



Invasive Plant Species Early Detection Monitoring Plan

A Tiered Approach for the Mojave Desert Network

Natural Resource Report NPS/MOJN/NRR—2017/1447



ON THE COVER

Photograph of the native evening primrose (*Oenothera deltoides* ssp. *deltoides*) and the invasive Mediterranean grass (*Schismus barbatus*) blanketing sand dunes in Mojave National Preserve.

Photograph by Nicole Hupp.

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Standard Operating Procedures (SOPs)

Standard operating procedures (SOPs) are located in a separate accompanying document, available at: <https://irma.nps.gov/DataStore/>.

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Executive Summary

The Mojave Desert Network Inventory and Monitoring Program (MOJN I&M) is one of 32 National Park Service (NPS) inventory and monitoring (I&M) networks nationwide. These networks use vital signs monitoring to assess the condition of park ecosystems and to “improve the ability of the NPS to provide state-of-the-art management, protection, and interpretation of and research on the resources of the NPS” (NPS 1998). MOJN I&M monitors natural resources in nine park units in Arizona, California, and Nevada that comprise the Mojave Desert Network (MOJN): Castle Mountains National Monument (CAMO), Death Valley National Park (DEVA), Great Basin National Park (GRBA), Grand Canyon-Parashant National Monument (PARA), Joshua Tree National Park (JOTR), Lake Mead National Recreation Area (LAKE), Manzanar National Historic Site (MANZ), Mojave National Preserve (MOJA), and Tule Springs Fossil Beds National Monument (TUSK).

Beginning in 2002, the MOJN parks (only six at that time) identified and prioritized park vital signs – indicators of ecosystem health – and tasked MOJN I&M with assisting the parks in monitoring these vital signs (see Chung-MacCoubrey et al. 2008). Through this process, park superintendents and resource managers agreed that (among other vital signs) invasive species management, particularly early detection of invasive species, is a high priority resource management concern. Invasive species impacts can be financially costly and ecologically irreversible; therefore it is critical to catch invasive species early in their invasion of new habitats (formally referred to as “early detection monitoring”).

Currently (2017), each MOJN park is conducting invasive species management and often calling on the Lake Mead Exotic Pest Management Team (LAKE EPMT) to assist with treating infestations. However there is an opportunity to increase communication among parks, share effective early detection methods across the park boundaries, and utilize data management techniques that improve efficiency for all. **The goal of this plan is to promote early detection monitoring methods that have proven useful within the network while employing a state-of-the-art data management system.** This plan provides methods for MOJN parks to identify and prioritize threatening invasive plant species, detect these species early, monitor infestations and treated areas over time, and provide sound data management.

The MOJN parks are hugely variable in size, availability of resources, and in the types of threats from invasive species. A “one-size-fits-all” approach to early detection is not sufficient to meet the needs of each individual park. Therefore, this plan specifies tiers of monitoring that can be implemented in each park depending on the resource availability and management priorities. The tiers are a la carte (that is, a park can choose to implement any or all of them) and range in commitment of park resources from volunteer-based monitoring to the deployment of trained vegetation crews. The responsibility of implementing this early detection plan in the field belongs to the MOJN park units. It is also still at the parks’ discretion to request the LAKE-EPMT to treat infestations as needed. MOJN I&M’s primary role will be to manage the collected data and store that data in a system shared with LAKE-EPMT.

This plan has four objectives:

1. Develop and maintain a list of target species that currently occur in localized areas of all parks, do not occur in parks but are found nearby, or are not known to occur nearby but would cause major ecological or economic problems if they were to become established.
2. Detect new invasive species and new populations of invasive species before they become established beside roads, along trails, and in areas of high management importance.
3. Collect data that can be used to monitor invasive species occurrence, changes in populations over time, and treatment effectiveness in the short and long term.
4. Increase communication between individual parks and with LAKE-EPMT, while providing an effective data management plan. Together, these measures will improve flow of information to LAKE-EPMT to allow for rapid response when treatment is requested by park managers.

Accomplishing these objectives will allow resource managers in the MOJN parks to assess each invasive species early detection record on an individual basis and target limited management resources toward the highest priority risks.

Acknowledgments

This document draws upon text and ideas without citations from “Invasive Species Early Detection and Rapid Response Plan: Cumberland Piedmont Network” (Keefer et al. 2014) and “Early Detection Monitoring of Invasive Plant Species in the San Francisco Bay Area Network, A Volunteer Approach” (Williams et al. 2007). Likewise, protocols from other networks - primarily Heartland Network (HTLN), Southern Plains Network (SOPN), Klamath Network (KLMN), Northern Colorado Plateau Network (NCPN), and Eastern Rivers and Mountains Network (ERMN) provided useful direction to the content of this plan. These networks took creative approaches to invasive species early detection work within the NPS Inventory & Monitoring Program and are worth emulating. Additionally, this document was written collaboratively with all vegetation biologists and natural resource personnel in the parks of the Mojave Desert Network. Much information and direction came from existing plans within the Network, such as the Lake Mead Exotic Plant Management Plan and associated staff (Carrie Norman and Alice Newton), products from the Lake Mead Exotic Pest Management Team (LAKE-EPMT; Curt Deuser and Tim Federal), and other park management plans. All Mojave Desert Network parks contributed effort and time to developing early detection species lists, developing usable designs, and providing general feedback. Previous collaborators Donovan Craig and Scott Abella laid the framework for this plan, as did much of MOJN I&M staff.

List of Acronyms

BLM: Bureau of Land Management

DEVA: Death Valley National Park

EDRR: Early Detection Rapid Response

GRBA: Great Basin National Park

I&M: Inventory and Monitoring

IPSED: Invasive Plant Species Early Detection

JOTR: Joshua Tree National Park

LAKE: Lake Mead National Recreation Area

LAKE-EPMT: Lake Mead Exotic Pest Management Team

MANZ: Manzanar National Historic Site

MOJA: Mojave National Preserve

MOJN: Mojave Desert Network

MOJN I&M: Mojave Desert Network Inventory and Monitoring Program

NPS: National Park Service

PARA: Grand Canyon- Parashant National Monument

SOP: Standard Operating Procedure

TES: Threatened and Endangered Species

TIPS: Target Invasive Plant Species

TUSK: Tule Springs Fossil Beds National Monument

US EPA: United States Environmental Protection Agency

USGS: United States Geological Survey

1 Background, Rationale and Objectives

1.1 Background on “Invasive Plants”

An invasive plant is a non-native species that aggressively spreads when introduced to a new range (see Richardson et al. 2000 for additional definitions). More technically, Presidential Executive Order 13112 defines invaders as “any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem” (USPEO 1999). These species are introduced deliberately or unintentionally into an environment in which they did not evolve and are capable of establishing self-sustaining populations in “untransformed ecosystems” (MacDonald et al. 1989). Species have always moved around the planet, expanding into new territories, traveling through wind, and being transported by other animals. However, since the late fifteenth century, humans have dramatically increased the rate at which species can enter new ecosystems and allowed them to travel across the globe. There are many different mechanisms for invasion, and invaders can be “successful” in new ecosystems for a variety of reasons.

Invasion often depends on three factors (Figure 1): the attributes of the invader, the biotic characteristics of the new range (site biotic characteristics), and the abiotic characteristics of the new range (site environmental conditions) (Perkins et al. 2011). In terms of invader attributes, successful invasive species tend to have broad ecological requirements and tolerances, and effective reproductive and dispersal mechanisms (Rejmanek and Richardson 1996). In relation to biotic interactions, invaders are often, for different reasons, better competitors than natives in introduced systems (Vila and Weiner 2004). Additionally, sometimes these introduced species have no natural enemies, such as herbivores or pathogens, to limit their reproduction and spread (Keane and Crawley 2002). This is often due to chemical weaponry, such as allelopathic or antimicrobial chemicals, that are novel in the new system (Callaway and Ridenour 2004). In terms of abiotic conditions, while some natives may require disturbance (Connell 1978), invaders frequently flourish after disturbance events (Hobbs and Huenneke 1992). In addition to these factors, invaders disproportionately benefit from long-distance dispersal mechanisms, which are usually linked to globalization and humans (e.g. cattle, cattle feed, boats, or vehicles) (Meyerson and Mooney 2007).



Figure 1. Three factors that play a role in invaders establishing themselves in new ranges (adapted from Perkins et al. 2011).

Probability of invasion is highest in places with heavy human use and in areas with frequent disturbance. Drainages, roads/trails, and borders are all major “vector pathways”, or means of introducing and moving invasive species from one point to another (Mack 2003). Many MOJN parks contain numerous drainages, are dissected by roads and trails, and are often bordered by developing communities and private lands. These corridors can function as points of entry where invasive species gain a foothold and then propagate. Allen et al. (2008) used invasive species data from 273 NPS units nationwide to show that invasive plant species richness is positively correlated with the number of visitors and the lengths of backcountry trails and rivers. Further, Hodkinson and Thompson (1997) demonstrated that motor vehicles act as effective seed dispersal mechanisms. Once new seeds are introduced, animals such as horses (Wells and Laurenroth 2007), deer (Myers et al. 2000), and birds (Simberloff and Von Holle 1999) become potentially important seed dispersal vectors. In addition, parks such as Manzanar National Historic Site are challenged with invasive plants that were deliberately cultivated as part of historic landscaping, which creates thought provoking trade-offs between cultural and natural resources.

Regardless of the means, once established invasive species negatively impact park resources and visitor enjoyment by altering landscapes in complex ways. These alterations include changing fire regimes, reducing native plant and animal habitat, blocking and altering viewsheds, and increasing the cost of trail maintenance. Examples from national parks include feral pigs in Big Thicket National Preserve increasing recruitment of invasive plants while decreasing recruitment of native plants (Seimann et al. 2009), and leafy spurge (*Euphorbia esula*) and Canada thistle (*Cirsium arvense*) establishment in Rocky Mountain National Park facilitating other invasive plants and dramatically altering soil biogeochemistry (Pritekel et al. 2006). In MOJN, tamarisk (*Tamarix* sp.), a now classic example of a cultivar gone rogue, is widespread along rivers and streams where, despite vigorous treatments, the invader often reappears. The impacts of this invader include negative feedbacks such as displacing natives, creating uninhabitable soils due to salinization, and the alteration of hydrological cycles (MacDonald et al. 1989). Invaders are also known to create monocultures, dense stands of plants with low species diversity, within which other species cannot thrive. For example, just sixteen invasive plant species alone occupy over 126 million acres in the 48 contiguous states (Duncan and Clark, 2005).

1.2 Threats and Concerns

Invasive plant species are financially and ecologically threatening all public lands nationwide. For the NPS, the consequences of non-native plant invasions present a significant challenge to the Agency’s ability to maintain natural resources “unimpaired for the enjoyment of future generations.” Although difficult to measure precisely, the overall economic impacts of invasive species in the United States were estimated ten years ago to be well into the tens of billions of dollars annually (Pimentel et al. 2005). Currently, there are over 6,500 invasive plant species that have been identified on national park lands (Otts et al. 2016). More NPS lands are infested daily despite diligent efforts to curtail the problem; even 20 years ago, estimates indicate that non-native plants infest 4,600 new acres of federal land each day (NPS 1996).

