# Lake Mead

National Recreation Area
National Park Service
U.S. Department of the Interior

# EXOTIC PLANT MANAGEMENT PLAN
# Lake Mead NRA

Clark County, Nevada
Mohave County, Arizona

October 2010

# Executive Summary

The overall goal of the Lake Mead NRA Exotic Plant Management Program, and thus this Plan, is to maintain native plant communities by preventing and removing exotic plants using an integrated approach that maximizes the effectiveness of the action while minimizing the undesirable impacts of the exotic plant and the management action. Exotic plant management is a key component of the park's efforts to maintain, and restore if needed, native plant communities and ecological processes for the purpose of protecting the integrity of the park's terrestrial and aquatic ecosystems.

Exotic plants are of increasing abundance and increasing concern for current and future resource managers for a myriad of reasons:

- Climate change, including changes in atmospheric deposition, has and will continue to have dramatic affects on terrestrial plant communities and there is some indication that many species of exotic plants will become more problematic as a result.
- The massive urbanization of the Las Vegas Valley and surrounding desert in the 1990's and early 2000's has greatly increased the potential for new introductions, many of which may not become widely recognized problems for some time due to the "lag" that follows initial introduction
- Changes in fire regime, namely the increase in fire frequency, size, and intensity, in the Mojave Desert can be at least partially attributed to the increase in fine fuel loads as a result of exotic annual grasses. These grass-fueled fires convert desert shrublands into exotic annual grasslands which serve to perpetuate the grass-fire cycle and may increase vulnerability to other invasions.

While the Park has maintained an active exotic plant management program since the early 1990s, this is the first attempt at a comprehensive Exotic Plant Management Plan. Development of such a plan provides comprehensive guidance and documentation for project managers and cooperators, provides a context for systematic evaluation and adaptive management, facilitates the transfer of information to the public and our partners, improves fiscal accountability by focusing on species and/or places where efforts yield the most benefit, enhances the effectiveness of the program by providing the required environmental analysis of more aggressive control measures (in an accompanying Environmental Assessment), improves efficiency by identifying and eliminating redundancies between program elements, and finally, lays a course for the future by identifying additional program elements that are needed to achieve the park's exotic plant management goals.

This plan is expected to have a useful life of about 20 years. To that end, the focus is on those program areas that are most stable, namely why exotic plants are treated, what the program includes, and how those actions are carried out, with less emphasis on who does the work as the dynamic nature of funding sources and organization relationships dictates that such details will vary over time. To extend the useful life of this Plan, it should be considered a living document and be updated as new information becomes available, provided the course of action still falls within the scope of the accompanying environmental assessment.

# Chapter 1: Introduction

## *1.1 Overview of Lake Mead National Recreation Area*

Lake Mead National Recreation Area includes two reservoirs (Lakes Mead and Mohave) along 140 miles of the former Colorado River from the southern tip of Nevada to the northwest corner of Arizona. It contains portions of Clark County, Nevada, and Mohave County, Arizona (Figure 1).

Lake Mead National Recreation Area is bounded on the north by the town of Overton, Nevada, the Virgin Mountains, and the Shivwits Plateau; on the east by Grand Canyon National Park and land administered by the Bureau of Land Management (BLM); on the south by Bullhead City, Arizona, and Laughlin, Nevada; and on the west by Boulder City, Nevada, the Eldorado Mountains, and the Newberry Mountains. The recreation area is generally associated with the city of Las Vegas, Nevada, which lies approximately 20 miles to the northwest (Figure 2). The recreation area is located in one of the fastest growing regions of the United States. The park visitation is approximately 9 million annually.

The recreation area contains approximately 1.5 million acres, of which 1,484,159 acres are in federal ownership administered by the National Park Service and 12,568 are nonfederal lands. An additional 4,488 acres surrounding Hoover and Davis Dams are administered by the Bureau of Reclamation. Lake Mead National Recreation Area is the fourth largest unit of the national park system outside the state of Alaska. Federal acreage divided by state reflects 60% of the park is located in Arizona and 40% is located in Nevada.

The upland areas within the park are rugged with deep canyons, dry washes, sheer cliffs, and mountains. The vegetation is primarily composed of communities typical of the Mojave Desert, with some species and plant assemblages typical of the surrounding Sonoran Desert and Great Basin Desert. Within Lake Mead NRA major vegetation types, generally arranged from low elevation to high elevation, include lowland riparian shrubland or woodland (often dominated by non-native saltcedar), creosote-bursage shrubland, desert grassland, blackbrush shrubland, Joshua tree woodland, and pinyon-juniper woodland. Over the low desert area, rainfall is typically less than 5 inches a year and may be slightly higher at higher elevations. Precipitation typically falls as winter rain and late summer thunderstorms associated with the southwestern monsoonal flow. However, precipitation is highly variable, with significantly above average rainfall in some years (such as 2004-05) and below average rainfall in most years. Winters are mild, and summers are very hot. Soils are typically low in organic matter. For most plant species, water is the limiting factor for growth and reproduction.

**Figure 1. Lake Mead NRA Region**

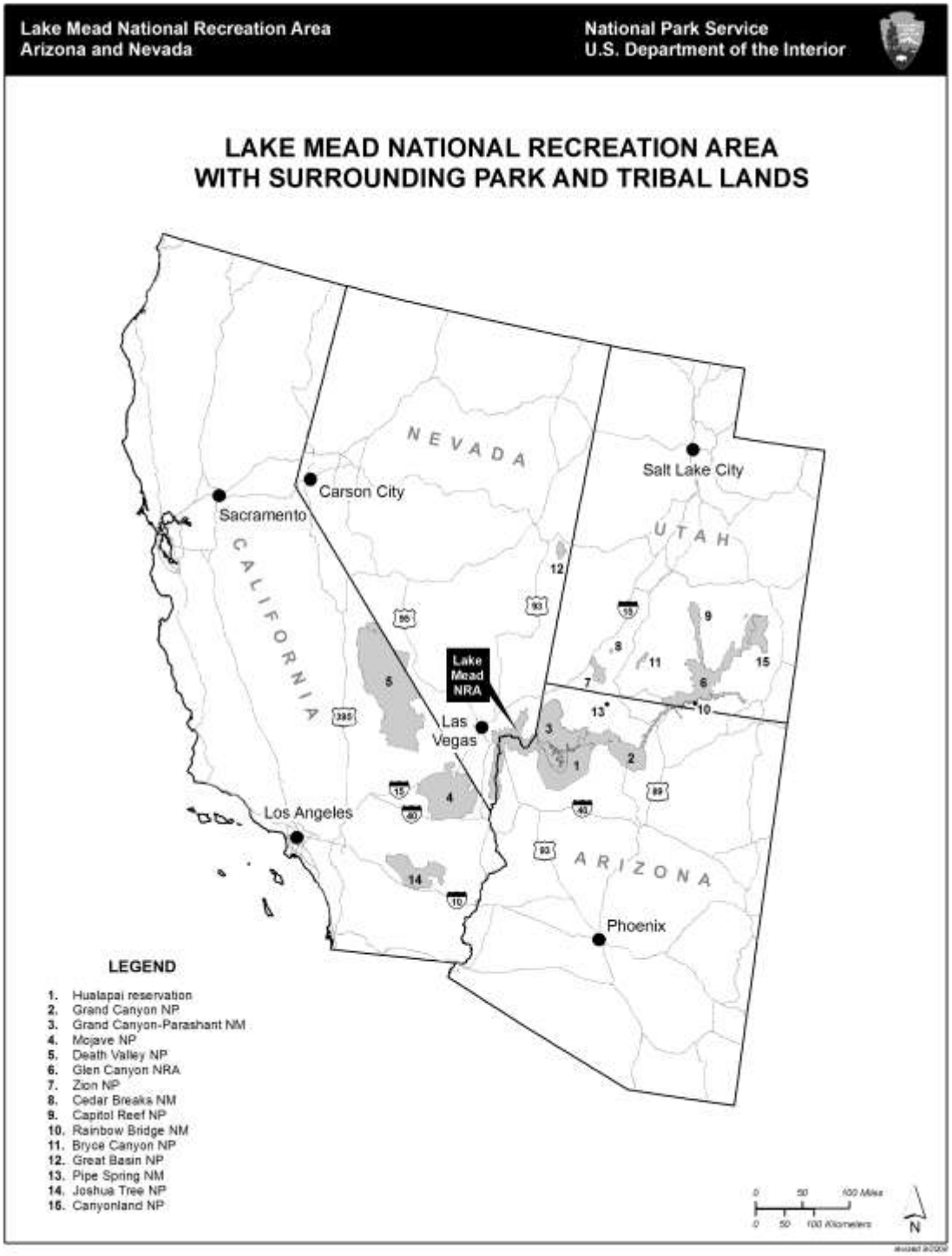
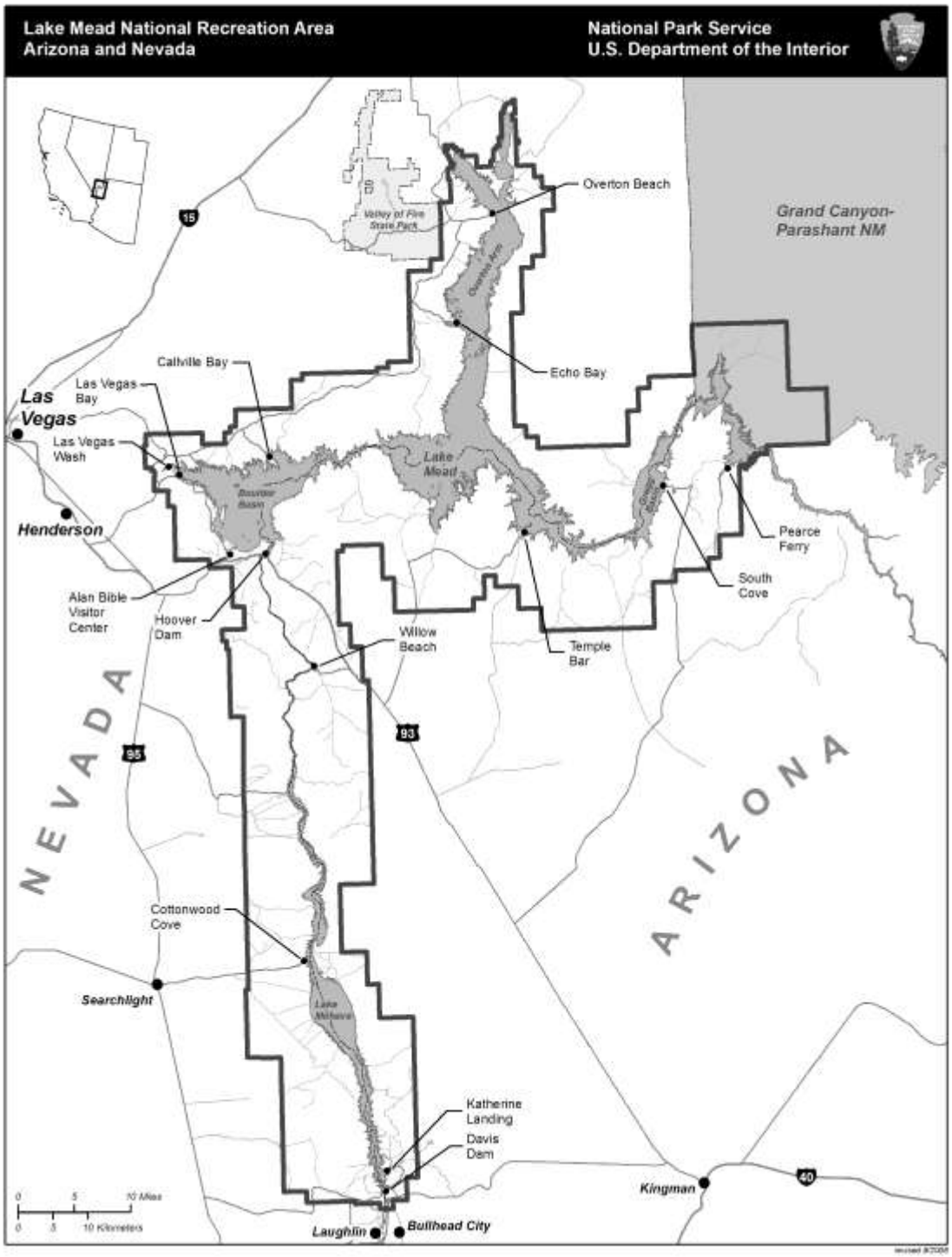


Figure 2. Lake Mead NRA



## *1.2 Relationship to Laws, Policies, and Other Plans*

### 1.2.1. Relevant Laws

The stated purpose of the NPS (*Organic Act of 1916*) is to "conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Lake Mead NRA was established by law in 1964 for "...the general purpose of public recreation, benefit and use, and in a manner that will preserve, develop, and enhance…the recreation potential, and in a manner that will preserve the scenic, historic, scientific, and other important features of the area…" (Public Law 88-639). The park considers its native plant communities to be important features of the area and thus their preservation, including management of exotic plants that threaten native plant communities, is consistent with the park's establishment as a unit of the National Park System.

The *Plant Protection Act* became law in June 2000 as part of the *Agricultural Risk Protection Act*. The *Plant Protection Act* consolidates all or part of 10 existing U.S. Department of Agriculture plant health laws into one comprehensive law, including the authority to regulate plants, plant products, certain biological control organisms, noxious weeds, and plant pests. The *Plant Quarantine Act*, the *Federal Pest Act*, and the *Federal Noxious Weed Act* are among the 10 statues that the new act replaces. The *Plant Protection Act* is necessary because of the major impact plant pests could have or currently have on the agriculture, environment, economy, and commerce of the United States. The *Plant Protection Act* gives the Secretary of Agriculture (and through delegated authority, the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture) the ability to prohibit or restrict the importation, exportation, and interstate movement of plants, plant products, certain biological control organism, and noxious weeds, and plant pests. The act also authorizes the Animal and Plant Health Inspection Service to regulate "any enemy, antagonist, or competitor used to control a plant pest or noxious weed."

Although the *Plant Protection Act of 2000* superseded and repealed most of the *Federal Noxious Weed Act of 1974*, section 15 (Management of Undesirable Plants on Federal Lands [7 USC 2814]) was retained. Section 15 requires federal land management agencies to develop and establish management programs to control undesirable plants of federal lands under the agencies' jurisdiction. Undesirable plants are those classified under state and federal law as undesirable, noxious, harmful, injurious, or poisonous. The act also requires that federal land management agencies enter into cooperative agreements to coordinate the management of undesirable plant species on federal lands where similar programs are being implemented on state and private lands in the same area. The Secretaries of Agriculture and the Interior must coordinate their respective control, research, and educational efforts relating to noxious weeds.

*Executive Order 13112 on Invasive Species* was signed on February 1999. Section 2 of the Executive Order directs federal agencies to identify actions that may affect the status of invasive species and take action to: prevent the introduction of invasive species, detect and respond

rapidly to control populations of such species in a cost-effective and environmentally sound manner, monitor invasive species populations accurately and reliably, provide for restoration of native species and habitat conditions in ecosystems that have been invaded, conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species, and promote public education on invasive species and the means to address them. The National Invasive Species Management Plan is an interagency document developed in support of EO 13112. The 2008-2012 Plan identifies five strategic goals: prevention, early detection and rapid response, control and management, restoration, and organizational collaboration.

*Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)* and the regulation established by the U.S. Environmental Protection Agency (40 CFR 116-117,195,170-172) serve as primary guidance governing pesticide registration, pesticide use, the training and certification of pesticide applicators, and the criminal and civil penalties associated with misuse of pesticides. *FIFRA* defines the term "pesticide" as (1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pests; (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant; and (3) any nitrogen stabilizer. Herbicide is a specific class of pesticide used to treat plants. All pesticides used in the United States must be registered by the U.S. Environmental Protection Agency. Registration ensures that pesticides will be properly labeled, and if used in accordance with specifications, will not cause unreasonable harm to the environment. Pesticide labels include direction for the protection of workers who apply the pesticide and direction for reducing exposure to non-applicators. Violation of these directions constitutes a violation of *FIFRA.* The storage and disposal of most pesticides are also regulated under the act, with specific direction provided on pesticide labels. Enforcement of the act is delegated to individual states. *FIFRA* also gives the U.S. Environmental Protection Agency review authority for biological control agents when they are used to control invasive pests.

The *National Environmental Policy Act* (NEPA) was enacted in 1969 for a simple reason: to make sure that agencies fully consider the environmental costs and benefits of their proposed actions before they make any decision to undertake those actions. The Act and subsequent regulations enacted by the Council on Environmental Quality establish two mechanisms to achieve this stated intent: (1) a requirement that all agencies make a careful, complete, and analytic study of the impacts of any proposal that has the potential to affect the environment, and alternatives to that proposal well before any decisions are made; and (2) the mandate that agencies be diligent in involving any interested or affected members of the public in the NEPA process. The National Park Service establishes agency policy and procedural requirements for compliance with NEPA in D*irectors Order/Reference Manual #12: Conservation Planning, Environmental Impact Analysis, and Decision-Making.* A separate environmental assessment was prepared in compliance with NEPA and agency procedures to analyze potential impacts that would result from the adoption of this Exotic Plant Management Plan for Lake Mead NRA. The environmental assessment analyzed impacts of routine and on-going activities but anticipates that additional analysis would be needed to introduce a new biological control agent or to conduct aerial herbicide application.

The *Wilderness Act of 1964* established a national wilderness preservation system "administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness (16 USC 1131)." The act defines wilderness as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Under Section 4(c) of the *Wilderness Act*, the following activities are generally prohibited in wilderness: commercial enterprises, permanent roads, temporary roads, use of motor vehicles, use of motorized equipment, use of motorboats, landing of aircraft, other form of mechanical transport, structures or installations. There are nine designated wilderness areas in Lake Mead NRA resulting in 185,051 acres: Jimbilnan, Pinto Valley, Muddy Mountains, Black Canyon, Eldorado, Ireteba Peaks, Nellis Wash, Spirit Mountain, and Bridge Canyon. Four of these wilderness areas are co-managed with wilderness on adjacent lands administered by the Bureau of Land Management: Muddy Mountains, Eldorado, Ireteba, and Spirit Mountain. There are an additional 212,900 acres of proposed, potential, and suitable wilderness within Lake Mead NRA. Exotic plants are known to occur in some wilderness areas of Lake Mead NRA. Thus treatment of these exotic plants in wilderness is constrained by the requirements of this Act and the NPS policies that implement it.

Congress passed the *National Historic Preservation Act* of 1966 because "the historical and cultural foundations of the Nation should be preserved as a living part of our community life and development in order to give a sense of orientation to the American people" (16 USC 470b [2]). Section 106 of the Act requires that federal agencies consider the effects of their undertakings on historic properties; that is, those cultural resources eligible for the National Register of Historic Places. Treatment methods proposed to control exotic plants and the presence of exotic plants among historic structures and archaeological sites may have effects on historic properties in the Park and thus require consideration and consultation under this Act.

Section 7 of the *Endangered Species Act* of 1973 requires all federal agencies to ensure that any action authorized, funded, or carried out by the agency will not jeopardize the continued existence of any endangered or threatened species or adversely modify any critical habitat of these species (16 USC 1536[a][2]). Each federal agency must consult with the U.S. Fish and Wildlife Service (or the National Marine Fisheries Service for certain marine and anadromous species) regarding any federal action that may affect a listed species. Numerous endangered or threatened species as well as critical habitat for these species exist in Lake Mead NRA. Pursuant to the Act, plans to control exotic plants must be consistent with the recovery plans for listed species, including the Clark County Multiple Species Habitat Conservation Plan which addresses the conservation of 232 species in Clark County Nevada, including some lands in Lake Mead NRA.

*Nevada Revised Statutes Chapter 555: Control of Insects, Pests, and Noxious Weeds* requires that every landowner or occupier of lands in Nevada control and/or eradicate noxious weeds. The Nevada Department of Agriculture (NDOA) defines a noxious weed as "any species of plant

which is, or is likely to be, detrimental or destructive and difficult to control or eradicate." An invasive plant is declared "noxious" in the State of Nevada after a legislative process is conducted that places the species on the State's Noxious Weed List. These statues also regulate the licensing of pesticide applicators in Nevada. These regulations, with some exceptions where federal law supercedes state law, generally apply to weeds and weed control efforts on those lands of Lake Mead NRA that are located in Nevada.

Noxious weeds and efforts to control them in the State of Arizona are regulated under *Chapter 2 of Arizona's Revised Statutes, Article 1: Dangerous Plant Pests and Diseases, Article 5: Pesticides, Article 6: Pesticide Control, and Article 6.1 Integrated Pest Management* . The Arizona Department of Agriculture has primary responsibility for administering the State's noxious weed program, including maintaining a list of noxious weed species. The Department regulates listed species, including all viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes). These regulations, with some exceptions where federal law supercedes state law, generally apply to weeds and weed control efforts on those lands of Lake Mead NRA that are located in Arizona.

### 1.2.2. Relevant Policies

*NPS Management Policies* (2006) Section 4.4.1.3 defines exotic species as " those species that occupy or could occupy park lands directly or indirectly as a result of deliberate or accidental human activities. Exotic species are also commonly referred to as nonnative, alien, or invasive species. Because an exotic species did not evolve in concert with the species native to the place, the exotic species is not a natural component to the natural ecosystem at that place." In section 4.4.4 the policy further defines the legal basis of a exotic plant management program by stating that "exotic species will not be allowed to displace native species if displacement can be prevented" and elaborates in section 4.4.4.2 that all exotic plant and animal species that are not maintained to meet an identified park purpose will be managed – up to and including eradication – if (1) control is prudent and feasible, and (2) the exotic species

- interferes with natural processes and the perpetuation of natural features, native species or natural habitats, or
- disrupts the genetic integrity of native species, or
- disrupts the accurate presentation of a cultural landscape, or
- damages cultural resources, or
- significantly hampers the management of park or adjacent lands, or
- poses a public health hazard as advised by the U.S. Public Health Service, or
- creates a hazard to public safety.

Section 4.4.5.2 prescribes that management of exotic species will be based on the use of an integrated pest management program to reduce risks to the public, park resources, and the environment from pests and pest-related management strategies. Integrated pest management is a decision-making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage by cost-effective means while posing the least possible risk to people, resources, and the environment. Specific policies

exist regarding pesticide use approval, storage, and reporting as well as the use of biological control agents.

*Director's Order/Reference Manual 12: Conservation Planning, Environmental Impact Analysis, and Decision-Making* (NPS 2001) lays the groundwork for how the NPS complies with the *National Environmental Policy Act* (NEPA). The Order sets forth a planning process for incorporating scientific and technical information and establishing a solid administrative record for NPS projects and programmatic plans, such as the Lake Mead Exotic Plant Management Plan. The Order requires that impacts to park resources be analyzed in terms of their context, duration, and intensity. It is crucial for the public and decision makers to understand the implications of those impacts in the short and long term, cumulatively, and in context, based on an understanding and interpretation by resource professionals and specialists. The Order also requires that an analysis of impairment to park resources and values be made as part of the NEPA document.

Management of wilderness in the National Park Service is guided by *NPS Management Policies* (NPS 2006) and *Director's Order/Reference Manual #41: Wilderness Preservation and Management* (NPS 1999). The Order directs "Potential disruption of wilderness character and resources and applicable safety concerns would be considered before, and given significantly more weight than, economic efficiency and convenience. If a compromise of wilderness resources or character is unavoidable, only those actions that have localized, short term adverse impacts would be acceptable." Any prohibited use proposed in wilderness for non-emergency activities must be considered and documented with a wilderness minimum requirement analysis. The wilderness minimum requirement analysis will first include a determination of whether such use is necessary for the administration of the area as wilderness, and if so, would then determine the minimum method or tool to that causes the least amount of impact to the physical resources and experiential qualities of wilderness as well as a discussion of alternatives considered.

### 1.2.3. Relevant Plans

The park's *Vegetation Management Plan* was completed in December 1992 and includes a chapter on exotic vegetation management; however, this document does not include an environmental analysis as required under the *National Environmental Policy Act* (NEPA). The park's *General Management Plan* was completed in 1986 and includes an environmental impact statement, but the scope of analysis for exotic plant management is limited to tamarisk control. The 1999 Lake Mead NRA *Resource Management Plan* and *State of Park Report* (1998) stated that the park should, "Develop a program for the management of exotic species, particularly plant species." Although the report states that over 100 alien species of plants exist in the park, only two plant species were mentioned by name. These two species were saltcedar and red brome. Saltcedar was noted as a significant invasive of riparian and spring systems, and red brome was mentioned as an invader of upland areas. Two additional park-wide plans have been completed in recent years: the *2003 Lake Management Plan and Environmental Impact*

*Statement* as well as the *2005 General Management Plan Amendment to Address Low Water Conditions and Environmental Assessment.* These documents focus on the shoreline and lake surface areas and their analyses of exotic plant management is limited to tamarisk control with very limited discussion of other exotic plant related concerns.

The Clark County Multiple Species Habitat Conservation Plan (MSHCP) was approved by the U.S. Fish and Wildlife Service in 2000. The MSHCP was prepared pursuant to section 10 (a) of the Endangered Species Act (ESA) of 1973, as amended, in support of an application for an incidental take permit for species listed under the ESA. The MSHCP identifies those actions necessary to meet the conservation goals and objectives of the plan for 78 species covered under the permit, including one species listed as endangered (southwestern willow flycatcher, *Empidonax traillii extimus*), one species listed as threatened (desert tortoise, *Gopherus agassizii*), and two candidate species for Federal listing (relict leopard frog, *Rana onca*, and yellow-billed cuckoo, *Coccyzus americanus*). The MSHCP planning area includes designated critical habitat for the desert tortoise, and proposed designated critical habitat for the flycatcher. The MSHCP also identified 103 evaluation and 51 watch list species that may be considered for inclusion under the permit for future phases of the MSHCP. All unlisted covered species are addressed in the MSHCP as if they were listed, meaning that the conservation measures in the MSHCP for those species would satisfy permit issuance criteria under section 10(a)(1)(B) of the ESA if the species was listed during the term of the permit. A total of 232 species are addressed. Implementation of the conservation measures in the MSHCP is a cooperative effort among many cooperators, including but not limited to the U.S. Fish and Wildlife Service, the Bureau of Land Management, the U.S. Forest Service, the National Park Service, the Department of Defense (DOD), Nevada Department of Wildlife, Nevada Department of Forestry, and other Federal and state land managers and regulators. The MSHCP includes species and habitats that occur in Lake Mead NRA that are impacted by exotic plants and might be impacted during weed management activities.

The Clark County MSHCP Weed Management Plan was developed in 2005 to coordinate existing activities and prioritize new projects focusing on weed inventory, eradicate, and monitor weeds in Clark County, Nevada. The Plan is used to comply with the requirements of the U.S. Fish and Wildlife Service for the conservation of species and habitats identified in the MSHCP and reaffirms Clark County's commitment as steward of weed management. In addition, the Weed Management Plan is used to aid in planning and coordination of future weed management activities for MSHCP partner agencies and serves as a standard by which the County measures progress toward the conservation goals identified in the MSHCP. The Weed Management Plan identifies goals and objectives for the management of weeds throughout Clark County, including prevention, detection, assessment/control, and restoration.

## *1.3 Exotic Plant Management Situation at Lake Mead NRA*

### 1.3.1. Exotic Plants are Increasing

Lake Mead has been spared invasion by many of the worst exotic plants in the Southwest, with the exception of saltcedar. Saltcedar (*Tamarix ramosissima*) has been the main invasive species of focus for the last 20 years, as it was recognized that saltcedar overgrew valuable springs and replaced native vegetation along the shoreline of the lakes. Saltcedar is well established on the shoreline along the entire river corridor and has serious detrimental effects on remnant native riparian vegetation and on endangered species, such as the Southwestern willow flycatcher (*Empidonax traillii extimus*), dependent on this habitat (DeLoach and Tracy, 1997; Walker and Smith, 1997). For many years, saltcedar control was the only invasive species control program in the park, with a focus on invaded springs and seeps in Lake Mead NRA with minimal effort on the reservoir shoreline as this area is constantly re-invaded by upriver seed sources and the fluctuating water levels leave a suitable environment for new colonization. Springs and seeps and certain riparian areas within Lake Mead NRA are considered high diversity sensitive habitats. Many springs contain or support sensitive animal species and also support rare plant species that are unique to these areas. All of these values are threatened by saltcedar invasions.

Springs that have had saltcedar removed at Lake Mead NRA have been partially restored to a pre-saltcedar condition. Native trees and plants return to the spring and native animals are again served by the spring. However, saltcedar is widespread in the region, particularly along the shorelines of Lakes Mead and Mohave, and seeds are capable of being wind dispersed long distances. Saltcedar removals and maintenance of a saltcedar–free area requires vigilance and control work to stay ahead of re-invasion. Experience at Lake Mead NRA indicates that it requires a relatively low level of maintenance to keep a treated spring saltcedar free, on average a visit every 1 to 3 years is sufficient to remove the subsequent re-sprout and regeneration of saltcedar.

