporobolus* spp.) were common, and this was the only place where elderberry species were found. Native grasses were dominant, with Bermuda grass being the only non-native grass present, and that only at the southern tip of the drainage at <1% cover. Russian thistle was found throughout this area, although only at <1% cover. Amaranth was more common, ranging from <1% to 25–50% cover.

3.2.5 Riparian scrub

This area is characterized by steep, rocky slopes between the hilltop and the river channel to the west. The dominant vegetation was hackberry trees and large catclaw acacia and graythorn shrubs. Native grasses grew in shady cracks in the rocks. Where this wooded area approaches the riverbed to the west, the slopes become shallower and sandy soil replaces rocks, providing prime habitat for most of the invasive species found in this area. A fence separates this area from the riverbed proper, even though the park boundary extends beyond the fence, where it is demarcated by posts in the riverbed. An open pedestrian gate in this fence leads to a small pathway up the slope, at the base of which

a handful of Bermuda-grass plants has become established. Other than these individuals, most of the Bermuda grass in this area appeared to have spread inward from the riverbed, and was present at between <1% and 5% cover. Amaranth was present in a number of sizable colonies ranging from 6–25% to 51–75% cover, mainly where the soil was sandy and exposed near the riverbed. Lehmann lovegrass and Russian thistle were sparse, at <1% cover, although uprooted individuals of the latter had gathered in significant numbers against the riverbed side of the fence. Stink grass was present at 1–5% cover, most commonly in the sandy, exposed areas.

3.2.6 Riverbed

This section of the Calabazas unit lays in a channel of the Santa Cruz River, although no surface water was present. Cows roam this area freely and many were grazing and lying down in the shade at the time of the survey. The ground was sandy and moist, and a few large mesquite trees provided some shade. This area is not fenced, but rather is marked by a number of National Park Service boundary posts. Bermuda grass was at 6–25% cover, the highest percentage in the unit, and was observed to be spreading from the riverbed into the riparian scrub area. Amaranth was also abundant, at 26–50% cover. Russian thistle was present at 1–5% cover, but many uprooted plants had blown against the fence where they were stacked a few feet high, possibly forming a seed bank. Grasses were present, but were cropped short enough by grazing that identification was problematic.

3.3 Los Santos Ángeles de Guevavi unit

The Guevavi park unit is located 23 km SSE of the Tumacácori unit and is 2.83 ha in size. This unit contains a small stretch of the Santa Cruz River within its boundary. While this and the Calabazas units are quite remote, fenced, and not open to visitation except through monthly, ranger-guided tours, they can both be accessed by way of the Santa Cruz River or from surrounding private lands. Surveyors mapped this area to the fenced boundary and, as can be seen in the maps in Appendix B, this resulted in polygons somewhat larger or offset from the legislative boundary shapefile on file in the Sonoran Desert Network office.

Both of these smaller units are currently mesquite-dominated shrublands/woodlands, each containing upland areas on which the mission structures were built and surrounding lower areas sloping down toward the river channel. Five non-native plant species were recorded here during the mapping effort in 2006. All of these species had been observed or documented previously at these units during either the 2003 biological inventory or during other projects (Powell et al. 2005). The same suite of five species was found at both the Guevavi and Calabazas units: Palmer's amaranth, stink grass, Lehmann lovegrass, Russian thistle, and Bermuda grass.

At Guevavi, there were two distinct lowland drainages, one of which ran along the southeast section of the hilltop (where the ruins stand) and the other wrapping around the northern part of the hilltop, meeting the first drainage at the northwest boundary. The species composition in these drainages was distinct from that on the hilltop, clearly reflecting the greater availability of water which flowed into them.

3.3.1 Southeast drainage

The southeast drainage was characterized by riparian scrub; hackberry (*Celtis reticulata*) was the dominant plant in a dense thorny shrubland, mixed with graythorn and catclaw. Amaranth was present in the drainage at 6–25% cover where the wooded slope began to yield to a sandy wash at the eastern boundary. Some Russian thistle was found in this same area, although only at 1–5% cover.

3.3.2 Northern drainage

The northern drainage resembles a small flood plain, with sandy soils and relatively shallow slopes leading to the hilltop and surrounding elevations. Native grasses dominated, chiefly dropseed bunchgrasses, with large mesquite trees scattered throughout, especially at the base of the hill to the south. Amaranth was present at 51–75% cover, the highest concentrations at Guevavi, and had invaded most of the drainage not already occupied by mesquite or the significant clusters of dropseed. Individual Russian thistle and stink grass plants were scattered, both with <5% cover. A stack of uprooted Russian thistle created a sizable hedge near the eastern boundary.



Los Santos
Ángeles de
Guevavi unit.

3.3.3 Mission site

The mission ruins and accompanying footpaths occupy the top of the hill at the center of the unit. The hilltop around the ruins is somewhat bare and appears more disturbed than the surrounding elevations. Amaranth was the dominant species, with 26–50% cover. Mixed native grasses were abundant, making up a significant part of the plant community. One small patch of Lehmann lovegrass was found with 6–25% cover; stink grass was present at 1–5% cover. Russian thistle was present at only <1% cover.

3.3.4 Hilltop

This section of the Guevavi unit is essentially an extension of the mission site, but it was less marked by human disturbance, despite the presence of a two-track dirt road. Here again, amaranth was the dominant species, with 25–50% cover. Native grasses were well-represented, as were large mesquite trees on the southern and western borders of this section. Lehmann lovegrass and stink grass were present at <1% cover, with Russian thistle at 1–5% cover.

3.3.5 Riverbed

The riverbed section encompasses a sandy, unfenced strip of the Santa Cruz River channel, dry at the time of this survey. There was evidence of use by cattle and by humans, in the form of foot traffic and horseback riding. Amaranth was abundant in the riverbed at 26–50% cover, and Bermuda grass, almost nonexistent in the rest of the Guevavi unit, grew here at 1–5% cover. Russian thistle was also present at 1–5% cover, as were some scattered Lehmann-lovegrass individuals.

Chapter 4

Discussion

4.1 Roaming surveys

Of the 79 target species (74 AZ-WIPWG plants + 5 plants of interest to Tumacácori NHP staff), 14 were observed during roaming surveys at Tumacácori NHP units in 2006 (Tables 4.1-1, 4.1-2, 4.1-3). Of these 14 species, only 5 were recorded at the Calabazas and Guevavi units; these two sites were affected by the same suite of 5 species. Maps of each species, by park unit, appear in Appendix B. Table 4.1-1 provides measures of area affected and infested within the park unit by species. During an April 2007 visit, three new species were encountered: wild oats, rescue brome, and Mediterranean grass. Wild-oats locations were mapped; the rescue brome and Mediterranean grass were not mapped. These species are not included in the tables below nor in any analysis of area affected or infested.

Area *affected* is a measure of plant distribution calculated directly from mapped polygon

boundaries; this measure does not reflect the intensity of invasion. For example, a 1.5-ha polygon estimated at 25–50% cover would represent 1.5 ha affected.

Area *infested* is a measurement of the actual land area infested by each target species. Area infested was calculated using polygon data by multiplying the cover-class midpoint by the polygon's area. For example, a 1.5-ha polygon estimated at 25–50% cover would represent 0.5625 ha ($1.5 * 0.375 = 0.5625$) infested. In both calculations, points were estimated to represent 0.5 m².

4.2 Circular plot sampling

Of the 79 target species, 9 were recorded within the circular plots (Table 4.2). Three 1-m² quadrats were located within each circular plot, in which percent cover of all species was recorded to the nearest 1%. Using these data, the relative

Table 4.1-1. Total area affected and total area infested by target species within Tumacácori NHP's main unit.

Scientific name	Common name	Hectares affected	Percent of unit affected	Hectares infested	Percent of unit infested
<i>Ailanthus altissima</i>	tree of heaven	T	T	T	T
<i>Amaranthus palmeri</i>	Palmer's amaranth	101.25	76%	18.20	14%
<i>Arundo donax</i>	giant reed	T	T	T	T
<i>Conium maculatum</i>	poison hemlock	45.95	34%	3.83	3%
<i>Cynodon dactylon</i>	Bermuda grass	96.38	72%	30.92	23%
<i>Eragrostis cilianensis</i>	stink grass	18.06	13%	0.48	T
<i>Eragrostis lehmanniana</i>	Lehmann lovegrass	48.67	36%	0.64	T
<i>Malva parviflora</i>	cheese weed	1.69	1%	T	T
<i>Marrubium vulgare</i>	horehound	13.58	10%	T	T
<i>Salsola tragus</i>	Russian thistle	81.96	61%	5.81	4%
<i>Sisymbrium irio</i>	London rocket	16.14	12%	1.32	T
<i>Sonchus</i> spp.	sowthistle	2.52	2%	T	T
<i>Sorghum halepense</i>	Johnson grass	13.28	10%	1.26	T
<i>Tamarix chinensis</i>	tamarisk	56.39	42%	2.27	2%

T denotes area <0.1 ha or <0.1%

Table 4.1-2. Total area affected and total area infested by target species within the Calabazas unit.

	Hectares affected	Percent of unit affected	Hectares infested	Percent of unit infested
<i>Amaranthus palmeri</i>	7.62	86%	0.23	2%
<i>Cynodon dactylon</i>	2.39	27%	T	T
<i>Eragrostis cilianensis</i>	3.24	37%	T	T
<i>Eragrostis lehmanniana</i>	4.92	55%	0.19	2%
<i>Salsola tragus</i>	6.52	73%	0.19	2%

T denotes area <0.1 ha or <0.1%

Table 4.1-3. Total area affected and total area infested by target species within the Guevavi unit.

	Hectares affected	Percent of unit affected	Hectares infested	Percent of unit infested
<i>Amaranthus palmeri</i>	3.48	95%	1.05	37%
<i>Cynodon dactylon</i>	0.78	21%	T	T
<i>Eragrostis cilianensis</i>	1.74	48%	T	1%
<i>Eragrostis lehmanniana</i>	0.86	24%	T	T
<i>Salsola tragus</i>	3.07	84%	T	2%

T denotes area <0.1 ha or <0.1%

Table 4.2. Target species occurrences and relative abundances within circular plots.

Species	Circular plot occurrences	Circular plot relative abundance (foliar cover)
<i>Amaranthus palmeri</i>	24	1.6%
<i>Conium maculatum</i>	1	0.02%
<i>Cynodon dactylon</i>	17	13.4%
<i>Eragrostis cilianensis</i>	8	0.24%
<i>Eragrostis lehmanniana</i>	3	0.24%
<i>Marrubium vulgare</i>	2	0.59%
<i>Salsola tragus</i>	5	0.51%
<i>Sisymbrium irio</i>	1	0.16%
<i>Sorghum halepense</i>	3	1.76%

T denotes area <0.1 ha or <0.1%

abundance of the target species was calculated (Table 4.2).

4.2.1 Comparison of roaming surveys and circular plots

The circular plots were implemented to estimate spatial bias and accuracy of the roaming surveys. Stohlgren et al. (2003) suggested randomly locating these plots and comparing the foliar cover of target species within the circular plots to the foliar cover of target species collected during the roaming surveys. This comparison identifies observer bias to particular regions of the study area (i.e., near roads or riparian areas).

Figure 4.2.1 depicts foliar cover of target species collected via circular plots plotted against foliar cover of target species collected via roaming surveys. Both datasets were transformed using the cube-root transformation. The relative abundance of target species is rather consistent between the two methods ($R^2 = 0.62$), indicat-

ing that roaming surveys perform well at estimating abundance of target species.

Overall, the circular plots detected fewer target species; 9 target species were captured in circular plots, whereas 13 target species were identified through roaming surveys. This, in part, could be attributed to some of the species' being found in very small quantities; only one or a few individuals of tree of heaven and cheese weed were recorded in the park.

4.3 APRS prioritization

Giant reed was omitted from the APRS because insufficient information was available to generate a ranking score. Additionally, only one individual was recorded during this inventory and, though it is not considered to pose a serious threat at such low abundance, its removal would be relatively easy to achieve should it be considered. Of the 13 species ranked using the APRS system, most fell into the medium-to-low impact category; tamarisk was ranked as