In the Southwest, invasive plant species are one of the single largest threats to the integrity of desert ecosystems (Brooks and Pyke 2002). Annual invasive exotic plants such as red brome and cheatgrass (*Bromus* spp.) are not simply displacing native plants, they are altering the ecological processes associated with the region by creating larger more frequent wildfires once uncommon in the desert Southwest (D'Antonio and Vitousek, 1992). Slow growing and long-lived native desert plants are generally not adapted to wildfires and thus may be incapable of persisting in areas susceptible to a grass-fire cycle. In the Mojave Desert, the federally threatened desert tortoise (*Gopherus agassizii*) is a species at risk due to human-induced habitat loss. Altered fire cycles due to cheatgrass dramatically change tortoise habitat and may further habitat loss. Invasive plants also negatively affect other sensitive desert species in ecologically complex ways, such as the sage grouse (*Centrocercus urophasianus*; Fischer et al. 1996).

For these reasons, invasive species are and most certainly will remain a management priority for the National Parks. In 2006, the NPS drafted an Invasive Species Action Plan (NPS 2006) to address how the agency will fight current and future invasions. One of the primary categories in the plan is “early detection and rapid response”, a method for finding and eradicating infestations before they grow to be insurmountable. Invasive species have been consistently ranked as a top vital sign for long term monitoring as part of the Inventory & Monitoring Program. As of 2012, 21 of 32 networks and 205 parks have invasive plants as a top vital sign for monitoring under the broad category of biological integrity.

Executive Order 13112 (1999) identified these threats and summarized the many statutes that had been used to authorize the prevention and reduction of invasive species infestations in the United States. This order established the Invasive Species Council, directed federal agencies to prevent the spread of invasive species, and, where feasible, remove established populations. The statutes mentioned in the order include the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended (16 U.S.C. 4701 et seq.), Lacey Act, as amended (18 U.S.C. 42), Federal Plant Pest Act (7 U.S.C. 150aa et seq.), Federal Noxious Weed Act of 1974, as amended (7 U.S.C. 2801 et seq.), and Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). Invasive species threaten park habitats, and managers may cite the Organic Act of 1916, a park's enabling legislation to preserve and protect areas from invasive species.

In 2002, the National Research Council thoroughly reviewed the state of knowledge on invasions, including predicting introductions and establishment. Their key recommendations for furthering knowledge and preventing invasions of non-native species include the following:

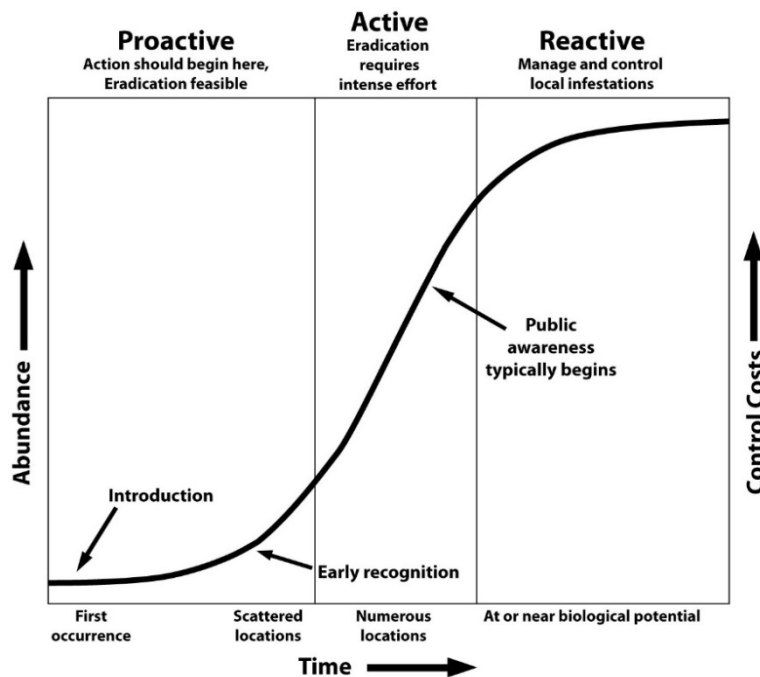
- “... Careful recording of the circumstances of arrival, persistence, and invasion of non-indigenous species in the United States would substantially improve prediction and risk assessment.”
- “Information on the structure and composition of natural ecosystems in North America (and the disturbance regimes within them) should be reinterpreted by the scientific community to analyze these ecosystems' vulnerability to biotic invasion. Attention should be paid to

identifying groups of native species that could be vulnerable or could facilitate the establishment of non-indigenous species.”

Through the implementation of this MOJN I&M plan, the National Park Service will be building on these important recommendations as a contribution to the greater body of knowledge regarding the threat of invasive species in the United States.

1.3 Why Implement Invasive Species Early Detection?

Early detection efforts increase the likelihood that invasions will be discovered while populations are localized and population levels are small enough to be contained or eradicated (Figure 2; The Early Detection and Distribution Mapping System (EDDMapS) cooperative). In terms of treating invasive populations, there are often three stages for managers: proactive, active, and reactive. The first stage occurs when a species is introduced to a new system and is not fully established. If managers can detect species in this low abundance stage, the species can potentially be eradicated and the control costs are comparatively low. The active stage occurs when the species experiences rapid spread. By the reactive stage, the control costs are high and regardless of the effort expended, the best possible outcome is management and control of local infestations. As the MOJN parks have seen in the case of tamarisk, once populations are established, eradication is no longer possible and management focus shifts to partial mitigation of negative impacts (Rejmanek and Pitcairn 2002).



Phases of Invasive Species Invasion and Control

Figure 2. For invasive species management, the relationships between infestation size, cost, and time are dynamic. There are three stages of invasion which generally require different management responses. During the proactive stage, eradication is possible and management costs are low; control is the management goal for the reactive stage and management costs are much higher. Figure from the Center for Invasive Species and Ecosystem Health, University of Georgia, <http://www.eddmaps.org/about/pictures/9.jpg>.

For managers, this distinction in stages is financially and ecologically relevant. The financial costs associated with eradicating a species using early detection- rapid response (EDRR) efforts are typically far less than those of long-term invasive species control (Harris et al. 2001, FICMNEW 2003, Lodge et al. 2006). From an ecological perspective, EDRR eradication efforts minimize ecological damage by preventing the severe ecosystem degradation that follows invasive species establishment and avoiding mitigation damage stemming from control efforts (Smith et al. 1999, Timmins and Braithwaite 2001).

1.4 Goals and Objectives

The goal of this plan is to promote early detection monitoring methods that have proven useful within the network while employing a state-of-the-art data management system. We selected methods that are practical tools for each park in MOJN to detect incipient infestations of target invasive plant species. This plan incorporates five optional tiers of early detection monitoring. The tiers are a la carte (that is, a park can choose to implement any or all of them), which allows parks flexibility and increases usability.

We provide a variety of methodologies for invasive species management ranging from an opportunistic strategy with minimal staff in the field to a full volunteer/staff program. Importantly, this plan builds on and standardizes efforts already in place in many parks; it was an important priority of park managers to not “reinvent the wheel”, but build on already successful methods.

Objectives:

1. Develop and maintain a list of target species that currently occur in localized areas of all parks, do not occur in parks but are found nearby, or are not known to occur nearby but would cause major ecological or economic problems if they were to become established.
2. Detect new invasive species and new populations of invasive species before they become established beside roads, along trails, and in areas of high management importance.
3. Collect data that can be used to monitor invasive species occurrence, changes in populations over time, and treatment effectiveness in the short and long term.
4. Increase communication between individual parks and with LAKE-EPMT, while providing an effective data management plan. Together, these measures will improve flow of information to LAKE-EPMT to allow for rapid response when treatment is requested by park managers.

1.5 Parks Involved

MOJN is comprised of nine park units in Arizona, California, and Nevada. Parks in this network vary greatly in size, but combined MOJN encompasses the largest total park area of all networks in the lower 48 states (over 3.3 million hectares combined, or 9.7 percent of the total land area NPS manages; Figure 3). MOJN parks include: Castle Mountains National Monument (CAMO), Death Valley National Park (DEVA), Great Basin National Park (GRBA), Grand Canyon-Parashant National Monument (PARA), Joshua Tree National Park (JOTR), Lake Mead National Recreation

Area (LAKE), Manzanar National Historic Site (MANZ), Mojave National Preserve (MOJA), and Tule Springs Fossil Beds National Monument (TUSK). These parks vary in size, elevation, native plant diversity, and invasive plant diversity (Table 1.)

Table 1. Basic information on the parks of MOJN. The newest parks, TUSK and CAMO (established 2014 and 2016, respectively), do not have information on plant species occurrences at this time.

Park	Size (Hectares)	Elevation range (m)	Number Vascular Plant Species	Number Non-native Plant Species
CAMO	8,445	1,096 to 1,684	-	-
DEVA	1,374,420	-86 to 3,368	1,222	101
GRBA	31,194	1,615 to 3,981	773	59
JOTR	321,327	156 to 1,773	712	61
LAKE	521,346	152 to 1,719	846	102
MANZ	329	1,158	108	23
MOJA	619,923	274 to 2,438	913	86
PARA	424,242	366 to 2,447	1,042	106
TUSK	9,158	645 to 1,007	-	-

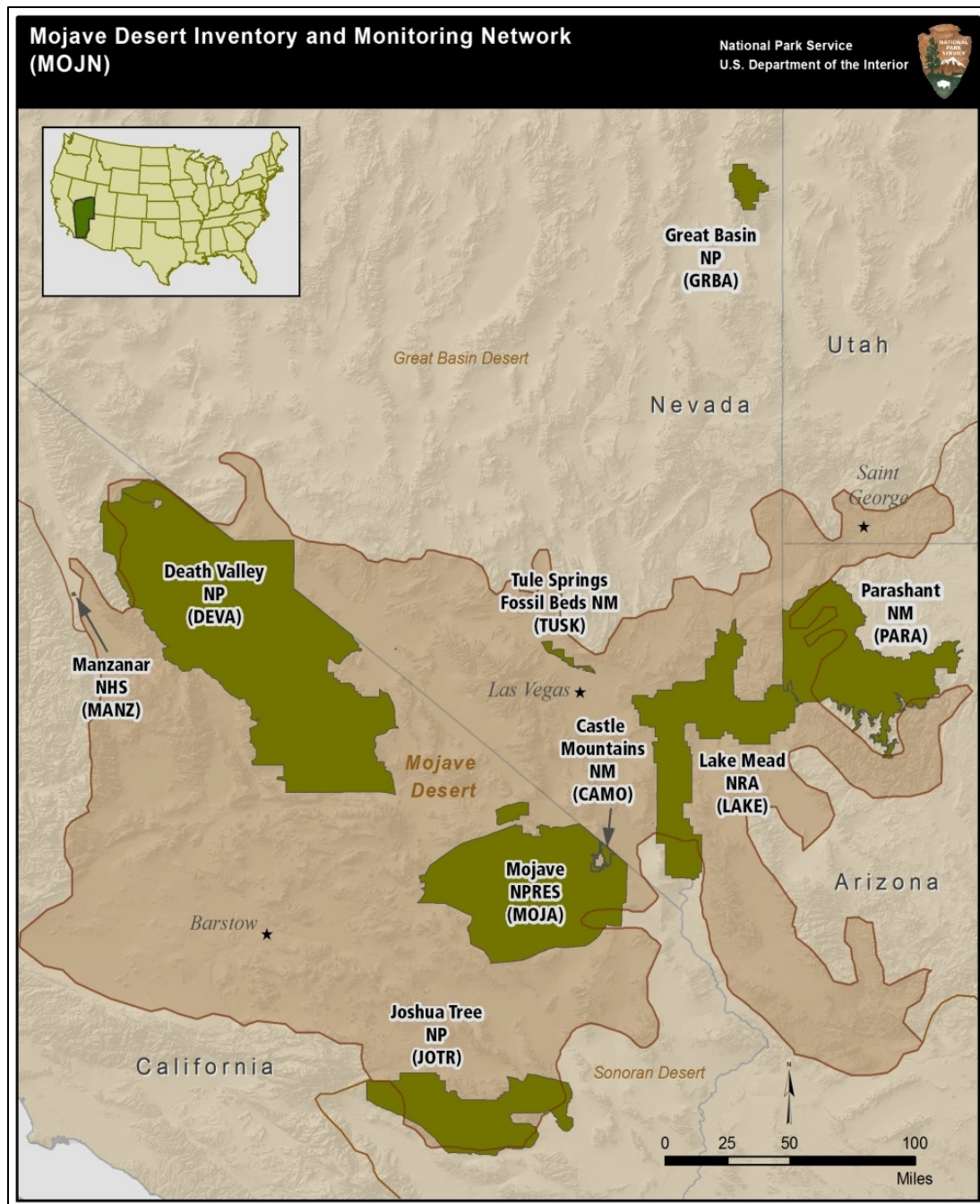


Figure 3. Map of the Mojave Desert Network parks. Note that CAMO is a new park to MOJN that has very recently been added to the network and therefore not included in this plan.