More recently, a survey of developed areas and shorelines indicated that Lake Mead NRA had many more incipient and highly invasive species than previously known. The comprehensive inventory of alien invasive plants in Lake Mead NRA began in November 1999 and is ongoing. There are currently 101 species of alien plants recorded for Lake Mead NRA. This represents about 11% of the total flora. Although many of these species are rare or currently non-invasive, a number are seriously invasive. Other non-native plant species that are known to be invasive that have been found on the shoreline of Lakes Mead and Mohave are athel (*Tamarix aphylla*), fountaingrass (*Pennisetum setaceum*), tree tobacco (*Nicotiana glauca*), oleander (*Nerium oleander*), date palm (*Phoenix* sp.), Mexican paloverde (*Parkinsonia aculeata*), Sahara mustard (*Brassica tournefortii*), camelthorn (*Alhagi pseudoalhagi*) and giant reed (*Arundo donax*).

Currently, invasive species of plants can be found in developed areas (such as along roadways and at boat launch areas) and to a lesser extent in undeveloped areas (such as springs, washes, remote shorelines, and open desert). As human pressures on the park have increased, so have the number and magnitude of invasive plant species. New alien species are regularly recorded from the park and occasionally these new records coincide with recognition of the invasive nature of the species. Sources of exotic plant introductions and spread are the inflow areas of the lakes,

washes that drain into the park, people, construction, ground disturbance, vehicles and road corridors, boaters, animals, and from adjacent lands including urban gardens.

The Colorado River can act as a corridor for exotic plants to move from Lakes Mead and Mohave to areas downstream and upstream - including Grand Canyon National Park and the lower Colorado River. Exotic plants can enter Lake Mead from the urban Las Vegas area via Las Vegas Wash, or from washes or river systems entering the Colorado River, such as the Muddy and Virgin Rivers.

Visitors come from all over the country to recreate in Lake Mead NRA. Roads, utility corridors, concessioner-operated areas, campgrounds, housing, and other recreational areas are present within the park, with new development and construction activities occurring periodically. Major highways provide access throughout the park, including U.S. Highway 93, U.S. Highway 95, Nevada Highway 163 and Arizona Highway 68. Road improvement and construction activities have been taking place consistently throughout the recreation area for the past 15 years. All of these factors involve the disturbance of natural ecosystems, one of the most significant factors in the spread of invasive plant species.

### 1.3.2. Aquatic Environments and Exotic Plants

Boating activities have the potential to introduce and spread invasive plant species. They can bring aquatic exotic plants from other water bodies and spread them to different areas within the recreation area. The spread of aquatic invasive plants is easily accomplished if a boat carrying an invasive plant launches and pumps water from the hold, or fragments of the invasive fall from the propeller while on the lakes. Aquatic invasive species could be damaging to the entire lake ecosystem, as well as to recreation, fisheries, water delivery, power generation, and dam operations.

In addition to harboring exotic aquatic plants, water may also aid in the seed dispersal of upland exotic plant species. Recent research at Lake Mead found that Sahara mustard seed can withstand six weeks of submergence while still remaining viable and capable of colonizing new areas as currents float the seeds to other shorelines (Bangle et al. 2008). Other species, such as perennial pepperweed, oleander, and giant reed, may exhibit similar water aided dispersal mechanisms. Thus the lakes themselves may serve as primary vectors to transport exotic plants from one shoreline to another. With approximately 1200 miles of shoreline on Lakes Mead and Mohave, much of which is an exposed mud flat along the shores of Lake Mead as a result of lake level declines, this situation is a prime opportunity for exotic plant spread to new and sometimes remote areas.

### 1.3.3. Landscaping

Native and non-native animals, including domestic animals and livestock, can also be vectors or dispersal mechanisms for certain invasive plant species.

Construction, development, and landscaping all are ground disturbing activities that have the potential, or that have led to the introduction and spread of alien plant species within the recreation area.

It is well known that some of the most invasive species in natural environments were introduced to those environments by humans (Mooney et al. 2005). Lake Mead NRA is no exception. Several species of invasive plants were first introduced to Lake Mead NRA in landscaping and still remain in landscaped areas, with a few species that have naturalized into adjacent natural areas. Examples include: giant reed (*Arundo donax*), Bermuda grass (*Cynodon dactylon*), oleander (*Nerium oleander*), tree tobacco (*Nicotiana glauca*), fountaingrass (*Pennisetum setaceum*), date palm (*Phoenix dactylifera*), athel (*Tamarix aphylla*), and chastetree (*Vitex agnus-castus*). One of these species, athel, has proven to be more invasive at Lake Mead NRA than has been documented elsewhere.

### 1.3.4. Cactus and Hybridization

Certain groups of plants, particularly the genus *Opuntia*, the genus of beavertails and cholla cactuses are known for their ability to hybridize. Any non-native *Opuntia* cactus that is planted in landscaping at Lake Mead NRA could potentially pollute the gene pool of the native cacti in the area. Some examples in Lake Mead NRA developed areas include cow's tongue pricklypear (*Opuntia lindheimeria* var. *lingulformis*) and cinnamon cactus (*Opuntia microdasys* var. *rufida*) which exist in some of the trailer villages. The consequence of this gene-pollution may be invisible or scarcely noticed, but may have significant effects over time on the native cactus population.

### 1.3.5. Off-Road Vehicles

Illegal use of off road vehicles (ORV) damage undisturbed soils and vegetation. They create scars on the landscape, compact soils, destroy plants, kill animals, and damage sensitive biological crusts (Gelbard and Belnap 2002). However, one of the most lasting and damaging effects of ORV activity may be the introduction of invasive species in remote and undisturbed areas that may go undetected for some time. Therefore, exotic plants that get established in hidden or remote areas may increase in population size to the point of being quite damaging and hard to control before ever being discovered. Off road vehicles may have been used in areas where invasive species were present prior to being brought into the park. The vehicles may still have mud or dirt attached to tires or other parts of the vehicle. Because the vehicles run over and through vegetation, they may pick up exotic plant seed and vegetation from roadsides and transfer invasive exotic plants to areas of the park that are free of exotic plants. Even though the tracks may be raked out and the visual impact of the violation diminished, the potential for the beginning of a hidden, hard to locate, exotic plant infestation has been created.

### 1.3.6. Construction Zones

Lake Mead NRA has numerous construction projects underway at any one time. Some are NPS-led projects related to administrative or recreational facility maintenance or expansion, but most construction projects in the park are undertaken by outside organizations. The Park includes almost 1000 miles of approved roads as well as many other linear corridors such as powerlines and water lines. Since 2003, a major Federal Highway Administration construction project has been underway in the Park to re-route U.S. Highway 93 around Hoover Dam for national security purposes. There are also several major facilities within the park boundary that are operated by outside organizations, including two major hydroelectric dams, two fish hatcheries, multiple wastewater discharge systems, and multiple municipal water intakes. These corridors and facilities periodically require construction for their maintenance or expansion, thus leaving a foot print on the park. While the park, and specifically the Resource Compliance Branch, works closely within the park and with outside organizations to avoid, minimize, and mitigate impacts as a result of these construction projects, they almost all leave some sort of footprint of surface disturbance that may be vulnerable to colonization by exotic plants. The impact of these new invasions is magnified by the fact that many of the construction zones may serve as vectors for further exotic plant dispersal (e.g. roads, parking lots, etc).

### 1.3.7. Urbanization and Human Population Growth

The park is adjacent to Las Vegas and has urban areas on three of its four boundaries: Overton to the north, Las Vegas to the west, and Laughlin/Bullhead City to the South. The eastern boundary communities of Dolan Springs and Meadview, Arizona are still small towns but are expanding. For the last several years, Las Vegas has been one of the fastest growing cities in the United States, with the current population estimated at 1.6 million people. It has been recently reported that the number of invasive species in a region is positively correlated with the length of time people have been in the region and with the number of people in the region (Kowarik 2003).

Another side effect of urbanization is roadway development, which serve to connect disparate parts of the landscape and serve as conduits for exotic plant invasions (Gelbard and Belnap 2003). These road corridors allow species to disperse across inhospitable landscapes to other suitable landscapes, made accessible by the road itself. Once established along roadsides, some exotic plant species can then invade adjacent wildlands. Young et al. (2003) state that "every major exotic range weed in the Great Basin, including cheat grass, started out as a roadside weed." Thus the impacts of urbanization are not limited to the urban areas but also to the roads and utility corridors that connect areas of human population.

In addition, new species of plants are constantly being introduced as garden and landscaping plants, while native desert habitats are constantly being destroyed by urban development. The invasiveness of garden and landscaping species is not a consideration for importation approval. The focus on drought- and heat-tolerant landscaping species means that new, potentially invasive species are constantly being brought into the urban areas in a quest for attractive, hardy, and low maintenance urban landscapes.

The relative scarcity of exotic plants in southern Nevada compared to elsewhere in the United States may simply be an artifact of the lower human population the state of Nevada has had in the past and the reprieve may be ending. The fact that the region is one of the driest and hottest in the country may not protect it from alien plant invasions as more people means that more non-native species may be imported both intentionally and unintentionally. It is expected that the park will continue to be invaded by an assortment of exotic plants arriving from various areas of the country and the world into the foreseeable future.

### 1.3.8. Invasibility of Wildlands

The concept of invisibility focuses on the traits of the lands and plant communities that serve to either encourage exotic plant invasions or resist them. Two promising concepts explaining community invasibility are the diversity-resistance hypothesis and the resource-enrichment hypothesis (Gilbert and Lechowicz 2005). The diversity-resistance hypothesis suggests that a more diverse native community is more resistant to invasion (Kennedy et al. 2002); while the resource-enrichment hypothesis presumes that communities are susceptible to invasion when there is a decrease in the use of resources (e.g. water, soil nutrients, etc.) (Davis et al. 2000, Gilbert and Lechowicz 2005). Anthropogenic disturbances play a significant role in altering invisibility under either hypothesis through human-induced changes in community composition, diversity, and cover; all of which can impact available resources.

Anthropogenically-caused habitat destruction and fragmentation, often considered some of the major threats to biodiversity (Ehrlich 1998), may be more destructive than originally thought by facilitating invasive species introductions and establishment (Gelbard and Belnap 2003; Merriam et al. 2006), decreasing native diversity, and altering community's resource balance. Of particular concern are linear disturbances like roads, trails, utility corridors, and fuel breaks which can serve to foster invasion of exotic plants into otherwise remote wildland settings. In this way, the widespread ecological damage caused by the invasion of exotic species is far out of proportion with the relatively small size of the initial disturbance (e.g. the footprint of a utility corridor).

Many invasive plants are ruderal species and perform well in disturbed habitats. Wildlands, wilderness, and backcountry areas which retain self-sustaining ecosystem processes and remain relatively free of human disturbance present opportunities to manage and maximize community resistance. Managing disturbance to prevent the spread of invasive plants into wildlands requires a thorough examination of human activities. Effective prevention is possible, but only when those directly affected understand the risks, requirements, expectations, and lines of communication (Le Maitre et al. 2004). As a result, adherence and participation in a prevention program is likely to vary externally (visitors and adjacent landowners) and internally (park staff and functions), requiring different methodologies for each.

Minimizing the spread of weeds through agency practices involves the integration of four general practices in all park operations: education, disturbance mitigation and minimization, prevention, and restoration. Many necessary park operations and legitimate uses have the ability to disrupt otherwise stable communities and create infection points where weeds can begin their invasion process. Park operations and uses with inherent disturbance include road and trail creation, maintenance, and use; building and maintaining utility corridors; creation and maintenance of fire/fuel breaks; livestock grazing; and trail riding. Disturbance mitigation and management, with ecologically appropriate methods and restoration plans, incorporated into park activities maximizes the inherent ability of communities to resist invasion.

### 1.3.9. Climate Change

The Earth's atmosphere controls the climate and ultimately the environmental conditions in which species live and die (Schlesinger 1997). There is significant evidence showing that the atmosphere is changing as a result of human activities (Schlesinger 1997, Hegerl et al. 2007). Globally increasing temperatures have been attributed to increasing atmospheric $CO_2$ since the start of the industrial revolution in the late 1800's (Miller 2003). Changes in the earth's temperature are now detectable on land, in the atmosphere and in our seas. Alterations in the abiotic components of ecosystems have dramatic effects on habitats as well as plant and animal distributions. A landscape of shifting climates and habitats may offer new opportunities for exotic plants to invade as many of the world's most successful invasive species tolerate a wide range of conditions, including heat and/or drought (Henson 2008).

Modern climates have been documented for over 100 years with most data sets consistently recorded since 1948 (NOAA 2007). Over the relatively short period of recorded climatic data, several patterns of change emerge at a variety of spatial scales. Analyzing data between 1890 and 1996, the EPA reports a change in global mean surface temperatures that vary between 0.6-1.2$^{o}$F (EPA 1998). In the Lake Mead NRA region, climate data for Las Vegas, Nevada from 1937 to 2006 also show a definite warming trend: the ten warmest years on record have all occurred since 1981 and five of the top ten have occurred since 2000 (Gorelow 2005). Similarly, the ten hottest minimum temperature years have all occurred since 1994. The implications are that the Mojave Desert, already one of the hottest places in North America, is getting hotter.

The individualistic and the general trend of plant species response to past climate fluctuations offer some insight into how ecosystems may respond to modern climate change and what impact invasive species will have in the future. First, plant species migrating at varying rates will increase disturbance associated with population effects of competition, predation, and disease; furthermore, such disturbances undoubtedly make ecosystems more susceptible to invasion by exotic species. Second, humans disperse exotic plants through the economic trade of ornamental, aesthetic, and agricultural plant species. Many exotic species are good dispersers and as climates change invasive species may thrive in new environmental regions (Middleton 2006) through purposeful or unintentional human-assisted migration. Human dispersed plants

are anticipated to be the weeds of the future as climates fluctuate potentially creating favorable conditions for spread and invasion.

Historically, plants have been able to follow favorable growing conditions unabated. Modern landscapes are fragmented by features like roads, cities, and political boundaries (e.g. the international border fence between the United States and Mexico) that will probably become impediments to the dispersal of some native plants while roaming towards ideal environmental conditions (Naumburg 1997). Predicting plant response, native or invasive, to climate change in a fragmented landscape may prove increasingly difficult; however, a few principles set the expectations for the future of plants in changing climates:

- Plants adapted for long-distance dispersal are likely to find favorable conditions.
- Rare plants and poor dispersers may experience local extinctions.
- Isolated populations near the edges of native ranges will be most vulnerable to climate change (Pitelka 1997).
- Plants dispersed through horticultural trade may prove to be the weeds of tomorrow.

These principles coupled with an increasing anthropogenic demand for resources, specifically water in the southwest USA, will further degrade many of the unique habitats of desert ecosystems. The redistribution of surface and ground water to meet human demands will impact some of the most important ecosystems in deserts including wetlands, springs, and riparian areas by drawing down groundwater and reducing availability. Climate change and habitat destruction combined cause a double bind where species most likely perish (Pitelka 1997, EPA 1998).

Some exotic plant species may benefit indirectly from realized and anticipated changes in atmospheric conditions. Experimental research has shown that some weeds, particularly the brome grasses (*Bromus spp*.) which already infest millions of acres in the western US, may find elevated $CO_2$ conditions even more suitable, thus allowing them to increase their range and abundance. Increased invasion by brome grasses will continue to alter fire regimes of the west and further alter ecosystem structure and function favoring an annual brome dominated fire cycle replacing native vegetation unable to compete or respond rapidly to an increased fire frequency (Brooks et al. 2004, Chambers et al. 2007).

A series of complex and interacting factors make absolute predictions of how species move, where they will go, and which species are likely to be successful in the future difficult; however, the physical properties of ecosystems, such as adiabatic rates and geographic barriers, will not change but may exaggerate effects of climate change. Climate change will likely impact exotic plants in ways similar to native species; however, in a disturbed and fragmented landscape continued invasion by exotics seems likely. Locations in close proximity to development will likely become invaded by new and novel weeds, while the effects of climate change may further the invasion of known weeds.

## *1.4 Purpose of this Plan*

The overall goal of the Exotic Plant Management Program, and thus this Plan, is to maintain native plant communities by preventing and removing exotic plants using an integrated approach that maximizes the effectiveness of the action while minimizing the undesirable impacts of the exotic plant and the management action. Exotic plant management is a key component of the park's efforts to maintain, and restore if needed, native plant communities and ecological processes for the purpose of protecting the integrity of the park's terrestrial and aquatic ecosystems.

This action is needed to avoid, minimize, and mitigate the impacts of exotic plants on park resources. Exotic plants enter the park by various means. Seeds and plant parts are brought into the parks by wildlife, wind, water, and humans. Fast-growing exotic plants encroach from populations established outside park boundaries, particularly from the surrounding urban areas. Once inside park boundaries, the most aggressive of these species can quickly spread into undisturbed as well as disturbed areas. These invasive plants often cause irreparable damage to natural resources. The ecological balance of plants, animals, soil, and water achieved over many thousands of years is destroyed. As native plants are displaced, wildlife populations that rely on the plants for food and shelter also decline. Exotic plants may reduce or deplete water levels, or alter runoff patterns and watershed processes, thus diminishing both the land and water quality. Some exotic plants release toxic chemicals into the soil or harbor diseases, increasing the stress on native plants. Some nitrogen-fixing exotic plants increase soil fertility, allowing other exotic plants to outcompete plants that have evolved in the nutrient-poor native soils. Exotic plants that interbreed with native plant species can contaminate native gene pools. The growth and spread of exotic plants can also change fire frequency, size, and intensity, resulting in an altered ecosystem.

Threats from exotic plants continue to increase as the opportunity for new species or at least new seed sources of other species continues to increase with the increase in development in the Vegas Valley. Las Vegas Wash carries the stormwater and wastewater effluent directly from the urban environments of Las Vegas to Lake Mead, which also carries seed and propagules into the park. There is also the potential for invasion from river flows that feed Lake Mead, specifically Virgin River, Muddy River, Upper Colorado River, and Meadow Valley Wash. Boats also serve as vectors for the transport of exotic plants, specifically aquatic exotic plants.

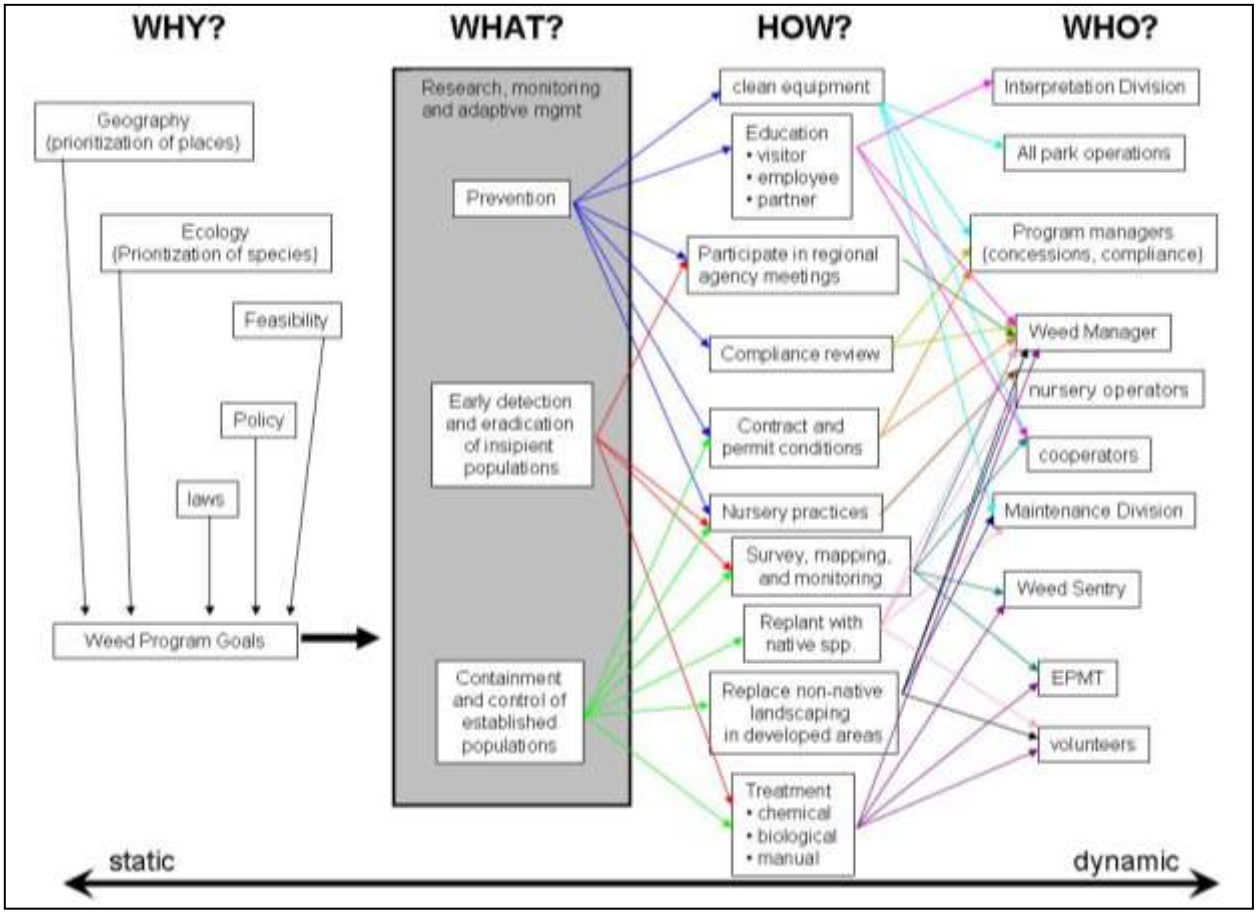
The park has initiated several new exotic plant management projects in recent years in response to the increased priority placed on exotic plant management in the National Park Service and the increased opportunities to fund such efforts through internal and external funding sources. Increased partnerships and cooperation have also led to new opportunities to address the park's exotic plant issues. One example of a successful exotic plant-focused management project is the Lake Mead Exotic Plant Management Team which focuses on treatment of high priority exotic plant populations in several desert parks. There are also on-going park operations that contribute to exotic plant management in various ways, including the Lake Mead Native Plant Nursery which provides native plants to restore sites that have been degraded by exotic plants, the interpretation program which seeks to educate park visitors and the surrounding communities

about the parks native resources, and the compliance program which analyzes proposed projects for potential impacts to native plant communities.

While these project-based efforts and contributing programs have been individually successful their effectiveness could be magnified if they were integrated into a comprehensive exotic plant management program and implemented programmatically under an Exotic Plant Management Plan. Additionally, development of such a plan would provide comprehensive guidance and documentation for project managers and cooperators, provide a context for systematic evaluation and adaptive management, facilitate the transfer of information to the public and our partners, improve fiscal accountability by focusing on species and/or places where efforts yield the most benefit, enhance the effectiveness of the program by providing the required environmental analysis of more aggressive control measures, improve efficiency by identifying and eliminating redundancies between program elements, and finally, lay a course for the future by identifying additional program elements that are needed to achieve the park's exotic plant management goals. This plan is accompanied by a programmatic environmental assessment that analyzed impacts of routine and on-going activities but anticipates that additional analysis would be needed to introduce a new biological control agent or to conduct aerial herbicide application.

This plan is expected to have a useful life of about 20 years. To that end, the focus is on those program areas that are most stable, namely why exotic plants are treated, what the program includes, and how those actions are carried out, with less emphasis on who does the work as the dynamic nature of funding sources and organization relationships dictates that such details will vary over time. Figure 3 graphically shows the major program areas of Why?, What?, How?, and Who? and briefly lists the elements of each. Note that elements listed under "How" and "Who" are not meant to be complete lists, but rather examples of the major elements of that program area. The lines show the logical relationships between the program areas and elements, thus illustrating how law and policy are translated to on-the-ground management actions and accountability of the persons responsible.

Figure 3. Exotic plant management strategy and relationship between program elements.



## *1.5 Exotic Plant Management Program Goals*

- Vegetation Program Goal: Maintain, and restore if needed, native plant communities and ecological processes for the purpose of protecting the integrity of the park's terrestrial and aquatic ecosystems, thus reducing their vulnerability to invasion.

- Exotic Plant Management Goal: Maintain native plant communities by preventing and removing exotic plants using an integrated approach that maximizes the effectiveness of the action while minimizing the undesirable impacts.

  - Objective 1: The exotic plant management program operates within a framework of adaptive management where research and monitoring are used to systematically evaluate actions and outcomes for the purpose of improving management actions.
    Actions:
    - At a minimum, use North American Weed Management Association standards for geospatial data collection devices and databases to systematically collect and store data about exotic plant monitoring efforts, exotic plant occurrence, treatments implemented, and treatment effectiveness.
    - Analyze collected data to determine if the current course of action is best or should be modified to better meet the program goals and use scientific analysis and statistical controls where appropriate.
    - Share information with partners, the public, and the scientific community.

  - Objective 2: Proactively prevent the introduction and/or expansion of new exotic plant species.
    Actions:
    - Park-wide SOPs – equipment cleaning, fill sources, top soil salvage and re-use, etc.
    - Education – employee, visitor, partner
    - Landscaping requirements (including replacement)
    - standard contract language
    - standard permit language
    - compliance review process
    - nursery practices (SOPs)
    - participation in regional agency meetings to monitor surrounding exotic plant vector sources and collaborate on treatment and research

  - Objective 3: Actively detect and eradicate incipient exotic plant populations.
    Actions:
    - Focus on high priority exotic plant species using a plant-based approach
    - Participation in regional agency meetings
    - Nursery practices (SOP)
    - Survey, mapping, and monitoring
    - Implement integrated pest management practices using chemical, manual, cultural practices and/or biological controls

- monitor and treat major in-park exotic plant vector sources using a site-based approach
- monitor and treat highly valuable natural habitats such as springs using a site-based approach

- Objective 4: Contain and, if possible, eradicate established exotic plant populations. Actions:
  - Focus on high priority sites (springs, endangered species habitat, vector sites) using a site-based approach
  - Implement integrated pest management practices using chemical, manual, cultural practices and/or biological controls

# Chapter 2: Exotic Plant Science

## *2.1 Exotic Plant Ecology*

Certain plant species are adapted to be early colonizers of disturbed habitats. Disturbance, whether natural or manmade, is a niche in which certain species of plants that are adapted to live in that niche, can exploit. These species usually have fast growth, frequently are annual plants or reproduce soon after establishment, have high viable seed output, often without the need for cross-pollination, and have long distance dispersal mechanisms. All of these life history features allow these species to arrive on a disturbed site early after disturbance and to dominate it for a short period of time. Furthermore, the life history features that make many of these species good invaders of disturbed habitats make them easy to spread by humans to new environments and to persist in those new environments. Therefore, many early successional plants have become disturbance followers of humans in diverse environments around the world.

Certain early colonizing species would probably decline during succession in their native environments, as other more competitive, longer lived, or taller growing native species establish on the initially disturbed site. Human disturbance followers have had an ongoing niche that never has declined in availability. A large portion of the alien flora of the United States and the world are these species. It is somewhat expected that disturbed sites become inundated with aliens and native plants that are considered weeds.

In agricultural areas, which are chronically disturbed, invasive exotic plants can have serious detrimental economic effects. Part of the rationale for establishing federal and state noxious weed laws was to combat invasive exotic plants in agricultural systems. On large landscape scales, invasive exotic plants can require expensive applications of herbicides, breeding programs to enhance vigor and competitiveness of crop plants, and other methods of control. The invasive exotic plants, if left untreated, can spread rapidly to neighboring fields, districts, and states.

The alien species of plants of most concern to managers and protectors of natural ecosystems are usually not the annuals that follow disturbance and decline as natural succession proceeds, but perennial species of plants that persist in and dominate natural functioning systems, and which may halt natural succession or severely disrupt it. The plants that are vigorous invaders of a particular ecosystem are those plants that for some reason have features that allow them to survive and reproduce adequately in their native environment. Those same features make the plant highly competitive in the new environment, where constraints to growth, reproduction, or dispersal do not exist. In other words, the most serious invaders are species of plants that thrive better in the new ecosystem than they do in their native environment.

**Example**

Honey mesquite, *Prosopis glandulosa*, which is vigorously protected at Lake Mead NRA is a major invasive of Africa and Australia. Monterey pine, *Pinus radiata*, which is protected in its narrow native range in California, is an invader of open lava fields and diverse habitats in Australia, New Zealand, and Africa. Showy lupine, *Lupinus polyphyllus*, considered a rare native of Lake Mead NRA is an invasive species of New Zealand.

The severe environment of the Mojave Desert does not prevent the desert from being invaded by alien plants. Lake Mead NRA has already been invaded by several species of plants that have become ubiquitous in the flora. Saltcedar has invaded riparian areas and springs with incredible success. The open desert has been invaded by annual invaders. The most successful invasive species in the Mojave Desert appear to be annuals that establish early in the season, grow rapidly, and in effect, displace native annuals in the same habitat. Native annuals may not germinate or be able to establish and grow under the canopy of early establishing alien herbs and grasses and in competition with aliens for moisture and favorable microsites. Over time, the seed bank of the native species probably declines as the seed bank of the alien species increases.

Riparian zones in the Mojave Desert will always be invaded by perennial aliens that are able to replace natives in that habitat. The open desert will be constantly inundated by alien annual species. All of the widespread invasive exotic plant species of Lake Mead probably were once either uncommon roadside weeds or a shrub in a spring or along the shoreline.

## *2.2 Invasion Ecology*

Plant invasions tend to follow a pattern that can be predicted (Cronk and Fuller, 1995). An invasive plant is introduced to an ecosystem or area, usually intentionally brought in as a landscape or garden plant, or unintentionally naturally, on machinery, vehicles, or boats, or as part of management practices. The plant begins to naturalize and the naturalized populations appear to remain small for a length of time, a period called the lag time (Kowarik, 1995). During this period, managers monitoring the population may conclude that the plant is not a threat.