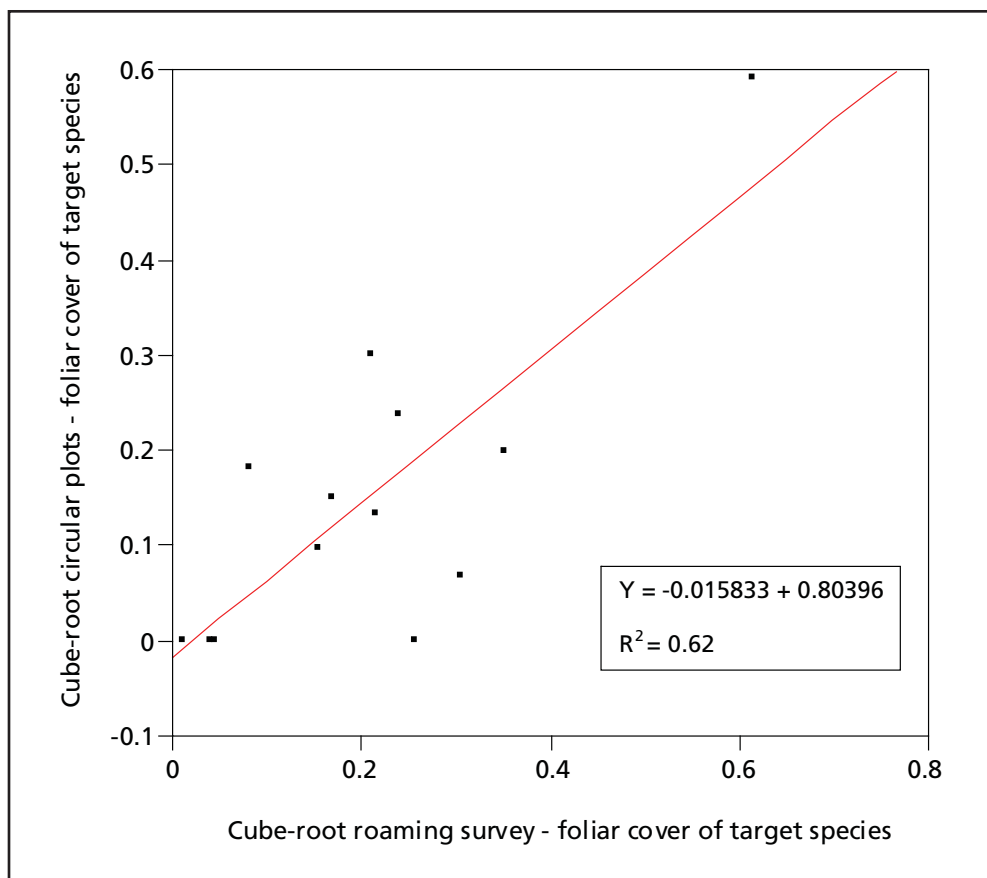
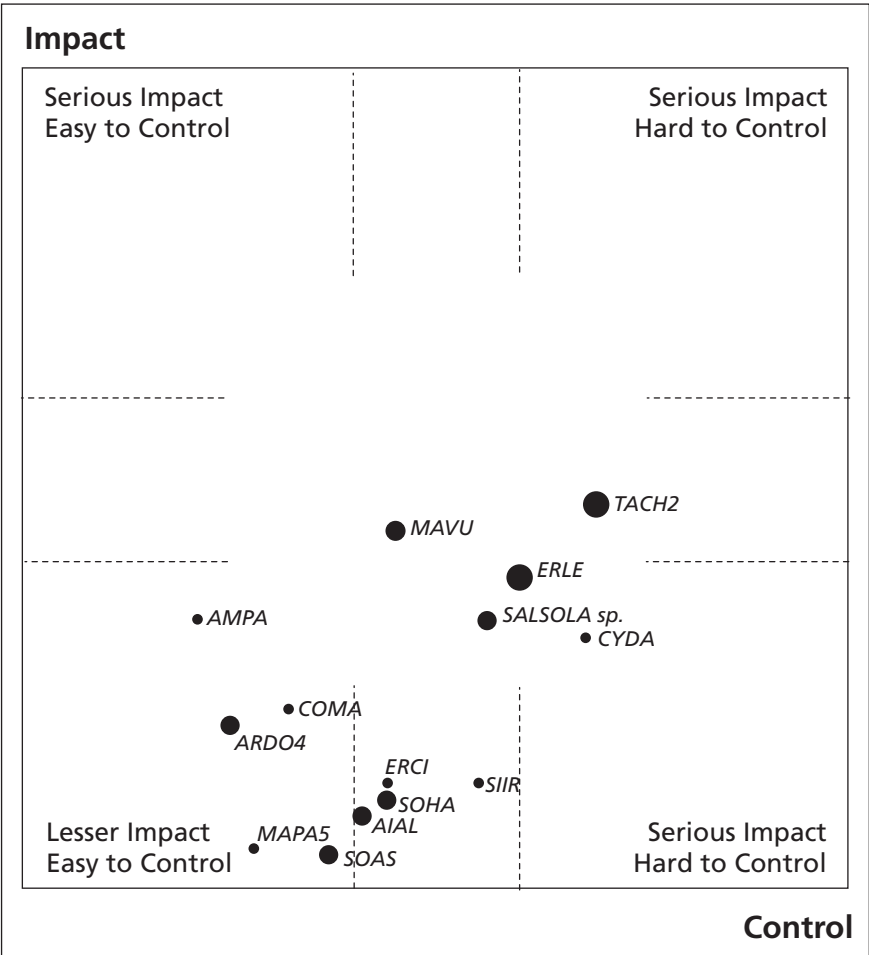


Figure 4.2.1. Relative abundance of target species collected via circular plots plotted against relative abundance of target species collected via roaming surveys.

Figure 4.3-1.
Species plotted
by level of impact
versus difficulty to
control.

The size of the dot
represents the Pest
score.



having the greatest impact. Horehound also approached the medium-impact zone (Figure 4.3-1). Species ranged from easy-to-control to difficult-to-control (Figure 4.4-2). On the 100-point scale, plants ranged from 24 to 76 for significance of impact, from 4 to 47 for innate ability to become a pest, and from 21 to 69 for feasibility of control (Table 4.3).

The less widespread annual species fell mostly within the lesser-impact and easy-to-control quadrant, with only tamarisk approaching both the very-hard-to-control/serious-impact quadrant.

Tamarisk was ranked hardest-to-control, with the greatest risk of becoming a major pest. Giant reed could become more of a pest should it spread, but currently should be quite easy to control. Annuals tended to fall to the left of the diagram, with scores reflecting relative ease of control and minor pest status.

Key to Figures 4.3-1 and 4.3-2	
AIAL	tree of heaven
AMPA	Palmer's amaranth
ARDO4	giant reed
COMA2	poison hemlock
CYDA	Bermuda grass
ERCI	stink grass
ERLE	Lehmann lovegrass
MAPA5	cheese weed
MAVU	horehound
SALSOLA sp	Russian thistle
SIIR	London rocket
SOAS	spiny sowthistle
SOHA	Johnson grass
TACH2	tamarisk

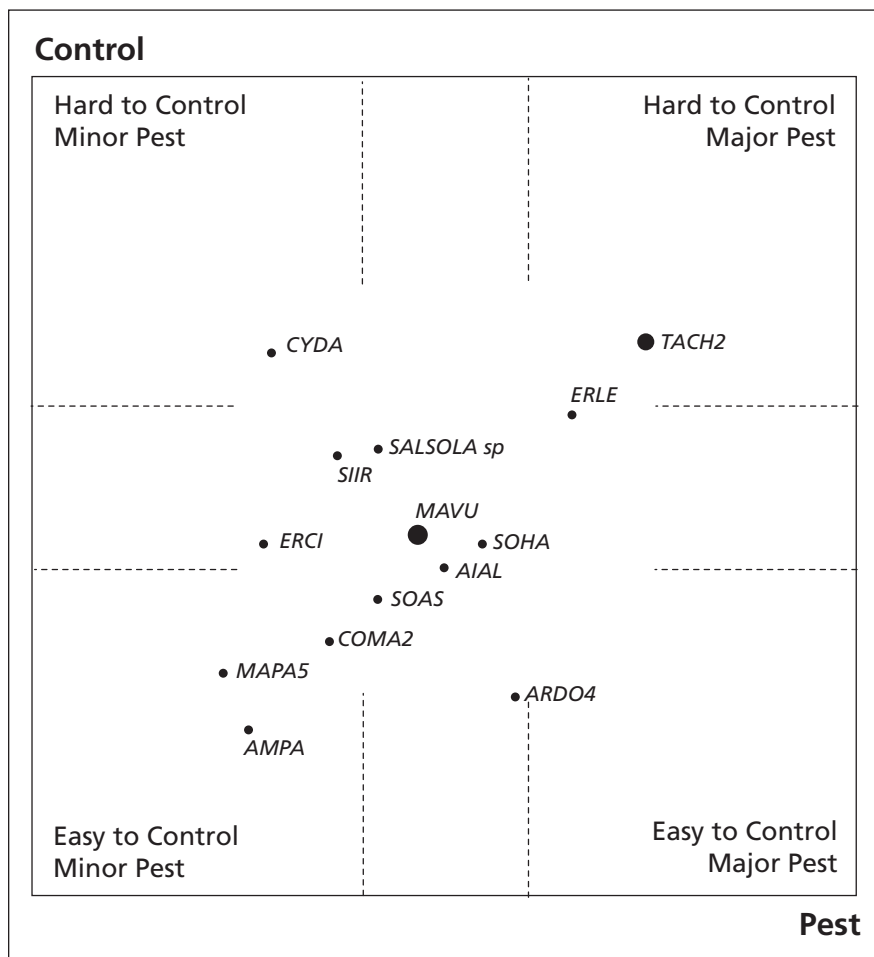


Figure 4.3-2.
Species plotted
by ease of control
versus ability to
become a pest.

The size of the
dot represents the
impact score.

Table 4.3. Ranks of target species for significance of impact (Impact), innate ability to become a pest (Pest), and feasibility of control or management (Control).

Species	Impact	Pest	Control
<i>Ailanthus altissima</i>	51	9	41
<i>Amaranthus palmeri</i>	27	33	21
<i>Arundo donax</i>	60	20	25
<i>Conium maculatum</i>	37	22	32
<i>Cynodon dactylon</i>	30	31	68
<i>Eragrostis cilianensis</i>	29	13	44
<i>Eragrostis lehmanniana</i>	67	38	60
<i>Malva parviflora</i>	24	5	28
<i>Marrubium vulgare</i>	48	44	45
<i>Salsola sp.</i>	43	33	56
<i>Sisymbrium irio</i>	38	13	55
<i>Sonchus sp.</i>	43	4	37
<i>Sorghum halepense</i>	56	11	44
<i>Tamarix chinensis</i>	76	47	69

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Chapter 5

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Appendix A

AZ-WIPWG Invasive Plant Species List

Table A.1. Arizona Wildlands Invasive Plant Working Group invasive plant species list.

Latin name	Common name
<i>Acroptilon repens</i> (L.) DC	Russian knapweed
<i>Aegilops cylindrical</i> Host	jointed goatgrass
<i>Amaranthus palmeri</i> S. Wats	Palmer's amaranth**
<i>Alhagia maurorum</i> Medik.	camelthorn
<i>Arundo donax</i> L.	giant reed
<i>Asphodelus fistulosus</i> L.	onionweed
<i>Avena fatua</i> L.	wild oat
<i>Brassica tournefortii</i> Gouan	Sahara mustard
<i>Bromus diandrus</i> Roth	ripgut brome
<i>Bromus inermis</i> Leyss.	smooth brome
<i>Bromus rubens</i> L.	red brome
<i>Bromus tectorum</i> L.	cheatgrass
<i>Cardaria chalapensis</i> (L.) Hand.-Maz.	lenspod whitetop
<i>Cardaria draba</i> (L.) Desv.	whitetop
<i>Cardaria pubescens</i> (C.A. May) Jamolenko	hairy whitetop
<i>Carduus nutans</i> L.	musk thistle
<i>Centaurea biebersteinii</i> DC.	spotted knapweed
<i>Centaurea diffusa</i> Lam.	diffuse knapweed
<i>Centaurea melitensis</i> L.	Malta starthistle
<i>Centaurea solstitialis</i> L.	yellow starthistle
<i>Chondrilla juncea</i> L.	rush skeletonweed
<i>Cirsium arvense</i> (L.) Scop.	Canada thistle
<i>Cirsium vulgare</i> (Savi) Ten.	bull thistle
<i>Conium maculatum</i> L.	poison hemlock
<i>Convolvulus arvensis</i> L.	field bindweed
<i>Cortaderia selloana</i> (J.A. & J.H. Schultes) Aschers. & Graebn.	pampas grass
<i>Cynodon dactylon</i> (L.) Pers	Bermuda grass
<i>Cynoglossum officinale</i> L.	houndstongue
<i>Echinochloa crus-galli</i> (L.) Beauv.	barnyardgrass
<i>Eichhornia crassipes</i> (Mart) Solms	water hyacinth
<i>Elaeagnus angustifolia</i> L.	Russian olive
<i>Elymus repens</i> (L.) Gould	quackgrass
<i>Eragrostis cilianensis</i> (All.) Vign. Ex Janchen	stink grass
<i>Eragrostis curvula</i> (Schrud.) Nees	weeping lovegrass
<i>Eragrostis lehmanniana</i> Nees	Lehmann lovegrass
<i>Erodium cicutarium</i> (L.) L'Her ex Ait.	redstem filaree
<i>Euphorbia esula</i> L.	leafy spurge
<i>Euryops multifidus</i> (Thunb.) DC.	sweet resinbush
<i>Hordeum murinum</i> L.	mouse barley
<i>Hydrilla verticillata</i> (L.f.) Royle	hydrilla

Table A.1. Arizona Wildlands Invasive Plant Working Group invasive plant species list, cont.

Latin name	Common name
<i>Lepidium latifolium</i> L.	perennial pepperweed
<i>Leucanthemum vulgare</i> Lam.	oxeye daisy
<i>Linaria dalmatica</i> (L.) P. Mill.	dalmatian toadflax
<i>Linaria vulgaris</i> P. Mill.	yellow toadflax
<i>Lolium perenne</i> L.	perennial ryegrass
<i>Malva parviflora</i> L.	cheese weed**
<i>Marrubium vulgare</i> L.	horehound**
<i>Melilotus alba</i> Medikus	white sweetclover
<i>Melilotus officinalis</i> (L.) Lam.	yellow sweetclover
<i>Mesembryanthemum crystallinum</i> L.	common iceplant
<i>Mesembryanthemum nodiflorum</i> L.	slenderleaf iceplant
<i>Myriophyllum aquaticum</i> (Vell.) Verdc.	parrot's feather
<i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil
<i>Onopordum acanthium</i> L.	Scotch thistle
<i>Panicum antidotale</i> Retz.	blue panicum
<i>Pennisetum ciliare</i> (L.) Link	buffelgrass
<i>Pennisetum setaceum</i> (Forssk.) Chiov.	fountain grass
<i>Phalaris minor</i> Retz.	littleseed canarygrass**
<i>Rhus lanceae</i> L.f.	African sumac
<i>Rubus armeniacus</i> Focke	Himalayan blackberry
<i>Rubus discolor</i> Weihe & Nees	Himalayan blackberry
<i>Saccharum ravennae</i> (L.) L.	Ravennagrass
<i>Salsola collina</i> Pallas	slender Russian thistle
<i>Salsola paulsenii</i> Litv.	barbwire Russian thistle
<i>Salsola tragus</i> L.	prickly Russian thistle
<i>Salvinia molesta</i> Mitchell	giant salvinia
<i>Schismus arabicus</i> Nees	Arabian schismus
<i>Schismus barbatus</i> (Loefl. ex L.) Thellung	common Mediterranean grass
<i>Sisymbrium irio</i> L.	London rocket**
<i>Sonchus asper</i> (L.) Hill	spiny sowthistle
<i>Sonchus oleraceus</i> L.	annual sowthistle
<i>Sorghum halepense</i> (L.) Pers.	Johnson grass
<i>Tamarix aphylla</i> (L.) Karst	Athel tamarisk
<i>Tamarix chinensis</i> Lour.	five-stamen tamarisk
<i>Tamarix parviflora</i> DC.	smallflower tamarisk
<i>Tamarix ramosissima</i> Ledeb.	saltcedar
<i>Tribulus terrestris</i> L.	puncturevine
<i>Ulmus pumila</i> L.	Siberian elm
<i>Verbascum thapsus</i> L.	common mullein
<i>Vinca major</i> L.	bigleaf periwinkle

** Indicates plant not on AZ-WIPWG list; added to survey by Tumacácori NHP staff.

Appendix B

Species Maps

Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Amaranthus palmeri (Carelessweed amaranth) Map T-1