1.6 Current Management Efforts and Other Vital Signs Monitoring

All of the MOJN parks have had some level of invasive plant management, whether they have complex management plans and dedicated staff who control and monitor infestations or they are small parks with few staff that have relied on outside support for control activities. Below is a snapshot of current efforts in each park (as of 2016) in terms of monitoring, treatment, data management, and personnel:

1.6.1 DEVA

- Vegetation managers track invaders opportunistically and note infestations (K. Lund, NPS, personal communication). The Park surveys and monitors exotics by revisiting previously known sites and continually searches for new infestations along popular vector corridors.
- DEVA has a successful history in treating infestations at the most effective time, in terms of plant phenology, for annuals, palms, and tamarisk species. LAKE-EPMT performs some of the treatments in DEVA as do Park staff.
- The Park uses multiple Microsoft Access databases to record areas treated, treatment method, number and type of plant treated, and who applied the treatment. These records include treatments that DEVA applies as well as those that LAKE-EPMT applies. There are currently four databases, one each for palms, tamarisk, perennials, and annuals. Additionally there are four databases with legacy treatment information on tamarisk species, palms, and perennials.
- Botany staff, volunteers, and seasonal interns, coordinated by the vegetation manager, have been instrumental in controlling infested areas by either herbicide use or hand-pulling exotics. Interns monitor and treat infestations based on the previous year's known infestations and areas treated.

1.6.2 GRBA

- An invasive species management plan was completed in 2014 for GRBA, which they use to standardize treatment methods (B. Roberts, NPS, personal communication). However, GRBA does not have a standardized monitoring plan at this time. Occurrences are generally recorded opportunistically on a GPS unit and stored in a database to track and eradicate the infestation.
- Active control of several species has been ongoing in GRBA. The LAKE-EPMT performs some of the treatments in GRBA, as do Park staff. The Park and the LAKE-EPMT conduct surveillance on areas of concern as time and money allow.
- The Park does not have an invasive plant species database system. However Park staff record invasive species occurrences, when haphazardly discovered, on paper forms which provide valuable information about invasive plants in the Park.
- Members of field crews (wildlife, streams, trails, etc.) and other Park personnel with plant identification experience report occurrences as possible (e.g. spotted knapweed was reported by stream crews).

1.6.3 LAKE

- LAKE implements a detailed Exotic Plant Management Plan created in 2008 (C. Norman, NPS, personal communication). This plan uses elements of the Weed Sentry Model (a monitoring plan developed by LAKE, University of Nevada- Las Vegas, and Clark County Nevada) to monitor for invasive plant species.

- Many invasive plant species are currently being treated at LAKE, particularly fountain grass, tamarisk, and Sahara mustard. LAKE personnel and LAKE-EPMT carry out the treatments for these species.
- LAKE uses an Access database for all invasive plant occurrence and treatment data. Additionally, LAKE-EPMT has an extensive treatment database for LAKE which is frequently accessed by LAKE personnel.
- Personnel resources in LAKE include a vegetation manager, invasive species lead, occasional interns, and many volunteers. LAKE-EPMT frequently treats infestations at Lake Mead, particularly tamarisk in high priority areas such as springs and washes (though it is not actively treated in the drawdown zone or elsewhere in the Park).

1.6.4 JOTR

- The Park does not currently have an exotic plant management plan; however vegetation staff has been successful at treating infestations once they are encountered (N. Frakes, NPS, personal communication). For example, vegetation managers successfully treated and eradicated invasive plants introduced on the interface with neighborhoods on the Park boundary. This area has been hand-pulled by staff and continually monitored.
- The Park has a list of species that it actively treats including tamarisk, fountain grass, salsola, and tumble-mustard species.
- Vegetation managers have a large amount of legacy data on invasive plants in the Park. These data are in several different Access databases that although currently challenging to utilize, could be helpful in the future.
- The LAKE-EPMT performs some of the treatments in JOTR as do Park staff.

1.6.5 MANZ

- A floristic inventory was conducted for both MANZ and MOJA (Andre 2006). This inventory provided the known presence of exotic plant species for both parks. The LAKE-EPMT conducts exotic species control efforts in the Park when necessary.
- Due to the very small size of MANZ and its limited staff availability, there is currently no ongoing plant data collection or invasive species monitoring.

1.6.6 MOJA

- Park staff is keeping invaders under surveillance as possible and noting infestations that appear to be controllable (D. Hughson, NPS, personal communication). There is not currently an invasive species management plan for MOJA.
- Vegetation projects have provided plant community data within MOJA that may be useful for evaluating exotic species but are not formally utilized at this time.

- Active control of several species has been ongoing in MOJA. Volunteers and staff have been instrumental in treating infested areas by hand-pulling and spraying. The LAKE-EPMT performs some of the treatments in MOJA as do Park staff.

1.6.7 PARA

- The Park uses a thorough protocol created by the vegetation manager in 2014 (J. Fox, NPS, personal communication). This plan has detailed SOPs that call for crews of two to monitor for invaders along roads by establishing transects and quantifying species composition in quadrats. Work crews are comprised of seasonal interns and Park staff.
- Since the protocol is quite new, data are currently entered into Microsoft Excel files and are not yet in a database. Occurrence and control treatment information is available, but effectiveness data are not available at this time.
- Active control of several species has been ongoing in PARA. The LAKE-EPMT performs some of the treatments in PARA as does BLM Arizona Strip District staff.
- Personnel in PARA include the vegetation manager, interns, volunteers, and LAKE-EPMT. The BLM also provides some treatment support in PARA.

1.6.8 TUSK

- TUSK was established in 2014 and therefore has not developed an invasive species management strategy at this time.

1.6.9 CAMO

- CAMO was established in 2016 and therefore has not developed an invasive species management strategy at this time.

2 Monitoring Plan

2.1 Rationale for Monitoring Approach

Effective early detection and rapid response depend on a basic progression of information: a park needs to know what species to monitor, how to monitor those species, how to initiate a treatment effort when those species are detected, and also how to record their monitoring and treatment efforts in a usable way. This progression in MOJN cannot be a “one size fits all” plan due to the differences in park size, resources, personnel, ecology, topography, and goals. Additionally, MOJN needs an early detection strategy that can standardize, improve, and at times supplement efforts already in place, since indeed, most parks are monitoring for invaders to some degree. Therefore, this plan provides an approach with optional tiers that parks can utilize based on their needs and available resources.

Our approach outlines four components to an early detection program: creating and updating a species list, determining and prioritizing areas to monitor, implementing a tiered approach to monitoring invaders in parks, and utilizing a shared data management system. These components will allow park resource managers to assess each invasive species on an individual basis and target limited management resources and coordination toward the highest priority risks. Choosing appropriate treatments and mobilizing efforts will vary greatly by park and is therefore beyond the scope of this plan.

2.2 Creating a List of Target Invasive Plant Species

The initial Target Invasive Plant Species (TIPS) list was created at the same time as this plan (2016) and utilized prioritization tools as well as park manager input. In the future, park vegetation managers will update the list annually following the steps in SOP 1 Updating TIPS and Most Wanted Species List.

2.2.1 Rationale for Using Species Prioritization Tools to Create Initial TIPS List

The initial TIPS list was created using several technical tools designed to assist with invasive species prioritization, categorization, and risk assessment. The invasive plant prioritization tools we used focus on criteria shown to be relevant for managing invasive plants, such as specific geographic locations (Mehrhoff 2000, Warner et al. 2003), current level of species impact, and feasibility of control (Hiebert and Stubbendieck 1993). For example, U.S. Invasive Species Impact Ranks (I-Ranks) and the associated Invasive Species Assessment Protocol, guides individuals through a series of questions to determine I-Rank and uses extensive biogeographical information as criteria to rank plant invasiveness at local, regional, national, and global scales (Morse et al. 2004). The Invasive Plant Atlas of New England (IPANE) uses six specific biological criteria to prioritize or “track” specific invasive plants in New England (IPANE 2009). Each of these systems provides a well-conceived model for ranking invasive plants. We also used other less formal tools that draw species information across a range of resource management disciplines. For example, state and federal noxious weed lists have historically targeted agricultural pest plants. We used many of these tools together to rank and prioritize invasive species for the MOJN parks. This process was time consuming but provided a very informed starting point.

2.2.2 Rationale for Using Expert Opinion for Future TIPS List Updates

Though the ranking and prioritization tools were employed for guidance in the initial process for creating the TIPS list, a less formal process for prioritizing early detection species will be used in the future. Park managers often have an informed and specific understanding of their parks' vegetation; using their informed opinion to prioritize species is less time consuming and likely more effective than using a prioritization tool. Several "lessons learned" led to this decision. For example, prioritization systems like I-Ranks viewed in NatureServe Explorer were only helpful in certain situations where common and widespread species information was required or more general information regarding a particular species was desired. The Invasive Species Assessment Protocol is "configured for use for regions of interest that are contiguous" and it is not recommended that "a highly fragmented area (such as an assemblage of scattered land holdings of a single government agency) be used as a region of interest with this protocol, since only a small sampling of a species' regional status, impacts, trends, and dispersal dynamics would be considered" (Morse et al., 2004). Anecdotal information, knowledge of each individual park's habitats, and local field testimonials provided by park personnel were by far the most valuable tools utilized to prioritize species in this plan.