Then, for various reasons, some of which may be unknown, the alien species begins to reproduce more rapidly and population starts to grow rapidly and then exponentially (Cronk and Fuller, 1995). At this point, management resources are rarely able to keep pace with the rate of the invasion. In some cases, established populations of exponentially growing species are difficult to reduce and total control could be impossible.

Some of the ecological reasons that a seemingly non-invasive plant may appear to become suddenly invasive may include climate or habitat changes that favor invasive species (such as, allelopathy, increased attractiveness to dispersal or pollinator vectors, increased chances for genetic mixing, increased fuel loads that lead to wildfires, or increased soil fertility), chance or random dispersal to favorable habitats, dispersal or pollination mechanism or vector changes due to increase in or introduction of vectors, or increase in activity of the vectors, evolution of

favorable genetic combinations due to chance mutation or gene combinations, and hybridization with newly introduced genetic stock (Cousens and Mortimer 1995). Although all of these factors may influence invasiveness of seemingly non-invasive species, most cannot be reasonably predicted.

Many major invasions have started with a few seemingly benign individuals in a garden or a field, or naturalizing along a road or a riverbank. While one invasion is prioritized for control, other invasions may be just starting or spreading, making the task of alien plant control ever more daunting. If a plant species is recognized as invasive and controlled when the population of naturalizing individuals is still small, the chance for total control is greater (Cronk and Fuller, 1995). As long as the plants that are the source of the invasion are still present in the environment, total elimination of the invasive plant may be impossible, but containment may be realistic when the invasion is caught early.

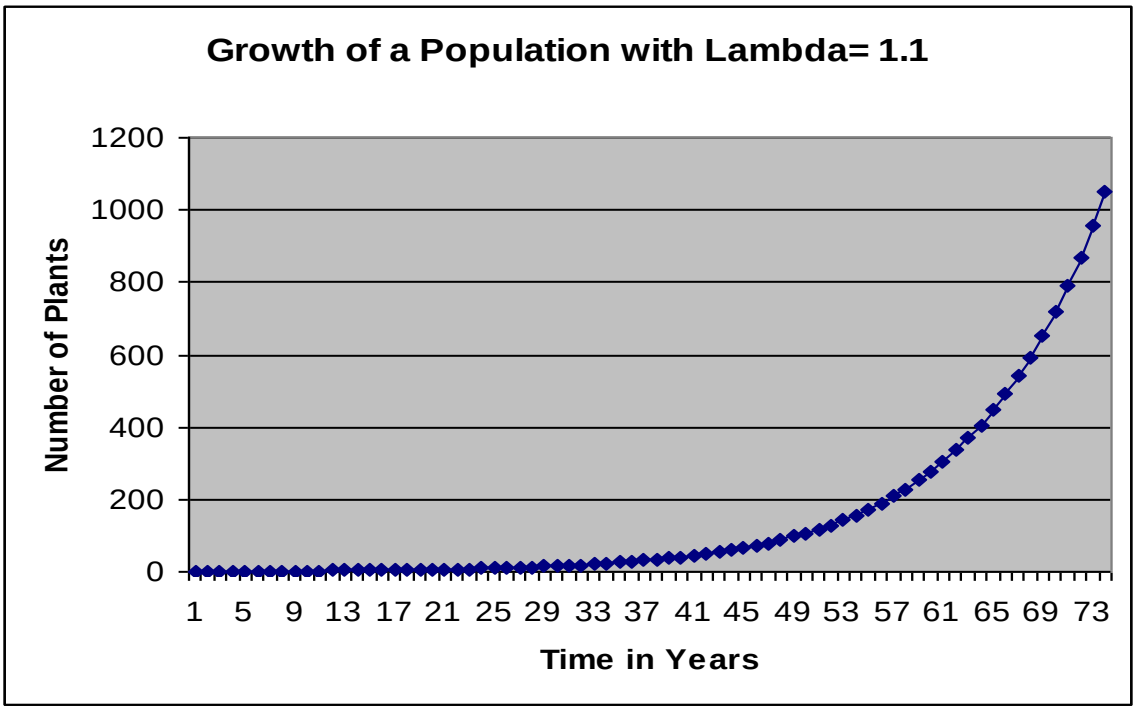
Alien species do not have to prove their invasiveness and destructive abilities before they are eliminated from natural areas. Any plant species capable of naturalizing in the natural environment of a region should be removed from cultivation, if cultivated, and aggressively eliminated or contained if total elimination is impossible.

## *2.3 Population Growth*

Any population of entities or living creatures that reproduces itself over time with a net positive gain in population size can be considered a growing population. Similarly a population of entities that does not increase in net numbers over time could be considered a stable population. A population that declines in net size (or numbers) over time could be called a declining population. The symbol that is used in mathematics to define population growth rate is lambda ( $\lambda$).

When $\lambda$ equals 1, a stable population is defined. If $\lambda$ is less than 1 then a declining population is defined. If $\lambda$ is greater than 1 then an increasing population is defined, and the population growth is positive over time. When $\lambda$ is greater than 1, then the population will have a growth curve that is the same as that of an invasive species in a new environment (Figure 4). The X axis of this chart is time, and could be years or generations of the species being measured. The Y axis is the number of individuals in the population. For this curve, the number in population starts at 1 individual and a $\lambda$ value of 1.1 was used. The curve is generated by successively multiplying 1 times 1.1 and the outcome of each multiplication iteration again by 1.1.

Figure 4. Mathematical considerations of exotic plant population growth.




The long flat part of the early portion of the growth curve is called the lag time or lag phase. The population during this part of the growth curve appears to be growing in numbers very slowly. For the example given, the population does not reach even 2 individuals until year 9, but it only takes 4 years later to reach 3 individuals. By year 26, there are ten individuals in the population. To most observers, this population would appear to be stable and non-invasive: the small increase in the number of plants would not be noticeable over the time frame observed. It may appear that the plant did nothing for over 25 years and then suddenly, became invasive. In fact, the population does not even reach 100 plants before year 50. However, by year 57, the population has doubled. By year 74, the population has reached 1,000 individuals. If the plant was annual and experienced population fluctuations, it may be even harder to notice a gradual increase in numbers during the lag time phase.

Although the overall appearance of the growth curve during the lag phase is of a flat or stable population, it is growing at an ever increasing rate. The number of years between doubling of the population size becomes increasingly less, until the curve begins to start to curve into an exponentially increasing growth curve. However, mathematically, the multiplication factor has not changed: it is still 1.1 for every year. In other words, the number of individuals in the population has reached a critical mass, such that even a small positive growth rate has large consequences in each multiplication iteration (or year or generation).

The exponential growth curve demonstrated here is similar to ones that have actually occurred for a wide variety and scale of living organisms, from bacteria on a petri plate to humans on earth. In other words, a chronic, long term average, positive rate of growth, a simple definition

of which may be that there are more individuals now than before, always will result eventually in a population growing at an exponential rate of growth. Because it is obvious that this rate of growth cannot continue indefinitely, ecological limits (to be discussed below) can dampen the growth rate: populations may crash to extinction when resources become exhausted or the environment becomes polluted or poisonous to the point at which it either cannot support or actually, prevents life.

It is generally accepted in invasive plant ecology texts that in order to prevent a population of invasive species from getting out of control, that is, growing more rapidly in numbers than control can possibly or realistically prevent or dampen, control must start before the exponential or rapid growth part of the curve is reached. Once growth has become this rapid, eradication may become impossible and if the growth rate is extremely rapid, even control may be impossible.

Rarely is a plant species identified as invasive before there is a rapidly growing and large population of plants to contend with. At this point in time, various aspects of the species that had been ignored or overlooked are now becoming obvious. For instance, the plant has invaded natural areas, it appears to compete with native plants, or it appears to adversely affect ecosystem functions. None of these negative attributes may be obvious or even definable when the population was small.

All natural environments are limited in resources or opportunity for chronic positive growth for native species. These limits can be physical: light, water, moisture, humidity, temperature (climate), soil chemistry, nutrients, texture, etc. or biological: predation, parasitism, reproductive requirements (pollinators), competition with other species, or niche availability. The niche is a combination of the physical and biological factors that make up a particular species' place (spatial and temporal) in the community of plants and animals in which it lives. A species can only survive in the community as long as it has a niche that is not filled by another species, or as long as the niche is not destroyed or degraded to the point at which it cannot support the species or leaves the species vulnerable to other limiting factors.

All non-native plant species brought into a new environment are not universally adapted to become invasive in that new environment. Only those species for which the population growth is chronically (or on average) positive will become invasive. The population growth of these species, therefore, is not limited (enough to prevent a positive growth rate) by the physical and biological constraints in the new environment. It is sometimes said that a species may, therefore, be "pre-adapted" to the new environment. A species must be able to obtain a niche in the new environment, either by occupying a niche that is unfilled by other species (inventing a niche) or by out competing a native species for its niche (stealing a niche).

It is not always obvious which species will be able to obtain a niche in a particular natural environment at Lake Mead NRA. Many exotic plant species apparently are not able to move from the landscape environment or from chronically disturbed environments to the open desert environment at Lake Mead NRA. However, other invasive species, such as saltcedar, are able to

make the move to natural environments at Lake Mead NRA (steal a niche) to the detriment of native vegetation quite readily. These species can potentially have a very high positive growth rate and appear to become instantaneously invasive (Examples: fountaingrass, *Pennisetum setaceum*, and Sahara mustard, *Brassica tournefortii*). Other species quietly and slowly build large populations before their invasive nature is apparent (i.e. athel, *Tamarix aphylla)*. Athel's ability to spread unnoticed at Lake Mead NRA was aided by the general misconception that the species was sterile.

Non-native invasive species growth rate can be aided by a number of factors. One of these factors is the size of the population itself. Large population size can confer more than mathematical advantage to a species. Large population can often attract insect pollinators, reproduce (find genetically suitable mates) easier, produce enough seed or propagules to saturate environment or satiate predators, and may be able to alter ecosystem process to benefit themselves more readily than can a few scattered plants. Small populations are more vulnerable to extinction due to random changes in the environment or by chance alone than are large populations.

Another factor affecting growth rate is dispersal. Species requiring specialized dispersal vectors that do not occur in the new environment will be limited in ability to increase in population size. Species with adaptations which aid dispersal readily and easily to new areas rapidly increase ability to have a positive growth rate and avoid chance events that can cause extinction. Species which utilize vectors (such as animals) or dispersal mechanisms that are similar to those found at Lake Mead NRA may be able to disperse readily.

Certain species of plants have physiological plasticity - the ability to live and adapt readily to a variety of environmental conditions. For example, a plant from a part of the world with a rapidly changing environment may either have a mechanism that is genetic or physiological, or both, that allows the species to track changes and survive over time. The species may have a high mutation rate or high heterozygosity (many different gene expressions within the population of the species) for certain genes or have certain traits which allow it to live under multiple conditions. An example is a plant species that produces seed by flowering and also reproduces vegetatively by underground rhizomes. For these species, having both reproductive mechanisms can mean the difference between survival or not in environments in which pollinators or seed dispersal vectors are limited or unpredictable, or in which ground dwelling animals prey on rhizomes. These species may become extremely aggressive invaders in systems where neither vector is limiting and predators are absent.

A plant that has high heterozygosity in certain genes, which is able to continue to reproduce (perhaps setting and dispersing seed, but seeds do not survive in the local environment) under one set of conditions (in landscaping, for example), may eventually, by chance, create a particular gene combination that confers survivability in the local environment and consequently, a plant that once had a stable growth rate, suddenly exhibits a positive growth rate and becomes invasive.

Other environmental changes can occur to trigger invasiveness in seemingly stable species. A plant requiring a large population size in order to reproduce effectively suddenly becomes the popular plant for landscaping or is planted in large quantities on a certain property. A plant requiring a specialized pollinator to reproduce in a region has had that pollinator incidentally introduced to the same region. A species that is unable to grow well in a certain soil type or moisture regime is accidentally introduced to an area with the appropriate soil type or moisture regime. For example, fountaingrass seeds dispersed from landscaping in Laughlin onto the shoreline of Lake Mohave where the population invaded the shoreline. Global changes, such as changes in atmospheric $CO_2$ concentration and nitrogen deposition as well as climate, are expected to herald a number of changes in invasive species composition throughout the world (Hobbs and Mooney 2005).

The knowledge of the inevitability of an eventual high rate of growth for any species that exhibits a positive growth rate leads to the conclusion that any species that is able to naturalize once may be capable of becoming invasive. If a non-native plant is found in a new environment (i.e. a landscape plant found in a natural or near-natural environment or a roadside plant is found in open desert), it must be suspected that the species has the capacity to become invasive.

EXAMPLE

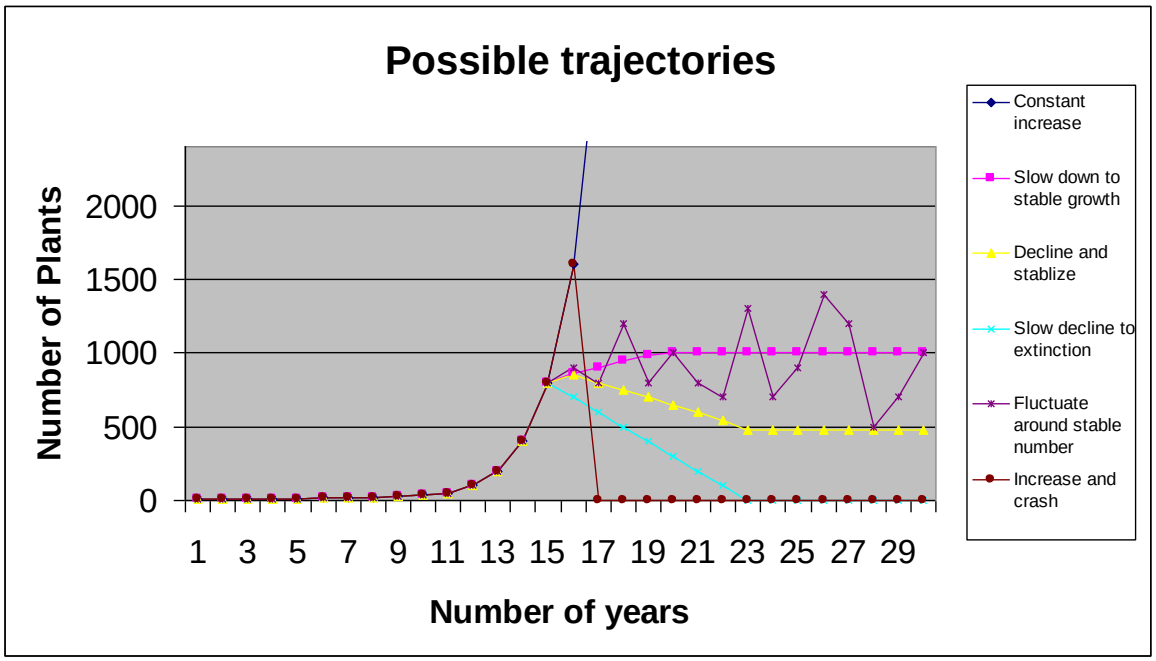
Trees of *Vitex agnus-castus* were discovered in Las Vegas Wash and in Overton Wildlife Management Area on June 3 and 4, 2003. This species was known only as a popular landscaping plant in Las Vegas Valley. A search of the Internet revealed that this plant has a number of features that not only make it an excellent landscaping plant, but also a potentially invasive plant at Lake Mead NRA. It is drought tolerant, survives in both sun and shade, can tolerate a wide range of soil types, including salty soils. It grows in several different vegetation climate zones, grows rapidly, flowers profusely, and produces numerous seeds. Also, from the size of the plants when discovered, it is thought that they had survived at least 2 years in place before being found. No further information about the invasiveness of this species at Lake Mead NRA, nor information about its impact on the ecosystems of Lake Mead NRA, is required to know that this species is a probable threat. It is far cheaper to uproot or kill two trees near a heavily traveled area than a forest of trees in a remote area of shoreline. The trees were subsequently removed from Lake Mead and a bulletin was sent out to interested individuals that a new potentially invasive species had been discovered at Lake Mead NRA. It is likely that more individuals of this species will be discovered at Lake Mead. Prevention measures include removing from developed area landscaping and not planting the species in future landscaping, thereby, lowering the potential for spread.

## *2.4 After Exponential Growth*

No population of organisms can continue growing indefinitely, or at least, it does not seem possible. At some point in time, growth slows, declines, or stops all together (Figure 5). The growth curve of rapid and precipitous decline to extinction is that shown by bacteria on a petri plate, or plants or animals in confined spaces with limited resources, such as rabbits on a small

island (refs). In the case of invasive species, it is thought that many invasive species will slow their growth after habitats are filled. At this point growth may slow to a stable replacement level. Growth may even show a slight decline due to "overcrowding" and overuse of resources, before stability is reached. As long as a habitat is available for invasive species, or the species has "stolen" a niche in the new environment, there may be little other than lack of habitat to prevent further growth. This would mean that every native species within the niche may be lost or highly reduced in numbers. Another possible trajectory is that the population fluctuates around a stable population size. The trajectory of slow decline of the population to eventual or near extinction may occur if another species is able to reclaim the niche, heavy predation occurs on species, or another species is able to replace invasive species in the habitat over time.

Figure 5. Growth curve of exotic plant population growth.




Therefore, after exponential growth, a period of stable growth may follow, in which the invasive plant has become well established in the available habitat. At this point declines may occur due to an increase in predation, as new predators or parasites discover the species, or this may be balanced by the constant creation of new habitat via disturbance. If the habitat is limited and growth is slow, it may be possible to eliminate the invasive from that habitat, but the damage to the environment has already been done. Certain elements or species in the ecosystem may be lost, and may be incapable of returning to the environment, even if the invasive species is removed.

Removal of invasive species from the environment by active control is essentially adding predation to the limits to the species' growth in the environment. If the population is able to sustain the level of predation provided by control, the population may not actually ever decline. If the species is widespread in the environment and still increasing, control may simply provide

new habitat, and growth of the population may even continue to increase despite control measures. For this reason, ubiquitous and widespread invasive species are thought to be "out-of-control" - the population has gained so much momentum and is so large that control may not be capable of ever effecting environmental protection or restoration.

# Chapter 3: Exotic Plant Ranking and Management Priorities

## *3.1 Introduction*

Lake Mead NRA uses both weed-led and site-led programs to focus invasive exotic plant management activities. The term *weed-led* is used because the program is defined by what is needed to manage the spread of a specified weed species (Owens 1998) where each weed species known to occur or likely to occur is evaluated and ranked according to the "The Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" (Warner et al. 2003) or a similar framework for systematic evaluation. Such rankings then focus exotic plant management actions on specific species that pose the most threat to ecological values. A site-led program aims to protect the quality or integrity of the values within a particular place (Owen 1998). Its focus is a management unit with high ecological or political value, such as desert springs or rare plant habitat. Distinguishing between weed-led and site-led programs keeps our attention focused on why we are spending time and effort to manage invasive exotic plants. A weed-led program is a proactive strategy to minimize future risks – it focuses not on the needs of a specific place, but rather on what is required to eradicate or contain a specific weed species in the landscape. In contrast, site-led programs always focus on a specific place and what is required to protect the values of that place (Owen 1998). At Lake Mead NRA, the "default" strategy is to focus on weed-led priorities except where indicated below in the discussion of site-led priorities.

This chapter on exotic plant ranking and management priorities incorporates management direction from other sources. The Clark County Multi-Species Habitat Conservation Plan serves as the primary reference for site-led priorities while the weed-led priorities are based on the "The Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" (Warner et al. 2003) developed by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association for use in California, Arizona, and Nevada.

Both the site-led priorities as well as the exotic plant ranking will be reviewed annually for currency when preparing annual work plans. In addition, both lists will be thoroughly re-evaluated every five years and revised as necessary to reflect the most current status of both protected and exotic plant species and to incorporate the latest scientific findings and management recommendations.

## *3.2 Weed-led Priorities*

Weed-led priorities are the "default" status for Lake Mead NRA; that is, most weed management activities will focus on those weed species evaluated to be of high priority due to the intrinsic potential of the species to invade wildlands and/or that species status as a state-listed noxious weed.

One complicating factor in the classification of exotic plants is the anticipated effects of global climate change of species composition and distribution. Specifically, the Mojave Desert is expected to get hotter (Gorelow 2005) and as plant species ranges expand, contract, and/or shift there could be plant species common to other North American deserts that expand their range into the Mojave Desert. This could be particularly pertinent to the northward movement of Sonoran Desert riparian species up the Colorado River Valley into the Lake Mead area. In the past, some Sonoran Desert species (e.g. Mexican paloverde, *Parkinsonia aculeata*) and even some narrowly endemic Mojave Desert species (e.g. desert fan palm, *Washingtonia filifera*) have been managed as invasive species in the park as both were popular plants in urban landscapes and were observed to have naturalized into the park. While there are some site-led management situations where such species may still be controlled for protection of other values, at desert springs for example, these native North American species will no longer be considered as exotic species in Lake Mead NRA. With the adoption of this plan, only species from other continents will be considered for weed-led priorities. The intent of this management decision is to minimize interference with climate-induced shifts in species distributions and gene flow while focusing management effort on those species that are known to be truly foreign to our environment.

### 3.2.1. Incipient Invasive Species and Escaped Ornamentals

The highest priority species are those incipient invasives that are just arriving in the park. In many cases, these are escaped ornamental species from landscaping in nearby urban areas. And, in some cases, the observation of "naturalized" individuals may be the first indication that the species is potentially a concern to land managers. One example is the recent appearance of chastetree (*Vitex agnus-castus*), a common landscape plant sold in the Vegas Valley, that has become established in three locations in the Park. Re-occurring opportunities for seed and propagule transport into the park is provided by the close proximity of the Park to urban areas, and especially the fact that most urban storm drains in the surrounding communities eventually empty into either Lake Mead or Lake Mohave. In many cases, only one or a few individuals of a given species will be established when the species is first detected in the park. This small sample size makes it difficult to assess its ability to invade wildlands but makes it relatively easy to control. This reality, combined with the fact that there is usually very little ecological information available about such species beyond the horticultural production of the plant, makes it very difficult to evaluate these species using a standard protocol such as the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands." For these reasons, incipient invasives and escaped ornamentals will be treated as the park's urgent priority without requiring systematic evaluation. In such situations, the observation that the plant has established itself outside of its planted location is prima facie of the threat it poses to the Park.

### 3.2.2 Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands

All known exotic plant species in Lake Mead NRA were evaluated using the "The Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" (Warner et al. 2003). This product was developed by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association for use in California, Arizona, and Nevada. It ranks each plant's level of threat to the ecological health of wildlands through evaluation of its ecological impact, ability to invade natural vegetation communities, and current extent of its invasion using a Plant Assessment Form. A verbal description of each of the list categories follows. These categories correspond directly to the overall criteria scores that derive from the responses to individual criteria questions and section scores. Accordingly, the individual questions and section scoring matrices have been designed to appropriately weigh the ecological impacts, invasiveness, and ecological distribution of each species, conveying a synopsis of these factors through categorical groupings. A review of the questions and the completed Plant Assessment Forms (Appendix XX) for each species provides the most detailed and comprehensive explanation for the inclusion of a particular species within a category. The categories are defined as follows:

- High: These species have severe ecological impacts on ecosystems, plant and animal communities, and vegetational structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. These species are usually widely distributed ecologically, both among and within ecosystems.
- Medium: These species have substantial and apparent – but generally not severe – ecological impacts on ecosystems, plant and animal communities, and vegetation structure. Their reproductive biology is conducive to moderate to high rates of dispersal, though establishment is generally dependent on ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
- Low: The ecological impacts of these species are minor. Their reproductive biology and other invasiveness attributes result in low to moderate rates of invasion. Ecological amplitude and distribution are generally limited but these species may be locally persistent and problematic.
- Alert: This is an additional designation for some species in either the high or medium category, but whose current ecological amplitude and distribution are limited. The designation alerts managers to species that are capable of rapidly invading unexploited ecosystems, based on initial, localized observations, and on observed ecological behavior in similar ecosystems elsewhere.
- Evaluated but not listed: In general, this designation is for species for which information is currently inadequate to respond with certainty to the minimum number of criteria questions or for which the sum effects of ecological impacts, invasiveness, and ecological amplitude and distribution fall below the threshold for listing.
- Nominated: The designation is for species that were nominated for review, but not evaluated because either they are not known to escape into wildlands or there was a lack of sufficient information to complete an assessment.

The Park's Exotic Plant Manager first reviewed the species that had already been evaluated by Warner et al., made a few adjustments based on local conditions and knowledge, then used the same worksheet to evaluate exotic species in the park that had not previously been evaluated. This initial evaluation was done over several months during 2007 and 2008. These draft rankings

were then reviewed and revised as necessary by a workgroup that included park field staff and cooperators, including representatives of the Exotic Plant Management Team, Weed Sentry, and the Rare Plant Monitoring Program. The review workshop was held in August 2008 and the rankings are listed below in Table 1.

### 3.2.3. Nevada Noxious Weed List

The Nevada Department of Agriculture (NDOA) defines a noxious weed as "any species of plant which is, or is likely to be, detrimental or destructive and difficult to control or eradicate." According to Nevada Revised Statutes Chapter 555.150, every landowner or occupier, whether private, city, county, or federal, shall cut, destroy, or eradicate all noxious weeds.

An invasive plant becomes "noxious" in the State of Nevada after a legislative process is conducted that places the species on the State's Noxious Weed List. [Nevada Administrative Code (NAC) 555.010]. The Nevada Noxious Weed List categorizes listed species as identified below,

*Category A*—Weeds not found or limited in distribution throughout the state and actively excluded from the state; and actively eradicated wherever found; actively eradicated from nursery stock dealer premises; control required by the state in all infestations.

*Category B*—Weeds established in scattered populations in some counties of the state; actively excluded where possible, actively eradicated from nursery stock dealer premises; control required by the state in areas where populations are not well established or previously known to occur.

*Category C*—Weeds currently established and generally widespread in many counties of the state; actively eradicated from nursery stock dealer premises; abatement at the discretion of the state quarantine officer.

State listed noxious weeds that are known to occur at Lake Mead are indicated on Table 1. Some of the listed noxious weed species in Nevada are known to be problematic in agricultural settings but may or may not pose much of an ecological risk to desert environments. One example is Johnson grass (*Sorghum halepense*), which is known to occur rarely at Lake Mead NRA. Because this species is known to be exotic to the North American continent and is a state listed Noxious weed, it is considered a high priority for management even though it's threat to desert wildlands is minimal.

### 3.2.4. Arizona Noxious Weed List

Noxious weeds and efforts to control them in the State of Arizona are regulated under *Chapter 2 of Arizona's Revised Statutes, Article 1: Dangerous Plant Pests and Diseases, Article 5: Pesticides, Article 6: Pesticide Control, and Article 6.1 Integrated Pest Management* . The Arizona Department of Agriculture has primary responsibility for administering the State's noxious weed program, including maintaining a list of noxious weed species. The Department regulates listed species, including all viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes). As of October 2007, listed noxious weeds were classified into three categories:

*Prohibited:* These species of noxious weeds (includes, plants, stolons, rhizomes, cuttings and seed) are prohibited from entry into the state.

*Regulated:* These species of noxious weeds are regulated (includes plants, stolons, rhizomes, cuttings and seed) and if found within the state may be controlled or quarantined to prevent further infestation or contamination.

*Restricted:* These species of noxious weeds are restricted (includes plants, stolons, rhizomes, cuttings and seed) and if found within the state shall be quarantined to prevent further infestation or contamination.

Two of the Arizona state-listed species – Texas blueweed (*Helianthus ciliaris*) and dodder (*Cuscuta* spp.) -- are known to occur occasionally in Lake Mead NRA but these species are considered native to the southwestern and/or south central United States. As such, they will not be considered as an exotic species at Lake Mead NRA. These two species are not listed on Table 1, but all other Arizona listed noxious weed species known to occur in Lake Mead NRA are listed in Table 1 and are subsequently considered a high priority for management.

### 3.2.5. Lake Mead Weed-led Priorities

Lake Mead priority is the final ranking that will be used to guide the park's weed-led management activities. This ranking reflects the urgency to address incipient invasives and escaped ornamentals, the high priority attached to species found on state noxious weed lists, and the systematic evaluation of a species' impact and invasiveness according to the protocol prescribed in "The Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" (Warner et al. 2003). This final "LAKE Ranking" is found on Table 1.