Produced by Sarah Studd and Mark Zepp

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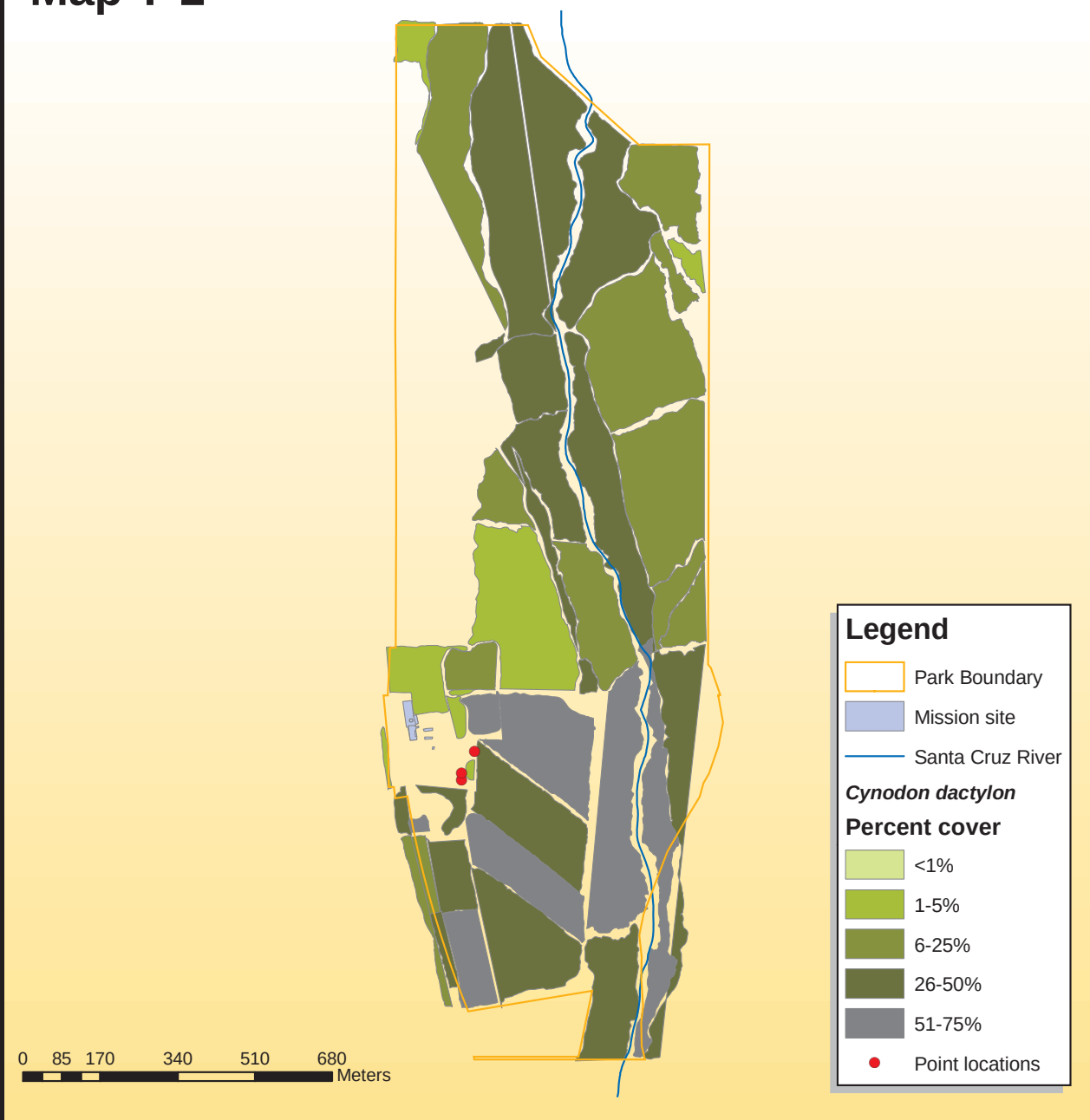
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Cynodon dactylon (Bermudagrass) Map T-2



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

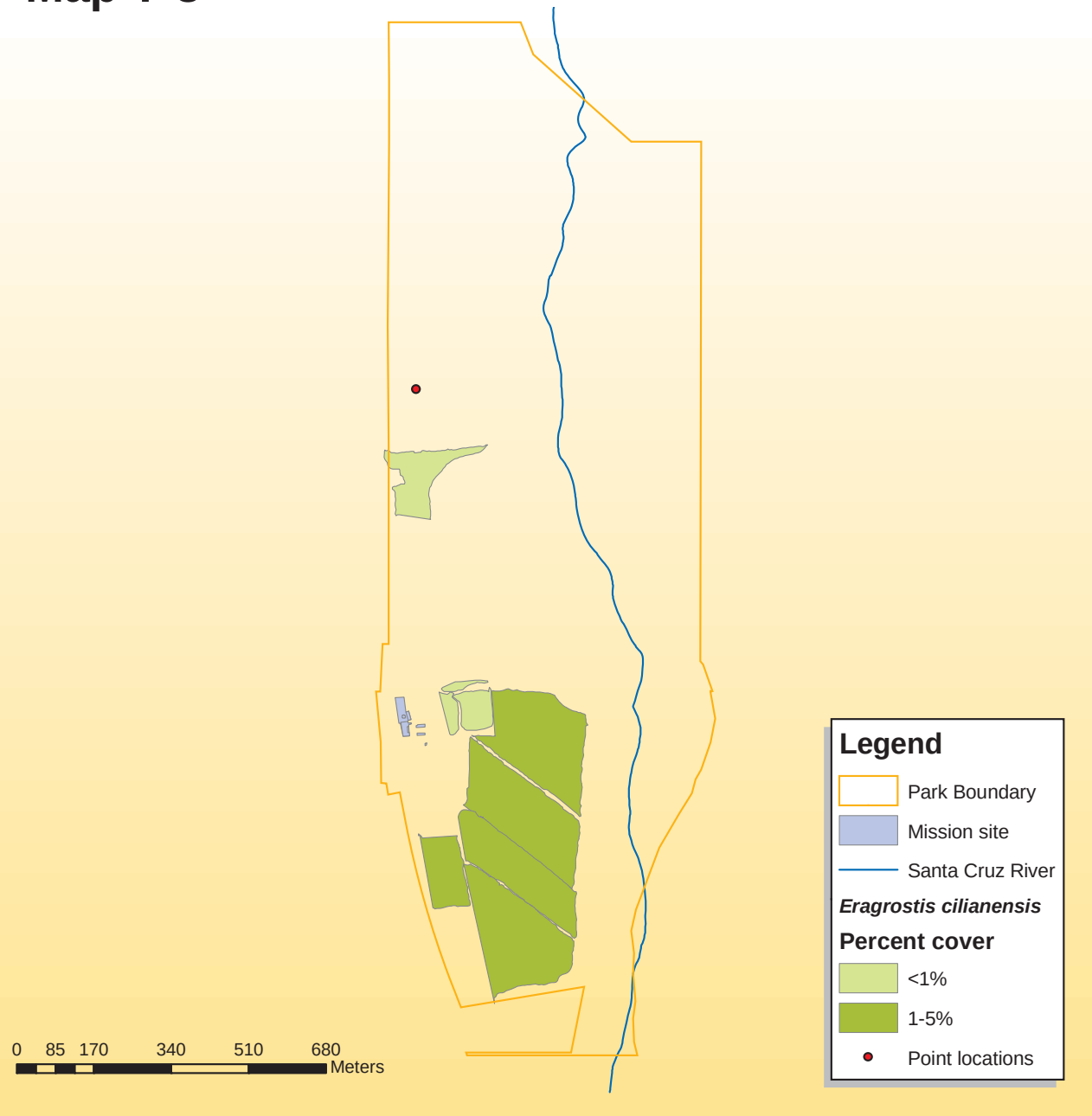
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Eragrostis cilianensis (Stinkgrass) Map T-3



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

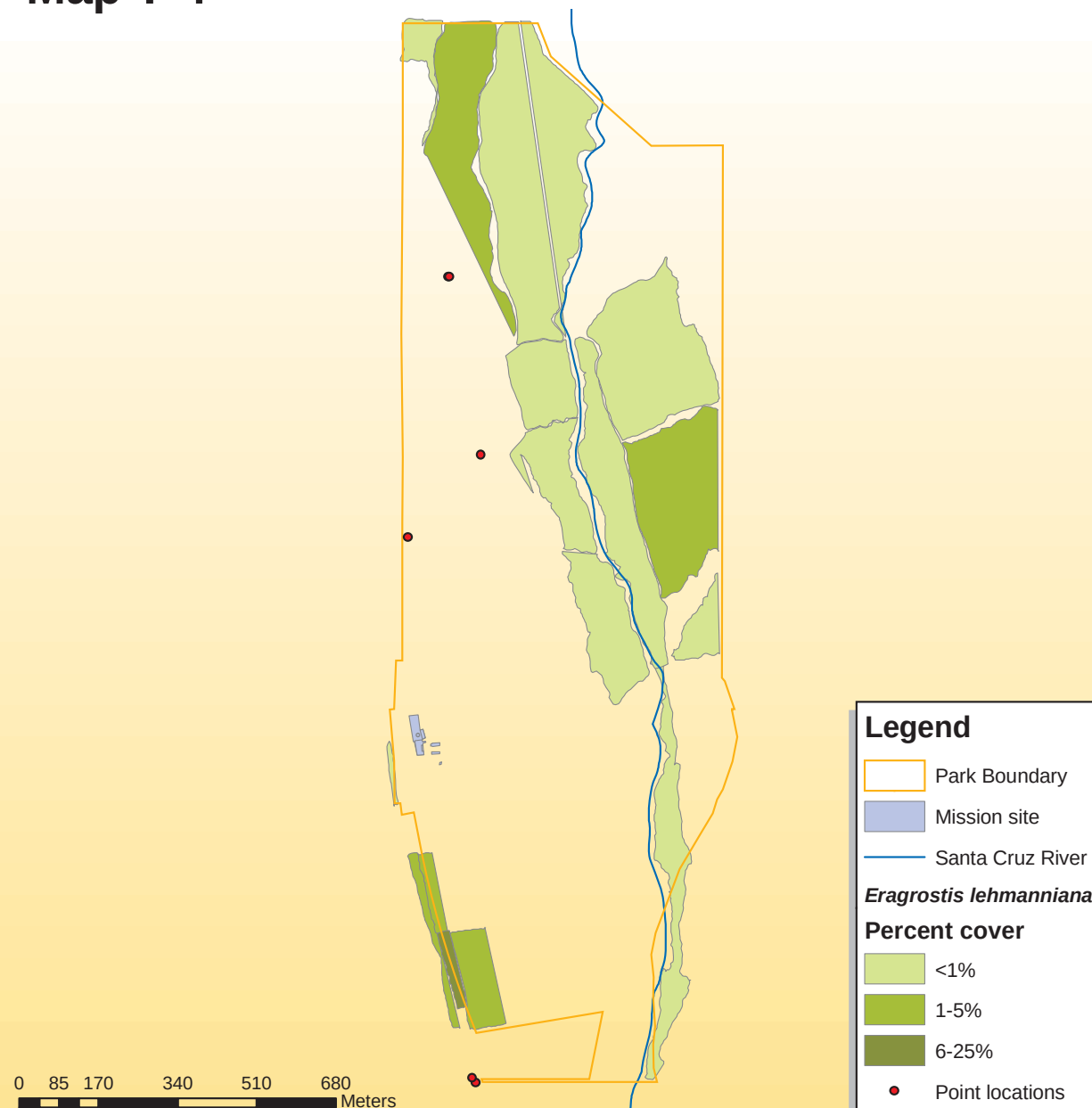
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Eragrostis lehmanniana (Lehmann lovegrass) Map T-4



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

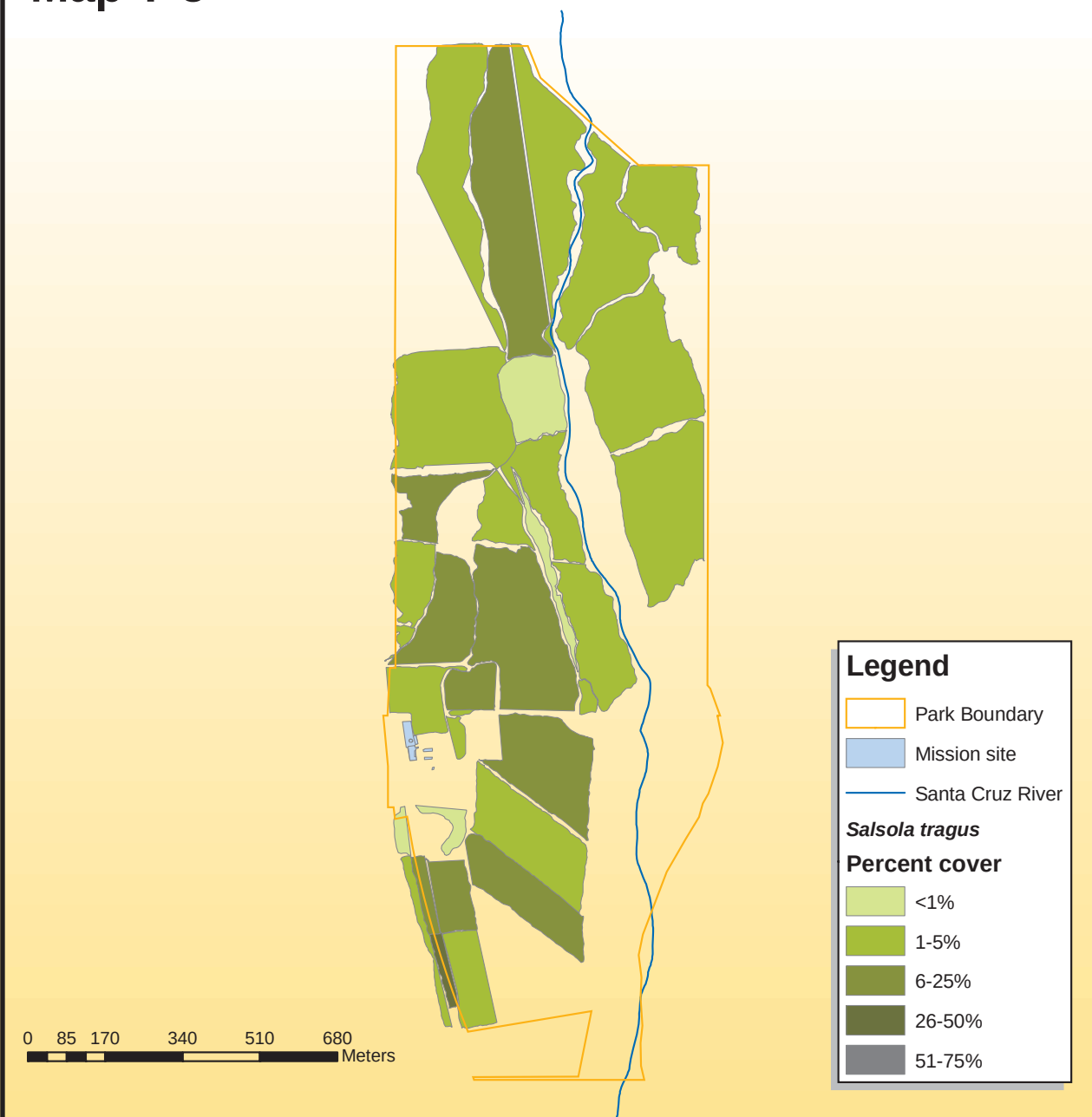
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Salsola tragus (Prickly Russian thistle) Map T-5