2.2.3 Finalizing the TIPS List and the Most Wanted Lists

Of the 356 exotic plant species compiled for the MOJN parks and region, 203 are considered mildly, moderately, or highly invasive, or are a priority to receive control if discovered (e.g. noxious status) (Appendix A). These 203 species comprise a TIPS list for early detection, control and/or long-term monitoring efforts. Since targeted monitoring of 203 species in each park would be costly, we distilled the TIPS list down to a park-specific "Most Wanted" list for each park. The Most Wanted lists generally consist of between 10 and 20 species. This is a more realistic number of species that observers can be expected to recall and identify in the field while conducting other duties. Parks that employ volunteers for the Invasive Plant Species Early Detection (IPSED) plan may choose to create an even smaller subset of five species suitable for individuals with very limited botanical experience. To clarify, TIPS is one large list of all target invasive plants Network-wide, whereas the Most Wanted lists are park specific, and there will be as many Most Wanted lists as there are parks.

The TIPS and Most Wanted lists will be reviewed annually by network staff, park natural resource managers, and other pertinent contacts to ensure that the list is current and contains the highest priority species. New invasive species threats should be evaluated for possible inclusion in the list, while the prior year's TIPS list should be evaluated to determine if any should be removed from the list. For example, if a high priority species is detected and eradicated, the species will likely remain on list. However, if a high priority species is detected with a large population size and not eradicated due to lack of resources or type of infestation, the natural resource manager, LAKE-EPMT, and field crew leaders will be consulted to determine whether the species should be removed from the TIPS list. Widespread species might be removed from the high priority list to ensure that management efforts are focused on those species at an early stage of invasion, where rapid response is most effective. In situations where high priority species are present only in localized areas of the park and are predicted to spread, the park natural resource manager will be consulted regarding species list inclusion or removal and included in all decision making processes. See SOP 1 Updating TIPS and

Most Wanted Species Lists for details on the process for updating the Most Wanted lists and how to prioritize invasive plant species.

2.3 Prioritizing Areas of Concern

In all parks, early detection efforts should focus on two types of Areas of Concern: those that are “High Value” (e.g. iconic sites, small isolated plant communities, high visitation areas, etc.) and those that are “High Risk” sites and vector corridors (e.g. roadsides, trails, drainages, springs and other watercourses, and places with large amounts of traffic). Known infestations from previous survey efforts are included with High Risk sites. Several parks have identified High Value and High Risk Areas of Concern where higher priority for early detection is required (Table 2). See SOP 2 Identifying High Value and High Risk Areas for additional information on selection and prioritization of these sites.

Table 2. Areas of Concern in MOJN parks. Since TUSK and CAMO are new parks, they are not included in this list at this time.

Park	High Value Areas of Concern	High Risk Areas of Concern
DEVA	Springs complexes, riparian areas, rare plant sites	Roadside easements, trails, Eureka Dunes (T&E)/dune complexes, Amargosa River corridor
GRBA	Riparian meadows and trailheads, rare plant sites	Road shoulders, trailheads, campgrounds, and low elevation sage habitats
JOTR	Live Oak, Cholla Cactus Garden, Joshua Tree woodlands, fan palm oases	Roads, trails, park boundaries near developed areas, dunes, and social trails at climbing areas
LAKE	Rare/sensitive plant habitats (sandy and gypsum soils), desert springs	Roads, trails, the drawdown zone
MANZ	Cultural resources	Entire Park shares similar risks
MOJA	Kelso Dunes, Piute Wash, Cima Dome, Joshua Tree Woodland, TES critical habitat (springs around Desert Study Center and Morning Star Mine containing Mojave Tui Chub, desert tortoise critical habitat wherever found, and springs important to bighorn sheep populations)	Roads, trails, powerline service roads, powerline structures, high use off-road areas, railways, grazing allotments, communication towers
PARA	Springs, mountainous areas (Trumbull, Logan)	Roads, trails, places where there is active and/or historical grazing

2.4 A 5 Tiered System for Early Detection Monitoring

The MOJN IPSED plan will use five tiers of monitoring, listed in order of increasing requirement of park resources:

Tier 1: Non-Technical Approach with Volunteers. This tier provides park managers with easy to use manuals to train volunteers on the iNaturalist app, how to use the Invasive Species Guide, and establishing Natural Resource Steward Program.

Tier 2: Non-Technical Approach with Staff. This tier trains all park employees how to identify species on the Most Wanted list and encourages employees to report occurrences and trains how to prevent weed transport.

Tier 3: Opportunistic Monitoring of High Risk Places. This tier utilizes crews already in the field to monitor roads and trails for infestations.

Tier 4: Targeted Monitoring of High Risk Places. This tier is for parks with the resources to have targeted monitoring throughout the park along roads and trails using technically trained field crews.

Tier 5: Targeted Monitoring of High Value Places. This tier is for parks with the resources to have specialized monitoring of infestations using technically trained field crews in locations that have special significance to the park and its visitors.

Parks may choose from among these tiers or use some combination of them depending on their goals and available resources.

2.4.1 Tier 1: Non-Technical Approach with Volunteers

This tier is designed for parks that cannot commit staff to IPSED, but have volunteers or temporary interns available. Plant identification materials are used to educate volunteers on park Most Wanted lists. Then using the iNaturalist smartphone app, volunteers record observations of invaders when they are detected. This information is included in a crowd-sourced database that is monitored by other users of the app. Vegetation managers at parks can easily obtain these observations from iNaturalist and could potentially greatly increase their awareness of invaders in parks. Refer to SOP 3 iNaturalist Training for additional details on using the app and SOP 4 Training Volunteers on Most Wanted Species.

Tier 1 gets additional eyes on the ground for monitoring, while educating the public. It will not provide data useful for detecting long-term trends, but will provide readily available, valuable information on invaders presence and location in the park. An additional benefit of Tier 1 is that observations are gathered in iNaturalist and entered automatically (with Wi-Fi) into iNaturalist; the data do not need to be entered by park staff. Additionally, the iNaturalist community reviews all submissions and checks for accuracy; though not entirely flawless, park managers do not need to check over submissions in iNaturalist.

Volunteers can also assist invasive species defense in a Natural Resource Steward program. In this program, volunteers can adopt a site in the park and monitor the site throughout the year. This program, already implemented in PARA, entails having informed participants who are capable of noticing small changes in plant communities in High Value places. See SOP 5 Natural Resource Steward Program for additional details and SOP 2 Identifying High Value and High Risk Areas for assistance selecting sites to include in this program.

2.4.2 Tier 2: Non-Technical Approach with Park Staff

Tier 2 focuses on all staff members of parks, including maintenance crews, entrance stations, and interpretive staff. This tier aims to educate all park staff about invaders in the park and employs all eyes on the ground to look for invasive plants. It also raises awareness about the spread of invaders, and a culture of awareness will help reduce transport. This tier includes training staff to use iNaturalist, and this information will be used in the same manner as Tier 1.

Staff will also be briefly trained to identify species on the park-specific Most Wanted list using the Invasive Plant Guide created by MOJN I&M and LAKE vegetation staff. See SOP 6 Training Park Staff using the Invasive Plant Guide for additional details.

2.4.3 Tier 3: Opportunistic Monitoring of High Risk Places

Tier 3 utilizes technically trained personnel in the park to increase the number of eyes on the ground for invasive species early detection. This element focuses on staff members that are frequently in the field and are familiar with plant identification but are not hired specifically for invasive species work. This includes personnel who work on vegetation crews, wildlife crews, or other types of biological technicians. These personnel are capable of opportunistically observing invasive plants on the park specific Most Wanted list. Because these personnel frequently travel through the park, and potentially to remote areas, they can increase the search area for early detection monitoring without adding a significant amount of staff time. Staff can be trained to identify invasive species using the Invasive Plant Guide created by MOJN I&M and LAKE vegetation staff. See SOP 6 Training Park Staff using the Invasive Plant Guide for additional details.

In this tier, technicians receive additional training on how to identify plants on the park's Most Wanted list. When these personnel encounter invasive species enroute to their regular tasks, they record their observations using the iNaturalist app, similar to the steps of Tier 2. Alternatively, these personnel can also opportunistically carry out elements of Tier 4 and collect observations in Arc Collector (see section 2.4.4 below) when they hike or drive on roads or trails of interest.

Observers with little to no formal plant identification skills should use the app iNaturalist to record observations. However, for personnel formally trained in plant identification, e.g. a botanist or a vegetation technician, observations should be recorded in Arc Collector.

2.4.4 Tier 4: Targeted Monitoring of High Risk Areas

Tier 4 provides a monitoring plan for early detection in High Risk areas, or vector corridors. Currently two parks in MOJN (LAKE and JOTR) survey these corridors using the Weed Sentry Model (Figure 4). The Weed Sentry model was developed by University of Nevada Las Vegas (UNLV) Public Lands Institute and was successfully implemented across Clark County, Nevada (Hoines et al. 2005). This model is appropriate for MOJN because it requires minimal resources and was designed specifically for early detection. Since this model is already implemented in two MOJN parks and is having success, it is included in this tiered approach for implementation in other parks if they deem it appropriate.

The Weed Sentry Model focuses resources on roads and trails. Observers walk transects along predetermined roads and trails. These locations will be selected by each park's invasive species coordinator (see SOP 2 Identifying High Value and High Risk Areas for an explanation of how sites are selected). Walking on both sides of a road, or along a trail, observers look for invaders in a 10m swath centered on the path traveled (transect). Observers then record presence and abundance of invaders that are detected along transects. Refer to SOP 8 Tier 4: Weed Sentry using Arc Collector for additional information about this monitoring.

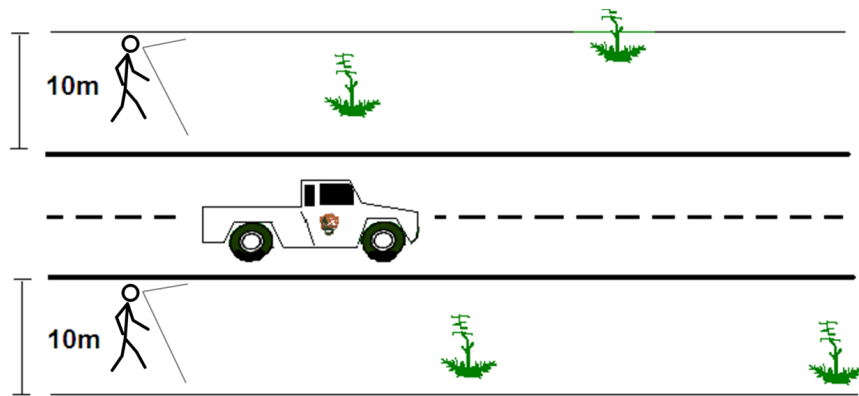


Figure 4. The Weed Sentry Model is an early detection plan that conducts targeted early detection monitoring along roads and trails.

2.4.5 Tier 5: Targeted Monitoring of High Value Places

This tier is for parks with interest and the additional resources to monitor for invasives in High Value places. This is especially important for parks that have Areas of Concern that are not already being monitored in some way. For example, the Live Oak in JOTR is a site popular and rare because of the unique and highly charismatic live oak tree. If red brome were to spread to this area, the risk of fire would increase and threaten the element that makes this site intriguing. However, currently there is no plant monitoring in this location. Live Oak therefore is an example of a high value area, and JOTR may wish to establish monitoring plots in the area for the early detection of invasive plants.

In this tier, resources managers use vegetation staff to conduct targeted monitoring in predetermined High Value places. In these locations, staff establish one or more 100m x 100m locations and walk transects within them to monitor for invaders (see Figure 5). This information is recorded and monitored over time. Revisit rates to these locations vary based on risk and availability of resources. See SOP 9 Tier 5: Targeted Monitoring using Arc Collector for additional information.