Table 1. Exotic plant species and their rankings for weed-led management at Lake Mead NRA.

| Scientific Name | state listed noxious[2] | "criteria" category | LAKE Ranking | Notes |
|---|---|---|---|---|
| *Elaeagnus angustifolius* | | N/A | Urgent[1] | |
| *Nerium oleander* | | N/A | Urgent[1] | |
| *Phoenix dactylifera* | | N/A | Urgent[1] | |
| *Vitex agnus-castus* | | N/A | Urgent[1] | |
| *Acroptilon repens* | NV-B; AZ | Medium | High | |
| *Alhagi pseudalhagi* | NV-A; AZ | Medium | High | |
| *Arundo donax* | NV-A | High | High | |
| *Brassica tournefortii* | NV-B | High | High | |
| *Bromus diandrus* | | High | High | |
| *Bromus rubens* | | High | High | |
| *Bromus tectorum* | | High | High | |
| *Centaurea melitensis* | NV-A | Medium | High | |
| *Convolvulus arvensis* | AZ | High | High | |
| *Helianthus cilaris* | | High | High | |
| *Lepidium latifolium* | NV-C | High | High | |
| *Myriophyllum spicatum* | NV-A | High | High | |
| *Pennisetum setaceum* | NV-C | Medium | High | |
| *Solanum elaeagnifolium* | NV-B | High | High | |
| *Sorghum halepense* | NV-C | High | High | |
| *Tamarix ramosissima* | NV-C | High | High | |
| *Tamarix aphylla* | NV-C | Medium | High | |
| *Tamarix spp. (hybrid)* | NV-C | Medium | High | |
| *Tribulus terrestris* | NV-C; AZ | High | High | |
| *Bassia hyssopifolia* | | Medium | Medium | |
| *Kochia scoparia* | | Medium | Medium | |
| *Malcolmia africana* | | Medium | Medium | |
| *Nicotiana glauca* | | Medium | Medium | |
| *Salsola paulsenii* | | Medium | Medium | |
| *Salsola tragus* | | Medium | Medium | |
| *Schismus arabicus* | | Medium | Medium | |
| *Schismus barbatus* | | Medium | Medium | |
| *Sisymbrium altissimum* | | Medium | Medium | |
| *Sisymbrium irio* | | Medium | Medium | |
| *Sisymbrium orientale* | | Medium | Medium | |
| *Agrostis stolonifera* | | Low | Low | |
| *Agrostis viridis* | | | Low | |
| *Amaranthus albus* | | | Low | |
| *Apium graveolens* | | | Low | |
| *Atriplex semibaccata* | | | Low | |
| *Avena fatua* | | | Low | |
| *Avena sativa* | | | Low | |
| *Bromus catharticus* | | | Low | |
| *Bromus japonicus* | | Low | Low | |
| *Bromus trinii* | | | Low | |
| *Capsella bursa-pastoris* | | | Low | |
| *Catapodium rigidum* | | | Low | |

| | | | | |
|---|---|---|---|---|
| *Cercidium floridum* | | | Low | |
| *Chenopodium album* | | | Low | |
| *Chloris virgata* | | | Low | |
| *Corispermum nitidum* | | | Low | |
| *Crypsis schoenoides* | | | Low | |
| *Cynodon dactylon* | | | Low | |
| *Descurania sophia* | | Low | Low | |
| *Digitaria sanguinalis* | | | Low | |
| *Echinochloa crus-galli* | | | Low | |
| *Eriochloa contracta* | | | Low | |
| *Erodium cicutarium* | | Low | Low | |
| *Gaura parviflora* | | | Low | |
| *Gnaphalium luteoalbum* | | | Low | |
| *Grindelia squarrosa* | | | Low | |
| *Hirschfeldia incana* | | | Low | |
| *Hordeum marinum* | | | Low | |
| *Hordeum murinum* | | | Low | |
| *Lactuca serriola* | | Low | Low | |
| *Lobularia maritima* | | Low | Low | |
| *Lolium multiflorum* | | Low | Low | |
| *Lolium perenne* | | | Low | |
| *Medicago sativa* | | | Low | |
| *Melilotus albus* | | | Low | |
| *Melilotus indicus* | | Low | Low | |
| *Melilotus officinalis* | | Low | Low | |
| *Phalaris minor* | | | Low | |
| *Plantago lanceolata* | | Low | Low | |
| *Polygonum argyrocoleon* | | | Low | |
| *Polygonum aviculare* | | | Low | |
| *Polypogon monspeliensis* | | Low | Low | |
| *Potamogeton crispus* | | Low | Low | |
| *Rumex crispus* | | Low | Low | |
| *Sinapis arvensis* | | Low | Low | |
| *Solanum nigrum* | | | Low | |
| *Solanum rostratum* | | | Low | |
| *Sonchus asper* | | Low | Low | |
| *Sonchus oleraceus* | | | Low | |
| *Spergularia bocconii* | | | Low | |
| *Sorghum bicolor* | | | Low | |
| *Taraxacum officinale* | | Low | Low | |
| *Thlaspi arvense* | | | Low | |
| *Triticum aestivum* | | | Low | |
| *Vallisneria americana* | | | Low | |
| *Veronica anagallis-aquatica* | | | Low | |
| *Vulpia bromoides* | | Low | Low | |

[1] "Urgent" focuses on incipient invasives and escaped ornamentals without consideration of systematic evaluation or state listing.
[2] All state listed noxious weeds are ranked as high regardless of their score in the systematic evaluation.

## *3.3 Site-led Priorities*

While most weed management activities at Lake Mead focus on weed-led priorities, in some specific locations management activities focus on site-led priorities. In these specific geographic areas, the purpose of management actions or deliberate in-actions is to protect specific values of the site that might be impacted by either exotic plant species or exotic plant management activities. In some cases, site-led priorities and weed-led priorities will be the same; that is, the same weed species will be treated the same way even though it occurs in a conservation site. However, in other cases, site-led priorities will be different than weed-led priorities. For example, a lower priority weed species (as evaluated in the weed-led priority section above) will be actively controlled in a conservation site if it is determined that the weed poses a risk to a rare plant population. One such instance is the encroachment of African mustard (*Malcomia Africana*) into gypsum habitats occupied by Las Vegas bearpoppy (*Arctomecon californica*). Another example of site-led priority is demonstrated in the techniques used to manage exotic plant species. In most of the park, high priority weed species are managed using an integrated approach with multiple control methods that may include both chemical and manual control methods. However, in some conservation sites, the conservation species may be susceptible to damage by herbicide so only manual methods are used and chemical methods are not, or the timing of treatment might be altered due to the life history of the protected species.

The Clark County Multiple Species Habitat Conservation Plan (CCMSHCP) was approved by the U.S. Fish and Wildlife Service in September 2000 to conserve a wide variety of species and their habitats throughout Clark County Nevada (including approximately 581,000 acres in Lake Mead NRA), pursuant to Section 10(a) of the Endangered Species Act of 1973, as amended (Act). The CCMSHCP identifies those actions necessary to maintain the viability of natural habitats in the county for approximately 232 species residing in those habitats. All species identified for site-led priority are listed in the CCMSHCP. Within this group four weed management priorities are established and a justification for that priority is provided.

**PRIORITY 1 SITES** –

- All sandy areas that are currently known to support *Astragalus geyeri* and *Eriogonum viscidulum*; 7 sites including, Sandy Cove, Lime Cove, Glory Hole, Kline Hole, Overton Beach Road, Middle Point, Ebony Cove.
    - JUSTIFICATION: Both *Astragalus geyeri* and *Eriogonum viscidulum* are restricted to sandy habitats derived from sediments of the Muddy Creek Formation. The habitat that supports these two species is threatened (differs depending on site) by the invasive species *Brassica tournefortii, Tamarix ramosissima, Salsola tragus, Bromus tectorum, B. rubens, Schismus arabicus,* and *S. barbatus.* These species

are capable of competitive exclusion of native species and/or soil stabilization in sandy environments.

- All gypsum communities that currently support *Arctomecon californica* and *Anulocaulis leiosolenus var. leiosolenus*; 11 sites including, St. Thomas, Overton Beach Road, Blue Point, Stewarts's Point, Valley of Fire, Echo Wash, Pinto Valley north, Pinto Valley south, Callville Wash north, Big Gyp Hills, Bearing Peak (remote site- consider for Priority 2).
    - JUSTIFICATION: Both species are gypsum endemics. *Arctomecon californica* is limited geographically and is threatened outside of LMNRA by development and ORV use. Although *Anulocaulis leiosolenus* is not a state listed species, we need to be concerned about it because of its disjunct and patchy distribution from here to south Texas and into Mexico. Our plants don't quite fit into the var. *leiosolenus* group (per. Richard Spellenberg) and with more detailed genetic analyses and ecological research, it may be assigned a unique species or var. name. Both species are facing a new threat from the invasive species *Malcomia africana,* thus further supporting a Priority 1 classification of this critical habitat. *Bromus rubens, Schismus arabicus* and *S. barbatus* occur minimally in this habitat as well, but to date have not adapted to be competitive in this environment. Also occurring in this habitat are the CCMSHCP evaluation/watch species *Enceliopsis argophylla* and *Astragalus preussii* var. *laxiflorus.*

**PRIORITY 2 SITES -**

- All sandy areas that historically supported *Astragalus geyeri* and *Eriogonum viscidulum* within LMNRA. These sites should be bumped up to Priority 1 if modern surveys in a good rain year confirm existing populations of either species. These sites include: Ann Margaret Cove, Engine Beach, Little Bitter Wash, Fire Cove road.
    - JUSTIFICATION: Potential habitat for *Astragalus geyeri* and *Eriogonum viscidulum* (see above).

- All sites supporting populations of *Astragalus mokiacensi*s, including Devils Cove, Pinto Valley (ridges to the north), and Fortification Hill/Promontory Point areas.
    - JUSTIFICATION: This species is listed as an evaluation species of high priority on the CCMSHCP. Many of the populations are remote and it is unknown which invasive species (if any) threaten those populations. The Gold Butte, Devils Cove (may no longer exist), and Fortification Hill populations are threatened by one or both of the following, *Brassica tournefortii* and *Bromus tectorum.* This species will not re-establish in high density weed infested areas (Alexander 2001).

- All sites supporting *Pediomelum castoreum* that do not co-occur with *Astragalus geyeri* or *Eriogonum viscidulum*, including: Sandy Point and Delmar Butte area.
    - JUSTIFICATION: *Pediomelum castoreum* is a watch species for the CCMSHCP. It's low growing and occurs on sandy habitats and is threatened by invasive species

such as, *Brassica tournefortii*, *Bromus tectorum, B. rubens, Schismus arabicus,* and *S. barbatus*. These species are capable of competitive exclusion of some species and/or soil stabilization in sandy environments.

**PRIORITY 3 SITES**:

- All sites supporting *Enceliopsis argophylla* that do not co-occur with *Arctomecon californica*, including: Northshore Road, Lake Shore Drive.
    - JUSTIFICATION: *Enceliopsis argophylla* is an evaluation species of high priority on the CCMSHCP list. This species is strongly associated with gypsum, but is not restricted to gypsum. *Malcomia africana* may threaten this species in some locations.

- All sites supporting *Astragalus preussii* that do not co-occur with *Arctomecon californica*, including: Northshore Road, Tassi Wash, Pearce Ferry.
    - JUSTIFICATION: *Astragalus preussii* is now endemic to the Lake Mead region where it is found in abundance on gypsum/selenium soils. The only known California populations have not been re-located in many years and are now presumed to be extinct. Invasive species threats are mainly from *Malcomia africana*.

**PRIORITY 4 SITES**:

- All desert springs, particularly perennial springs. There are 88 springs documented in Lake Mead NRA.
    - JUSTIFICATION: Water in the desert is a rare but essential component of the natural environment and, as such, springs often support unusual plant species and assemblages. Invasive species in these settings can displace the native flora, degrade the habitat value for native wildlife, and some invasive plant species with high evapotranspiration rates (e.g. saltcedar) may even reduce the water volume.
- High use recreation sites such as designated beach areas, boat ramp areas, campgrounds, and picnic areas.
    - JUSTIFICATION: The primary purpose for the establishment of Lake Mead National Recreation Area is to provide recreational opportunities. In some cases, exotic plants may interfere with safe or enjoyable recreational use. For example, puncturevine sometimes becomes established on beach areas, where the spiny fruits create a public nuisance and minor safety concern for beach users.

**PRIORITY 5 SITES**:

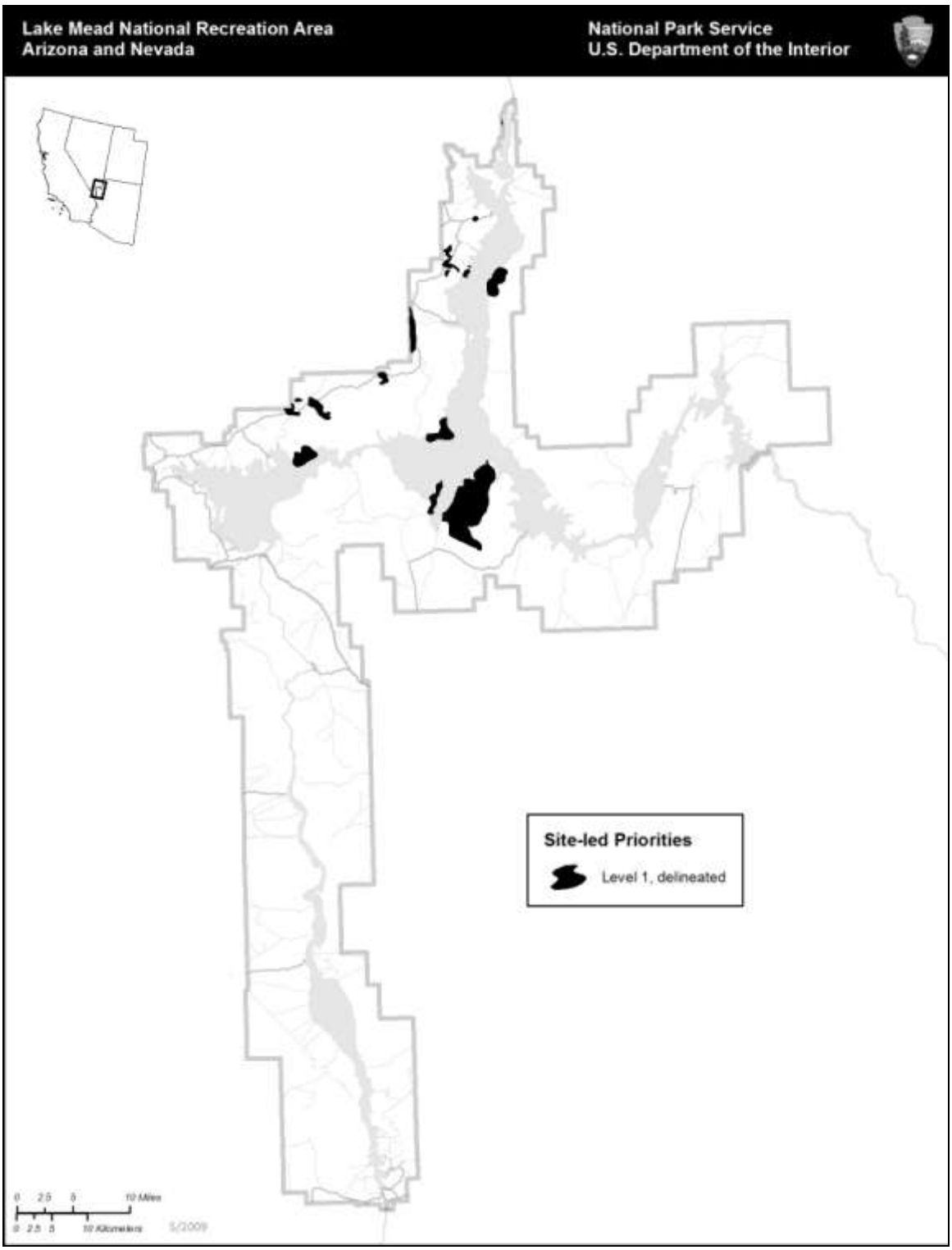
- Vector locations such as parking lots, roads, and trails.
    - JUSTIFICATION: Exotic plant species may be easily spread to other areas by vehicles, hikers, horses and pack stock traveling on the park's roads and trails. As these sites are easily accessible for frequent monitoring and treatment, it may be advantageous to remove exotic plants without regard to weed rank before they are spread to other areas. In some instances, it may be appropriate to treat a

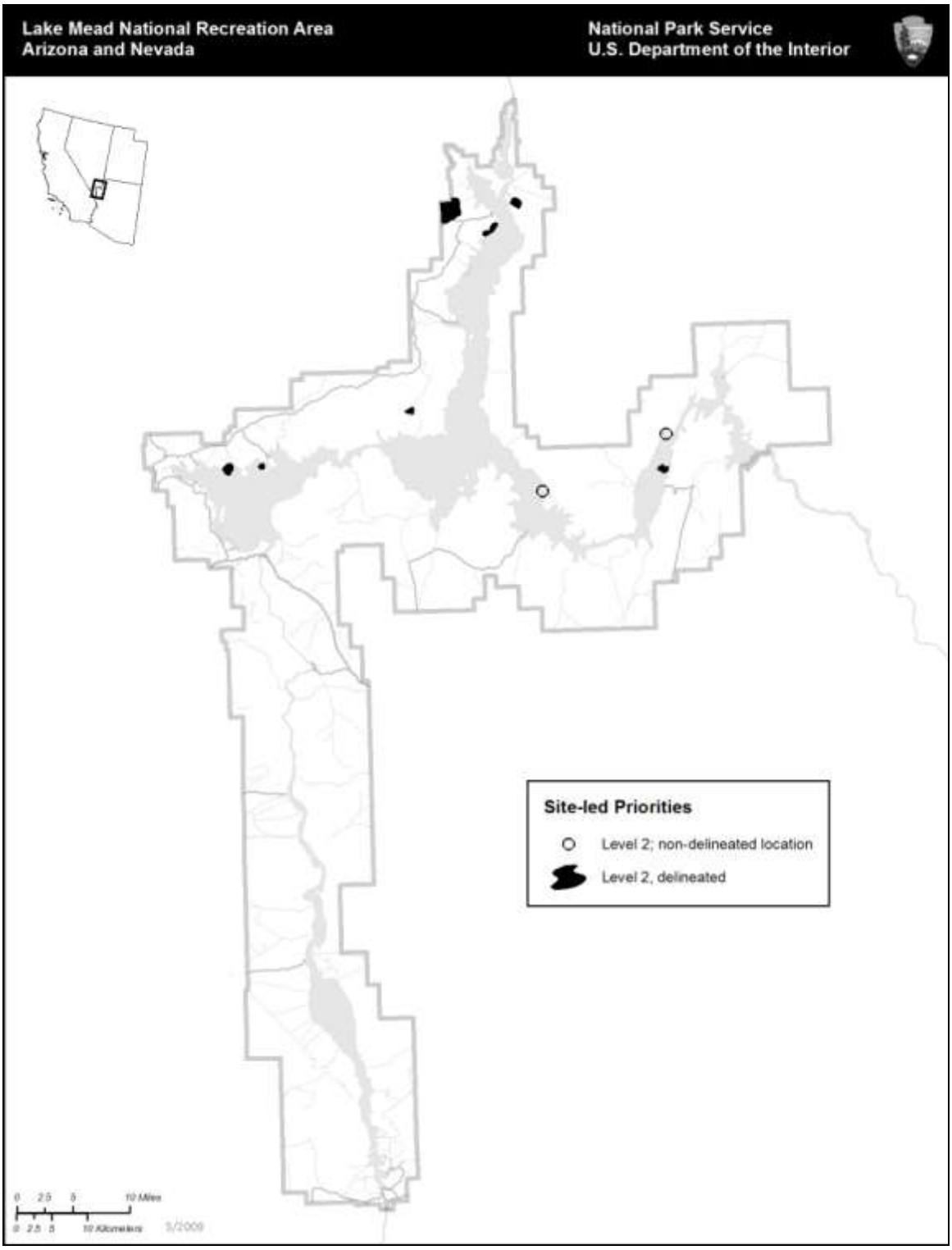
widespread exotic plant species in these areas to prevent specific hazards (e.g. removal of red brome from unpaved parking areas to prevent accidental ignitions and subsequent wildfires caused by plant contact with the underside of hot vehicles).

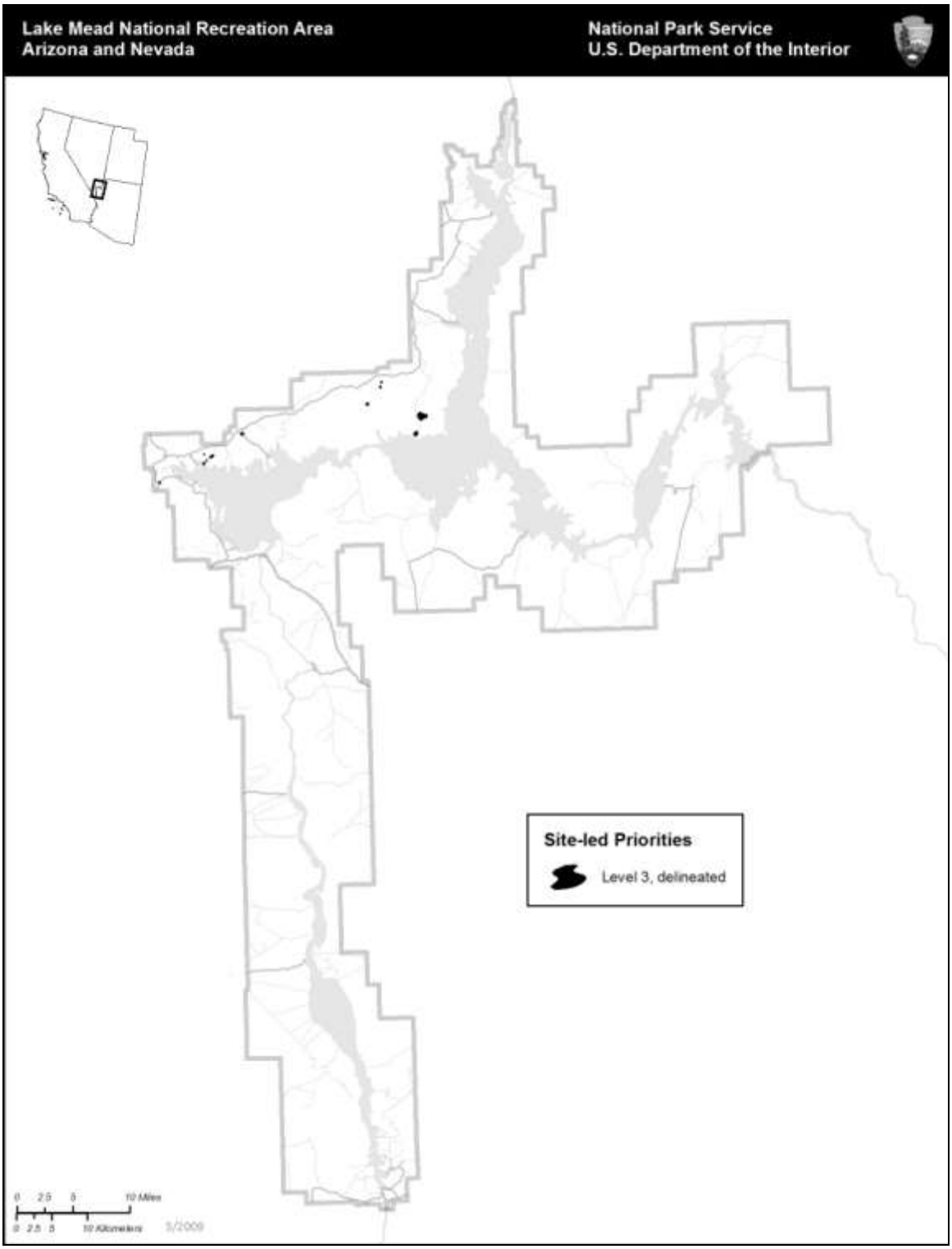
- Cultural Landscapes eligible for listing on the National Register of Historic Places
    - JUSTIFICATION: National Park Service policy (2006) directs that cultural landscapes will be treated to preserve significant physical attributes, biotic systems, and uses when those uses contribute to historic significance. Exotic plants can both threaten cultural landscapes and, in some cases, be a protected attribute of cultural landscapes (e.g. planted ornamental species that known to be invasive). Furthermore, treatment methods used to remove exotic plants may have impacts on other plants that are part of the cultural landscape.

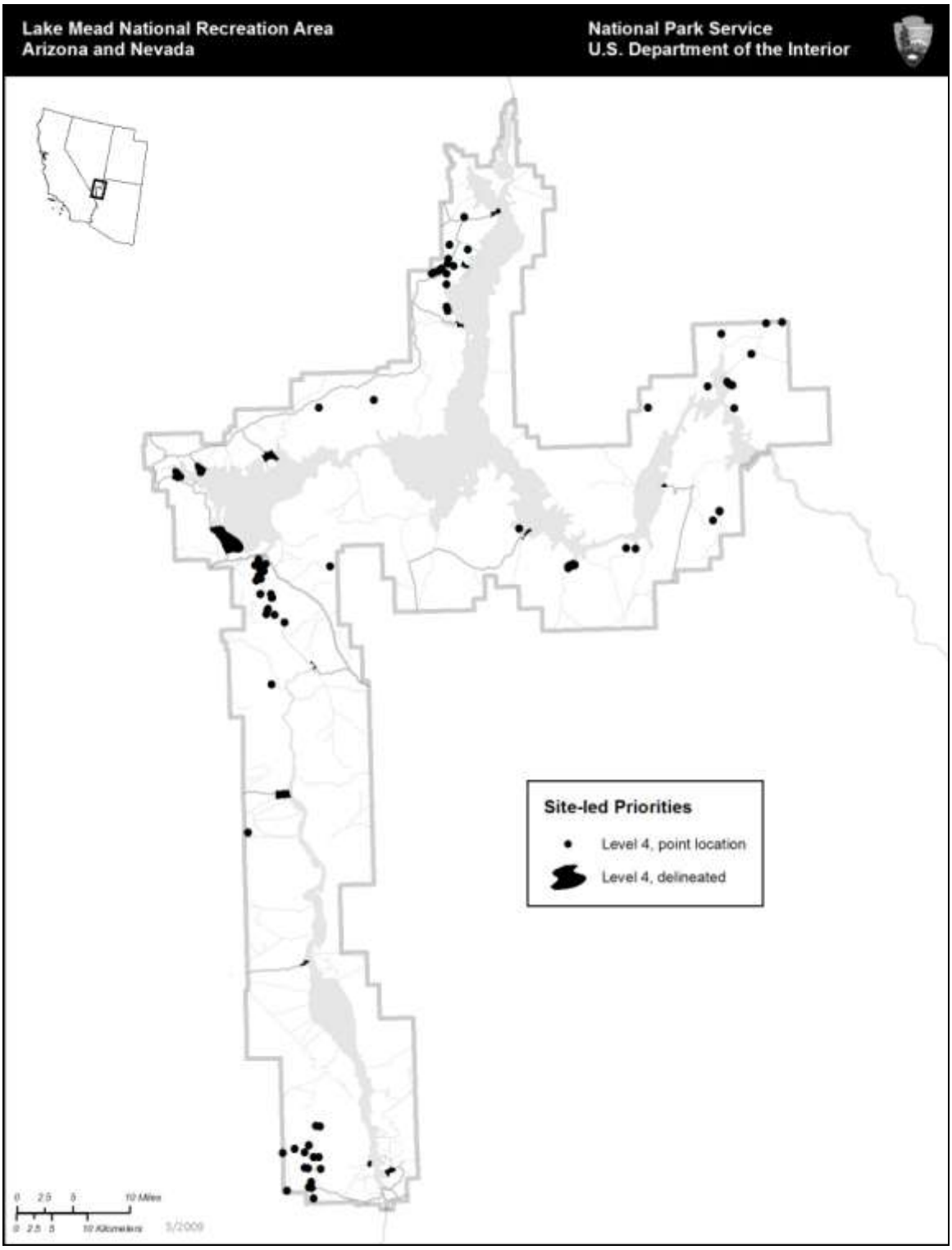
Site led priority areas are shown on Figure 6. For the protection of the conservation species this map is intended to show the landmarks identified in the site-led priority descriptions rather than the exact location of specific populations

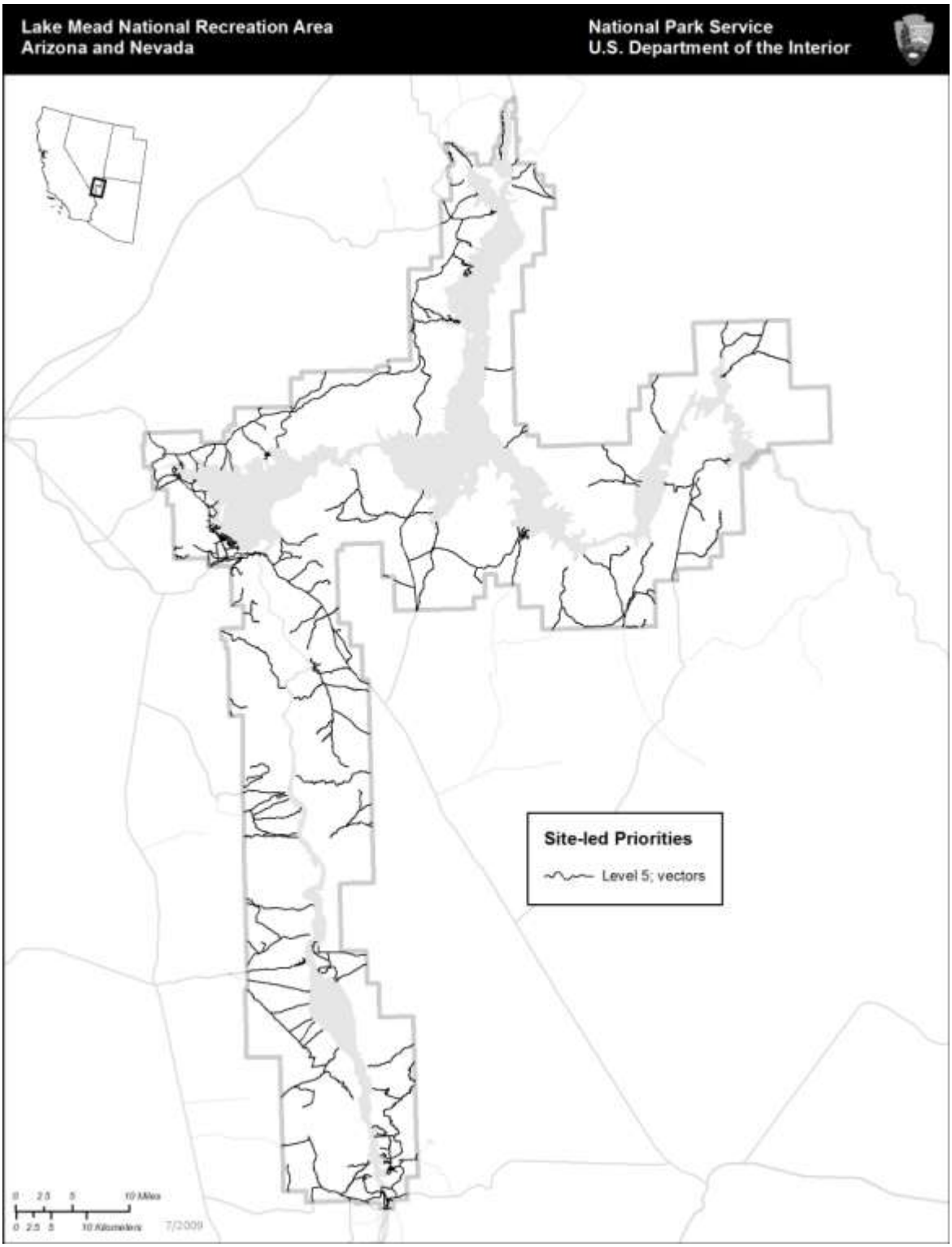
Figure 6. Generalized maps of site-led priority areas.