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

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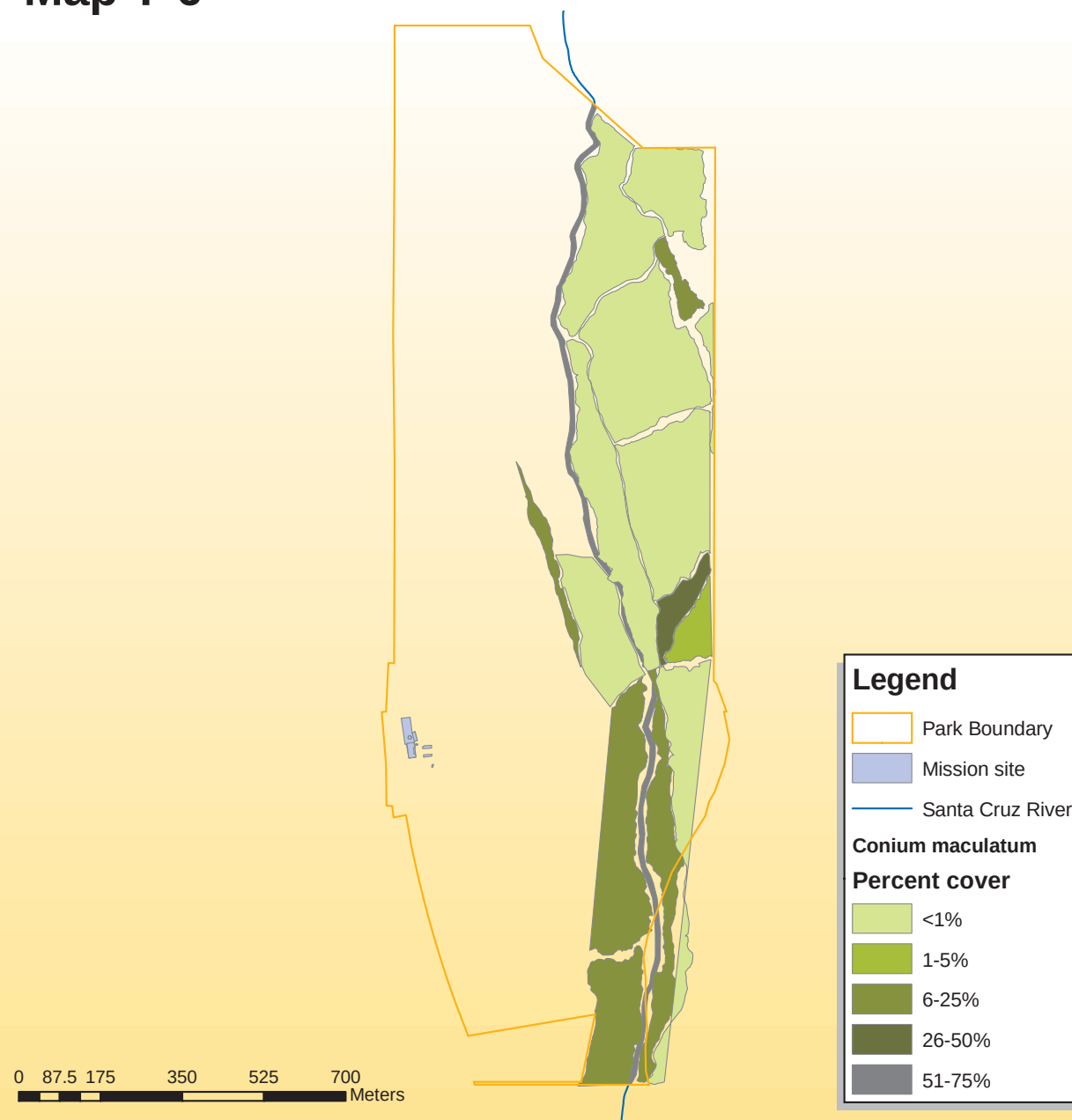
Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Conium maculatum (Poison hemlock)

Map T-6



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

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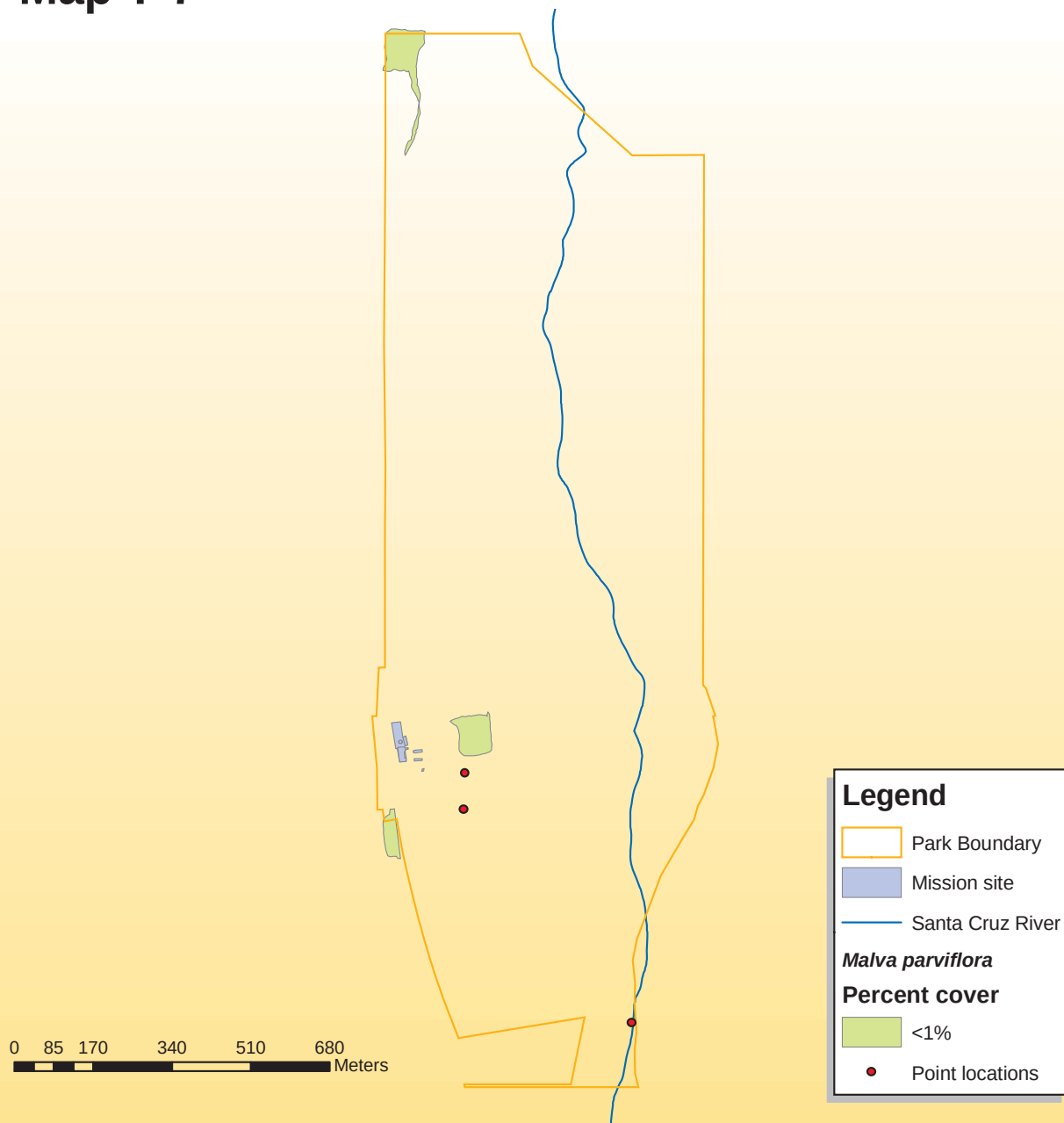
Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Malva parviflora (Cheeseweed mallow)

Map T-7



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

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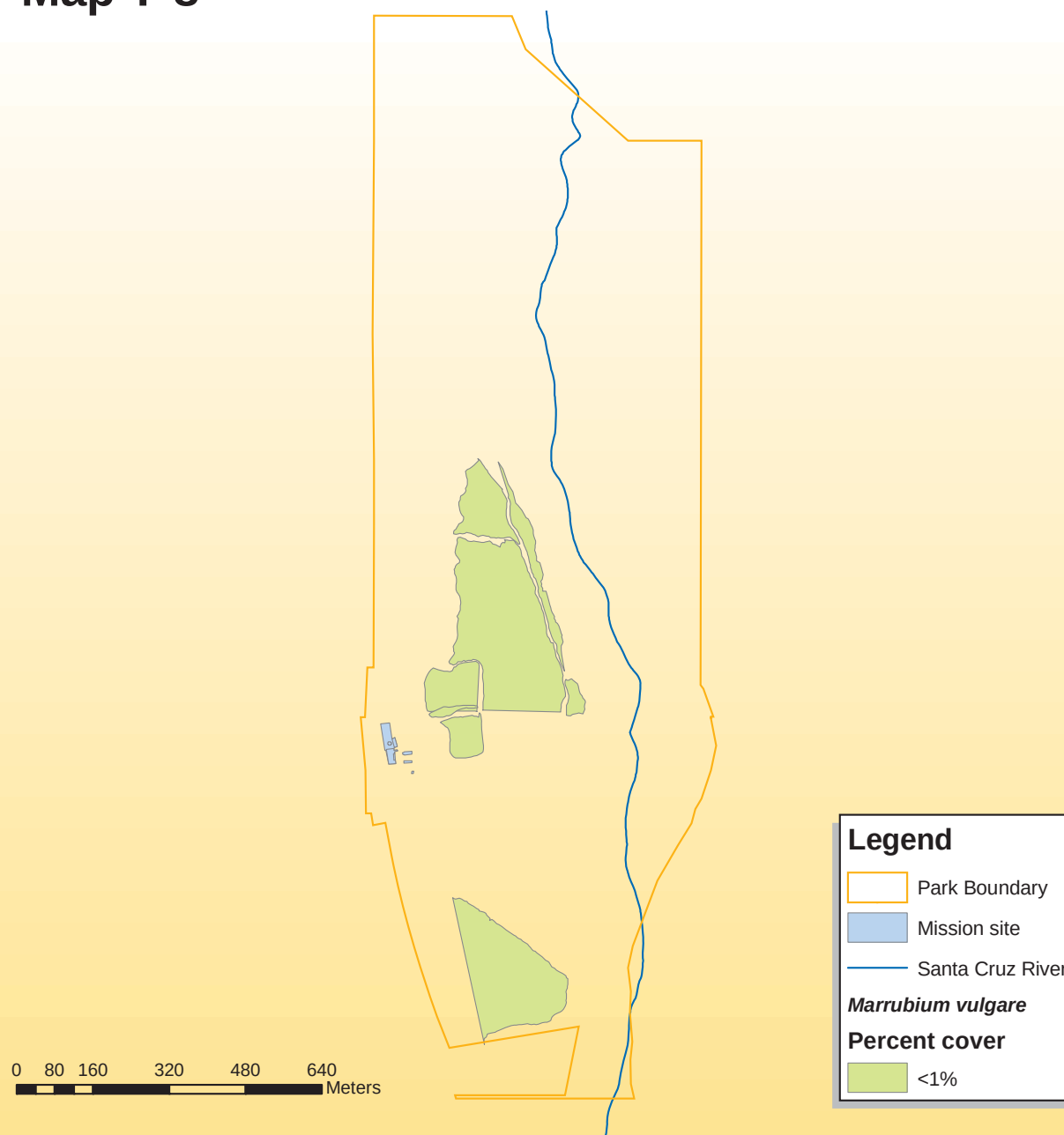
Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Marrubium vulgare (Horehound)

Map T-8



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

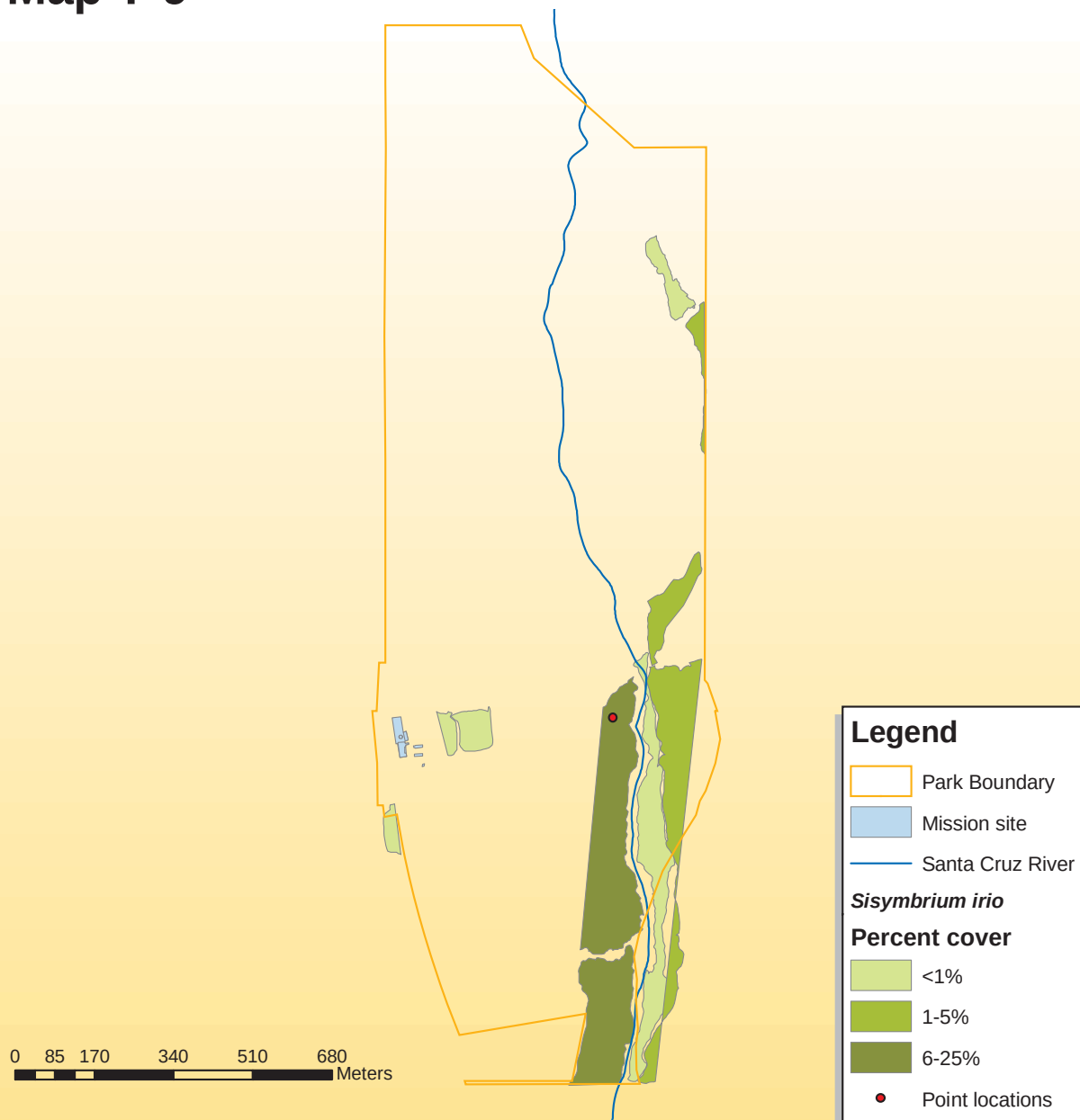
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Sisymbrium irio (London rocket) Map T-9