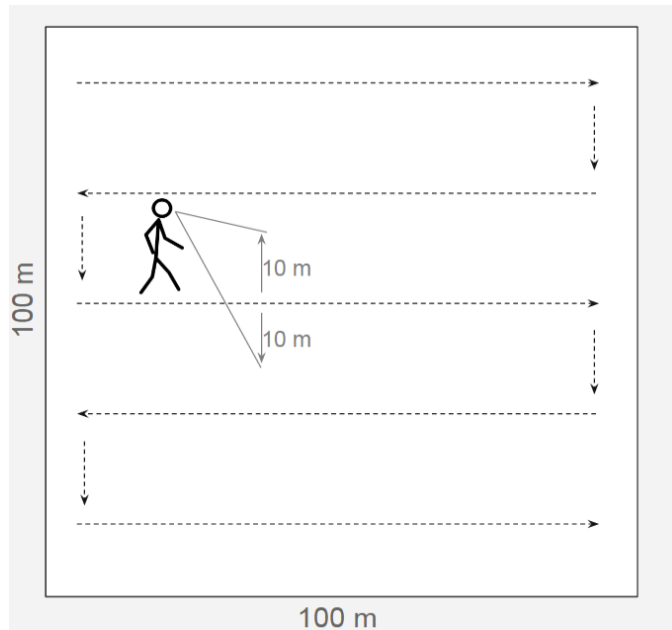


Figure 5. Targeted monitoring sampling design for High Value places occurs in 100m by 100m plots. The observer walks transects through the plot, starting at one corner and walking in straight lines from side to side. The observer looks for invasive species within 10m on both sides of the transect. When invaders are encountered, they are recorded in the Arc Collector app.

2.5 Field Season

Monitoring for invasive plants is a year round task since different invaders emerge at various times of the year; parks have to be vigilant for invaders almost constantly. Field seasons in the lower Mojave Desert (i.e. DEVA, JOTR, LAKE, MOJA, and TUSK) can start during late winter months (e.g. January-February) if temperatures and precipitation events facilitate early green-up of many invasive/exotic annuals. Based on phenology information, we know that some of the most aggressive invaders (*Bromus* sp., *Brassica* sp.) may emerge following surprisingly minimal precipitation events in fall and winter. Part of the success of many of these exotic annuals is that they can initiate growth much earlier than most native species, thus usurping resources (water, nutrients) before natives.

Thus, some flexibility is required by managers to assure that monitoring efforts do not miss the unpredicted opportunities where unnoted annual invaders might proliferate. Given that many of the highest impact species are annuals, early detection surveys need to be conducted when conditions are most suitable for easy identification and hopefully, successful control. Additionally, biennial species (such as *Carduus* sp. and *Cirsium* sp.) must be eradicated in their vegetative or dormant stage.

Conversely, many of the perennial invasive species can be identified during all seasons and, thus, are less sensitive to scheduling. Refer to SOP 1 Updating TIPS and Most Wanted Species Lists list for additional suggestions on when to detect species on the TIPS list.

3 Data Handling, Analysis, and Reporting

This section outlines the overview for data handling, analysis, and report development, while details and procedural steps are documented in the SOPs (11-15), which are available in the NPS Data Store. This data management section is written with the assumption that as the plan is implemented and adjusted through its lifecycle, the SOPs can be periodically updated as needed while the narrative of the plan will remain largely unchanged. Additional details and context for this section may be found in the MOJN I&M Vital Signs Monitoring Plan (Chung-MacCoubrey et al. 2008), and the MOJN I&M Data Management Plan (DMP; MOJN 2008).

3.1 Project Information Management Overview

The data management process outlined here is structured enough that it meets the needs of the IPSED plan, yet is dynamic enough to respond to changes in data management tools and software. Responsibility for project information management will be shared between parks and MOJN I&M but also relies on the assistance of park staff, network staff, and LAKE-EPMT.

3.2 Overview of Databases and Tools

This IPSED plan utilizes two systems for data management (Figure 6). The primary data storage system is an enterprise geodatabase, the NPS EPMT maintained National Invasive Species Information Management System, or NISIMS. Capable of storing spatial data, NISIMS will be used to store and summarize all monitoring, occurrence, and treatment data after they have gone through the QA/QC process. For our purposes, NISIMS will be used in conjunction with the second system, the ESRI cloud-based platform, ArcGIS Online (AGOL). AGOL will be used to store data directly after collection and during the QA/QC process, while NISIMS is used to store data once they have been verified and accepted; once accepted, data will not be edited in NISIMS. AGOL will also store a read-only copy of accepted data, as this platform offers convenient tools for parks to visualize and download data. The role of AGOL is explained in further detail below in section 3.2.2 and in SOP 11 Data Management Workflow.

The additional database, NPSpecies, is used to maintain and update the Network-wide Target Invasive Species List and make smaller park specific Most Wanted lists readily available to park staff and visitors. NPSpecies is a web-based system created and managed by NPS that provides parks a way to build, manage, and share park species information.

This plan also utilizes iNaturalist, a web-based platform that contains crowd-sourced occurrence data. However, iNaturalist is purely a tool to obtain occurrence data, which parks can use as a starting point for monitoring. To clarify, this tool will *not* be used to store data nor will information harvested from iNaturalist be stored in a database.

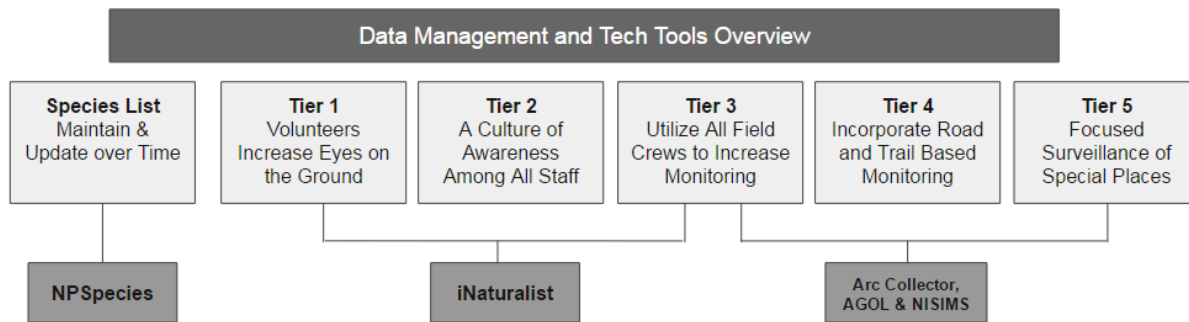


Figure 6. Overview of data management and associated apps for the IPSED plan. The TIPS list will be stored in NPSpecies. In Tiers 1 and 2, observers will collect observations in the app iNaturalist. In Tiers 4 and 5, vegetation personnel will collect data in Arc Collector, upload and access that data in AGOL, and store that data in NISIMS. Tier 3 has the flexibility to use iNaturalist to collect observations opportunistically, or formally collect invasive species data using Arc Collector (depending on resources and plant identification skills of the personnel).

3.2.1 NPSpecies

Annually, park managers will update and reprioritize the Invasive Species List for their parks (see SOP 1 Updating TIPS and Most Wanted Species Lists for details how to select species for this list). This list must be widely accessible for all managers, as well as visitors, in order to increase invasive species awareness and management. Each species on this list will be tagged in the NPSpecies database. NPSpecies is a component of the NPS Integrated Resource Management Applications (IRMA) online portal that is used to store, manage, and discover information on species on NPS lands. This online database is maintained through the NPS I&M Program and is accessible to all parks, as well as the general public. Sources of information in NPSpecies include species inventories, monitoring projects, reports, publications, and museum collections.

The MOJN invasive species coordinators are responsible for ensuring the species are assigned a “park tag” in NPSpecies that identifies a given species as an “Invasive Species of Concern”. Parks are responsible for maintaining the TIPS list but should contact the MOJN I&M Data Manager for help when needed (Refer to SOP 15 Managing Target Species List in NPSpecies for additional details).

3.2.2 National Invasive Species Information Management System (NISIMS) and ArcGIS Online (AGOL)

For Tiers 3, 4, and 5, species observation and treatment data will be stored in NISIMS. This tool is appropriate for IPSED monitoring because it combines weed survey data collected by the parks with spatial information. Additionally, parks benefit from using a system already used by LAKE-EPMT because it increases the flow of information between these two entities. This allows parks and LAKE-EPMT to map and analyze infestations in space and time and increases the communication between parks and LAKE-EPMT. NISIMS stores five categories of exotic species management spatial data: weed survey, weed infestation, proposed treatment, treatment, and photo location.

Data within NISIMS will be managed and used by park invasive species coordinators, the MOJN I&M Data Manager, and the LAKE-EPMT Data Manager (Figure 6). The national EPMT data

manager and NPS software developers are responsible for future development and maintenance of this application. Refer to SOP 11 Data Management Workflow and SOP 13 Reporting and Exporting Data for additional details.

Once data are collected they will be uploaded into AGOL (Figure 7). Importantly, data are immediately available for parks, EPMT, and MOJN I&M to view in AGOL, even before data are checked for quality, approved, and uploaded to NISIMS; if urgent treatment is needed, managers can share data through AGOL to expedite a management response, temporarily bypassing the QA/QC schedule required for permanent storage in NISIMS. Also through AGOL, field crews and the invasive species coordinator will have the ability to make corrections to in-season data as needed and flag records for deletion. Finally when data have fully gone through the QA/QC process, been assessed and approved, the data will be made available in NISIMS and the raw data in AGOL will also be updated (further explanation below in section 3.7 Data Delivery).

As the NISIMS system is still in an active development phase, the SOPs that accompany this plan will be updated as the system evolves and to reflect any lessons learned as the data are processed, reviewed for quality, analyzed, and archived. Documentation describing the NISIMS database design is available in the IRMA Data Store.

3.3 Data Entry and Processing

Park field crews will initially record survey, treatment, and resurvey data in Arc Collector. The data dictionaries and drop-downs for this program will be created by MOJN I&M data managers. Data entry is electronic and will proceed as described in SOPs 7, 8, and 9. Though photos are not required by Tiers 4 and 5 of this plan, they can be helpful to illustrate an infestation or be used to verify plant identification. Arc Collector will be used to take photographs if needed, as described in SOP 8 Tier 4: Weed Sentry Using Arc Collector and SOP 9 Tier 5: Targeted Monitoring Using Arc Collector.

The MOJN I&M Data Manager will conduct quarterly QA/QC and summarization routines before submitting data (including photographs) to the park invasive species coordinator for confirmation of species identification and final review. The MOJN Data Manager will then upload the corrected data to NISIMS.

3.4 Quality Review

There are two parts of quality review associated with data acquisition. First, all field data entry will be reviewed for quality assurance following the guidelines presented in the NPS National Data Management Plan (2008). Second, data will be checked for quality, completeness, and logical consistency by both parks and MOJN I&M. The MOJN Data Manager will run pre-designed queries to screen the data in the field database for outliers, missing values, illogical values, and inconsistencies, and then submit the field database and a report of errors to the park invasive species coordinator for additional review. Any errors and inconsistencies that cannot be corrected will be documented and included in the metadata (see SOP 13 Data QA/QC and Sensitivity Assessment for details). Once the quality review is complete and the data are accepted, the local geodatabase is submitted to the national EPMT Data Manager for import into NISIMS.