Lake Mead National Recreation Area
Arizona and Nevada
National Park Service
U.S. Department of the Interior
Site-led Priorities
Level 2; non-delineated location
Level 2, delineated
0 2.5 5 10 Miles
0 2.5 5 10 Kilometers
5/2009


Lake Mead National Recreation Area
Arizona and Nevada
National Park Service
U.S. Department of the Interior
Site-led Priorities
Level 3, delineated
0 2.5 5 10 Miles
0 2.5 5 10 Kilometers
5/2009


Lake Mead National Recreation Area
Arizona and Nevada
National Park Service
U.S. Department of the Interior
Site-led Priorities
Level 4, point location
Level 4, delineated
0 2.5 5 10 Miles
0 2.5 5 10 Kilometers
5/2009


Lake Mead National Recreation Area
Arizona and Nevada
National Park Service
U.S. Department of the Interior
Site-led Priorities
Level 5; vectors
0 2.5 5 10 Miles
0 2.5 5 10 Kilometers
7/2009

# Chapter 4: Overview of Exotic Plant Management Program

This chapter introduces the major components of the Lake Mead Exotic Plant Management Program as well as the exotic plant management strategies and treatments used within the context of integrated pest management. Finally, this chapter introduces several decision making tools that are used to implement adaptive management strategies whereby the Park is continually learning from our experiences and improving the effectiveness and efficiency of our exotic plant management efforts. Subsequent chapters will elaborate on the details of how these tools are used to meet the weed management goals.

## *4.1 Integrated Pest Management*

National Park Service policy (NPS 2006) requires the use of an integrated pest management (IPM) approach to pests, including invasive exotic plants. This concept is defined in policy as follows: "4.4.5.2. Integrated pest management is a decision making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage by cost-effective means while posing the least possible risk to people, resources, and the environment."

An IPM program generally consists of the following strategies:

- Identification of the pest
- Monitoring pest populations and damage levels
- Establishing injury and threshold/action levels
    - Injury level is the population size at which the pest causes unacceptable damage
    - Threshold or Action level is the population size at which some management action must be taken to prevent the population from reaching the injury level
- Implementing treatments
    - Indirect Suppression such as habitat modification, modifying human activities
    - Direct Suppression such as physical or mechanical removal, biological control, or chemical treatment
- Evaluation of treatment results
- Education of staff and others

IPM often employs a combination of treatment strategies specific to the species and location that are: least disruptive of natural controls; least hazardous to human health; least toxic to non-target organisms; least damaging to the general environment; most likely to produce permanent reduction in the pest; easiest to carry out effectively; and most cost effective in both the short- and long-term. For example, it is common to implement cultural practices to prevent the spread of weed seeds along with manual and chemical treatment of incipient and established populations.

The Lake Mead Exotic Plant Management Plan incorporates IPM concepts and strategies throughout the document. The procedural requirements of IPM as practiced in the NPS are identified in Appendix A.

## *4.2 Major Components of the Lake Mead NRA Exotic Plant Management Program*

As previously shown in Figure 3, the Lake Mead exotic plant management program has three major components that all take place within an environment of adaptive management, monitoring, and research. These major components are each addressed in detail in their own chapter of this plan:

- Prevention (Chapter 5), which focuses on internal and external education as well as standard operating procedures for agency-controlled activities to prevent the introduction of new weeds and the spread of existing weeds.
- Early Detection and Eradication of Incipient Populations (Chapter 6), which focuses on proactive monitoring of high risk areas for detection of new weed infestations and aggressive treatment of new infestations to prevent population establishment and growth.
- Control and Containment of Established Populations (Chapter 7), which focuses on priority species and sites to be treated using various methods and tools to contain and reduce established weed populations.

Adaptive management, monitoring, and research are not stand alone programs, but rather are incorporated into all of the Park's exotic plant management efforts. Details of these aspects of the Exotic Plant Management Program are elaborated in Chapter 8.

## *4.3 Treatment Methods*

A variety of exotic plant treatment methods are used at Lake Mead, including:

- Cultural
- Manual/Mechanical
- Biological Control
- Chemical
- Prescribed Fire

Each of these treatments is described below and prescribed for specific purposes in subsequent chapters of this document.

### 4.3.1. Cultural Treatments

Cultural treatments are practices that promote the growth of desirable plants and reduce the opportunities for exotic plants to grow. Cultural treatment methods involve manipulating treatment areas to present exotic plants with effective native competitors.

Prevention of exotic plant introduction and/or spread is a high priority cultural treatment due to its long-term cost-effectiveness and effectiveness in protecting native plant communities. The exotic plant prevention strategy at Lake Mead is discussed in detail in Chapter 5 and has two major components:
1) Education of employees, cooperators, and visitors
2) Proactively incorporating exotic plant prevention into agency operations and agency-controlled activities

Another common cultural treatment is the maintenance and restoration of native plant communities that are resistant to invasion and resilient after invasion and treatment. The Park has an active Restoration Program that deals primarily with human-caused disturbances (e.g. damage to soils and plants due to off-road vehicle trespass) and the Lake Mead Native Plant Nursery that propagates native plants for a variety of purposes. It is beyond the scope of this Exotic Plant Management Plan to detail every effort to maintain and/or restore native plant communities, but the capacity of the park to undertake restoration after weed treatment is important to the long-term success of the weed management effort.

### 4.3.2. Manual and Mechanical Treatments

Manual and mechanical treatments involve physical damage to or removal of part or all of the plant. Manual treatments involve physically damaging or removing exotic plants through non-mechanical means. Examples of manual treatment include hand pulling or the use of draft animals to remove large individual plants. Mechanical treatments involve the use of tools to remove or physically damage exotic plants. Examples of mechanical treatments used at Lake Mead NRA include using cutting tools (shovels and clippers), pulling tools (such as weed wrenches™), and power tools (such as weed eaters and chainsaws). Any manual and mechanical methods would be highly selective for individual plants. Both manual and mechanical treatments can be used to treat individual plants or specific treatment areas. Manual or mechanical treatments may need to be performed several times during a season and are often used in concert with other treatment methods. For example, mechanical treatments of exotic trees, such as saltcedar, may be followed by application of pesticides.

Manual treatment can be used in any area. Manual treatment is most effective for pulling shallow-rooted, non-rhizomatous species. Hand pulling is conducted by removing as much of the root as possible while minimizing soil disturbance. Manual treatment is generally not appropriate for rhizomatous species because the root fragments left behind will regenerate into many new plants where there was formerly only one, thus increasing the weed population.

Types of mechanical treatment include using hand cutting tools, pulling tools, power tools, or heavy equipment.

Hand cutting tools are a treatment option for removing the above ground portions of annual or biennial plants. Use of hand tools, such as trowels, shovels, and pulaskis are simple forms of mechanical treatments. These tools can be used to remove a larger portion of the root system or to sever the plant's taproot below the point where nutrients are stored. In some cases, mechanical treatment may be used to simply remove the seed heads of the plants prior to dispersal to prevent seed set that growing season. This is particularly appropriate for some biennial species with a large tap root (e.g. common mullein) for treatment of second year plants that are naturally going to die after seedset where it would take a substantial amount of effort to remove the entire plant and no additional weed reduction would be realized from the effort. Where mechanical treatment is used to remove only seeds special effort must be made to contain the seeds to prevent accidental dispersal during the removal process, and the population needs to be monitored frequently throughout the remainder of the growing season to be sure that the plants do not produce new seeds prior to senescence.

Pulling tools are a treatment option for removing individual plants that are deep-rooted. Pulling tools can be used to control small infestations, such as when an exotic plant is first identified in an area. These tools grip the weed stem and remove the root by providing leverage. Pulling tools are most effective on firm ground rather than soft, sandy, or muddy substrate (Tu et al. 2001:1.2).

Power tools can be used to treat small to large infestations. Power cutting tools act as hand cutting tools to remove aboveground biomass, reduce seed production, and reduce plant growth, but can effectively be used on larger plants and woody species that exceed the capacity of hand tools. Power tools are useful for controlling annual plants before they set seed. Power tools can also be used along with other treatments, such as chemicals or prescribed fire, to treat perennial exotic plants. By removing aboveground biomass, nutrient reserves that are stored in root or rhizome systems are depleted. Once nutrient reserves are depleted, some exotic plants become more susceptible to subsequent chemical or fire treatments. Chainsaws are a power tool that may be used to remove aboveground biomass of shrubs and trees. Following biomass removal, chemicals are often applied directly to the stumps to prevent suckering. This is a common practice for the treatment of saltcedar at Lake Mead NRA.

### 4.3.3. Biological Control

Biological treatments are commonly referred to as biological control, or biocontrol. Biological treatments involve the use of "natural enemies" (including insects and microorganisms) to reduce the abundance of an exotic plant. Natural enemies are insects, mites, or pathogens that are imported from areas where the target exotic plant occurs as a native plant and are deliberately released into areas where the plant is exotic. These natural enemies limit the growth or reproduction of exotic plants or in some cases may damage the plant in ways that make it susceptible to other pathogens. Biological control may be a long-term solution for controlling some exotic species that are too widespread for control by other means. Biological control is best suited for infestations of a single, dominant exotic plant species that is not closely related to

other native plant species. Some biological control agents for some priority weed species at Lake Mead and those that might become an issue in the near future are listed in Table 2.

In the United States, biological control agents are identified, tested, and regulated by the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS).

Biological control relies on the use of other biological organisms to maintain pest populations below the action thresholds. In some cases, such as when native insects and herbivores are not maintaining exotic plants at acceptable levels, releases of biological control agents may be necessary. Release of biological control agents at Lake Mead NRA will adhere to the following Best Management Practices:

- Only those biological control agents approved by APHIS are allowed for use at Lake Mead NRA.
- Prior to release, an implementation plan must be written to include: a summary of species biology and effectiveness of control, establishment of population and/or control thresholds, acquisition of biocontrol agents, strategy for actual release of organisms, and a strategy for monitoring the success of the release. The implementation plan should be peer reviewed by at least three people, one of which should be experienced in the use of that specific biocontrol agent and pest plant.
- Before a biological control agent is released on NPS land, the Lake Mead Exotic Plant Manager must submit the implementation plan and receive approval from the National IPM Coordinator to release the agent.
- If biological control agents are to be obtained from another state, a permit which has been reviewed by the State Entomologist must also be obtained from APHIS. The transport, handling, and release of biological control agents must be in accordance with all permit conditions.
- Biological control agents should be released in each climatic zone that is occupied by the host so that the natural enemy has a chance to develop in all areas where the host occurs.
- The number of biological control agents released should account for the size and density of the treatment area and the number of agents required to maintain a viable biological control agent population.
- More than one release in an area may be necessary for successful establishment.
- Releases should be synchronized with the time period when the host plant is present.
- Biological control agents should be released at times of the day when they will not disperse from the treatment area.
- Biological control populations should be monitored according to the strategy identified in the implementation plan. Monitoring should occur annually at a minimum.

Table 2. Biological control options for exotic plant species at Lake Mead NRA.

| Biocontrol Agent | Target Plant | Target Habitat | Mode of Action | Impact on Target and Notes |
|---|---|---|---|---|
| Weevil, *(Cyrtobagous salviniae)* | giant salvinia *(Salvinia molesta)* | Aquatic | Larvae burrows through plant tissues | Kills plants with enough damage. Established in many southern and southwestern states, including the Colorado River |
| Chinese leaf beetle, *(Diorhabda elongata)* | Saltcedar *(Tamarix ramosissima)* | Riparian | Adults and larvae feed on foliage | Defoliates plants and can eventually cause death to individual trees. Established in several Great Basin states in the Colorado River drainage.[1] |
| Seed-feeding weevil *(Microlarinus lareynii)*; Stem- and crown-mining weevil *(M. lypriformis)* | Puncturevine *(Tribulus terrestris)* | Upland | Seed destruction; stem, and crown damage | Reduces recruitment; kills plants with enough damage. Established in several southwestern states |
| Head smut fungus *(Ustilago bullata)* | Cheatgrass *(Bromus tectorum)* | Upland | Infects plant flowers and prevents seed production | Reduces recruitment. Needs to be combined with native plant re-establishment for optimal effect. |
| 'Black fingers of death' soil fungus *(Pyrenophora semeniperda)* | Cheatgrass *(Bromus tectorum)* | Upland | Kills cheatgrass seed in the soil | Reduces recruitment. |

[1] This species is expected to colonize Lake Mead NRA within the next few years, but was not intentionally released within the park nor endorsed by the NPS.

### 4.3.4. Chemical Treatments

Chemical treatments involve applying pesticides as prescribed by their labels, using a variety of application methods. Pesticides are most effective for treating monotypic stands of a single exotic plant species in areas where desirable plants are scarce or absent and where pulling or cutting is not feasible. The specific category of pesticide used to treat exotic plants is known as herbicide. As the scope of this document is limited to plants, the terms herbicide and pesticide are used interchangeably.

Active ingredients and their mode of action for herbicides that are used or expected to be used at Lake Mead NRA are summarized in Table 3. It is anticipated that new formulations of pesticides will become available in the future and new weed species are targeted for treatment using pesticides not currently in use at the park, thus this table is not meant to be a list of the only active ingredients allowed for use. Pesticides containing active ingredients that are not listed on Table 3 may also be used at Lake Mead; however, the use of any pesticide must meet all conditions outlined in this document and must also be approved annually through the IPM system by the NPS Regional or National IPM Coordinator through a Pesticide Use Proposal.

Table 3. Summary of herbicides for use at Lake Mead NRA.

| Active Ingredient | Approved Uses | Mode of Action | Method of Application | Reference |
|---|---|---|---|---|
| 2, 4-D amine | Herbaceous and aquatic broadleaf plants | It is absorbed by plant leaves, stems, and roots, and moves throughout the plant. It accumulates in growing tips. It mimics auxin, a plant growth hormone, which causes uncontrolled and disorganized plant growth and eventually death. | Aerial spraying, spraying from ground based equipment, cut stump treatments, foliar spray, basal bark spray, tree injection. | Tu et al. 2004 |
| Aminopyralid | Broadleaf weeds in grasses, especially members of the sunflower, legume, and nightshade families | Absorbed by the leaves and roots of the plant and moves rapidly through the plant. It acts as a natural growth regulator causing disruption of plant growth processes. | Aerial spraying, spraying from ground based equipment, cut stump treatments, foliar spray, basal bark spray, tree injection. | Hartzler 2006 |
| Chlorosulfuron | Pre-emergent and early post-emergent control of annual, biennial, and perennial broadleaf weeds | Absorbed by foliage and roots. It inhibits a key enzyme needed to synthesize proteins which causes disruption of plant growth processes. | Aerial spraying, spraying from ground based equipment, foliar spray. | DuPont 2007a |
| Clopyralid | Annual and perennial broadleaf plants, especially members of the sunflower, legume, and knotweed families | Absorbed by the leaves and roots of the plant and moves rapidly through the plant. It acts as a natural growth regulator causing disruption of plant growth processes. | Spraying from ground based equipment. | Dow AgroSciences, no date |
| Dicamba | Used in the control of annual and perennial broadleaf weeds, brush, and vines in rangeland and non-cropland areas. | Dicamba uptake is through roots, leaves and stems. The chemical moves to all plant tissues but builds up in growing tissues. Dicamba acts like a naturally occurring plant hormone and causes uncontrolled cell division and growth in plants. | Ground or aerial broadcast, soil (band) treatment, basal bark treatment, stump (cut surface) treatment, frill treatment, tree injection, and spot treatment. | National Pesticide Information Center 2002 |
| Glyphosate | Grasses, herbaceous plants including deep-rooted perennial plants, brush, some broadleaf trees and shrubs, and some conifers. Does not control all broadleaf | Absorbed by leaves and rapidly moves through the plant and accumulates in actively growing parts of the plant. It prevents the plant from producing an important enzyme which then disrupts plant synthesis of compounds | Aerial spraying, spraying from ground based equipment, wipe application, frill treatment, cut stump treatment. | National Pesticide Information Center 2000 |

| | | | | |
|---|---|---|---|---|
| | woody plants | necessary for growth. | | |
| Imazapic | Annual and perennial herbaceous plants and grasses. | Inhibits the production of an enzyme, which interferes with protein synthesis and growth. | Aerial spraying, spraying from ground based equipment. | Tu et al. 2004 |
| Imazapyr | Annual and perennial grass, herbaceous weeds, brush, vines, and deciduous trees. | Absorbed by leaves and roots, then moves rapidly through the plant where it inhibits a specific enzyme required for protein synthesis and cell growth. | Aerial spraying, spraying from ground based equipment, basal bark and stem treatment, cut stump treatment, tree injection. | Tu et al. 2004 |
| Metsulfuron methyl | Woody plants, annual and perennial herbaceous plants. | Absorbed through the roots and foliage and moves rapidly through the plant where it inhibits cell division in the roots and shoots, which stops growth. | Aerial spraying, spraying from ground based equipment. | DuPont 2007b |
| Picloram[1] | Herbaceous plants, vines, and woody plants. | Absorbed through plant roots, leaves, and bark. It moves both up and down within the plant and accumulates in new growth. It acts by deregulating plant growth metabolic pathways which interferes with vital plant growth processes. | Aerial spray as broadcast or low volume dormant spray, broadcast or spot foliar or soil treatment, basal spot treatment, tree injection, frill treatment, stump treatment, basal bark treatment, or low-volume dormant stem spray. | Dow AgroSciences 2002 |
| Triclopyr | Control of woody plants and broadleaf weeds on right-of-way, non-crop areas, non-irrigation ditch banks, forests, wildlife openings, rangeland, and permanent grass pastures. | Triclopyr is absorbed by green bark, leaves, roots, and cut stem surfaces and moves throughout the plant where it accumulates in the meristem (growth region) of the plant. It mimics a plant growth hormone which interferes with normal plant growth processes. | Aerial spraying, spraying from ground based equipment, basal bark and stem treatment, cut surface treatment, tree injection. | National Pesticide Information Center 2002 |

[1] Products containing picloram are classified as "restricted use." As a result of this designation, the sale and use of these products are limited to licensed pesticide applicators only for the uses covered by their applicator's certification. The restricted use classification is due to picloram's mobility in water and the sensitivity of many important crop plants to damage.

An adjuvant is a substance added to a pesticide to aid its action, but has no pesticide action by itself. Some pesticides require the addition of an adjuvant to work effectively. Surfactants are adjuvants used in conjunction with pesticides to increase absorption of the chemical by the plant. Another adjuvant commonly used with herbicide is a dye product that turns the chemical mixture a specific color, usually blue, so that treated plants (or portions of plants) are easily recognized to aid the pesticide applicator in assuring a thorough application of the chemical to the targeted

plant. Safety procedures must be adhered to and Material Safety Data Sheets must be kept on site for all adjuvants used at Lake Mead NRA as described in Appendix B.

Pesticides can be applied using one of several application methods. The most appropriate application method is determined by the weed being treated, the herbicide being applied, the skills of the applicator, and the application site (Tu et al.2004). Methods of application can be broadly classified as follows:

- Foliar application where herbicide is applied to intact, green leaves
    - Spot application using a precise tool such as a backpack applicator or spray bottle
    - Wick application where the herbicide is physically wiped onto the leaf surface
    - Broadcast application using boom or boomless sprayers to distribute herbicide over a relatively large area depending on the swath width
- Basal bark application where herbicide is applied to intact bark around the circumference of the trunk
- Frill or "hack and squirt" methods where the trunk or stem is first cut into the cambium layer then herbicide is applied to the cut
- Injection where herbicide is injected through the bark into the cambium layer
- Cut stump treatment where the tree or stem is first cut straight across then the herbicide is applied to the freshly cut stump for transport to the root system
- Pelletized treatment where herbicide is made into a pellet that is implanted at the plant's base
- Pre-emergent where the herbicide is applied to the soil before the target species seeds germinate and emerge

Pesticides selected for use at Lake Mead must be labeled for that application, known to be effective on the target exotic plant, and known to have a minimal effect on the environment. To minimize potential environmental effects, pesticides would be selected based on the presence of non-target plants (including sensitive and traditional use plants), soil texture, depth and distance to water, and environmental conditions. Only those pesticides that have been registered by the U.S. Environmental Protection Agency are allowed for use at Lake Mead NRA and all use must conform to the product label regarding application rates, methods, environmental protection measures, etc.

Best Management Practices (BMPs) would be followed to ensure that the overall effectiveness of pesticides is maximized and the potential for impacts is minimized. These general BMPs include the following:

- All product labels would be read and followed by pesticide applicators. It is a violation of federal law to use a pesticide in a manner that is inconsistent with its label.
- Pesticide applicators would obtain and maintain any certifications or licenses required by the state and/or county.
- Pesticides would be applied as near to the target plant as possible.
- Pesticide application would account for meteorological factors such as wind speed, wind direction, inversions, humidity, and precipitation in relation to the presence of sensitive resources near the treatment area and direction provided on labels. Pesticides would only

be applied when meteorological conditions at the treatment site allow for complete and even coverage and would prevent drifting of spray onto non-target sensitive resources or areas used by humans.

- Pesticides would be applied only during periods of suitable meteorological conditions as indicated on the pesticide label. The extreme high temperatures common at Lake Mead may limit the use of pesticides during the summer months.
- Pesticides would be applied using large droplet size (coarse sprays) to minimize the potential for drift. Avoid combinations of pressure and nozzle type that would result in fine particles (mist). Add thickeners if the product label and application equipment permits.
- Pesticides would be applied at the appropriate time based on the pesticide's mode of action. Poor timing of application can reduce the effectiveness of pesticides and can increase the impact on non-target plants.
- Pesticides would be applied according to application rates specified on the product label.
- In areas where there is the potential to affect surface water or ground water resources, pesticide pH and soil pH would be considered to select the pesticide with the lowest leaching potential.
- Highly water-soluble pesticides would not be used in areas where there is potential to affect surface water or ground water resources.
- Pesticides with high volatility would not be used to treat areas located adjacent to sensitive areas because of the potential for unwanted movement of pesticides to these areas.
- Pesticides with high soil retention would be used in areas where there is potential to affect surface water or ground water resources.
- Pesticides with longer persistence would be applied at lower concentrations and with less frequency to limit the potential for accumulation of pesticides in soils.
- As needed to protect the efficacy of the pesticide, water used in chemical dilution would be buffered, depending on hardness, pH, and other factors.
- Safety protocols for storing, mixing, transporting, handling spills, and disposing of unused pesticides and containers are included in Appendix B and would be followed at all times. Plans for emergency spills are included in Appendix B.
- All federal, state, and local regulations regarding pesticide use would be followed at all times.
- To maintain pesticide efficacy, only pesticide amounts that are expected to be used in a 1 year period will be purchased, as per NPS policy (NPS 2006).
- Equipment would be maintained and calibrated prior to each application of pesticides. During all applications, droplet size would be controlled to decrease the risk of pesticide drift to non-target species outside the immediate treatment area. Droplet size is controlled by nozzle settings.
- Only pesticides that are registered for use in aquatic habitats would be used in or near surface water (including reservoirs, rivers, springs, and seeps, but not including dry washes where no hydrophytic vegetation is present).

- Only those pesticides that have a low potential toxicity, would be used in areas with a high leaching potential.
- Applications of pesticides would be avoided during periods and in areas where seasonal precipitation is likely to wash residual pesticides into waterways.
- Applications of pesticides within 50 feet of surface water bodies (including streams, rivers, lakes, and waterways) would be done by hand or with vehicle mounted ground equipment to minimize the potential impacts to surface waters.

Once the Lake Mead Exotic Plant Manager determines that a pesticide is the appropriate weed management tool for the species and location, and a pesticide and application method has been selected, the Exotic Plant Manager would seek NPS approval. At the time of this writing, the approval process is to submit a pesticide use proposal using the Intranet-based IPM System. The proposal is generally reviewed and approved by the Regional IPM Coordinator. However, review and approval from the National IPM Coordinator would be required for pesticide use proposals that involve: aquatic applications or situations in which the applied pesticide could reasonably be expected to get into waters or wetlands; pesticide uses that may affect rare, threatened, or endangered species or associated critical habitat; pesticide use involving aerial application; pesticide use on 400 or more contiguous acres; or use of a restricted-use pesticide as defined by the USEPA (e.g. picloram). Once approved, the pesticide can be purchased and applied as prescribed. All pesticide use is reported annually on a pesticide use log submitted to the Regional IPM Coordinator.

### 4.3.5. Prescribed Fire Treatments

Prescribed fire is any fire ignited by management actions to meet specific objectives. It follows a written, approved prescribed fire plan that includes specific objectives for undertaking the burn, as well as prescriptions for fire behavior and operational details. Effects of the prescribed fire treatment on specific plant species and vegetation communities are monitored. Monitoring is usually conducted at regular intervals, such as immediately after the fire, 1 year post-fire, 2 years post-fire, and 5 years post-fire.

One objective for a prescribed fire may be to decrease exotic plant species and/or increase native plant species. Prescribed fire can be a very effective weed management tool where exotic plants that are not fire tolerant grow interspersed with native plant species that are fire tolerant. It may also be used to remove exotic plant species that grow earlier than native plant species when both are not fire tolerant, thus establishing a narrow window of opportunity to use fire to damage the early growing exotic plants while the native plants are not susceptible to damage. In some cases, prescribed fire can be used as part of a multi-treatment approach to exotic plant management. For example, dense tamarisk stands can be difficult to access for treatment and foliar application of herbicide on a dense stand of mature trees requires a great deal of chemical and application effort due to the volume of leaf area. In these cases prescribed fire may be used to burn the dense stand. Tamarisk will readily sucker post-fire and those suckers can either be treated with a foliar application of herbicide or with a cut-stem treatment of herbicide. Then after the viability of the

existing tamarisk is sufficiently lowered, native tree and shrub species can be inter-planted to provide competition to newly germinated tamarisk seedlings and those seedlings can be manually treated. In this way, prescribed fire is part of a sequential exotic plant management scenario that involved fire, chemical treatment, cultural treatment, and manual treatment to achieve the objective of removing exotic plants and restoring a native plant community.

The use of prescribed fire at Lake Mead is addressed in the Lake Mead Fire Management Plan (2004) and Environmental Assessment, which states that:

> Prescribed fire may also be used to control invasive exotic plant species such as …. tamarisk trees (*Tamarix ramossisima*). Tamarisk pile burning may also be necessary following control projects.