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

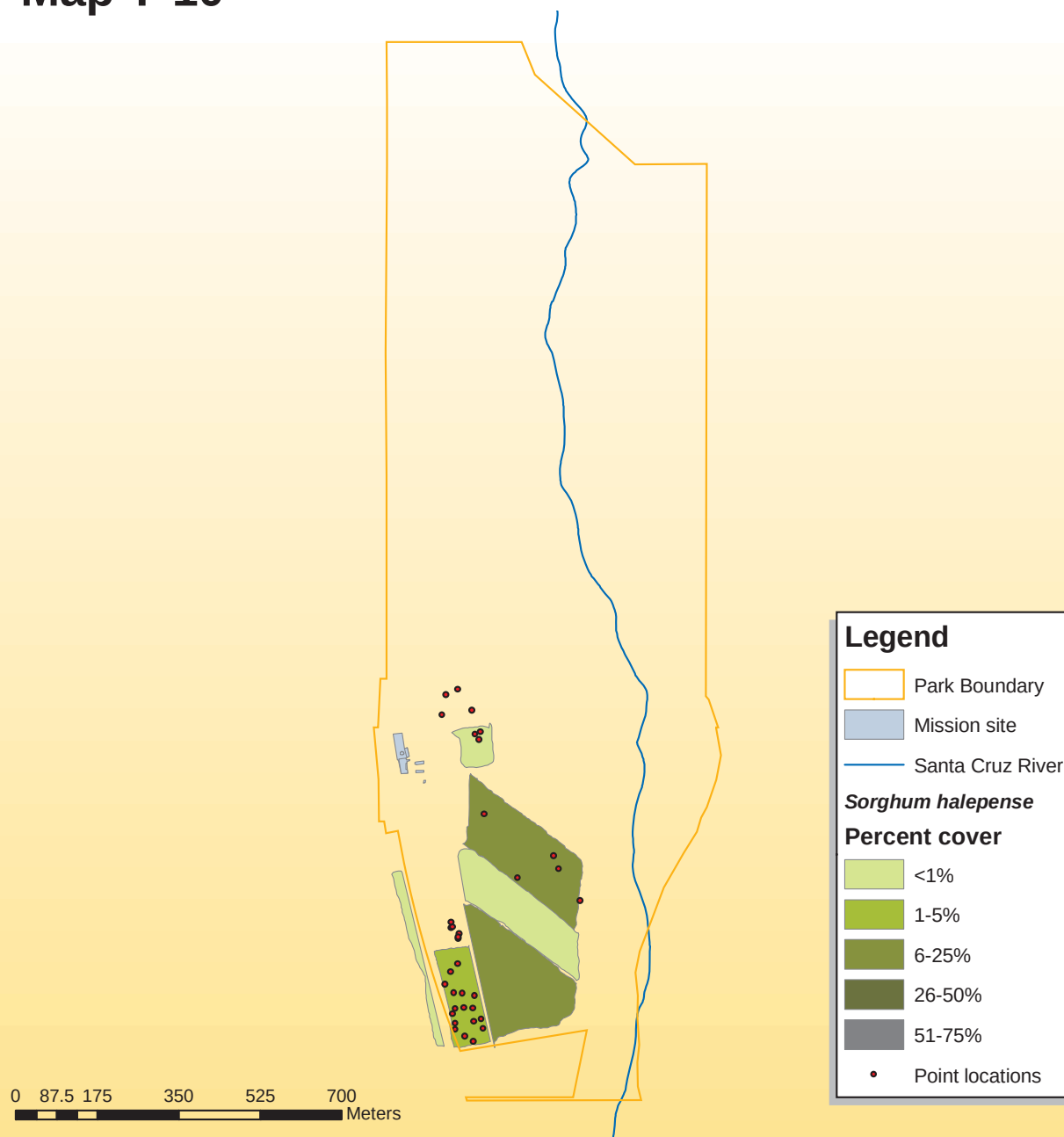
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Sorghum halepense (Johnsongrass) Map T-10



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

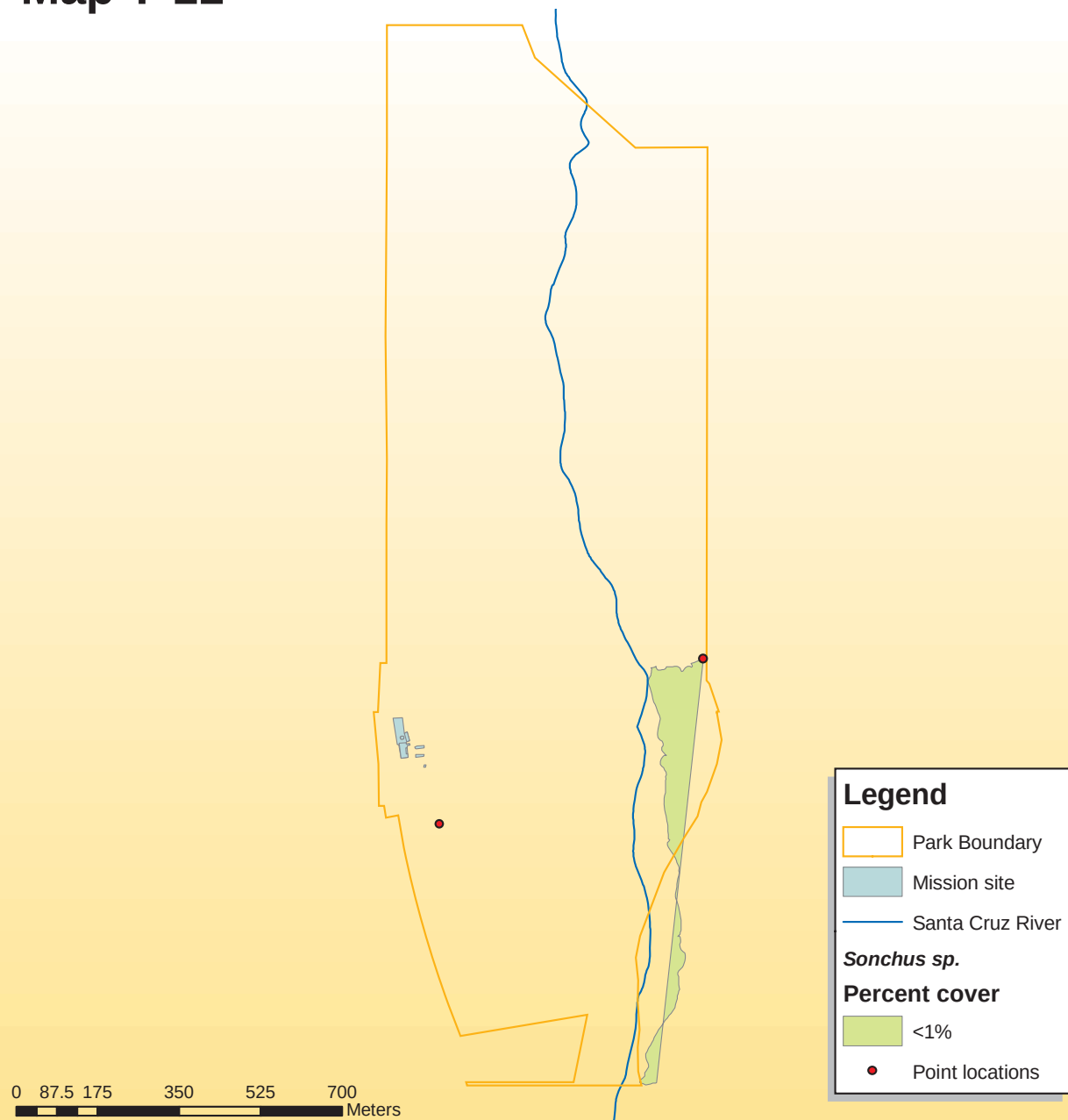
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Sonchus sp. (Sowthistle) Map T-11



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

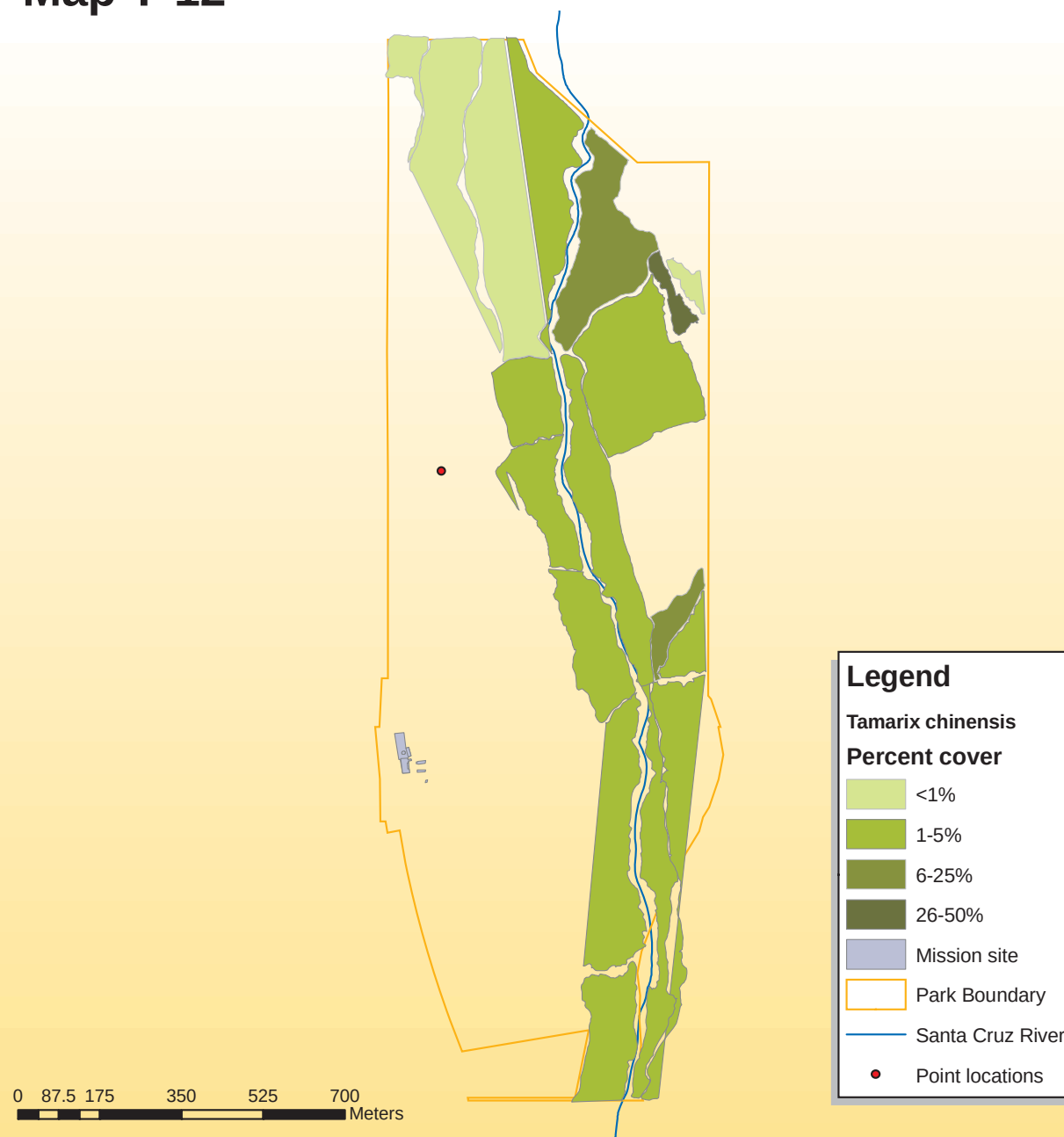
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Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Tamarix chinensis (Fivestamen tamarisk) Map T-12