3.5 Sensitive Information

An element of metadata development includes determining whether or not the data include any sensitive information (e.g., specific locations of rare, threatened, endangered, or commercially valuable species). Prior to submitting data to NISIMS, the Protocol Lead, Park Resource Managers and/or Vegetation Working Group need to identify any sensitive information in the data. Any decisions about removal of sensitive data will be documented and communicated to the Data Manager.

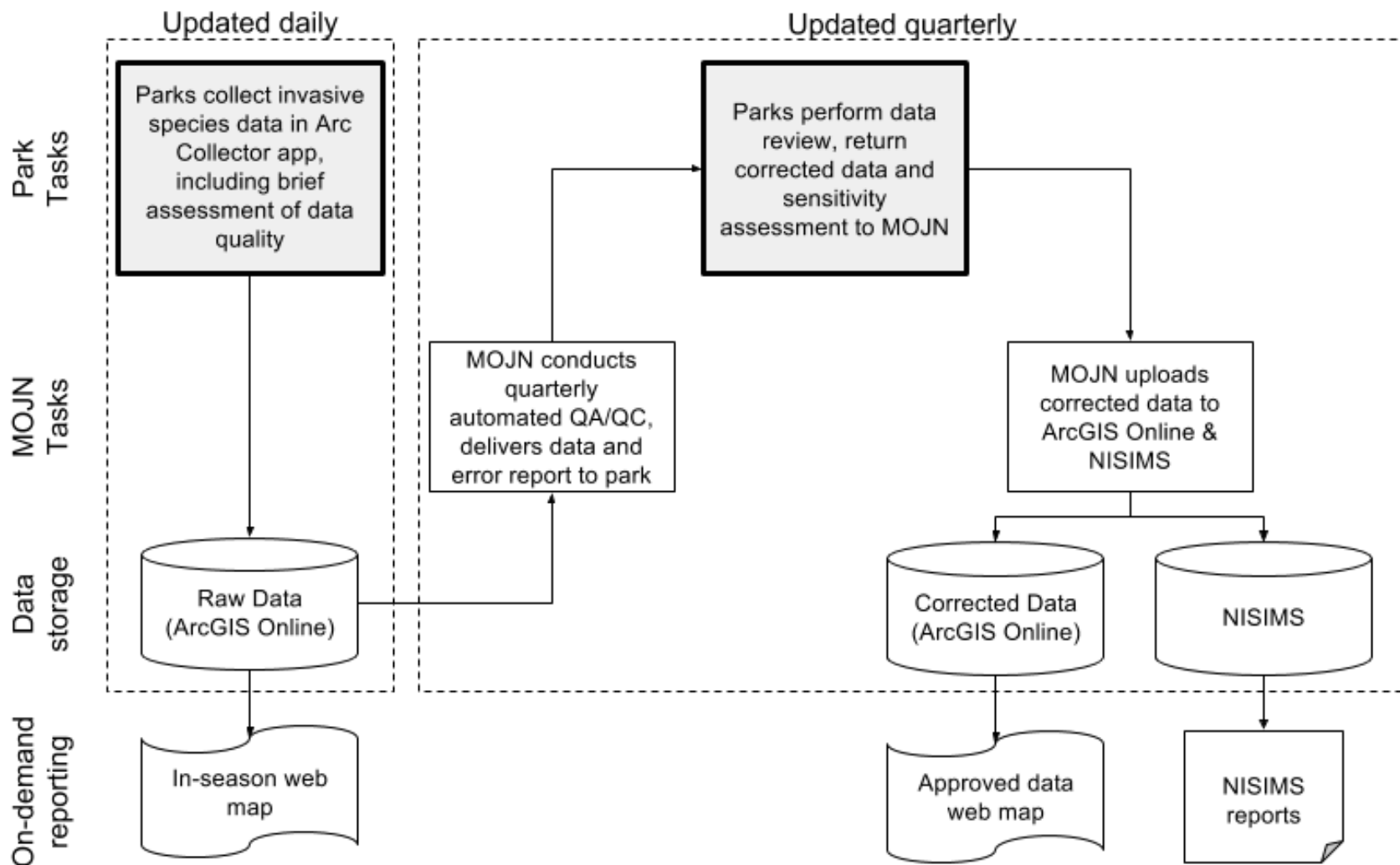


Figure 7. Data management workflow for parks, MOJN I&M, and LAKE-EPMT for the IPSED plan.

3.6 Data Acceptance

To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data acceptance step is an annual requirement for all tabular and spatial data. Data acceptance is a benchmark in the project information management process that indicates the data: 1) are complete for the period of record, 2) have undergone and passed the quality assurance checks, and 3) are appropriately documented and in a condition for archiving, posting, and distribution.

Acceptance is not intended to imply that the data are completely free of errors or inconsistencies that may not have been detected during quality assurance reviews. The park invasive species coordinator is primarily responsible for completing acceptance procedures with the assistance of the MOJN I&M Data Manager. When the acceptance process is completed, the data are ready for analysis and distribution as appropriate. Details of the acceptance and delivery processes are described in SOP 11 Data Management Workflow and SOP 12 QAQC and Sensitivity Assessment.

3.7 Data Delivery

After the data have been accepted, the Data Manager will submit data to the web-based NISIMS database. Once the data submission is processed by a NISIMS database administrator, park staff can use the summarization tools in NISIMS to create data reports but do not have data export ability. Until NISIMS supports data exports, accepted data will also be uploaded to AGOL by the MOJN I&M Data Manager. Data in AGOL can be downloaded in a variety of formats or viewed in a custom web map.

3.8 Data Analyses and Product Development and Delivery

Basic data summaries can be generated by parks using the web-based NISIMS platform. Parks are encouraged to view reports quarterly, to match the schedule of when data are uploaded to NISIMS. Additional summary and viewing functions are available in AGOL. Both the MOJN I&M Data Manager and invasive species coordinators in parks can use informational products for annual reports and other needs of vegetation managers.

The park invasive species coordinators will communicate with MOJN I&M Data Manager and other staff in late fall or winter to review associated park high priority exotic species lists, receive feedback, and make any necessary adjustments to the plan. They will also prepare summary reports when new invasive species are detected, using the format of a resource brief. In addition, e-mails to network and regional staff, as well as other federal, state, and private organizations, and website updates will be conducted on an as-needed basis.

4 Personnel Requirements

4.1 Implementation for Parks

4.1.1 Roles and Responsibilities of Park Staff

At the park level, the personnel and operational requirements to implement the IPSED plan will vary based on tiers carried out, personnel requirements, size of park, and amount of effort. Generally, it is up to the park to conduct early detection efforts and determine effort; this will have to be considered on a park-by-park basis.

4.1.2 Annual Schedule of Park Responsibilities

Depending on the phenology of invaders present in the park, the schedule for implementing IPSED is unique to each parks yearly situation but will typically be carried out year round. Additionally, depending on the tiers carried out and the amount of resources available, actual implementation of the IPSED plan is not standardized; generally there are minimal park responsibilities. However, for Tiers 3, 4, and 5, which use NISIMS to manage data, parks are required to upload data into the NISIMS database, and conduct internal QA/QC on that data before submitting it to the MOJN I&M Data Management Team quarterly. Additionally, park personnel are responsible for attending the annual vegetation working group meeting to update the TIPS list.

4.1.2 Qualifications and Training Responsibilities

It is the responsibility of the MOJN network parks to ensure that field staff, including volunteers and interns, are properly trained in the field methods provided in sections 2 and 3 of this plan. Additionally, parks are responsible for training staff on field safety, emergency communications, winter backcountry travel, and possibly river sampling, as applicable to their respective sites.

4.2 Implementation for MOJN I&M

4.2.1 Roles and Responsibilities of MOJN I&M Staff

At the network level, the MOJN I&M Ecologist and Data Management Team will provide assistance to parks, maintenance of the protocol and data management systems, and organization that will require a minimal budget consideration (Table 3). The MOJN I&M Ecologist, as the Plan Lead, will oversee plan implementation which includes providing technical assistance for park managers and serve as primary coordinator of updating the Target Invasive Plant Species (TIPS) list. For NISIMS data, the Data Management Team will conduct quarterly QA/QC and summarization routines before submitting data (including photographs) to the park invasive species coordinator for confirmation of species identification and final review. The MOJN Data Management Team will then upload the corrected data to NISIMS. The MOJN Program Manager will assign budgets, review associated products, and supervise the Ecologist and Data Manager. Other network staff may periodically assist with field work.

During the start-up years (2017-2020), the Ecologist and Data Management Team will provide support to parks as needed for the plan's roll-out. This includes assistance getting started with familiarizing parks with the tiers of the plan, data collection, data management, and updating the TIPS list.

Table 3. Invasive Species Early Detection annual budget estimate for the Mojave Desert Network (MOJN).

Assigned staff and time requirement	Responsibilities
Ecologist 120 hours	• Project oversight and administration • Protocol updates and revisions • Lead meetings to update TIPS and most wanted lists • Communicate with and solicit data from non-NPS resource managers that have additional information on new invasive species concerns • Complete reports, metadata, and other products • Start-up years: additional 80 hours for roll-out
Data Management Team 80 hours for Data Manager 80 hours for Assistant Data Manager	• Provide tech support for Arc Collector, iNaturalist, NISIMS, and NPSpecies • Coordinate with LAKE-EPMT to ensure that data is easily shared among parks, MOJN I&M, and LAKE-EPMT • Start-up years: additional 80 hours for Data Manager and 120 hours for Assistant Data Manager plan implementation and roll-out assistance including assisting parks to download required software, familiarizing parks with cell phone apps, and troubleshooting data flow issues
MOJN Program Manager 20 hours	• Project Lead oversight • Budget administration • Consultation on all phases of the plan review and implementation • Review reports and other products

4.2.2 Annual Schedule of MOJN I&M Responsibilities

Throughout the year, the Ecologist and Data Management team have responsibilities that are scheduled, such as conducting meetings and QA/QC. Unscheduled responsibilities, such as troubleshooting IT issues, editing SOPs, and providing park field assistance when possible, are impossible to predict and therefore not included on the annual schedule (Table 4).

Table 4. Estimated annual schedule for MOJN I&M tasks to carry out the IPSED plan. “X” denotes months when tasks should occur.

Action	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conduct conference call to update TIPS list	X	–	–	–	–	–	–	–	–	–	–	–
Conduct QA/QC on NISIMS data collected by parks	X	–	–	X	–	–	X	–	–	X	–	–
Compile status and trends report	–	–	–	–	–	–	–	–	–	X	–	–
Visit parks to assist with carrying out elements of IPSED plan	–	X	–	–	–	–	–	–	–	–	–	–
Update plan SOPs after each year of use, or more frequently	–	–	–	–	–	–	–	–	–	X	X	X

4.2.2 Qualifications and Training Responsibilities

While parks are ultimately responsible for implementing the IPSED plan, the MOJN I&M Ecologist will provide support for the implementation of the plan. We anticipate that the individual in this position will meet the basic requirements for a GS-9/11 Ecologist, which includes familiarity with ecological principles, field techniques, and statistical methods. Additionally, the Ecologist should be able to identify research needs and coordinate with parks to meet those needs to achieve broad ecosystem protection strategies. Training for the Ecologist includes field methods required for tiers 1-5, data analysis methods for reports, and safety procedures.