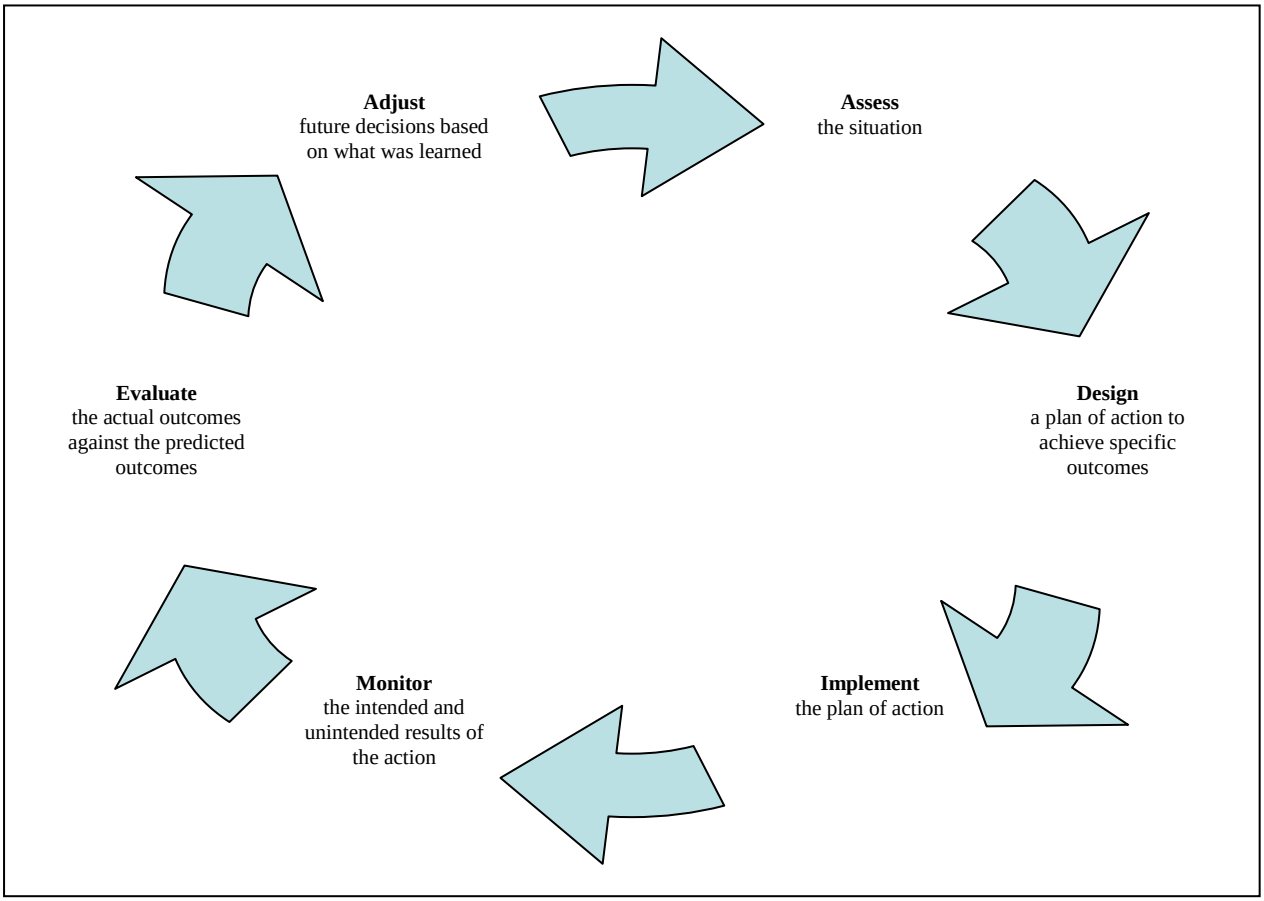
## *4.4 Adaptive Management*

Adaptive management has been defined in various ways since the 1970's when the concept first came into common usage. For the purposes of the Lake Mead Exotic Plant Management Plan, we use the following working definition taken from the Department of the Interior Technical Guide (Williams et al. 2007):

> *Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error process,' but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decision and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders.*

The adaptive management process is six steps which must be completed sequentially as shown in Figure 7.

Figure 7: Generic adaptive management process.




Adaptive management is incorporated into many aspects of the exotic plant management programs at Lake Mead NRA as illustrated in Figures 9-14. Figure 8 shows flowchart symbology while the remaining flowcharts illustrate decision making processes used for:

- Situation Evaluation Process (Figure 9)
- Site-led Treatment Process (Figure 10)
- Incipient Population Treatment Process (Figure 11) – further described in Chapter 6
- Established Population Treatment Process (Figure 12) – further described in Chapter 7
- Detail Chemical Treatment Flowchart to confirm compliance (Figure 13) – further described in Chapter 6
- Detail Biocontrol Treatment Flowchart to confirm compliance (Figure 14) – further described in Chapter 7

Figure 8. Key to symbology used in flowcharts.

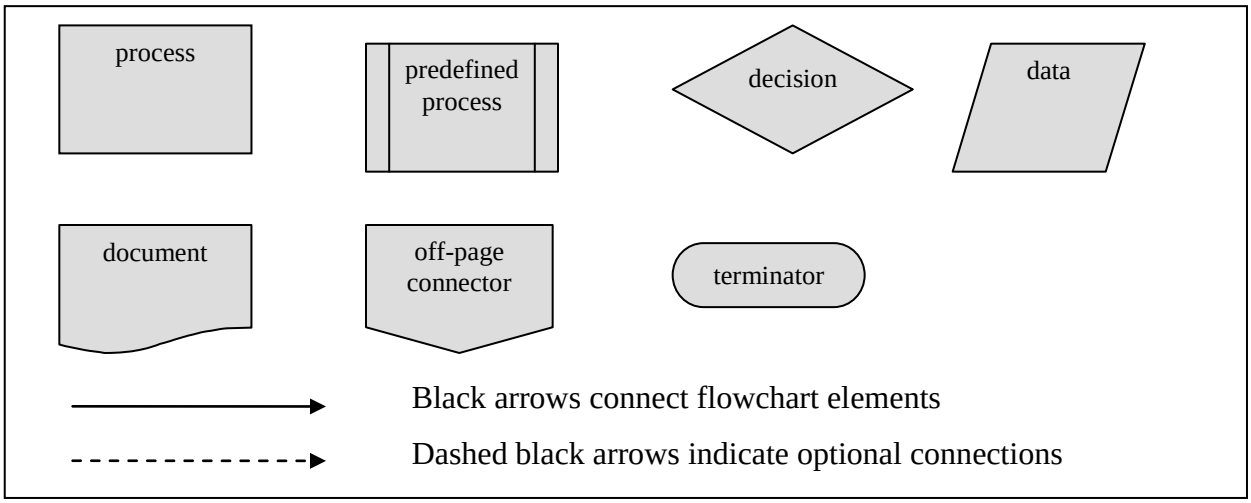


Figure 9. Flowchart of Situation Evaluation Process.

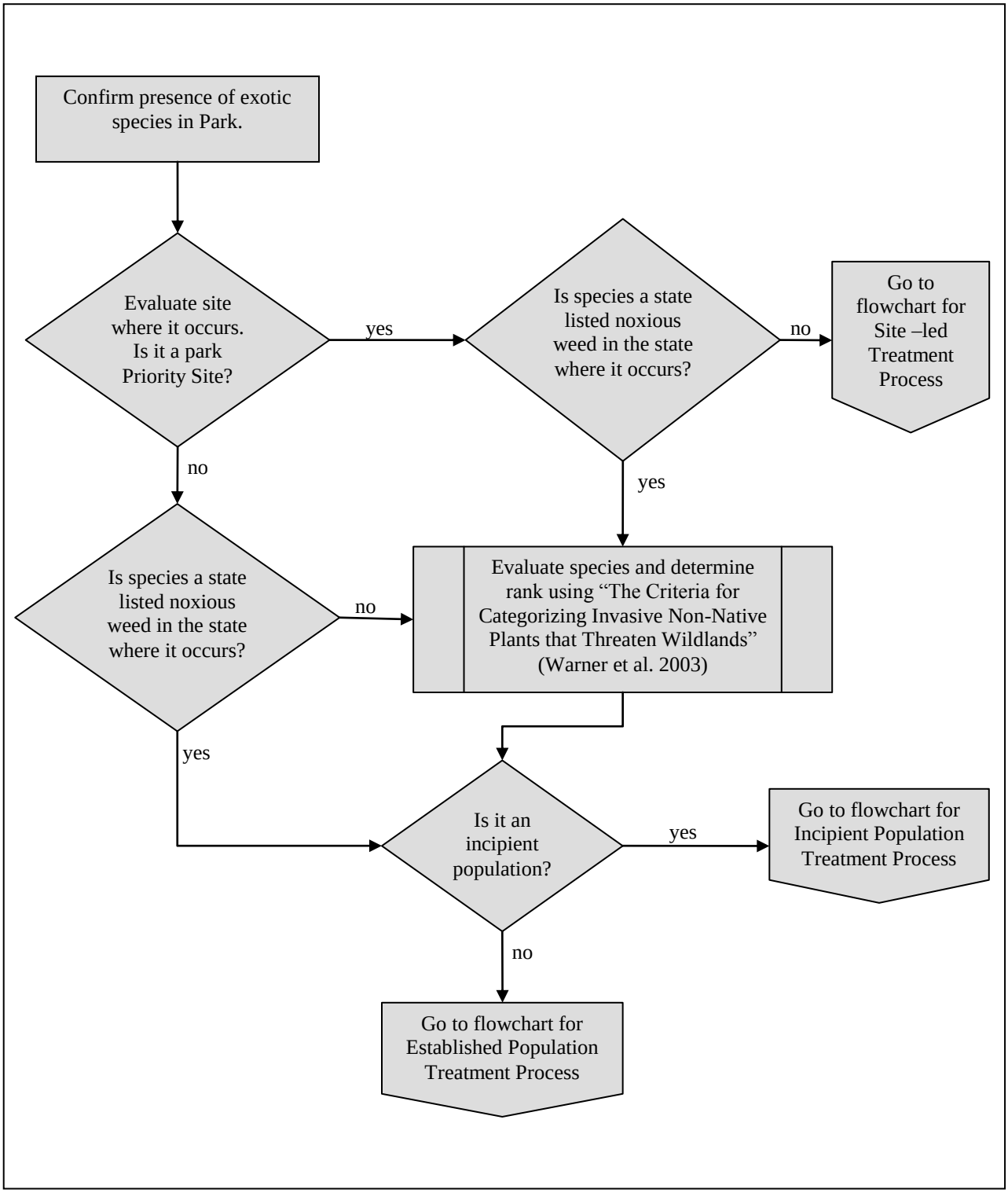


Figure 10. Flowchart for Site-led Treatment Process (page 1 of 2)

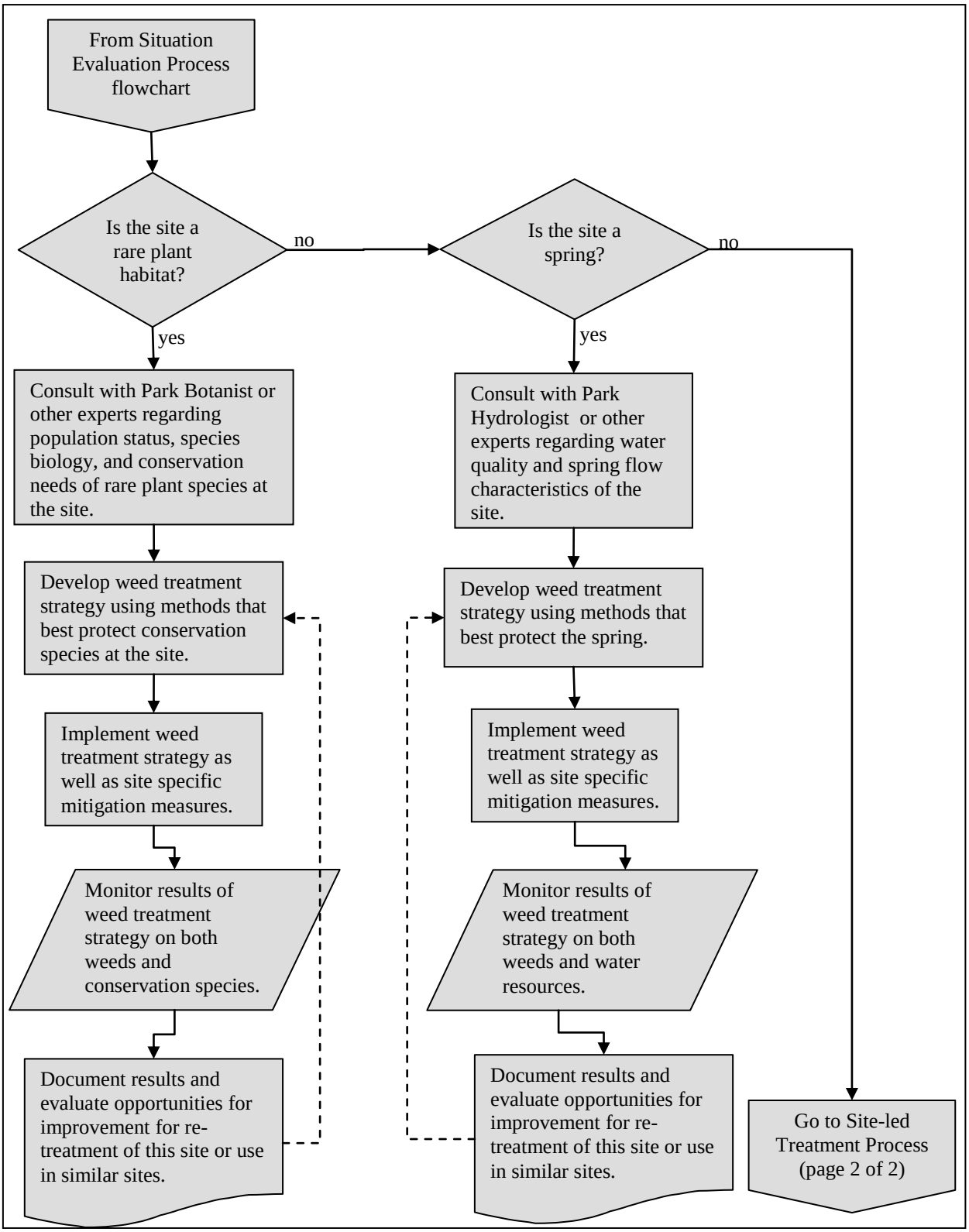


Figure 10. Flowchart for Site-led Treatment Process (page 2 of 2)

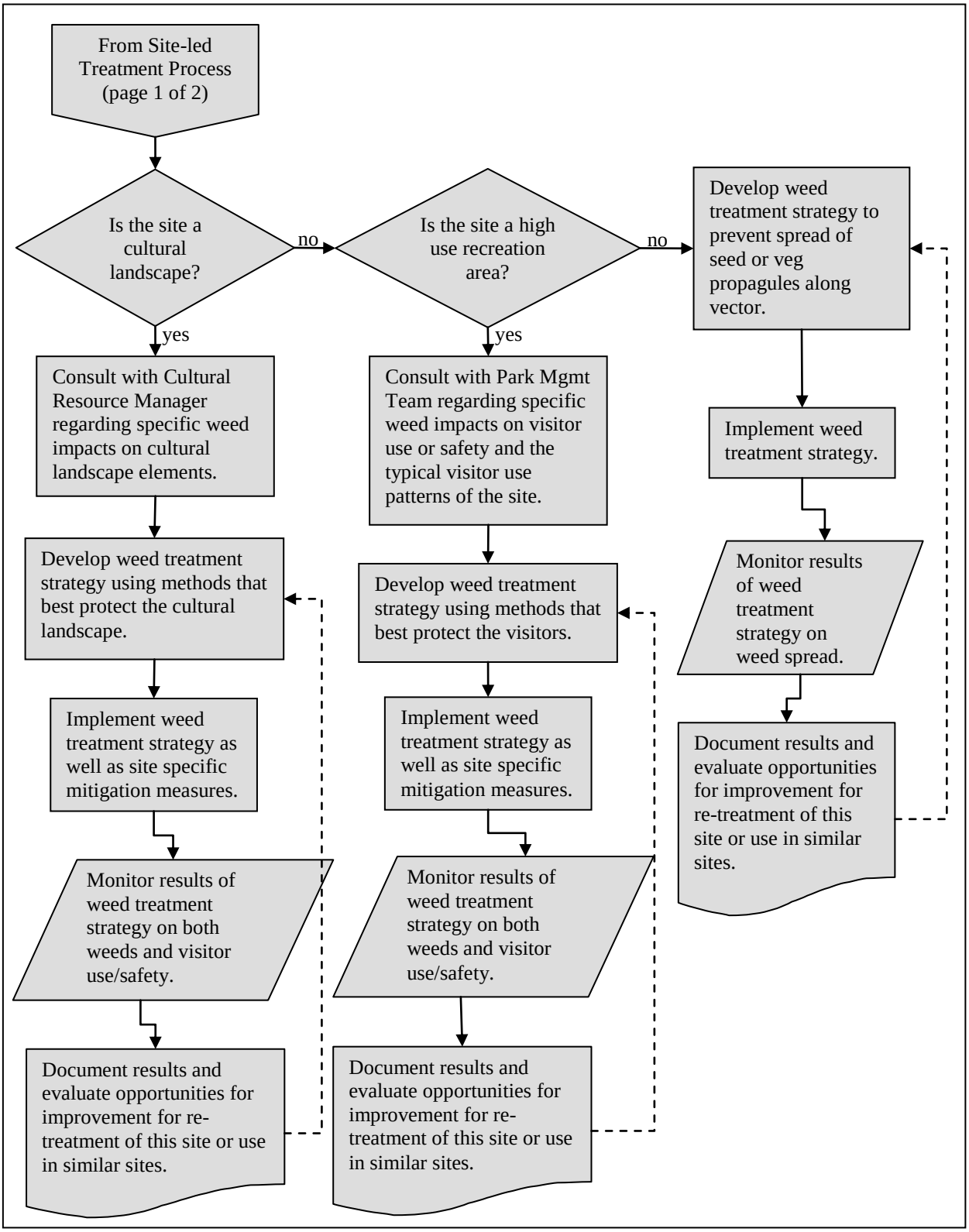


Figure 11. Flowchart for Incipient Population Treatment Process

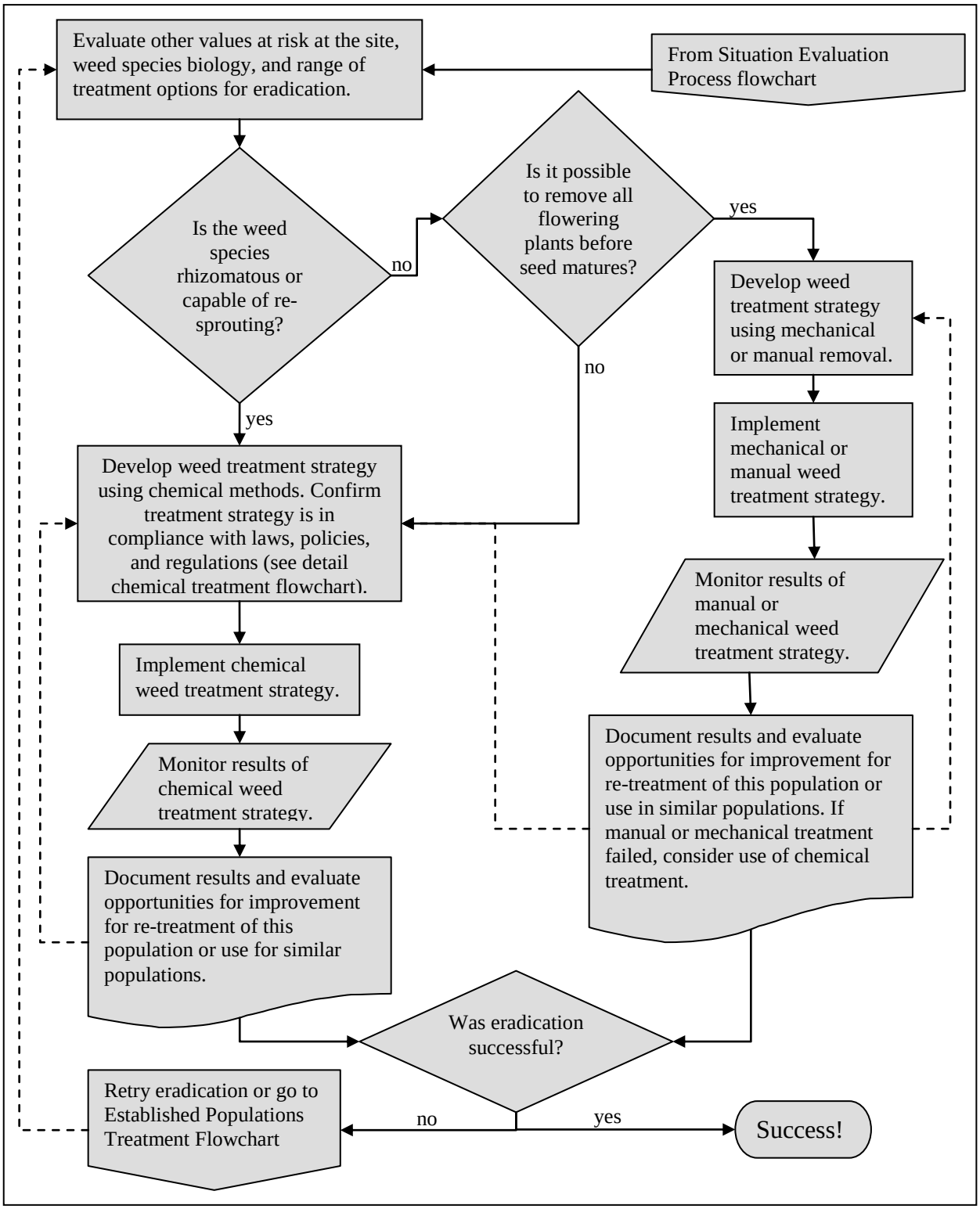


Figure 12. Flowchart for Established Population Treatment Process

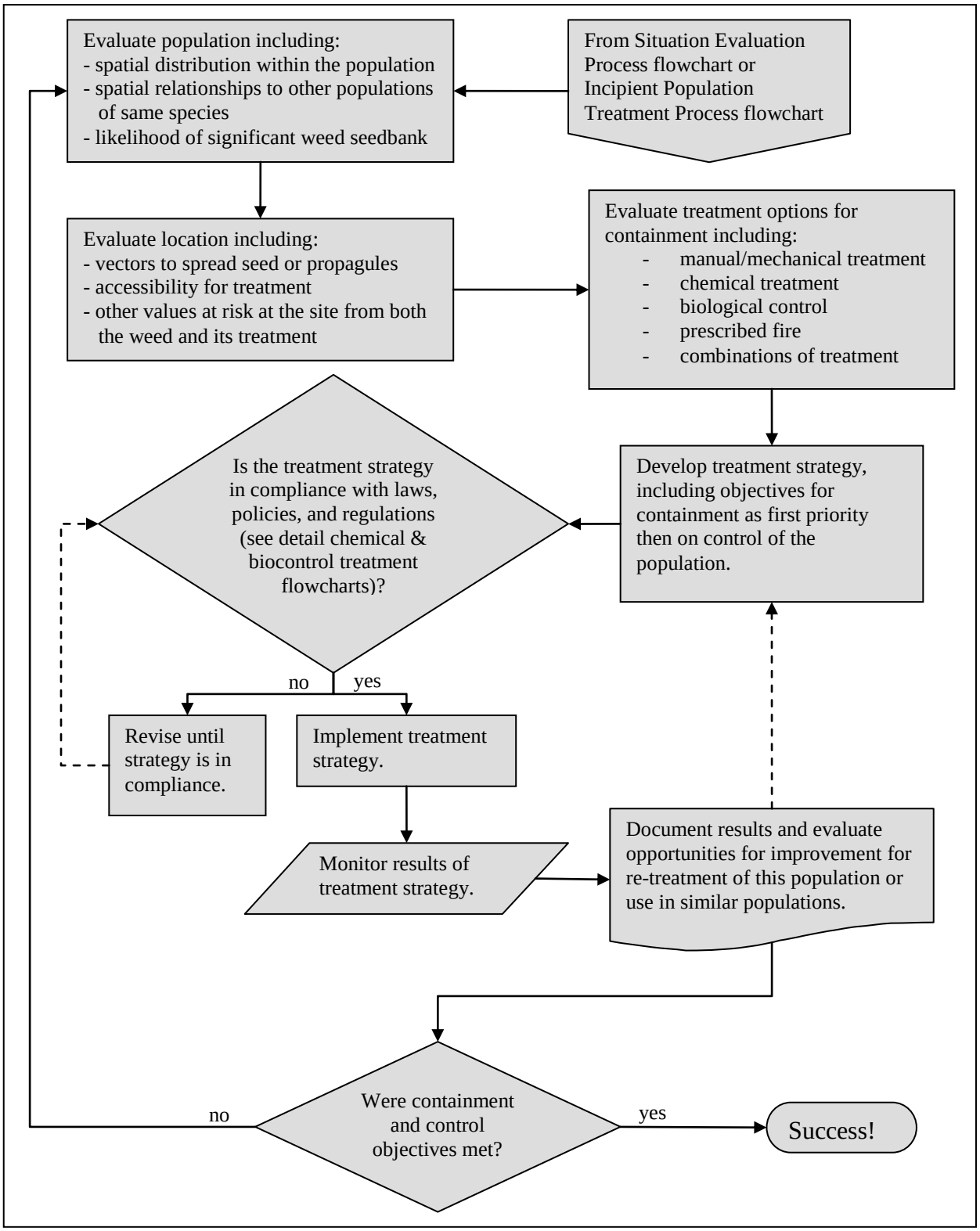


Figure 13. Detail Chemical Treatment Flowchart to confirm compliance.

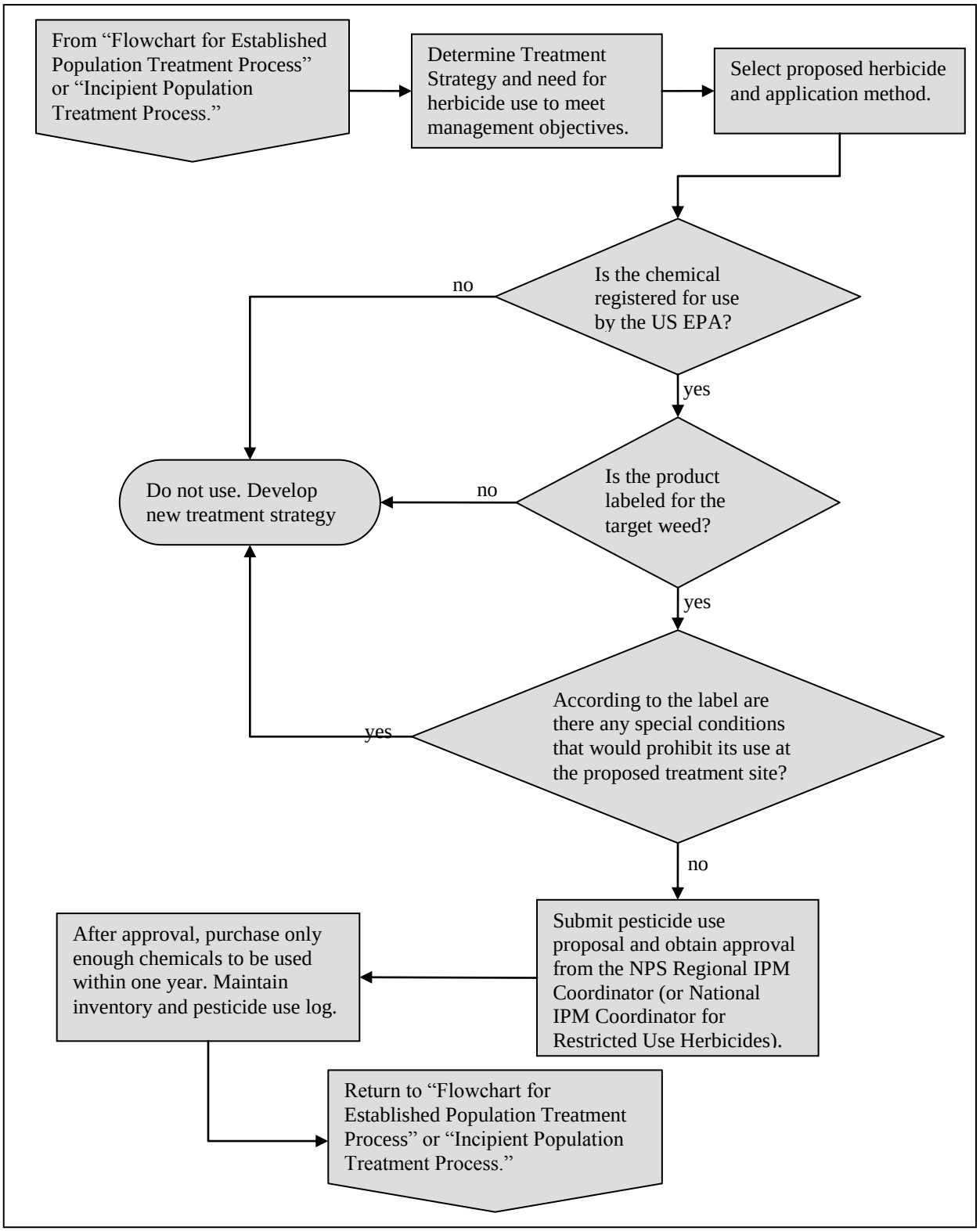
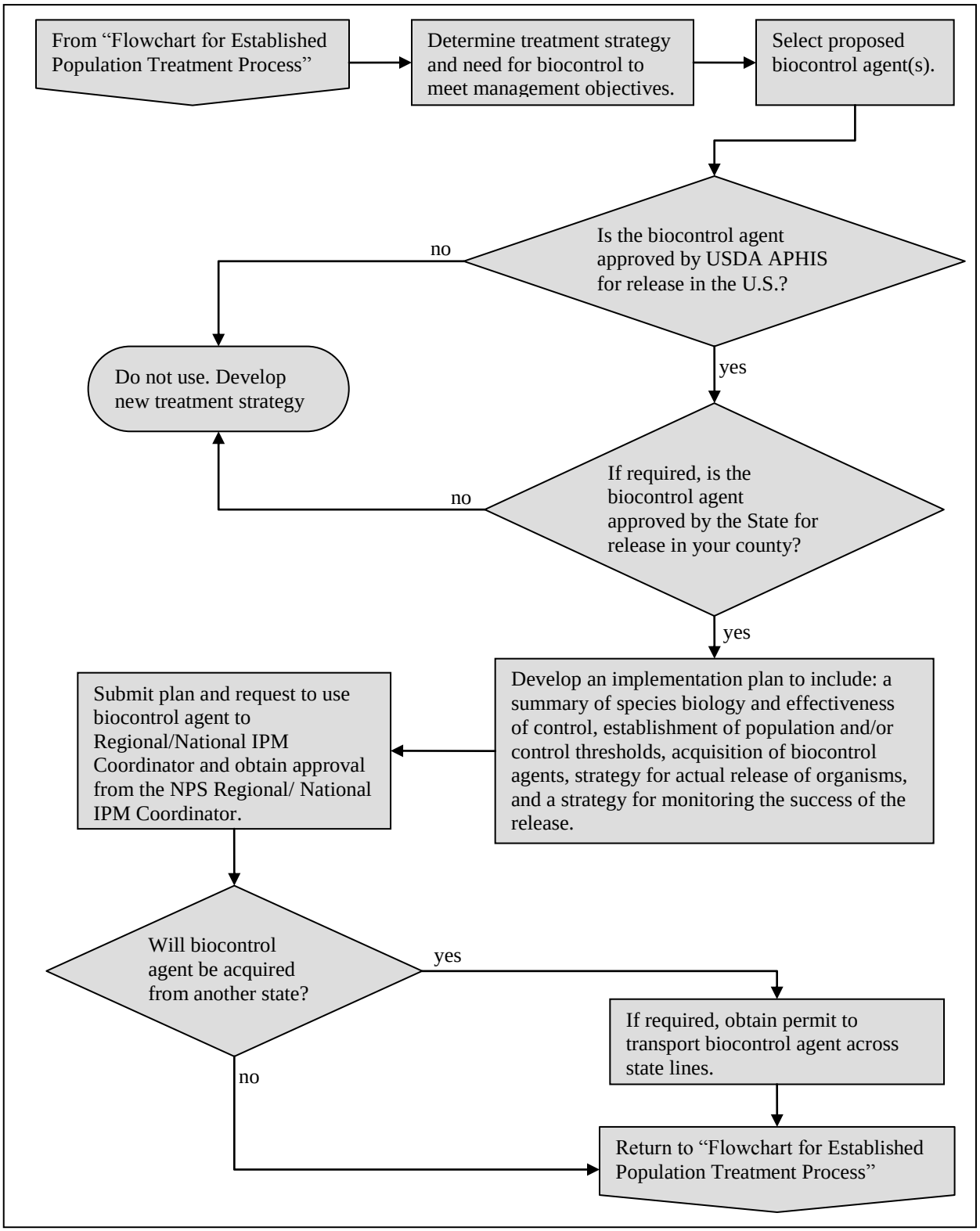


Figure 14. Detail Biocontrol Treatment Flowchart to confirm compliance.