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

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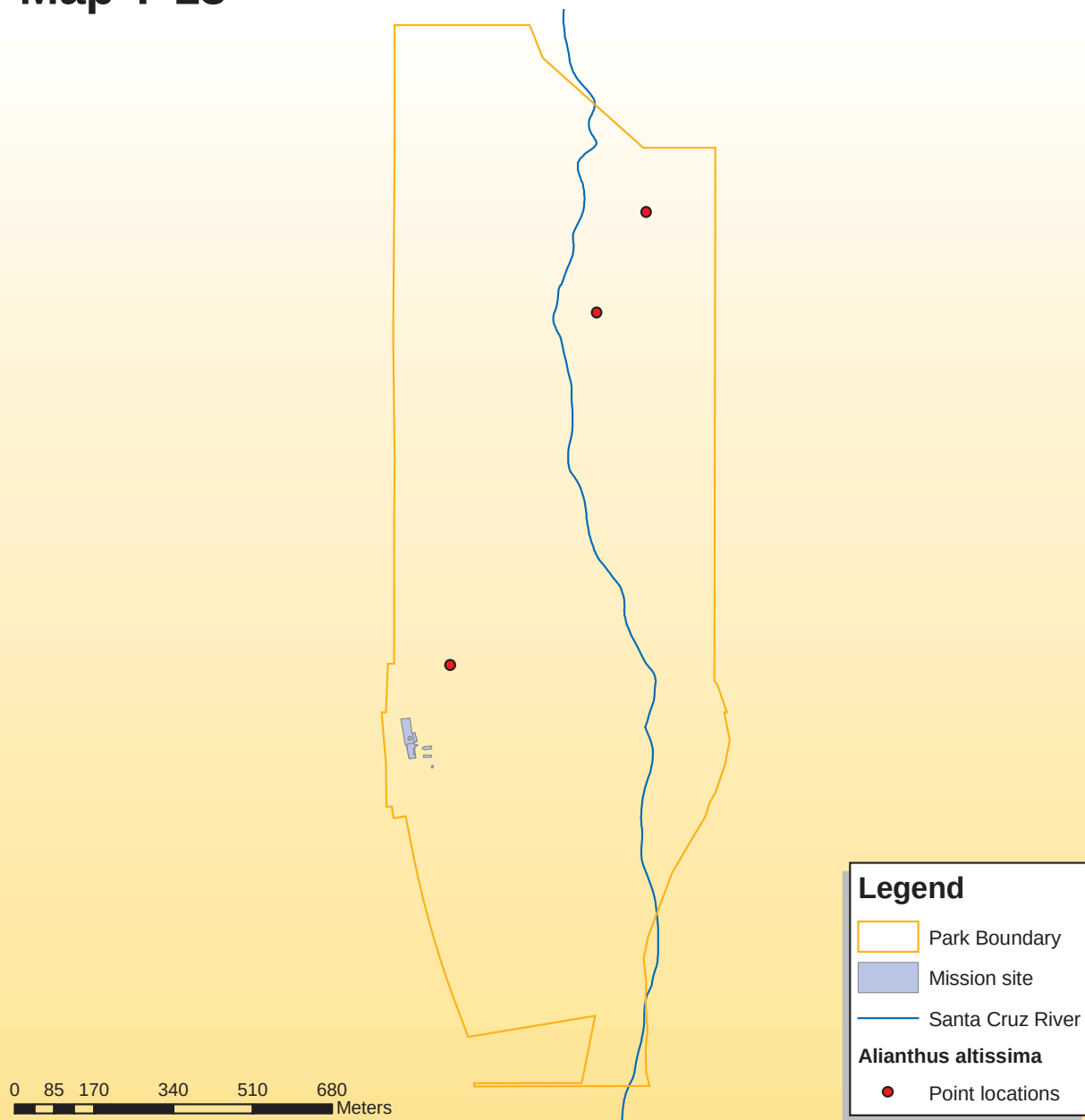
Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Alianthus altissima (Tree of Heaven)

Map T-13



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

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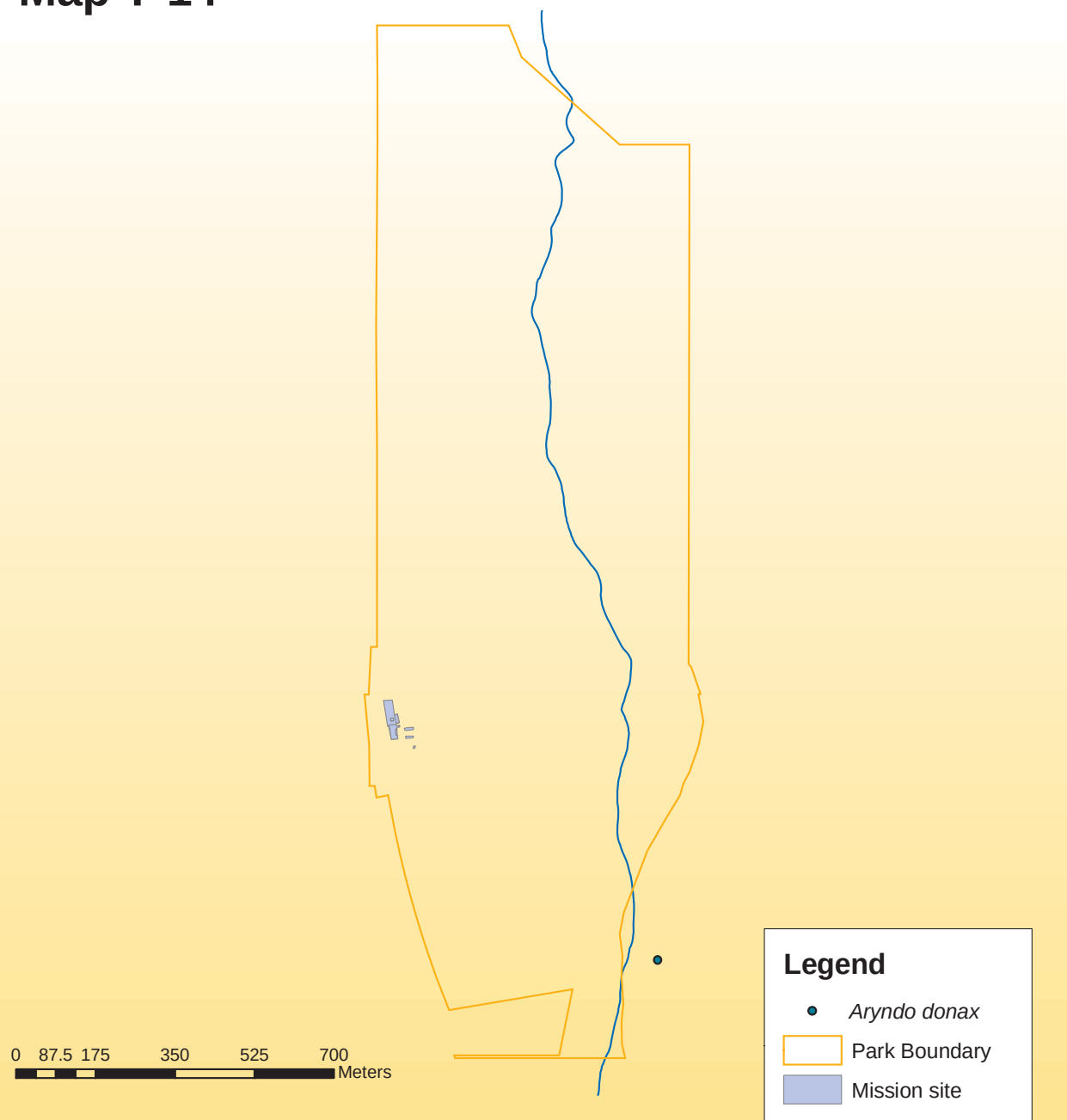
Tumacacori NHP
Arizona

National Park Service
U.S. Department of the Interior



Arundo donax (Giant reed)

Map T-14



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

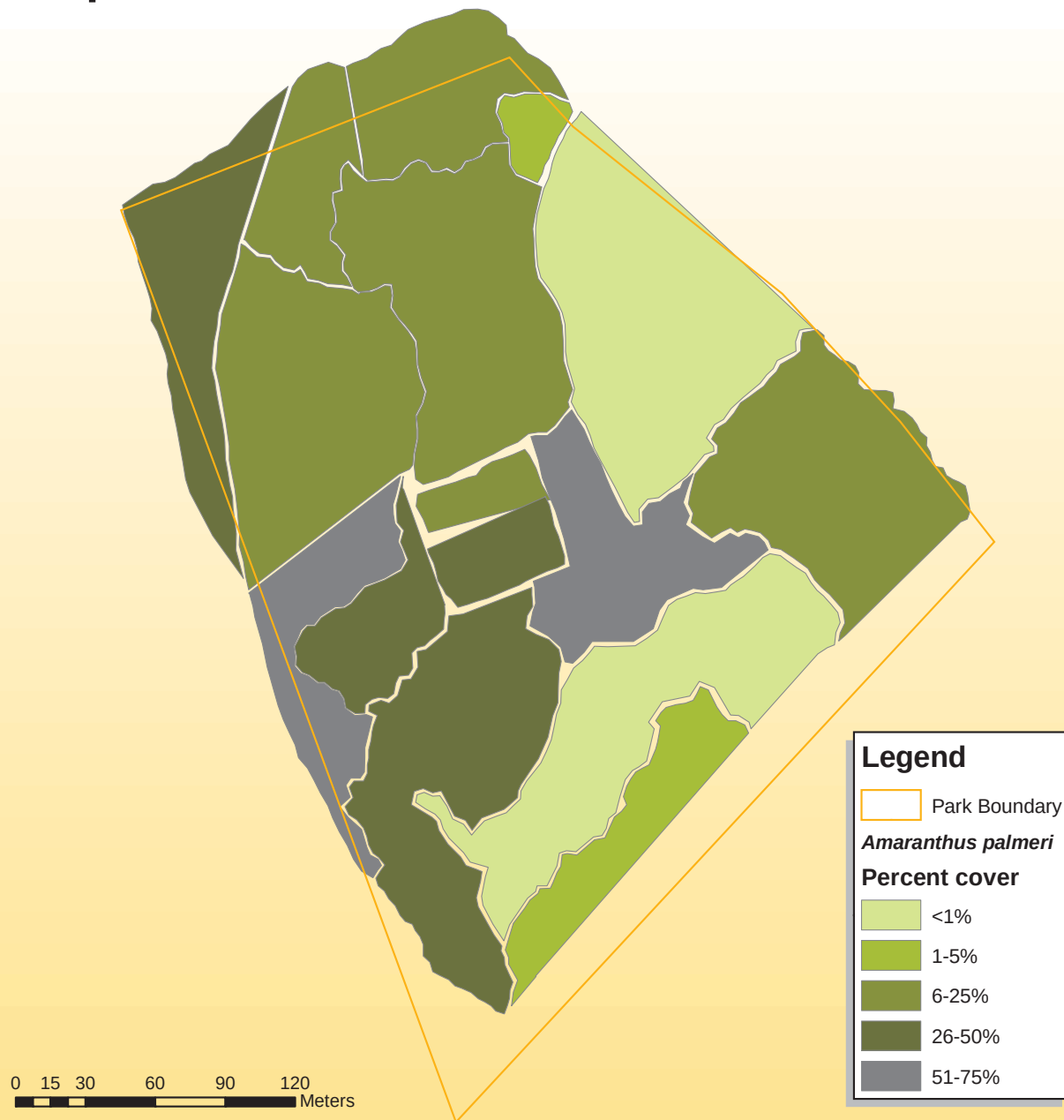
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Tumacacori NHP, Calabazas Unit
Arizona

National Park Service
U.S. Department of the Interior



Amaranthus palmeri (Carelessweed amaranth) Map C-1



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

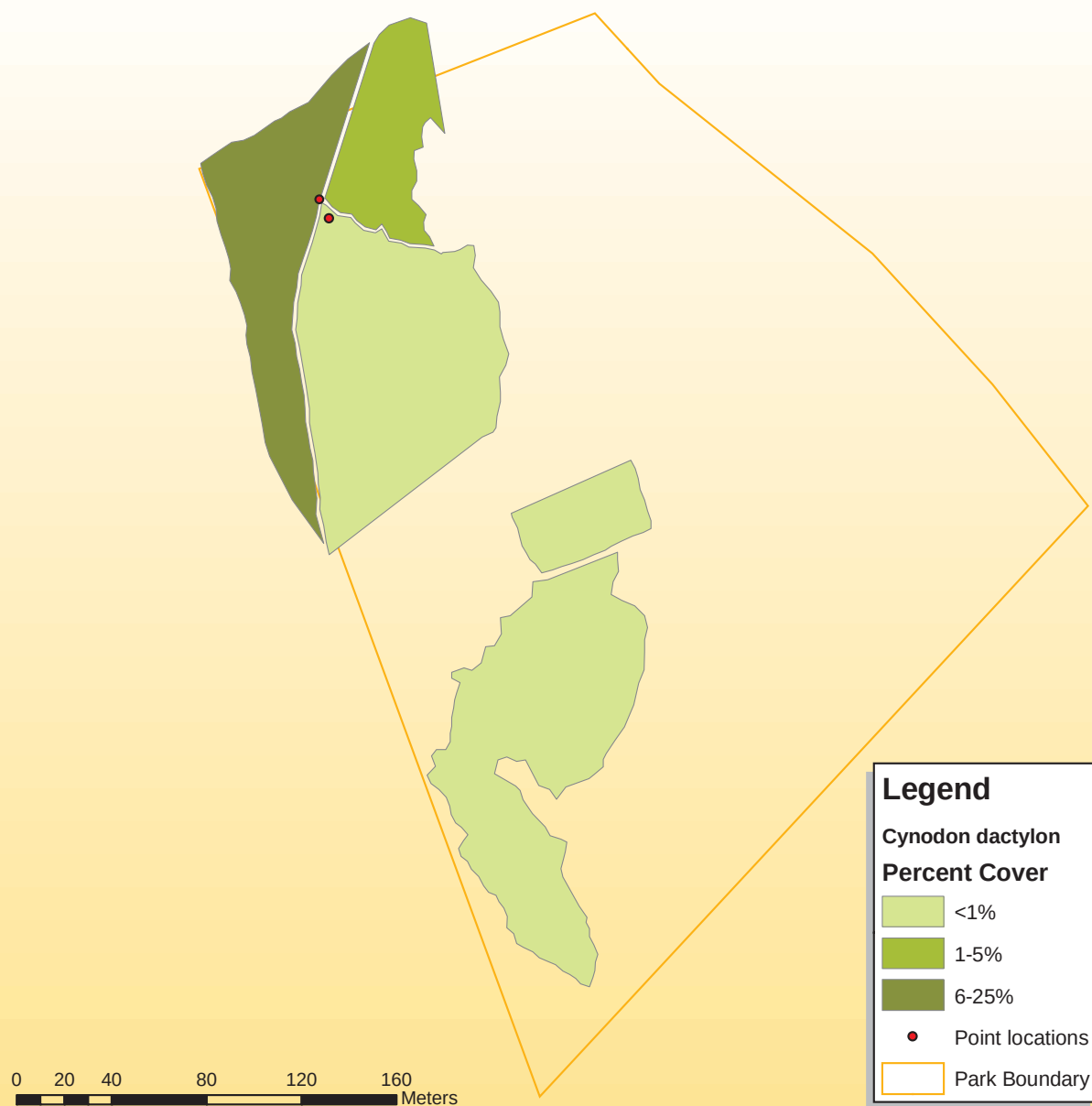
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Tumacacori NHP, Calabazas Unit
Arizona