This plan is also heavily reliant on a Data Management team, which include a Data Manager and Assistant Data Manager. We anticipate members of this team need familiarity with data collection on mobile devices, and particularly the ESRI suite of data collection apps, and the AGOL (ArcGIS Online) data cloud. Additionally, staff will need to be able to train and support users of these devices. Finally, the ability to create and execute extract-transform-load data processes involving SQL, geodatabase, and cloud services will be required.

5 Budget for Implementation

5.1 Personnel and Operational Costs

For MOJN I&M, the long-term annual budget for the IPSED plan is \$12,466 and includes MOJN staff salaries and funds that can be used to help support the parks with implementing the IPSED plan. We calculated this based on the expected costs, plus annual increases, for the first year the plan will be implemented *after* the start-up period (2021). For the start-up years, the estimated budget is \$22,802, which accounts for additional time developing the plan, updating SOPs and traveling to parks to roll-out the data management elements of the plan. This is calculated using the last year of the start-up phase (2020), to base calculations off the potentially highest cost year of the start-up phase (due to estimated salary increases annually). Travel costs may be used for periodic park visits by the Ecologist and/or Data Management Team, trainings, or to bring in outside technical expertise (Table 5).

Table 5. Annual MOJN I&M budget for IPSED plan which includes anticipated expenses for the initial start-up years (2017-2020) and long-term costs** for subsequent years after establishment.

Expense type	Expense detail	2017	2018	2019	2020	2021
Personnel*	Program Manager	\$1,120.00	\$1,142.40	\$1,165.25	\$1,188.55	\$1,212.32
	Ecologist (GS- 09/11)	\$6,000.00	\$8,120.00	\$8,162.40	\$8,163.25	\$4,963.25
	Data Manager (GS-11)	\$7,360.00	\$7,507.20	\$7,510.14	\$7,510.20	\$3,830.20
	Assistant Data Manager (GS-7)	\$5,400.00	\$5,508.00	\$5,510.16	\$5,510.20	\$2,270.20
Operations	Travel	\$430.00	\$430.00	\$430.00	\$430.00	\$190.00
Total					\$22,802	\$12,466

* Salary costs are based on 2017 wages and estimates. Though living expense salary increases are unpredictable from year to year, we included a 2% increase annually to estimate this expense.

** Long-term costs are calculated on the estimated costs of carrying out the IPSED plan starting in the year 2021.

5.2 Required Equipment and Associated Costs

Much of the necessary equipment and software for the IPSED plan is already owned by the parks and MOJN I&M including ESRI software, and smartphones or tablets. There is no cost associated with NPS use of the ESRI software. Additionally, the number of devices needed will vary widely based on a park's chosen implementation. Further, in many cases the needed equipment, such as smartphone and tablets, are already available in parks. Therefore, the associated costs for MOJN I&M does not add anything to MOJN I&M current budget. The associated costs for parks will vary based on tiers, but will mostly utilize already-purchased equipment.

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Appendix A. Target Invasive Plant Species (TIPS) List

Version 1 Created June 2016

The initial Target Invasive Plant Species (TIPS) list was created in 2016 and utilized prioritization tools and park manager input. This list was created using the assistance of park invasive species coordinators (personnel who are most qualified within their park to coordinate invasive species management) and various tools available to assist with invasive species prioritization, categorization, and risk assessment. The invasive plant prioritization tools we used focus on criteria such as specific geographic regions (Mehrhoff 2000, Warner et al. 2003), current level of species impact, and feasibility of control (Hiebert and Stubbendieck 1993). For example, U.S. Invasive Species Impact Ranks (I-Ranks) and the associated Invasive Species Assessment Protocol, which guides individuals through a series of questions to determine I-Rank, use extensive biogeographical information as criteria to rank plant invasiveness at local, regional, national, and global scales (Morse et al. 2004). The Invasive Plant Atlas of New England (IPANE) uses six specific biological criteria to prioritize or “track” specific invasive plants in New England (IPANE 2009). Each of these systems provides a well-conceived model for ranking invasive plants. Other less formal lists draw on experience across a range of resource management disciplines. As an example, state and federal noxious weed lists have historically targeted agricultural pest plants.

Of the 356 exotic plant species compiled for the MOJN parks and region, 203 are considered mildly, moderately, or highly invasive, or are a priority to control if discovered (e.g. noxious status). These 203 species comprise a TIPS list for early detection, control and/or long-term monitoring efforts. Since targeted monitoring of 203 species in each park would be costly, we distilled the TIPS list down to a park-specific “Most Wanted” list for each park. The Most Wanted lists generally consist of between 10 and 20 species. This is a more realistic number of species that observers can be expected to recall and identify in the field while conducting other duties. Parks that employ volunteers for the IPSED plan may also choose to create an even smaller subset of five species suitable for individuals with very limited botanical experience.

Table A-1. Target invasive plant species list (TIPS).

Family	Scientific Name	Common Name	MOJN rounded rank
Asteraceae	<i>Acroptilon repens</i>	Russian knapweed	High
Poaceae	<i>Arundo donax</i>	Giant reed	High
Brassicaceae	<i>Brassica tournefortii</i>	Sahara mustard	High
Poaceae	<i>Bromus rubens</i>	Red brome	High
Poaceae	<i>Bromus tectorum</i>	Downy brome (cheatgrass)	High
Asteraceae	<i>Centaurea solstitialis</i>	Yellow star-thistle	High
Asteraceae	<i>Centaurea stoebe</i>	Spotted knapweed	High
Poaceae	<i>Cortaderia selloana</i>	Pampas grass	High
Elaeagnaceae	<i>Elaeagnus angustifolia</i>	Russian olive	High

Family	Scientific Name	Common Name	MOJN rounded rank
Apiaceae	<i>Foeniculum vulgare</i>	Sweet fennel	High
Brassicaceae	<i>Lepidium latifolium</i>	Perennial pepperweed	High
Haloragaceae	<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	High
Poaceae	<i>Pennisetum setaceum</i>	Fountaingrass	High
Rosaceae	<i>Rubus armeniacus</i>	Himalayan blackberry	High
Fabaceae	<i>Spartium junceum</i>	Spanish broom	High
Tamaricaceae	<i>Tamarix</i> spp.	Tamarisk	High
Poaceae	<i>Bromus diandrus</i>	Ripgut brome	Medium
Brassicaceae	<i>Cardaria draba</i>	Whiteweed	Medium
Brassicaceae	<i>Cardaria pubescens</i>	Long-stalk hoarycress	Medium
Simaroubaceae	<i>Ailanthus altissima</i>	Tree-of-heaven	Medium
Fabaceae	<i>Alhagi maurorum</i>	Camel thorn	Medium
Chenopodiaceae	<i>Atriplex rosea</i>	Tumbling Orache (or saltweed)	Medium
Chenopodiaceae	<i>Atriplex semibaccata</i>	Australian saltbush	Medium
Poaceae	<i>Avena fatua</i>	Wild oat	Medium
Chenopodiaceae	<i>Bassia scoparia</i>	Kochia (summercypress)	Medium
Brassicaceae	<i>Brassica nigra</i>	Black mustard	Medium
Poaceae	<i>Bromus inermis</i>	Smooth brome	Medium
Asteraceae	<i>Carduus nutans</i>	Musk thistle	Medium
Asteraceae	<i>Centaurea melitensis</i>	Malta star-thistle	Medium
Asteraceae	<i>Cirsium arvense</i>	Canada thistle	Medium
Asteraceae	<i>Cirsium vulgare</i>	Bull thistle	Medium
Convolvulaceae	<i>Convolvulus arvensis</i>	Field bindweed	Medium
Poaceae	<i>Cynodon dactylon</i>	Bermudagrass	Medium
Boraginaceae	<i>Cynoglossum officinale</i>	Houndstongue	Medium
Poaceae	<i>Elymus repens</i>	Quackgrass	Medium
Geraniaceae	<i>Erodium cicutarium</i>	Redstem filaree	Medium
Brassicaceae	<i>Eruca vesicaria</i> ssp. <i>sativa</i>	Rocket-salad	Medium
Moraceae	<i>Ficus carica</i>	Fig tree	Medium
Chenopodiaceae	<i>Halogeton glomeratus</i>	Halogeton	Medium
Brassicaceae	<i>Hirschfeldia incana</i>	Shortpod mustard	Medium
Poaceae	<i>Hordeum marinum</i>	Seaside barley	Medium
Poaceae	<i>Hordeum murinum</i>	Mouse barley	Medium
Poaceae	<i>Hordeum murinum</i> ssp. <i>leporinum</i>	Hare barley	Medium
Verbenaceae	<i>Lantana camara</i>	Lantana, Hedgeflower	Medium
Asteraceae	<i>Leucanthemum vulgare</i>	Ox-eye daisy	Medium
Scrophulariaceae	<i>Linaria dalmatica</i>	Dalmation toadflax	Medium
Poaceae	<i>Lolium multiflorum</i>	Italian ryegrass	Medium
Brassicaceae	<i>Strigosella africana</i>	African mustard	Medium

Family	Scientific Name	Common Name	MOJN rounded rank
Fabaceae	<i>Melilotus albus</i>	Yellow sweetclover	Medium
Fabaceae	<i>Melilotus indicus</i>	Annual yellow sweetclover	Medium
Fabaceae	<i>Melilotus officinalis</i>	Yellow sweetclover	Medium
Lamiaceae	<i>Nepeta cataria</i>	Catnip	Medium
Apocynaceae	<i>Nerium oleander</i>	Oleander	Medium
Solanaceae	<i>Nicotiana glauca</i>	Tree tobacco	Medium
Asteraceae	<i>Onopordum acanthium</i>	Scotch thistle	Medium
Arecaceae	<i>Phoenix dactylifera</i> and <i>Phoenix canariensis</i>	Date palms	Medium
Potamogetonaceae	<i>Potamogeton crispus</i>	Curly pondweed	Medium
Polygonaceae	<i>Rumex acetosella</i>	Red sorrel	Medium
Poaceae	<i>Saccharum ravennae</i>	Ravenna grass	Medium
Chenopodiaceae	<i>Salsola paulsenii</i>	Barbwire Russian thistle	Medium
Chenopodiaceae	<i>Salsola tragus</i>	Prickly Russian thistle	Medium
Caryophyllaceae	<i>Saponaria officinalis</i>	Soapwort, bouncingbet	Medium
Poaceae	<i>Schismus arabicus</i>	Arabian schismus	Medium
Poaceae	<i>Schismus barbatus</i>	Mediterranean grass	Medium
Brassicaceae	<i>Sisymbrium altissimum</i>	Tall tumbledustard	Medium
Brassicaceae	<i>Sisymbrium irio</i>	London rocket	Medium
Brassicaceae	<i>Sisymbrium orientale</i>	Indian hedgemustard	Medium
Asteraceae	<i>Sonchus asper</i>	Spiny sowthistle	Medium
Asteraceae	<i>Sonchus oleraceus</i>	Common sowthistle	Medium
Poaceae	<i>Sorghum halepense</i>	Johnsongrass	Medium
Tamaricaceae	<i>Tamarix aphylla</i>	Athel	Medium
Zygophyllaceae	<i>Tribulus terrestris</i>	Puncturevine	Medium
Ulmaceae	<i>Ulmus pumila</i>	Siberian elm	Medium
Apocynaceae	<i>Vinca major</i>	Bigleaf periwinkle	Medium
Verbenaceae	<i>Vitex agnus-castus</i>	Lilac chastetree	Medium
Poaceae	<i>Vulpia myuros</i>	Rat-tail fescue	Medium
Brassicaceae	<i>Chorispora tenella</i>	Blue mustard	Low
Fabaceae	<i>Medicago polymorpha</i>	Bur clover	Low
Poaceae	<i>Agropyron cristatum</i>	Crested wheatgrass	Low
Poaceae	<i>Agropyron desertorum</i>	Desert crested wheatgrass	Low
Poaceae	<i>Agrostis stolonifera</i>	Creeping bentgrass	Low
Malvaceae	<i>Alcea rosea</i>	Hollyhock	Low
Brassicaceae	<i>Alyssum desertorum</i>	Desert madwort	Low
Amaranthaceae	<i>Amaranthus albus</i>	Tumble pigweed	Low
Amaranthaceae	<i>Amaranthus retroflexus</i>	Rough pigweed	Low
Primulaceae	<i>Anagallis arvensis</i>	Scarlet pimpernel	Low
Apiaceae	<i>Apium graveolens</i>	Wild celery	Low