# Chapter 5: Exotic Plant Prevention

## *5.1 Introduction to Exotic Plant Prevention*

This chapter specifically addresses Exotic Plant Management Program Objective 2: Proactively prevent the introduction and/or expansion of new exotic plant species.

The benefits of exotic plant prevention are simple. If exotic plant seeds and propagules are not brought into the park or they are prevented from becoming established after entry, exotic plant invasion does not occur and no additional management efforts are needed. This serves to protect ecological values of the park and surrounding lands, perpetuates the opportunity for visitors to enjoy a natural landscape, and saves money that would have been spent on exotic plant control. Thus, exotic plant prevention is the most efficient and cost-effective exotic plant management strategy available and thus is worthy of serious consideration. Continuous and diligent effort is needed by all members of the park staff and cooperators to sustain exotic plant prevention efforts.

The exotic plant prevention strategy at Lake Mead has two major components:
1) Education of employees, cooperators, and visitors
2) Proactively incorporating exotic plant prevention into agency operations and agency-controlled activities

## *5.2 Education*

### 5.2.1. Employees and Cooperators

Exotic plant education materials, including the park's exotic plant related Standard Operating Procedures and highest priority exotic plant species, will be provided to all new employees and/or cooperators as part of their new employee orientation.

Prior to the annual National Invasive Weed Awareness Week (generally late February to early March), the Park's Exotic Plant Manager will prepare a memo for the Superintendent's signature that briefly reminds employees and cooperators of the NPS policy on exotic plants and re-affirms the park's exotic plant prevention commitment. The memo and/or its attachments will be distributed to all employees as well as cooperators and concessioners and should include the following items:

- "Be on the Lookout" one-page attachment that includes brief, non-technical descriptions and photos of the park's current high priority exotic plant species for early detection
- Highlights of exotic plant prevention successes accomplished over the last year
- Reminder of the park's Standard Operating Procedures that are relevant to exotic plants
- Announcement of an invitation to participate in park activities planned in support of the National Invasive Weed Awareness Week

### 5.2.2. Visitors

A member of the park's interpretive staff will be assigned to work with the park's Exotic Plant Manager to prepare materials and events for the park's participation in the annual National Invasive Weed Awareness Week. Activities and special events will vary, but may include volunteer events to undertake exotic plant management projects, guided hikes that focus on preservation of native plant communities and recognition of exotic plants, posters and/or handouts of the park's "Be on the Lookout" species for the year, temporary visitor center exhibits, special presentations to community groups, and tours of the park's demonstration native landscape garden at the Alan Bible Visitor Center. As appropriate these events will include partners such as the Nevada Native Plant Society, Get Outdoors Nevada, and other organizations.

As appropriate, exotic plant awareness and prevention will be incorporated into the Park's ongoing interpretive and education programming, including ranger talks and walks, curriculum-based education programs, interpretive signage, visitor center exhibits, etc.

## *5.3 Park Operations and Agency-Controlled Activities*

Proactive exotic plant prevention at Lake Mead includes incorporating exotic plant prevention measures into operations of the National Park Service and exotic plant prevention in NPS-controlled activities such as concessions, contracts, research permits, special use permits, and other activities undertaken by non-NPS entities but under the authority of the park. To provide the most effective implementation of these measures, this chapter is written as a series of draft Standard Operating Procedures (SOPs) to be applied park-wide. In some cases the SOPs are specific to exotic plants, but in other cases they are more generic for invasive species (e.g. exotic plants, animals, aquatic organisms) such that their maximum utility in protection of park resources is realized. These drafts will be reviewed by the senior management team, revised as necessary, and ultimately adopted as final SOPs for park operations. Some of these SOPs are already in effect or at least are in practice, but this is the park's first attempt to create a comprehensive exotic plant prevention program. In the spirit of adaptive management, it is anticipated that these SOPs will be updated periodically and additional SOPs may be adopted to deal with emerging exotic plant management concerns.

The Standard Operating Procedures for exotic plant prevention are:

- SOP 803 (revised from 1992 version): Landscape Plant Selection
- SOP ###: Fire Operations
- SOP ###: Soil and Fill Selection and Management
- SOP ###: Nursery Operations
- SOP ###: Livestock Operations
- SOP ###: General Permit and Contract Conditions

# STANDARD OPERATING PROCEDURE 803

## LANDSCAPE PLANT SPECIES SELECTION AT LAKE MEAD NATIONAL RECREATION AREA

**This version supersedes SOP 803 dated 7/27/92**

Justification for Proposed Park Procedures

National Park Service (NPS) policy states that species native to the park should be used to the maximum extent possible for plantings in all zones. NPS Management Policies state that for landscaping and revegetation "Only native species will be allowed in natural zones. Use of exotic species in other zones will conform to the exotic species policy."

NPS Management Policies further state that landscape and plants in park development zones may be manipulated as necessary to achieve the purpose of that zone. It also states that landscapes and plantings adjacent to natural or cultural zones will use native or historic species or materials to the maximum extent possible. In addition to the above policies, the Western Regional Guide to Revegetation, NPS 77, and Lake Mead National Recreation Area's "Non-Native Plant Policy Statement" also show clear directive and justification for the use of native plant material.

Based on all these policy statements, the following landscape plant selection procedure is established for use at Lake Mead National Recreation Area (NRA).

General Provisions

Most plant species native and non-native to the park are listed in the publication "Checklist of Vascular Plants of Lake Mead National Recreation Area" by Dianne Bangle, March 2007. The species in this document, except for those listed as "ALIEN", are hereby adopted as the park's working native plant list. The park botanist will be responsible for additions and deletions to this list, which will be maintained by the Resource Management Division.

Lake Mead NRA's "Non-Native Plant Policy Statement" also contains a list of species known to be particularly invasive, or are listed as Noxious Weeds by the federal government and/or the states of Nevada and Arizona. Oleander and fan palm are two such species, both of which are common in developed areas. These species will be removed as soon as possible from landscapes wherever they occur in the park. Exceptions to this will be made on a case-by-case basis by park management staff.

Native plant material for any park zone or landscape purpose must be obtained from the Lake Mead Native Plant Nursery (Nursery) operated by Resource Management staff at Lake Mead NRA. This is to ensure the genetic integrity of all native plant material placed in projects throughout the park. Exceptions to this will be decided by park management staff on a case-by-case basis. The Nursery will provide park personnel and concessioners with a list of plant species and sizes available for restoration, landscape planting, or other purposes. This list, titled "Native Plant Species Availability", will be updated quarterly and will contain species under three categories: available immediately; available with three to six months notice; and available with one year or more notice. Since the Nursery is 100% grant and donation funded, suggested donations will accompany each list.

Natural Zones

Only native plant material will be used in natural zones. Material will be locally collected to preserve the genetic integrity of the natural zone. "Locally" will be defined as the area of natural dispersal including pollen, seed or other propagules of each species. Therefore, species may be collected from a source outside the park as long as seed, pollen or propagule dispersal from this source is likely to result in seed, pollen or propagules being deposited within the park boundary.

A few native species have extremely localized natural distributions within the park, but will be excluded from landscape use in order to prevent an unnatural extension of the plant's range.

Developed Areas

For the purpose of this SOP, developed areas are defined as all developed and maintained areas, excluding housing areas, cabin sites, trailer villages, demonstration areas and other concession areas, which are described below. Only native plant species shall be used for new plantings in the developed areas. The park's Professional Services Branch is responsible for developing planting plans and arrangements for installation for developed areas. Species used must be selected from the parks working native plant list, in collaboration with Resource Management Division. Propagules must be collected locally and plants may be pruned, watered, and fertilized to enhance the desired function.

Most park developed areas are presently landscaped with non-native plants. These will be replaced as they die with native species, or as money becomes available for large-scale conversions.

Demonstration Areas

The Alan Bible Visitor Center will be used as a landscape demonstration area. Guidelines for this demonstration area are the same as other park-developed areas; however individual plants that are not common to the surrounding environment may be used to help represent other plant communities for educational and interpretive purposes.

Other existing cactus and demonstration gardens throughout the park at ranger stations and visitor contact stations may be maintained as they are. However, future plantings in these areas must be restricted to the native plant species common to the surrounding area, and must be from stock collected locally. Large-scale conversion of demonstration gardens may take place as money becomes available.

Plants in demonstration areas may be pruned, watered, and fertilized to enhance the desired function.

The park Professional Services Branch, Visitor Services staff, and Resource Management staff must collaborate on design for demonstration areas. Resource Management must be provided with a list of desired species so that collection and propagation can be done to meet planting schedules.

Staff Housing Areas

The use of native species will be required in staff housing landscaping except for lawns which may not exceed 600 square feet per residence. Lawn grass species must be sterile cultivars of hybrid Bermuda grass, which is an exception to the approved working plant list above. Plants may be pruned, watered and fertilized to enhance the desired function. The park Landscape Architect and Resource Management staff must collaborate on design for park housing landscapes. Resource Management must be provided with a list of desired species so that collection and propagation can be done to meet planting schedules.

Many staff housing areas have not been landscaped to these specifications in the past. Non-native species will be replaced as they die with native species, or as money becomes available for large-scale conversions.

Vegetable gardens and flower beds composed of non-native species may be allowed; however, species must be approved by Resource Management staff. Individual tenants are responsible for obtaining approval by written request from Resource Management, and are also responsible for removing these species when vacating the residence. If a previously-allowed species is discovered later to be invasive or to interbreed with native plants, the tenant will be required to remove the non-native species in question.

Trailer Villages, RV Parks, and Cabin Sites

The use of native plants will be required for landscapes as described for park staff housing areas. Individuals located in trailer villages or RV parks wishing to landscape must contact the concessioner responsible for administration of their area for approval. The concessioner is then responsible for obtaining approval from Resource Management and Concession Management staff for their planting plan. Cabin site lessees must contact Concessions staff directly for approval. Under no circumstances will plantings be installed without proper park staff approvals. Any plantings found to be so will be removed at the tenant's expense.

Plants may be pruned, watered, and fertilized to enhance their desired function.

Vegetable gardens and flower beds may be allowed as described for park staff housing areas. All the above restrictions and conditions apply.

Commercial Concession Areas

It is recognized that commercial concession areas (restaurants, lodging, marinas, etc.) will present a more intensely-landscaped appearance in keeping with visitor-use function and have not been landscaped to native-plant specifications in the past. However, all concessioners are required to use native plant material in all new plantings and replacements. Native plant material must be obtained from the Lake Mead Native Plant Nursery and may be watered, pruned, and fertilized to enhance its desired function. Lawns may be allowed but must be sterile cultivars of hybrid Bermuda grass species, kept to a minimum size and have a specific recreational purpose. The concessioner must develop landscape plans in collaboration with Resource Management and Concessions Management divisions.

Park In-Holdings

Certain private in-holdings within park boundaries including the Hacienda Hotel and Casino, Katherine Resort Lands, and the community of Meadview are recognized as private property within the park. However, NPS concerns about protection of the native gene pool and potential escape of exotic plants into the park will be discussed with property owners in the hopes of developing a cooperative relationship with each owner.

Cooperative Agencies

Cooperative agencies include the Nevada Department of Wildlife, Southern Nevada Water System, U.S. Fish and Wildlife Service, and Arizona Game and Fish. Each of these agencies operates facilities within the boundary of Lake Mead NRA under agreement with NPS. These agencies will be made aware of NPS policies and be asked to submit proposed landscape or planting plans to the Resource Management Division for review. Native plants from the Lake Mead Native Plant Nursery will be made available to these agencies for a nominal fee. Historically, these agencies have not been aware of NPS guidelines and facilities have not been planted to these specifications in the past. The Resource Management staff will exercise its obligation to protect native plant communities by requesting the removal of any plants that become pests in the natural environment or that may interbreed with native species.

Procedures

Procedures for obtaining approvals and plant material for landscaping projects within Lake Mead NRA are as follows:

For NPS Sponsored Plantings

1. Initiating group will contact the Professional Services Branch and Resource Management Division with a written proposed planting plan at least three months prior to planting.

2. Professional Services Branch and Resource Management will review and provide input to plan, and either approve or approve with changes.

3. After approval, initiating group will arrange with the Nursery to provide native plant material as specified in the plan. The initiating group must provide for installation and maintenance of all plant material.

Vegetable and Flower Beds for NPS Staff Housing

1. Tenant shall provide Resource Management with a written planting plan.

2. Resource Management will review and provide input. Approval or approval with changes will be returned to tenant within five working days.

3. Tenant is responsible for planting and removal when vacating residence.

For Concession Plantings

1. The concessioner will provide Concessions Management, the park Professional Services Branch, and Resource Management Division with a written proposed planting plan at least three months prior to planting.

2. Concessions Management, the park Professional Services Branch, and Resource Management will review and provide input to plan, and either approve or approve with changes.

3. After approval, the concessioner will arrange with the Nursery to provide native plant material as specified in the plan. The concessioner must provide for installation and maintenance of all plant material.

For Trailer Village and RV Park Areas

1. Tenant must provide written proposal to the concessioner managing that particular area at least three months prior to planting.

2. If approved by concessioner, the concessioner will contact Concessions Management, the park Professional Services Branch**,** and Resource Management Division with the written proposed planting plan.

3. Concessions Management, the park Professional Services Branch, and Resource Management will review and provide input to plan, and either approve or approve with changes.

4. After approval, concessioner and/or tenant will arrange with the Nursery to provide native plant material as specified in the plan. The concessioner and/or tenant must provide for installation and maintenance of all plant material.

5. Procedures for vegetable and flower bed plantings will be the same, except that turnaround time is reduced to five days.

Cabin Sites

1. Lessee must provide written proposal to Concessions Management at least three months prior to planting.

2. Concessions Management, the park Professional Services Branch, and Resource Management will review and provide input to plan, and either approve or approve with changes.

3. After approval, lessee will arrange with the Nursery to provide native plant material as specified in the plan. The tenant must provide for installation and maintenance of all plant material.

5. Procedures for vegetable and flower bed plantings will be the same, except that turnaround time is reduced to five days.

# STANDARD OPERATING PROCEDURE XXX

## INVASIVE SPECIES PREVENTION IN FIRE OPERATIONS AT LAKE MEAD NATIONAL RECREATION AREA

Justification for Proposed Park Procedures

National Park Service (NPS 2006) policy states that the Service will… prevent the introduction of exotic species into units of the national park system, and remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.

The Lake Mead Fire Management Plan (NPS 2004) states that "Areas identified as problem areas for non-native plants would be mapped and designated as full suppression zones, except for tamarisk areas. To protect the region from the spread of non-native plants, no personnel or equipment would be permitted in the designated non-native plant problem areas, except in emergency situations." This standard serves to minimize the potential for exotic plant spread from fires within the park and additional measures are needed to prevent the accidental importation of seed from outside the park on incoming fire equipment. Additional guidance is also needed on post-fire rehabilitation guidelines as it relates to plant materials.

General Provisions for LAKE Equipment Returning from an Off-Park Assignment

All LAKE fire vehicles returning from off-park fire assignments will be cleaned before re-entry into the park. Cleaning shall include removal of all dirt, vegetation, and other foreign material from both the exterior and interior of the vehicle. Concentrate inspection and cleaning on the tire treads, wheel wells, undercarriage (including axles, frame, cross-members, motor mounts, and the area underneath steps, running boards, and front bumper/brush guard assemblies) and interior floor mats as these are the locations most likely to harbor foreign seed and propagules.

To prevent the spread of aquatic nuisance species (including aquatic exotic plants), all firefighting equipment in contact with natural water sources will be drained and dried before re-use in the park. Such equipment includes floatable pumps, hoses, fittings, water tanks, and portable tanks (e.g. pumpkins). Where appropriate and in compliance with manufacturers specifications, certain equipment may be decontaminated using as outlined on the tables at the end of this SOP. Draining of equipment should be done before re-entry into the park, but drying may take place in the fire cache area or other appropriate location.

All firefighting handtools will be cleaned at the assignment location to remove all dirt and foreign material before being loaded into the fire vehicles. Firefighter boots will be cleaned of all dirt and foreign material before re-entry into the park.

*Responsibility:* The engine captain is responsible for assuring the above procedures are accomplished before re-entry into the park and shall inspect the vehicles, equipment, handtools and boots, to assure the adequacy of the cleaning effort.

General Provisions for Incoming Fire Response Equipment during a LAKE Incident

Protection of life and property are the highest priority during fire response. To the extent that this priority is not compromised, all incoming fire vehicles and equipment will be inspected at Equipment Check-in and determined to be clean of dirt and foreign material or directed off park to the nearest commercial facility for cleaning prior to deployment in the park.

At demobilization, all non-local vehicles and equipment that operated off-pavement (including unpaved road shoulders and dirt parking lots) will be washed and inspected to assure that local exotic plants are not inadvertently transported to other wildland areas. Ideally, a hot water pressure sprayer should be used for the cleaning and one is available from Resource Management at Boulder City (Hilltop facilities) as well as at Katherine Landing (Maintenance yard). If water is not available for washing, compressed air will be used instead. The wash location must be in a location where wash water will not enter any drainages channels (natural or human-made) or bodies of water. The wash location must be mapped as part of the incident documentation and a copy provided to the park's Exotic Plant Manager to allow for follow-up inspections of the site to assure that no new exotic plants have become established.

Upon arrival or during demobilization, all non-local equipment operators will be notified that the park contains known invasive plant and animal species that may be transported off-site if precautions are not taken. Of specific concern is the potential for equipment damage caused by quagga mussels as well the potential for firefighting equipment leaving LAKE to spread this organism to other water bodies. The entirety of Lakes Mead and Mohave are infested with quagga mussels. Decontamination of water tanks and hoses should be included in all demobilization procedures for incidents that use raw lake water for any aspect of the fire operations. Other aquatic invasives are also known to occur in other areas of the Lower Colorado River System and/or western waters. Refer to the tables on the following 2 pages for species specific decontamination procedures as recommended for the Intermountain Region (which includes the Great Basin, where most of the fire equipment deployed at LAKE originates). Decontamination with quarternary ammonium compounds is preferred over use of bleach solutions due to personal and equipment safety concerns.

*Responsibility:* The Agency Rep and/or Resource Advisor is responsible for assuring that the Incident Commander (IC) and his/her Command and General Staff are made aware of these requirements. Ideally, these requirements should be identified in the delegation of authority from the Park Superintendent to the IC. In most cases, the implementation of these requirements will fall on the Planning Section Chief and more specifically the Resources Unit Leader (for incoming equipment) and the Demobilization Unit Leader (for outgoing equipment). The Incident Resource Advisor has the responsibility to map and report the wash location and Park's Exotic Plant Manager has the responsibility to inspect the location for the establishment of new exotic plants.

General Provisions for Post-fire Rehabilitation Practices

Experience in recent fires at Mojave National Preserve, Joshua Tree National Park, Bureau of Land Management Field Offices in Las Vegas and Ely, as well as research conducted by the US Geological Survey in the eastern Mojave Desert have found that post-fire seeding is a tricky proposition. Generally, seeding for the purpose of soil stabilization is very unlikely to succeed due to the precipitation patterns common in the Mojave Desert. Basically, for soil stabilization to work, the seed needs to be applied immediately after fire, germinate and develop a root system before the first heavy rain event. As most natural fires in the Mojave are the result of dry lightning that occurs just prior to the strong monsoonal flows that bring sporadic, but heavy rain to the desert, such seeding efforts are usually in vain. Seeding for the purpose of "re-establishing" the native desert flora is also prone to failure due to the complex seed germination requirements and species biology of most desert species coupled with the extreme environmental conditions of the desert.

For these reasons it is the general policy of LAKE that post-fire seeding or planting will be limited in scale and scope to meet a specific management need, such as providing forage to desert tortoise or re-establishing shrublands/woodlands in high use areas for visitor benefit, or to prevent exotic plant invasion in areas prone to such invasion. In these specific cases, the park's Vegetation Program Manager or their designee will work with fire rehabilitation specialists to determine the appropriateness of seeding/planting and the species and maturity most likely to succeed. Strong preference will be given for native plant materials of local genotypes available in the Lake Mead Native Plant Nursery. Secondary preference, particularly for larger quantities of plant materials, will be given to native plant species from designated sources. Only under extreme circumstances will the use of non-native plant materials be considered for post-fire rehabilitation at LAKE.

*Responsibility*
The Fire Management Officer and the Chief of Resource Management jointly have the responsibility to determine the need for post-fire rehabilitation planning. During the planning process, park staff as well as outside experts will make treatment recommendations. It is the responsibility of the Park's Vegetation Program Manager to assure that this SOP is communicated to the rehab planning team and that its intent is reflected in the final treatment recommendations. Local approval of the rehabilitation plan is made by the Park Superintendent. Final approval of the rehab plan lies with either the Regional Director or the National Fire Director, depending on the dollar amounts involved. Upon approval of a rehabilitation treatment plan, it is the responsibility of the Vegetation Program Manager to monitor implementation of those treatments that relate to plant materials to assure that the intent of this SOP is followed and the treatment is installed as designed.

| AQUATIC INVASIVE SPECIES OF CONCERN IN INTERMOUNTAIN REGION AND METHODS OF CONTROL | | | | | | |
|---|---|---|---|---|---|---|
| | **Whirling Disease** | **New Zealand Mudsnails** | **Chytrid Fungus** | **Zebra/Quagga Mussels** | **Didymo** | **Eurasian Watermilfoil** |
| **Sources** | C.Wilson; E. Wagner UDWR (Hedricks UCDavis)<br>Wagner 2002 | M. Vinson, USU<br>G. Schisler, CDOW<br>Hosea & Findlayson 2005<br>Richards et al 2004 | K. Hatch, BYU<br>(Johnson et al 03) | J. Herod, FWS; Cope et al. 2003 | L. Elwell, FFF<br>S. Spaulding, USGS<br>NZ Biosecurity | Smith&Barko 1990<br>Madsen&Smith 1997 |
| **Wash and remove organics (e.g. mud)** | Yes | Yes | Yes | Yes, pressure wash flushes veligers | Yes | Yes |
| **Temperature** | 90 °C (195 ° F);10 min | 46°C (120°F); 5 min<br>-3°C (27 °F); 1 hr | 60°C (140°F);5 min | ≥140°F water | 60°C (140°F); 1 min | NA |
| **Drying** | Be dry for 24 h, in sunlight best | Be dry for 48 hr, in sunlight best | Be dry for 3 hr, in sunlight best | 3-5 days, in sunlight best | Be dry for 48 h, in sunlight best | NA |
| **Bleach (6% hypochlorite)** | For 10 min:<br>1% bleach solution (500 ppm active ingred.)<br>=8.3ml/L<br>=1.3 oz bleach/gal<br>=2.6 Tbs bleach/gal | Not effective | For 30 sec:<br>20% bleach solution (>1% active ingred.) = 25oz/gal<br>OR<br>For 10 min:<br>7% bleach solution (0.4% active ingred.)<br>= 9oz/gal | Gear rinsed with 0.5% bleach solution (250 ppm active ingred)<br>=4.2ml/L<br>=0.6oz bleach/gal<br>=1.5 Tbs bleach/gal | For 1 min:<br>2% bleach solution=16.6ml/L<br>=2.6oz bleach/gal<br>=⅓ cup bleach/gal | NA |
| **Quaternary ammonium compounds**<br><br>(e.g. alkyl dimethyl benzylammonium chloride; dialkyl dimethyl ammonium chloride) | For 10-15 minutes:<br>(1500ppm active ingred)<br><br>2% *Quat 128* (7.7% act ingrd)=19.6ml/L =2.5oz/gal<br>OR<br>1.2% *Sparquat 256* (12.5% act ingrd)=12.0ml/L =1.5oz/gal | For 10 min:<br><br>5% *Quat128*<br>=50ml/L<br>=6.4oz/gal<br>OR<br>3.1 % *Sparquat256* (12.5% active ingred)<br>=31.3ml/L= 4 oz/gal | For 30 sec:<br><br>.001% *Quat128* solution = 1.0ml/L<br>=0.13oz/gal<br>= ¾ tsp/gal | No data, but likely effective | No data, but likely effective | NA |

Taken from *Preventing Spread Of Aquatic Invasive Organisms Common To The Intermountain Region Interim Guidance For 2007 Fire Operations* distributed by the Intermountain Region, USDA Forest Service, May 2007

| RECOMMENDATIONS | | | | | |
|---|---|---|---|---|---|
| **Whirling disease** | **NZ Mudsnails** | **Chytrid Fungus** | **Zebra/Quagga Mussels** | **Didymo** | **Eurasian Watermilfoil** |
| The principle vector for spread of whirling disease is contaminated fish parts and not typically through fire activities. Avoiding and removal of organics (the spores reside in mud), power washing, and flushing will greatly reduce or eliminate spores on external gear surfaces. However, wet internal tanks and hoses should be decontaminated with a quaternary ammonium compound, such as *Quat128*. While only 2.5 oz per gal is required for whirling disease, a higher concentration (6.4oz/gal) would also knock out NZ mudsnails. | NZ mudsnails are resistant to treatment, and may insert themselves in small crevices and resist flushing. However, unless vehicles are driving through streams, or buckets scrape bottom sediments, they are unlikely to get snails on external surfaces. Avoiding organics, power washing, flushing, and drying gear in the sun for 48 hours (if possible) will reduce risk. Wet internal tanks and hoses should be decontaminated with a quaternary ammonium compound, such as *Quat128* at a concentration of 6.4oz/gal. This concentration will also kill whirling disease spores and chytrid fungus. | Avoiding organics, power washing, flushing, and letting equipment dry in the sun for 3 hours (if possible) will reduce risk of transfer on external surfaces. However, wet internal tanks and hoses should be decontaminated with a quaternary ammonium compound, such as *Quat128*. While only ¾ tsp per gal is required for chytrid, a higher concentration (6.4oz/gal) would also knock out whirling disease and /or NZ mudsnails. | Fire activities are unlikely to come into contact with adult mussels. However, it is possible that water used for activities or surfaces of gear may be contaminated with the microscopic veliger stage. Pressure washing and strong flushing of tanks and hoses should be sufficient to injure and remove these organisms. | Didymo is a native diatom that erupts into high densities in special habitats, such as tailwaters below dams. Avoiding contaminated water sources and organics, power washing, and flushing would likely reduce risk of transfer on fire equipment to acceptable levels. For waders, routine protocols for chytrid or whirling disease may apply for this species. | Watermilfoil propagates from broken stems. Avoiding organics, power washing, and flushing to ensure the removal of all plant parts will prevent transport on external and internal gear. |

Taken from *Preventing Spread Of Aquatic Invasive Organisms Common To The Intermountain Region Interim Guidance For 2007 Fire Operations* distributed by the Intermountain Region, USDA Forest Service, May 2007

# STANDARD OPERATING PROCEDURE XXX

## INVASIVE SPECIES PREVENTION IN SOIL AND FILL SELECTION AND SOURCE MANAGEMENT AT LAKE MEAD NATIONAL RECREATION AREA

Justification for Proposed Park Procedures

National Park Service (NPS 2006) policy states that the Service will… prevent the introduction of exotic species into units of the national park system, and remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.