National Park Service
U.S. Department of the Interior



Cynodon dactylon (Bermudagrass) Map C-2



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

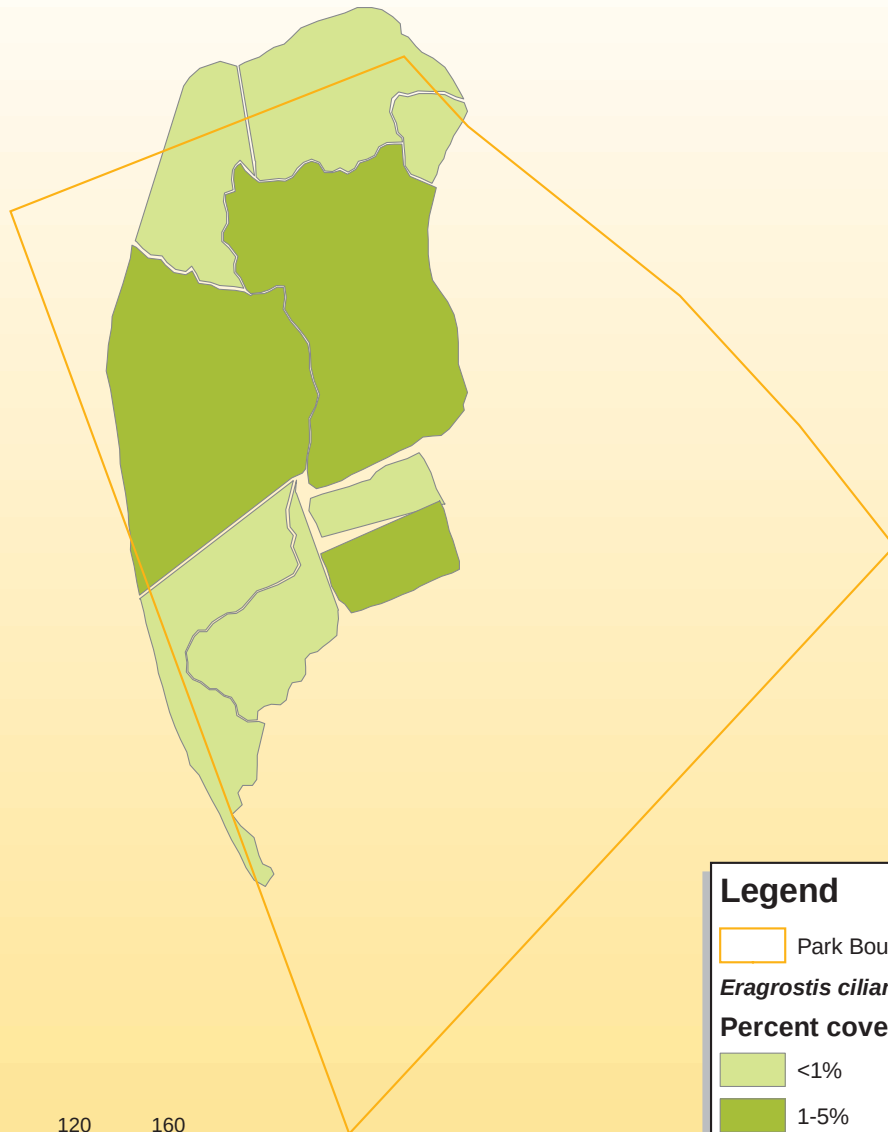
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Tumacacori NHP, Calabazas Unit
Arizona

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U.S. Department of the Interior



Eragrostis cilianensis (Stinkgrass) Map C-3



Legend

- Park Boundary
- Eragrostis cilianensis*
- Percent cover**
- <1%
- 1-5%

Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

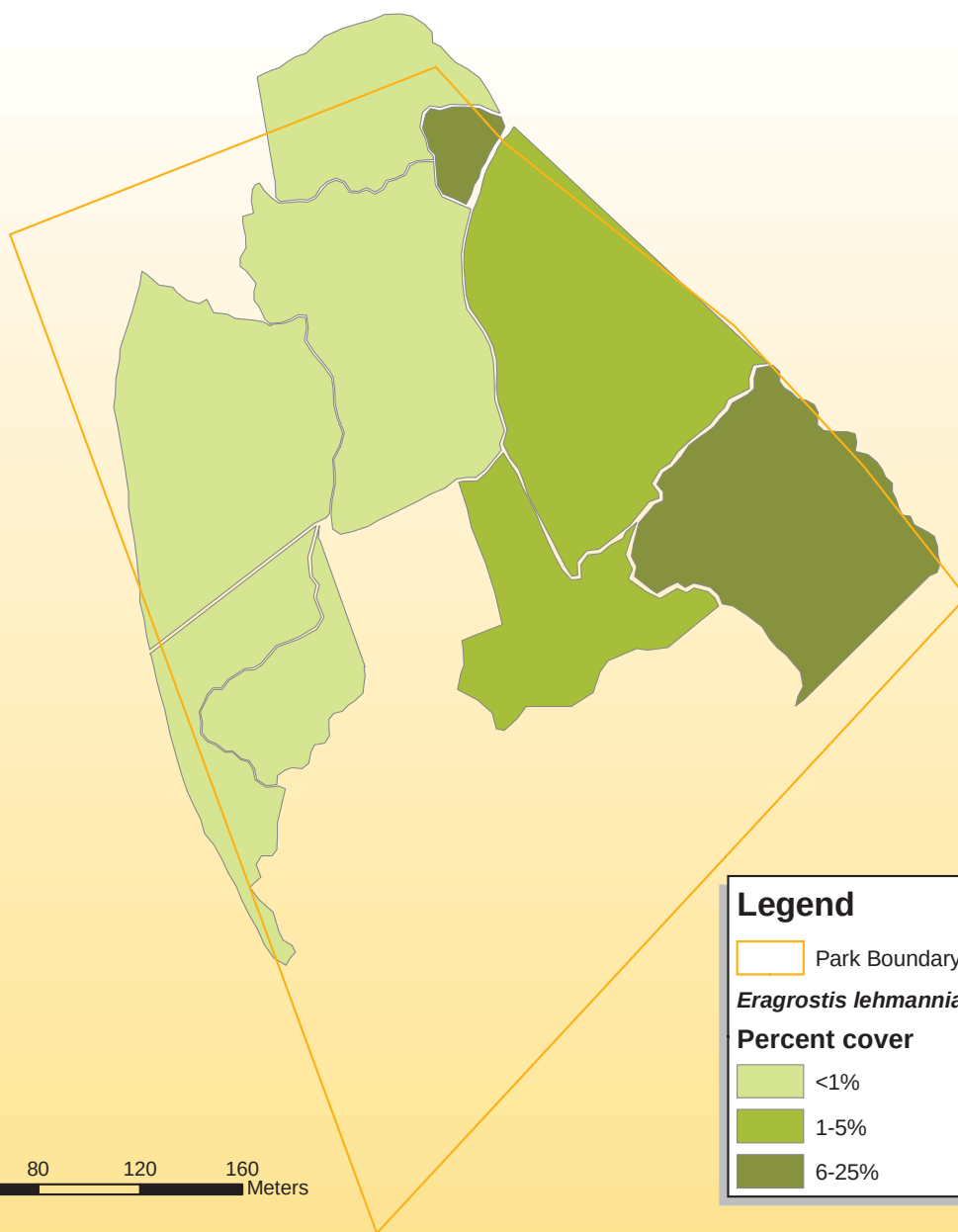
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Tumacacori NHP, Calabazas Unit
Arizona

National Park Service
U.S. Department of the Interior



Eragrostis lehmanniana (Lehmann lovegrass) Map C-4



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

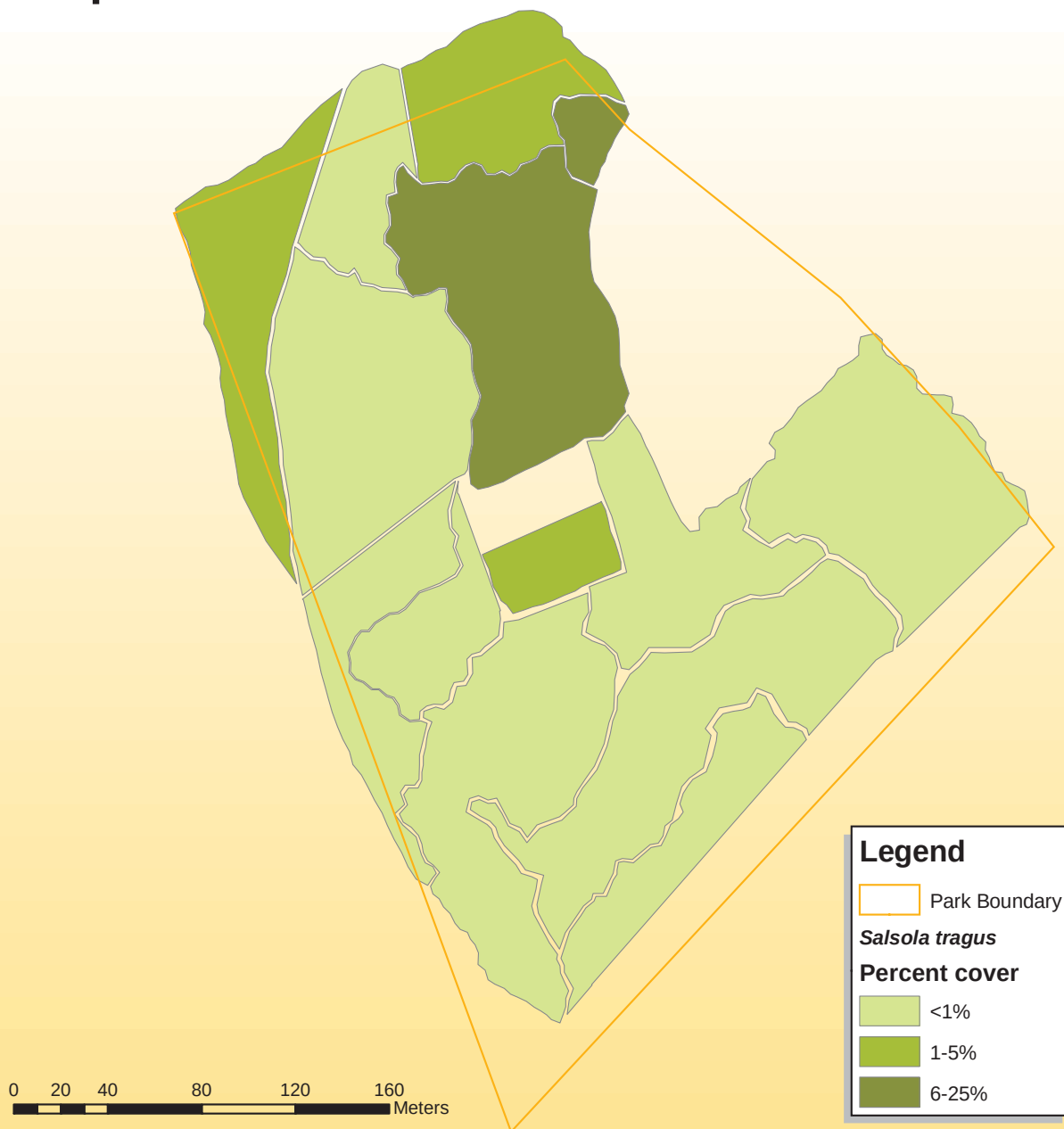
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Tumacacori NHP, Calabazas Unit
Arizona

National Park Service
U.S. Department of the Interior



Salsola tragus (Prickly Russian thistle) Map C-5



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

FILE: //inpsodn2800serv/Vital_signs/Exotic_Plant_Inventories/SODN_Park_files/Data_Spatial/ArcMap_Projects/TUMA/calatr_C5.mxd

Tumacacori NHP, Guevavi Unit
Arizona

National Park Service
U.S. Department of the Interior



Amaranthus palmeri (Carelessweed amaranth) Map G-1



0 12.5 25 50 75 100
Meters

Legend

Park Boundary

Percent Cover

1-5%

6-25%

26-50%

51-75%

Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

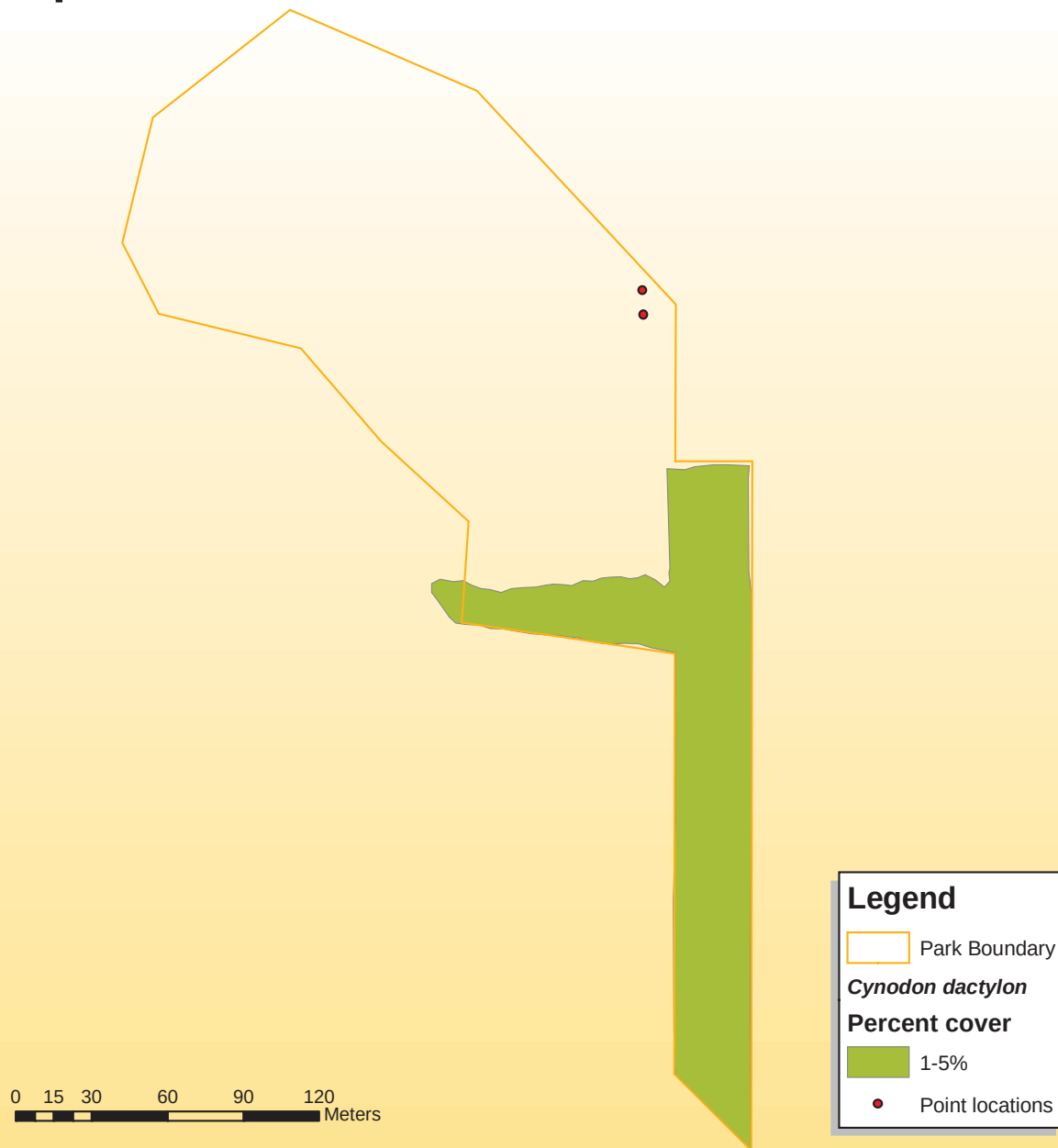
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Tumacacori NHP, Guevavi Unit
Arizona