Family	Scientific Name	Common Name	MOJN rounded rank
Asteraceae	<i>Artemisia biennis</i>	Biennial wormwood	Low
Liliaceae	<i>Asparagus officinalis</i>	Garden asparagus	Low
Poaceae	<i>Avena sativa</i>	Common oat	Low
Chenopodiaceae	<i>Bassia hyssopifolia</i>	Five-horn smotherweed	Low
Poaceae	<i>Bromus arenarius</i>	Australian brome	Low
Poaceae	<i>Bromus arvensis</i>	Field (Japanese) brome	Low
Poaceae	<i>Bromus berterianus</i>	Chilean chess	Low
Poaceae	<i>Bromus catharticus</i>	Rescue grass	Low
Poaceae	<i>Bromus hordeaceus</i>	Soft brome	Low
Poaceae	<i>Bromus madritensis</i> spp. <i>madritensis</i>	Foxtail brome	Low
Fabaceae	<i>Caesalpinia gilliesii</i>	Bird-of-paradise	Low
Brassicaceae	<i>Camelina microcarpa</i>	Littlepod false flax	Low
Cannabaceae	<i>Cannabis sativa</i>	Hemp	Low
Brassicaceae	<i>Capsella bursa-pastoris</i>	Shepherds purse	Low
Poaceae	<i>Catapodium rigidum</i>	Ferngrass	Low
Valerianaceae	<i>Centranthus ruber</i>	Red valerian	Low
Caryophyllaceae	<i>Cerastium fontanum</i> ssp. <i>vulgare</i>	Big chickweed	Low
Ranunculaceae	<i>Ceratocephala testiculata</i>	Bur buttercup	Low
Euphorbiaceae	<i>Chamaesyce maculata</i>	Spotted sandmat	Low
Chenopodiaceae	<i>Chenopodium album</i>	Lambsquarters	Low
Chenopodiaceae	<i>Chenopodium ambrosioides</i>	Mexican tea, Spanish tea	Low
Chenopodiaceae	<i>Chenopodium botrys</i>	Jerusalem oak goosefoot	Low
Chenopodiaceae	<i>Chenopodium murale</i>	Garden goosefoot	Low
Asteraceae	<i>Cichorium intybus</i>	Common chicory	Low
Cucurbitaceae	<i>Citrullus colocynthis</i>	Colocynth, citron	Low
Brassicaceae	<i>Conringia orientalis</i>	Hare's ear mustard	Low
Asteraceae	<i>Conyza bonariensis</i>	South American conyza	Low
Chenopodiaceae	<i>Corispermum nitidum</i>	Shiny bugseed	Low
Rosaceae	<i>Cotoneaster microphyllus</i>	Cotoneaster	Low
Rosaceae	<i>Cotoneaster pannosus</i>	Silverleaf cotoneaster	Low
Poaceae	<i>Crypsis schoenoides</i>	Swamp pricklegrass	Low
Poaceae	<i>Dactylis glomerata</i>	Orchardgrass	Low
Apiaceae	<i>Daucus carota</i>	Queen Anne's lace	Low
Brassicaceae	<i>Descurainia sophia</i>	Herb sophia	Low
Asteraceae	<i>Dimorphotheca sinuata</i>	Glandular Cape marigold	Low
Poaceae	<i>Echinochloa colona</i>	Jungle rice	Low
Poaceae	<i>Echinochloa crus-galli</i>	Barnyard grass	Low
Poaceae	<i>Eragrostis cilianensis</i>	Stink grass	Low
Poaceae	<i>Eriochloa fatmensis</i>	Tropical cup grass	Low
Brassicaceae	<i>Erysimum repandum</i>	Spreading wallflower	Low

Family	Scientific Name	Common Name	MOJN rounded rank
Araliaceae	<i>Hedera helix</i>	English ivy	Low
Poaceae	<i>Hordeum murinum</i> ssp. <i>glaucum</i>	Blue-gray barley	Low
Poaceae	<i>Hordeum vulgare</i>	Common barley	Low
Asteraceae	<i>Lactuca sativa</i>	Garden lettuce	Low
Asteraceae	<i>Lactuca serriola</i>	Prickly lettuce	Low
Brassicaceae	<i>Lepidium perfoliatum</i>	Clasping pepperweed	Low
Brassicaceae	<i>Lobularia maritima</i>	Sweet alyssum	Low
Poaceae	<i>Lolium perenne</i>	Perennial ryegrass	Low
Fabaceae	<i>Lotus corniculatus</i>	Bird's-foot trefoil	Low
Rosaceae	<i>Malus sylvestris</i>	European crab apple	Low
Malvaceae	<i>Malva neglecta</i>	Dwarf mallow	Low
Malvaceae	<i>Malva parviflora</i>	Cheeseweed mallow	Low
Lamiaceae	<i>Marrubium vulgare</i>	White horehound	Low
Asteraceae	<i>Matricaria discoidea</i>	Pineapple weed	Low
Fabaceae	<i>Medicago arabica</i>	Spotted medick	Low
Fabaceae	<i>Medicago lupulina</i>	Black medick	Low
Fabaceae	<i>Medicago sativa</i>	Alfalfa	Low
Meliaceae	<i>Melia azedarach</i>	Chinaberrytree	Low
Lamiaceae	<i>Mentha spicata</i>	Spearmint	Low
Molluginaceae	<i>Mollugo cerviana</i>	Thread stem carpetweed	Low
Moraceae	<i>Morus alba</i>	White mulberry	Low
Solanaceae	<i>Nicotiana acuminata</i> var. <i>multiflora</i>	Many flower tobacco	Low
Oleaceae	<i>Olea europaea</i>	Olive	Low
Poaceae	<i>Paspalum dilatatum</i>	Dallisgrass	Low
Poaceae	<i>Phalaris canariensis</i>	Canary grass	Low
Poaceae	<i>Phalaris minor</i>	Little seed canarygrass	Low
Poaceae	<i>Phleum pratense</i>	Timothy	Low
Plantaginaceae	<i>Plantago lanceolata</i>	Narrowleaf plantain	Low
Plantaginaceae	<i>Plantago major</i>	Common plantain	Low
Poaceae	<i>Poa annua</i>	Annual bluegrass	Low
Poaceae	<i>Poa bulbosa</i>	Bulbous bluegrass	Low
Poaceae	<i>Poa compressa</i>	Canada bluegrass	Low
Poaceae	<i>Poa pratensis</i>	Kentucky bluegrass	Low
Polygonaceae	<i>Polygonum arenastrum</i>	Oval-leaf knotweed	Low
Polygonaceae	<i>Polygonum argyrocoleo</i>	Silversheath knotweed	Low
Polygonaceae	<i>Polygonum aviculare</i>	Prostrate knotweed	Low
Poaceae	<i>Polypogon australis</i>	Chilean rabbitsfoot grass	Low
Poaceae	<i>Polypogon maritimus</i>	Mediterranean rabbitsfoot grass	Low
Poaceae	<i>Polypogon monspeliensis</i>	Annual rabbitsfoot grass	Low

Family	Scientific Name	Common Name	MOJN rounded rank
Poaceae	<i>Polypogon viridis</i>	Beardless rabbitsfoot grass	Low
Salicaceae	<i>Populus alba</i>	White poplar	Low
Portulacaceae	<i>Portulaca oleracea</i>	Common purslane	Low
Asteraceae	<i>Pseudognaphalium luteoalbum</i>	Jersey cudweed	Low
Asteraceae	<i>Pulicaria paludosa</i>	Spanish false fleabane	Low
Punicaceae	<i>Punica granatum</i>	Pomegranate	Low
Brassicaceae	<i>Raphanus raphanistrum</i>	Wild radish	Low
Resedaceae	<i>Reseda alba</i>	White mignonette	Low
Euphorbiaceae	<i>Ricinus communis</i>	Castorbean	Low
Brassicaceae	<i>Rorippa nasturtium-aquaticum</i>	Watercress	Low
Polygonaceae	<i>Rumex crispus</i>	Curly dock	Low
Polygonaceae	<i>Rumex dentatus</i>	Toothed dock	Low
Poaceae	<i>Schedonorus pratensis</i>	Meadow fescue	Low
Anacardiaceae	<i>Schinus terebinthifolius</i>	Brazilian peppertree	Low
Asteraceae	<i>Senecio vulgaris</i>	Common groundsel	Low
Poaceae	<i>Setaria pumila</i>	Yellow foxtail	Low
Caryophyllaceae	<i>Silene noctiflora</i>	Nightflowering silene	Low
Brassicaceae	<i>Sinapis arvensis</i>	Charlock mustard	Low
Solanaceae	<i>Solanum nigrum</i>	Black nightshade	Low
Solanaceae	<i>Solanum physalifolium</i>	Hoe nightshade	Low
Poaceae	<i>Sorghum bicolor</i>	Sorghum	Low
Caryophyllaceae	<i>Spergularia bocconii</i>	Boccone's sandspurry	Low
Tamaricaceae	<i>Tamarix gallica</i>	French tamarisk	Low
Asteraceae	<i>Taraxacum officinale</i>	Dandelion	Low
Poaceae	<i>Thinopyrum intermedium</i>	Intermediate wheatgrass	Low
Brassicaceae	<i>Thlaspi arvense</i>	Field pennycress	Low
Asteraceae	<i>Tragopogon dubius</i>	Goats beard, salsify	Low
Fabaceae	<i>Trifolium dubium</i>	Little hop clover	Low
Fabaceae	<i>Trifolium pratense</i>	Red clover	Low
Fabaceae	<i>Trifolium repens</i>	White clover	Low
Poaceae	<i>Triticum aestivum</i>	Common wheat	Low
Ulmaceae	<i>Ulmus parvifolia</i>	Chinese elm	Low
Ulmaceae	<i>Ulmus procera</i>	English elm	Low
Scrophulariaceae	<i>Verbascum thapsus</i>	Common mullein	Low
Scrophulariaceae	<i>Veronica biloba</i>	Bi-lobed speedwell	Low
Poaceae	<i>Vulpia bromoides</i>	Brome fescue	Low
Arecaceae	<i>Washingtonia filifera</i>	Fan Palm	Low

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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