National Park Service
U.S. Department of the Interior



Cynodon dactylon (Bermudagrass) Map G-2



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

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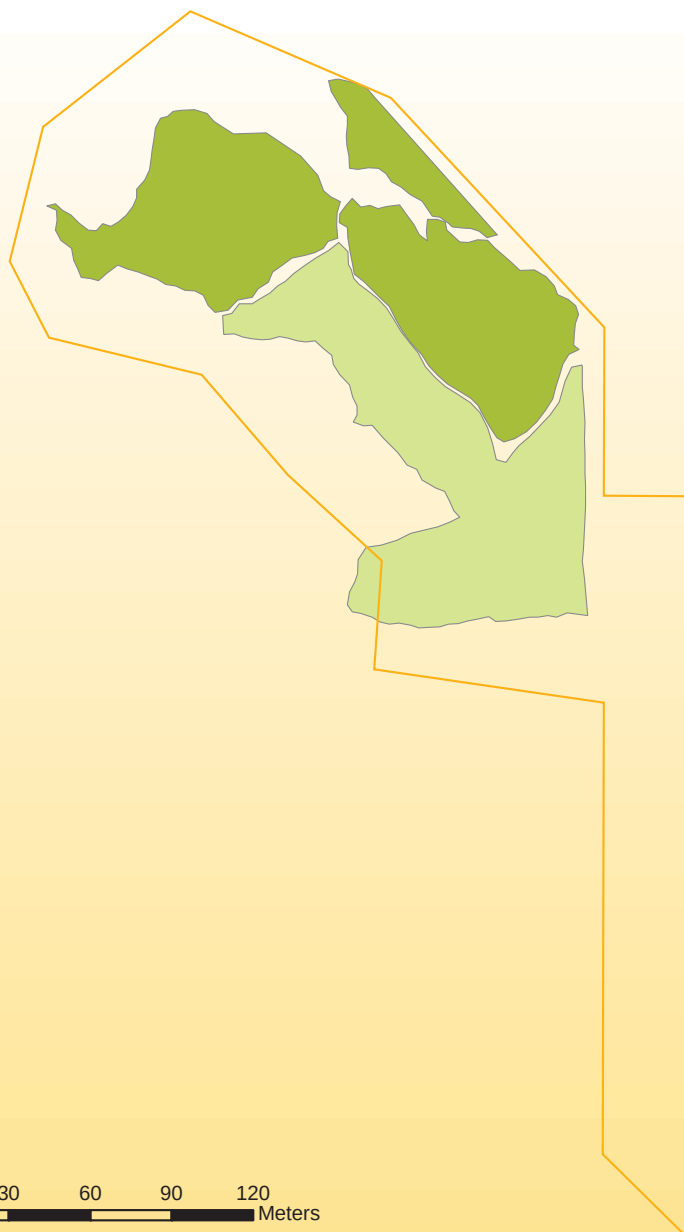
Tumacacori NHP, Guevavi Unit
Arizona

National Park Service
U.S. Department of the Interior



Eragrostis cilianensis (Stinkgrass)

Map G-3



0 15 30 60 90 120
Meters

Legend

Park Boundary

Eragrostis cilianensis

Percent cover

<1%

1-5%

Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

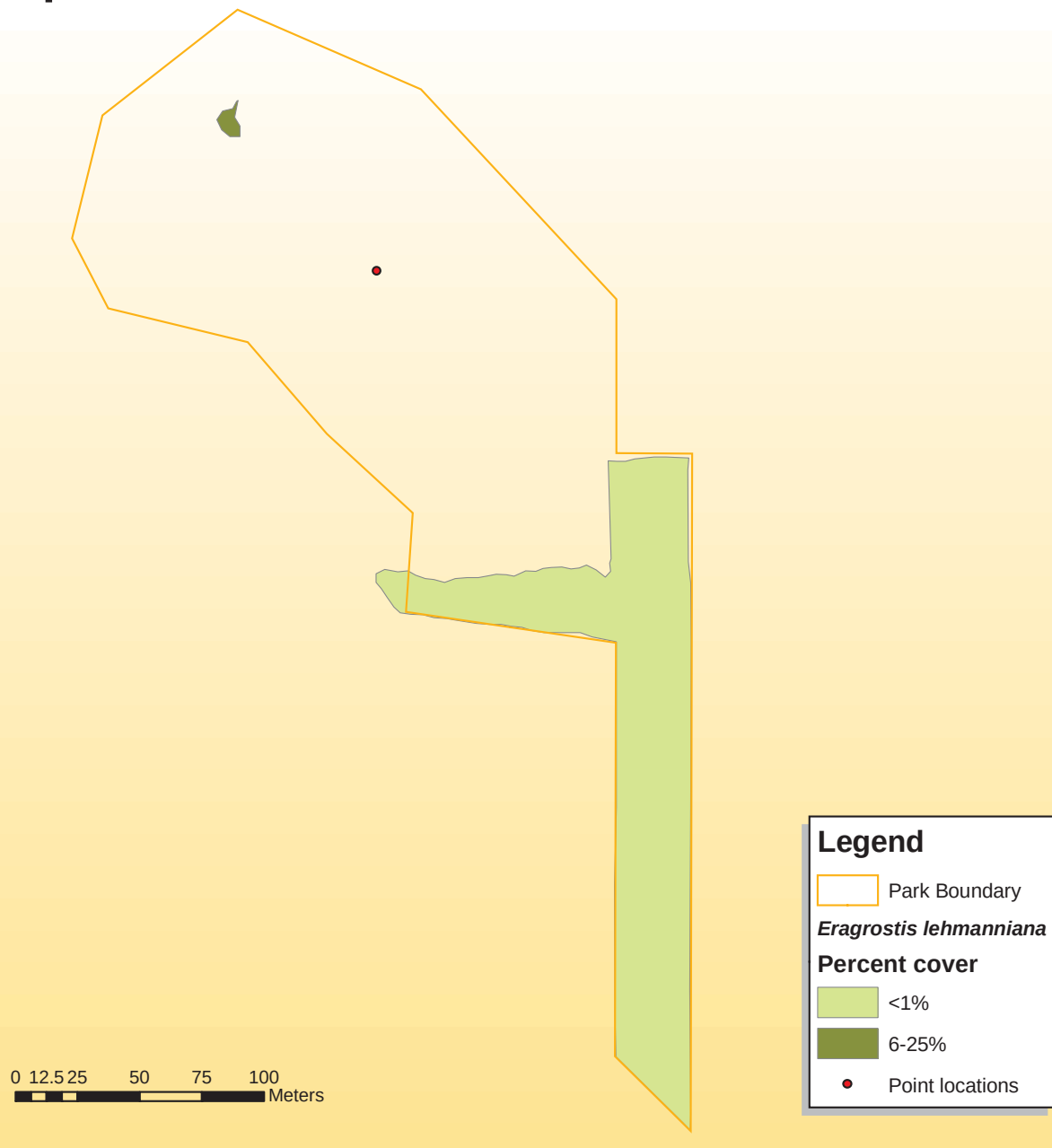
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Tumacacori NHP, Guevavi Unit
Arizona

National Park Service
U.S. Department of the Interior



Eragrostis lehmanniana (Lehmann lovegrass) Map G-4



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

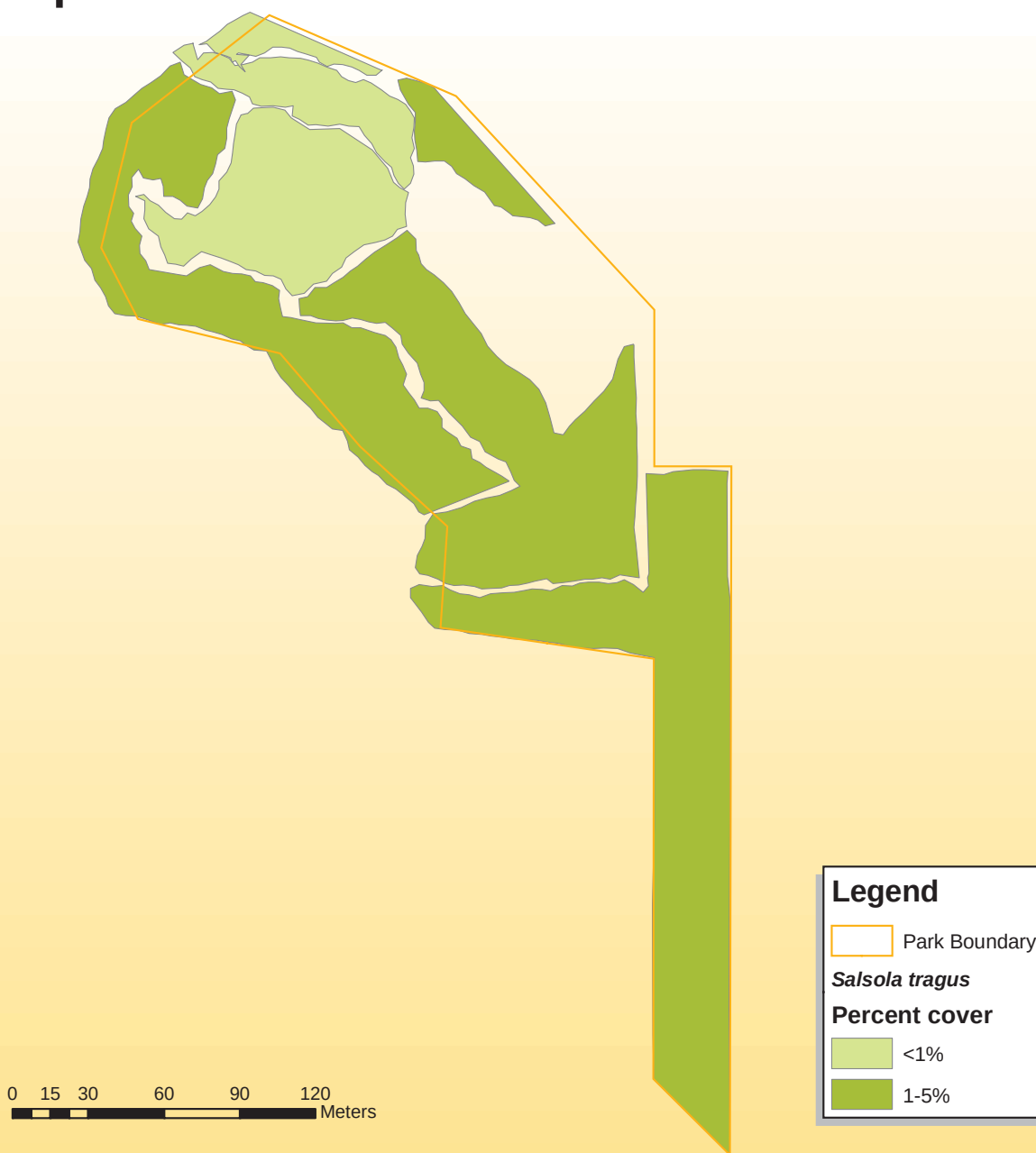
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Tumacacori NHP, Guevavi Unit
Arizona

National Park Service
U.S. Department of the Interior



Salsola tragus (Prickly Russian thistle) Map G-5



Data collected January-February 2006 using handheld PCs and Garmin 765 GPS units. Data are in UTM NAD83, Zone 12N.

Produced by Sarah Studd and Mark Zepp

03/06

FILE: //inpsodn2800serv/Vital_signs/Exotic_Plant_Inventories/SODN_Park_files/Data_Spatial/ArcMap_Projects/TUMA/gue_satr_G5.mxd

Appendix C

Plant Species Named in this Report

Table C.1. Plant species named in this report.

Scientific name	Common name
<i>Ailanthus altissima</i>	tree of heaven
<i>Acacia greggii</i>	catclaw
<i>Amaranthus palmeri</i>	Palmer's amaranth
<i>Arundo donax</i>	giant reed
<i>Atriplex</i> spp.	saltbush
<i>Avena fatua</i>	wild oats
<i>Baccharis sarothroides</i>	desert broom
<i>Bromus catharticus</i>	rescue brome
<i>Celtis</i> spp.	hackberry
<i>Celtis reticulata</i>	hackberry
<i>Cenchrus</i> spp.	sandbur
<i>Condalia lycioides</i>	graythorn
<i>Conium maculatum</i>	poison hemlock
<i>Convolvulus arvensis</i>	field bind weed
<i>Cynodon dactylon</i>	Bermuda grass
<i>Eragrostis cilianensis</i>	stink grass
<i>Eragrostis lehmanniana</i>	Lehmann lovegrass
<i>Ipomoea</i> spp.	morning glory
<i>Lycium</i> sp.	wolfberry
<i>Malva parviflora</i>	cheese weed
<i>Marrubium vulgare</i>	horehound
<i>Nicotiana glauca</i>	tree tobacco
<i>Populus</i> spp.	cottonwood
<i>Populus fremontii</i>	Fremont cottonwood
<i>Prosopis</i> spp.	mesquite
<i>Prosopis velutina</i>	velvet mesquite
<i>Salix</i> spp.	willow
<i>Salsola tragus</i>	Russian thistle
<i>Sambucus nigra</i>	elderberry
<i>Schismus</i> spp.	Mediterranean grass
<i>Sisymbrium irio</i>	London rocket
<i>Sonchus</i> spp.	sowthistles
<i>Sorghum halepense</i>	Johnson grass
<i>Sporobolus</i> spp.	dropseed
<i>Tamarix</i> spp.	saltcedar
<i>Tamarix chinensis</i>	tamarisk
<i>Ziziphus obtusifolia</i>	graythorn

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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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