Currently, the park does not have an approved borrow management plan, although one is in draft within the Facilities Management Division. The interim measures below will be used until such time as a Borrow Management Plan is approved and will be incorporated as appropriate within that Plan.

General Provisions for In Park Fill Sources

Every effort will be made to balance cut and fill so that additional fill material is not necessary. However, there will undoubtedly be some situations that require the use of fill and it is expected that the existing borrow sites in the park will continue to be used at least until such time as a Borrow Management Plan is approved. To maintain these in-park, pre-existing borrow sites in a weed free condition the following procedures will be adopted:

1) Borrow sites will be clearly delineated on the ground, including the use of fixed edge markers as necessary. Once delineated, the sites will be inspected by biologists to assure that no species of management concern are located in the area and will be re-inspected as needed.

2) The borrow locations will be routinely sprayed with glyphosate herbicide to maintain them in a barren condition. This is necessary because many invasive plants in the desert are small annual species that can complete their life cycle in a very short time frame. Thus it is necessary to spray green shoots before they have a chance to set seed. If some plants prove resistant to glyphosate the Exotic Plant Manager may prescribe a different herbicide formulation. Pre-emergent herbicides will not be used as this would interfere with site restoration of where the fill is placed. All herbicide applications will conform to the NPS Integrated Pest Management pesticide use proposal and pesticide use log requirements.

3) When fill material from a park borrow site is used, the location (GPS coordinates or marked map), source, and estimated quantity will be reported to the Exotic Plant Manager and the location will be added to the early detection target list.

*Responsibility:* It is the responsibility of the Project Manager to identify and delineate the borrow sites and coordinate with the Vegetation Branch Manager for initial inspections. It is the

responsibility of the Exotic Plant Manager to provide herbicide, application equipment, personal protective equipment, and training to the maintenance staff nearest to each borrow site. It is the responsibility of the local maintenance staff to do the herbicide application as necessary to maintain barren conditions and to report that use on a pesticide use log and submit the log to the Exotic Plant Manager each year. It is the responsibility of all staff members to report the use of in-park fill to the Exotic Plant Manager for follow-up monitoring. The Exotic Plant Manager is responsible for general oversight of the herbicide application, preparing pesticide use proposal each year for this purpose, submitting annual pesticide use logs, and conducting or coordinating the monitoring of sites where fill was applied.

General Provisions for Out of Park Fill Sources

Where feasible, in-park stock piles of material will be used to meet project demands. For example, there are mounds of fill available outside of the Southern Nevada Water Agency facility near Boulder Beach.

Where in-park stockpiles are unsuitable or insufficient to meet project demands, contracts will include the following requirements:

Before delivery of materials from sources outside Lake Mead NRA boundaries, heat all materials to 150 degrees C to ensure sterilization of noxious weed seed. Do not stockpile the heated material outside of Lake Mead NRA boundaries prior to delivery. Heating requirements may be waived if the source meets Park inspection. Submit a list of sources to be inspected within 2 weeks after the advertisement date. In addition to the source name and location, submit potential mitigative measures to be considered during the inspection to make the source weed-free. An inspection report will be furnished 1 week prior to the bid opening date, listing the status of the source and any mitigative measures that would need to be accomplished prior to use. No additional inspections will be made after the inspection report is furnished.

Alternatively, all imported material from Contractor-located sources must be certified by the Government to be free from noxious weeds or invasive plant materials and other deleterious material before entering the Park at the start of each construction season. To determine if a potential material source meets the weed-free requirement, submit a list of sources to be inspected by the Government. In addition to the source name and location, submit potential mitigative measures to make the source weed-free. The Government will furnish an inspection report, weather permitting, within 21 days of a submission of potential material sources, listing the status of the source and any mitigative measures that would need to be accomplished before use. Coordinate with the CO on specific dates. Before delivery of select borrow, riprap, and aggregate from sources other than the Government-provided optional sources, ensure sterilization of any noxious weed seed. Do not stockpile the sterile material outside the project boundaries prior to delivery. These requirements may be waived if the Contractor’s source meets Park weed-free requirements.

*Responsibility*:
It is the responsibility of the Contracting Officers Representative and the Contracting Officer to assure that the contract condition is applied to construction contracts as appropriate. It is the responsibility of the Contracting Officers Representative, with assistance from Compliance Monitors, to assure that the contract condition is adhered to during construction activities in the Park. It is also the responsibility of the Contracting Officers Representative to make arrangements with the Exotic Plant Manager for any on-site inspections of commercial borrow sources.

# STANDARD OPERATING PROCEDURE XXX

## INVASIVE SPECIES PREVENTION IN NURSERY OPERATIONS AT LAKE MEAD NATIONAL RECREATION AREA

Justification for Proposed Park Procedures

National Park Service (NPS 2006) policy states that the Service will… prevent the introduction of exotic species into units of the national park system, and remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.

The Lake Mead Native Plant Nursery operation provides an opportunity to preserve not only native plant materials and genetic integrity of the park's plant communities but serves an important role in propagating plant materials for many conservation partners from outside of the park. However, care must be used to assure that nursery operations do not unintentionally harbor and then spread via out planting of foreign plant species. Such concerns include the accidental introduction of exotic plant species into nursery soil and plant stock that then gets transported and planted in wildland areas of the park or a partner conservation organization.

General Provisions

To minimize the potential for foreign plant materials to be introduced into native plant stock, the following policies will be adhered to in all nursery operations:

1) Pure cultures will be maintained, meaning that only one species will be grown in a given container. All foreign plant materials will be removed upon emergence and disposed of in trash receptacles to prevent the potential for re-establishment via vegetative reproduction or seed set. The only exception to this policy will be for research projects where the design requires that more than one species be grown together, such as for common garden or plant competition experiments. In such cases, the non-pure cultures will be separated from the nursery's pure culture operations to the extent allowed by the facility layout and design.

2) Potting soil will be reused where appropriate unless the previously potted plant died of a disease (i.e. fungal, bacteria, spore, etc.) or the soil shows other signs of pest invasion. The disease contaminated soil will be disposed by placing it in a plastic bag and putting that bag in the dumpster or alternatively may be used to fill in holes around the nursery compound where intense heat and solar radiation will kill pests in the soil. Prior to reuse, the contaminated containers and tools that came in contact with the diseased soil will be sanitized by washing them in a 10% bleach solution.

3) The nursery and greenhouse environment will be maintained in condition as free of exotic plants as is practical. Any state-listed noxious weeds will be immediately removed, although some very common local exotic plants (e.g. *Erodium*) may be tolerated if their treatment would interfere with nursery operations. Treatment of exotic plants will follow NPS Integrated Pest

Management (IPM) procedures and may utilize cultural, mechanical, or chemical practices. Exotic plant control will be implemented in such a way as to avoid impact to nursery stock. Preference will be given to use of 100% organic pesticides for use within the nursery compound or 30 feet outside of the nursery perimeter. Only approved pesticides will be used and all pesticide use will be used according to the label. Applications will be reported on a pesticide use log submitted to the Lake Mead Exotic Plant Manager at the end of the calendar year.

4) Natives seeds will be collected, cleaned, sorted, and stored as pure cultures unless there are specific project requirements for mixed species collections. All species will be identified in the field prior to seed collection and re-inspected and verified in the nursery during sorting prior to storage or use. All seed will be identified as to species, variety or subspecies as appropriate, date of collection, and location of collection.

Responsibilities

The Nursery Manager has the primary responsibility to assure that the provisions above are communicated to and followed by nursery staff, visiting researchers, and cooperators. The Nursery Manager is also responsible for identifying emerging pest issues and initiating consultation with the Exotic Plant Manager to determine an appropriate IPM strategy for the situation, and is ultimately responsible for implementing the prescribed strategy and monitoring the results.

The Exotic Plant Manager has the responsibility to work with the Nursery Manager in pest identification, developing a pest treatment program, submitting the pesticide use proposal and annual pesticide use logs to the NPS Regional IPM Coordinator.

The Vegetation Program Manager (supervisor of the Nursery Manager) has the responsibility to assure that the nursery operations adhere to this SOP and to initiate review and revision of this SOP as necessary.

# STANDARD OPERATING PROCEDURE XXX

## INVASIVE SPECIES PREVENTION IN LIVESTOCK OPERATIONS AT LAKE MEAD NATIONAL RECREATION AREA

Justification for Proposed Park Procedures

National Park Service (NPS 2006) policy states that the Service will… prevent the introduction of exotic species into units of the national park system, and remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.

Legal livestock operations at LAKE addressed in this SOP include the following:
- Permitted grazing on ephemeral grazing allotments in Arizona
- Recreational equestrian and pack stock use
- Administrative stock use, primarily for wilderness pack stock and wild burro gathers

Livestock are known vectors for the dispersal of exotic plant species into wildland environments. Dispersal of seed and propagules can occur via several mechanisms, generally categorized as out-of-park origin and in-park origin. Out-of-park origin includes seeds consumed prior to entry into the park then deposited in the park in feces, feed (such as hay) and bedding materials brought into the park for the purpose of caring for livestock on park land, stock use equipment such as saddle blankets, stock transport equipment such as trailers and trucks, and finally the animals themselves as seeds may be imbedded in hoofs and hair. In-park origin generally consists of short-distance transport of exotic plants from one area of the park to another area either in the gut of the animal or attached to the animals hoofs, hair, or saddle blanket.

Certified weed-free hay is commonly prescribed by wildland managers as a prevention measure and LAKE also adheres to this policy. However, it is also acknowledged that certified weed-free hay is an imperfect treatment. First, it requires inspection of the original packaging (bailing wire/twine) and purchase receipt to determine that any bale of hay is actually certified weed-free. This can be accomplished, but takes effort and determination on the part of the stock handler and the Park to achieve. Second, certified weed-free means it is free from state-listed noxious weeds, it does not mean that it is composed of native plant material. In fact, most certified weed-free hay is mostly composed of alfalfa or crested wheatgrass, both of which are non-native and can be somewhat invasive in certain conditions. Fortunately for LAKE, the Mojave Desert is less than optimal conditions for either species, but these species might still be able to establish in moist soil areas such as around springs, shorelines, etc. Also, it should be noted that there are dozens of invasive species that are not on state-listed noxious weed lists that can legally be found in certified weed-free hay and therefore transported to Park lands. These short-comings of weed-free hay are highlighted here to provide some understanding for the need for follow-up inspection of stock use areas, even if weed-free hay is used. The feeding of cubes, which is essentially hay that has been compressed into a hard block under heat and pressure, alleviates many of these concerns, but some animals do not easily tolerate cubes and they are somewhat more expensive and difficult to obtain.

General Provisions for Permitted Grazing Operations

There are a few ephemeral grazing allotments in Arizona that are potentially subject to seasonal grazing via special use permit. These allotments are only available during years when the ephemeral forage production meets specific criteria, thus grazing does not occur every year. When the ephemeral forage production does meet the criteria and a permittee successfully applies for a grazing permit, the following exotic plant prevention concepts will be incorporated into permit conditions.

1) Prior to entry, cattle will be rounded up and fed only certified weed-free hay or cubes for at least 72 hours before release onto park lands. All equipment used to transport animals into the park (trucks and trailers) will be thoroughly cleaned of all dirt, manure, and hay before loading of livestock for transport to park lands.
2) Livestock management during the grazing period will be conducted by the permittee or their representative using only clean equipment and any horses used in livestock operations must be fed only certified weed-free hay or cubes for at least 72 hours prior to use in the park.
3) Existing range improvements will be kept in a condition free of exotic plants, including corrals and water sources. If exotic plants are determined by the Park's Vegetation Manager or their designee to be a concern, the range improvement may be temporarily removed from use until the exotic plant population is reduced to an acceptable level or the phenology of the exotic plant species is such that dispersal of viable seed and propagules is unlikely.

General Provisions for Recreational Equestrian and Pack stock Use
1) All saddle stock and pack stock recreational users will be encouraged to feed weed-free hay or cubes at least 72 hours prior to entry into the park and to keep their animals and equipment free from dirt and foreign material.
2) Any saddle stock or pack stock recreational event subject to a special use permit will be required to adhere to the same provisions as provided for administrative stock use below.

General Provisions for Administrative Stock Use
All administrative stock use, including pack stock used for wilderness projects, as well as wild burro gathers will follow these guidelines. For burro gathers conducted by cooperators or contractors, the following considerations will be incorporated into the interagency agreement, contract specifications, or other administrative instrument.
1) All stock to be used in the park will be fed weed-free hay or cubes or native grass hay from known sources (subject to inspection and approval of the park's Vegetation Program Manager or their designee) for at least 72 hours prior to entry into the park. While in use in the park, all stock as well as gathered burros will be fed the same as above.
2) All trucks, trailers, saddle blankets, and other tools or equipment used in stock handling will be thoroughly cleaned of all dirt, manure, and hay before entry into the park. Additionally, all pack and saddle animals taken into the park for project purposes will be groomed and their hooves cleaned in order to removal dirt and seed from the animal prior to entry into the park.

3) All stock used in the park as well as gathered burros will be corralled or picketed in areas free of noxious weeds and generally free from invasive species.
4) All corrals and picket areas used in the stock operation (including temporary corrals) will be recorded with GPS coordinate and that information will be relayed to the park's Vegetation Program Manager for subsequent and periodic inspection of the site to determine if exotic plants have become established at that location so that appropriate management action may be taken.

*Responsibility:* It is the responsibility of the park official processing the Special Use Permits for grazing or special equestrian events to assure that the above provisions are included and communicated to the permittee prior to arrival in the park. For administrative stock use, it is the responsibility of the wilderness project manager or Contracting Officer's Representative to assure that the above provisions are included and communicated directly to the stock handler prior to arrival in the park. Where such provisions are included in permits, contracts, agreements, and so forth, a copy of that document should be forwarded by the responsible party to the Park's Vegetation Program Manager prior to implementation. It is the responsibility of the Vegetation Program Manager or their designee to inspect stock use areas for the purpose of early detection and eradication of any exotic plants that may have become established as a result of stock use in that location.

# STANDARD OPERATING PROCEDURE XXX

## INVASIVE SPECIES PREVENTION FOR AGENCY-CONTROLLED ACTIVITIES AT LAKE MEAD NATIONAL RECREATION AREA

Justification for Proposed Park Procedures

National Park Service (NPS 2006) policy states that the Service will… prevent the introduction of exotic species into units of the national park system, and remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.

LAKE will incorporate reasonable exotic plant prevention measures into the legal and administrative instruments used to authorize agency-controlled activities, such as contracts, cooperative agreements, special use permits, and research permits. Such activities are permitted within the park at the discretion of the Park Superintendent and subject to NPS policy and applicable laws. As such, it is wholly appropriate to require specific and reasonable actions on the part of the permittee in order to prevent the accidental introduction of invasive species into the park.

General Provisions for Contracts and Agreements

All park contracts that require non-NPS vehicles or equipment to have soil contact within the park will include contract or agreement specifications that include the exotic plant prevention concepts identified below.

Equipment washing: All construction equipment that will be used off surfaced roadways, must be pressure washed to ensure freedom from exotic plant and noxious weed seeds prior to entering the Lake Mead National Recreation area. This pressure washing must take place outside the Park unless special provisions have been made to establish an in-park wash area for a prolonged activity (e.g. long-term construction project). All equipment cleaning shall be performed in a manner that will reasonably remove all soil, plant and other foreign material from the under-carriage of equipment and from any surface where soil containing exotic/noxious seeds may exist. All such equipment is subject to inspection by the NPS to ensure compliance. Equipment that leaves the Park shall be re-washed prior to re-entering the Park. The following guidelines will further clarify what vehicles/equipment are subject to this provision:

- Vehicles that enter through the entrance station and are normally used for highway driving and remain on asphalt pavement do not need washing.
- Vehicles used on well maintained/traveled service roads, such as those found in the developed areas, do not need washing.
- Vehicles used and/or parked in approved staging/parking areas do not need washing.
- Delivery trucks such as those delivering construction supplies like concrete, culverts, aggregate base, steel, equipment and other construction related supplies may not need washing, subject to the discretion of the project inspector.

- The requirement for washing construction equipment being moved between Park areas without leaving the Park will be discussed on a case by case basis. This will only be required if there is a substantiated danger of exotic plant and noxious weed seeds being moved from an infested area to a clean area within the Park. NPS to designate exotic plant infested areas and clean areas. NPS to designate areas within the Park where equipment washing can take place so Contractor does not have to go back outside the Park.

Inspection: All incoming contractor equipment and vehicles are subject to inspection by a NPS Compliance Representative. Vehicles often carry soil that harbors non-native seed from other construction areas. Inspection will focus on equipment with soil contact, including but not limited to: pickups, dozers, loaders, track hoes, bobcats, backhoes, rollers, water trucks, dump trucks, drill rigs, forklifts, dumpsters, screens, outhouses, and office trailers. Inspection will consist of the following procedure:

- Vehicles/equipment are driven or trailered to or near the project site. There is absolutely no off loading of any equipment from trailers until it passes inspection. Rental equipment is subject to the same inspection as contractor-owned equipment.
- Inspectors will be under the rig looking and feeling for dirt on springs, shocks, wire harnesses, bolts, frame ledges, on top of skid plates, inside bumpers, and other crevices.
- Inspectors will walk around looking and feeling for dirt on rippers, buckets, blades, tracks, cab floors, wheel wells, radiators, transmission coolers, booms, augers, cables, pickup beds, and any other areas that look suspicious.
- Soil particles the size of a pencil eraser qualifies that rig for rejection. Seeds cannot survive in asphalt, concrete, or greasy oil dirt so those substances alone will not qualify a rig for rejection.
- Inspections and re-inspections will be done expeditiously to get the equipment/vehicles passed and the work underway.
- Recommend that a hot water pressure sprayer at 200 degrees and 2000 psi be used prior to arrival in the park, concentrating on hidden dirt inside of bumpers, on the under carriage, and inside the wheel well.
- Contractors should arrange for inspection at least 7 calendar days prior to the first day of work. After the project has started, 24 hour notice is required for inspection of additional incoming vehicles/equipment.

Post-construction survey and monitoring

- Compliance Branch will initiate the process by informing Vegetation Branch Manager that a project has entered the completion/post-construction phase.
- The Vegetation Branch Manager and Exotic Plant Manager will determine the schedule for conducting early detection surveys based on the life history of the exotic plant species anticipated in the area. In most cases, multiple surveys of the same area will be needed to detect and eradicate the exotic plants. The Vegetation Branch will inform the Compliance Branch of the survey schedule.

- For every project area, the Vegetation Branch would supply an annual summary of survey data to the Compliance Branch, including what species were found, where exotic plants were located, and what actions were taken.

Where the activities to be implemented via contracts or agreements are subject to environmental compliance review, additional project specific exotic plant prevention measures may also be included.

*Responsibility:* It is the responsibility of the Contracting Officers Technical Representative (COTR) (sometimes known as a Contracting Officers Representative (COR)) to assure that appropriate exotic plant prevention measures are incorporated into the contract or agreement. It is the responsibility of the project inspector to inspect equipment upon entry and to assure that the contract specifications for exotic plant prevention are adhered to by the contractor as well as their subcontractors. In the event that a project inspector is not assigned, it is the responsibility of the COTR to conduct inspections and ensure compliance.

General Provisions for Special Use Permits

For all special events that include contact between participant's equipment and natural soil surfaces (e.g. unpaved roads) or park waters, special provisions will be included in the special use permits to prevent the spread of invasive terrestrial species and aquatic nuisance species (which includes aquatic exotic plants). Examples of such events include fishing tournaments, regattas, boat hauls for entry or exit in park marinas, dirt bike and 4x4 events, and trail events. The concern is for both the introduction of foreign organisms to the park environment and for the export of invasive species from the park to other areas.

The conditions may be tailored to the event or permit needs, but generally should include the following provisions.

It is the permittee's responsibility to assure that all participants receive the following instructions:

In general, all vehicles, boats, trailers, and equipment that contact water or natural soils must be cleaned prior to entry into the park or, for water based equipment, prior to launching on either Lake Mead or Lake Mohave (boat wash services are available at most park marinas). Likewise, all vehicles, boats, trailers and equipment should be thoroughly washed and dried prior to re-use in any other wildland environments outside of the park.

For water-based events, the following specific standards apply:
Upon take-out, while still in the immediate area of the lakeshore, the following tasks must be completed: drain the water from motors, live wells, and bilges on land; completely inspect vessels and trailers, removing any grit or debris.
2) Before leaving the local community, use a commercial boat wash or car wash facility to:

Flush motors and bilges with hot water of at least 104 F. Wash hulls, equipment, bilges, wells, holds, and any other surface exposed to lake water in hot water of at least 104 F.
Clean and wash trailers, vehicles, fishing equipment, or any other items that come into contact with lake water because nuisance aquatic species may be harbored in small pockets anywhere water collects.
3) If feasible, air-dry boats and other equipment for at least five (5) days before launching on any other waterway.
4) Do not reuse bait once it has been exposed to lake water and allow all fishing tackle to dry completely before reuse.

*Responsibility*: It is the responsibility of the special park use coordinator to apply the above conditions to permits where the proposed activity includes contact with natural soil surfaces or park waters. Monitoring of compliance with the permit conditions is the responsibility of the designated park office or personnel identified on the permit. Significant violations of the exotic plant prevention permit conditions should be mapped by the park monitor and the locations and nature of the violation should be reported to the Park's Vegetation Program Manager for follow-up monitoring and treatment if necessary.

General Provision for Research Permits

All research and collecting permits issued by LAKE will include the following language:

All equipment (instruments, vehicles, boats, footwear, etc) used in the park must be cleaned and dried prior to use and upon exit from the Park. Such equipment must be free of mud, water, or debris that could harbor non-native organisms and all such equipment is subject to inspection by NPS personnel.

*Responsibility:* It is the responsibility of the Research Coordinator to include this language in the permit conditions for all research permits that involve a physical presence at LAKE. The only exception will be for research performed wholly off-site, such as laboratory analysis for samples collected by park staff.

General Provisions for Commercial Use Authorizations and Concessioners

All concessioners would comply with the Lake Mead Exotic Plant Management Plan and NPS policy when applying pesticides. Concessioners would comply with guidance document, *Understanding the National Park Service's Integrated Pest Management Program* (NPS 2003).

Responsibility: It is the responsibility of the Concessions Management Office to assure that these provisions are incorporated into contracts and/or annual operating plans as appropriate and to monitor concessioner compliance with these provisions. It is the responsibility of the Lake Mead Exotic Plant Manager to submit annually pesticide use proposals and pesticide use logs on behalf of the concessioners in accordance with NPS Integrated Pest Management procedures. It is also

the responsibility of the Exotic Plant Manager to promptly communicate any changes in policy or procedure to the Concessions Management Office.

# Chapter 6: Early Detection and Eradication of Incipient Populations

## *6.1 Introduction to Early Detection and Eradication of Incipient Populations*

This chapter specifically addresses Exotic Plant Management Program Objective 3: Actively detect and eradicate incipient exotic plant populations. It focuses on proactive monitoring of high risk areas for detection of new weed infestations and aggressive treatment of new infestations to prevent population establishment and growth.

The longer a species goes undetected in the early, noninvasive stage, the less opportunity there is to intervene, the fewer options remain for its control or eradication, and the more expensive any intervention is (Mack et al 2000). Ultimately, the long-term ecological and economic costs of *not* controlling incipient exotic plant populations serves to illustrate the value of investing significant time and effort in early detection and eradication of new invasions. Although admittedly, it is sometimes difficult to appreciate the cost effectiveness of searching and not finding new invasions instead of focusing limited resources on the control of established exotic plant populations that are known to exist elsewhere in the park. However, the possibility of early eradication or early control of a new colonizer makes investment in early detection worthwhile (Wittenberg and Cock 2005).

## *6.2 Early Detection*

### 6.2.1 Priorities

Because not all alien species necessarily become invasive, species known to be invasive elsewhere under similar conditions are priorities for early detection (Wittenberg and Cock 2005). Las Vegas is a major tourism destination that annually draws millions of car travelers from surrounding states, particularly California and Arizona, and the entire storm drain and wastewater systems of the Las Vegas metro area ultimately cross park lands to empty into Lake Mead. Also, the Colorado River potentially serves as an importation route from upriver states to the park, particularly for aquatic exotic plants. For these reasons, it is important to update the park's Exotic Plant Watch List (Table 4) at least annually with consideration given to invasive plants that occur in similar desert environments and aquatic habitats. The list of species on Table 4 known from outside of the park is largely compiled from the surveys conducted by the Weed Sentry program in Clark County, Nevada as well as consultation with weed managers on nearby jurisdictions in both states.

Descriptions and images of both mature plants as well as seedlings of these Exotic Plant Watch List species will be provided to park personnel and cooperators as part of the education efforts

described in Chapter 5. Suspected new invasions are to be reported to the Park's Exotic Plant Manager for follow-up, species verification, and eradication or treatment.

Table 4. Watch List species for to focus early detection efforts at Lake Mead NRA.

| **Species known to occur in similar habitats nearby but not yet in the Park** | **Species that occur in low numbers in the Park , presumably still in the lag phase (see Figure 4)** |
|---|---|
| *Ailanthus altissima (*Tree of Heaven) – popular ornamental | *Alhagi pseudalhagi* (Camelthorn) |
| Centaurea biebersteinii (Spotted Knapweed) – found at Red Rocks NCA and Cal-Nev-Ari | *Avena fatua* (Wild Oat) |
| *Centaurea solstitialis (*Yellow Starthistle) – common problem weed in California | *Centaurea melitensis* (Malta Starthistle) |
| *Eragrostis lehmanniana (*Lehman's Lovegrass) – common problem weed in Arizona | *Chenopodium botrys* (Jerusalem Oak Goosefoot) |
| *Halogeton glomeratus* (Halogeton) – found on BLM land in Clark County | *Echinochloa crus-galli* (Barnyardgrass) |
| *Melia azedarach* (China Berry) – popular ornamental | *Lepidium latifolium* (Perennial Pepperweed) |
| *Onopordum acanthium* (Scotch Thistle) - found on BLM land in Clark County | *Malcolmia africana* (African Mustard) |
| *Peganum harmala (*African Rue) – found in Boulder City and Searchlight | *Melilotus officinalis* (Yellow Sweetclover) |
| *Pennisetum ciliare (*Buffelgrass) – common problem weed in Arizona, occurs in Kingman | *Nerium oleander* (Oleander) |
| *Salvinia molesta* (Giant Salvinia) – aquatic weed found below Lake Mohave in Lower Colorado River | *Nicotiana glauca* (TreeTtobacco) |
| *Solanum americanum* (Black nightshade) – found in Las Vegas Wash | *Pennisetum setaceum* (Fountain Grass) |
| *Polygonum ramosissimum* (Bushy knotweed) – found in Laughlin | *Sisymbrium altissimum* (Jim Hill Mustard) |
| *Sonchus oleraceus (*Common sowthistle) – found in Boulder City | *Sonchus asper* (Spiny Sowthistle) |
| *Plantago major* (Common Plantain) – found on Tassi Ranch at Parashant National Monument | *Sorghum halepense* (Johnson's Grass) |
| *Poa annua (*Annual Bluegrass) – found on Tassi Ranch at Parashant National Monument | *Vitex agnus-castus* (Chaste Tree) |
| *Anagallis arvensis (*Scarlet Pimpernel) - found on Tassi Ranch at Parashant National Monument | **Species that have been successfully eradicated on specific sites within the park** |
| *Bromus inermis (*Smooth Brome) - found on Tassi Ranch at Parashant National Monument | *Arundo donax* (Giant Reed) |
| *Malva parviflora* (Cheeseweed Mallow) - found on Tassi Ranch at Parashant National Monument | *Eleagnus angustifolia* (Russian Olive) |
| *Medicago arabica* (Spotted Medik) - found on Tassi Ranch at Parashant National Monument | *Hirschfeldia incana* (Short Pod Mustard) |
| *Medicago lupulina* (Black Medik) - found on Tassi Ranch at Parashant National Monument | *Solanum rostratum* (Buffalo nightshade) |
| *Marrubium vulgare (*Horehound) - found on Tassi Ranch at Parashant National Monument | *Tamarix aphylla* (Athel) |
| *Medicago polymorpha (*Burclover) - found on Tassi Ranch at Parashant National Monument | *Tamarix ramosissima* (Saltcedar) |

In addition to the efforts described in Table 4, the park will proactively survey locations at high risk for invasion. These locations, targeted species, and appropriate times of year for survey and effective treatment are identified in Table 5. Survey efforts will be directed by the park's Exotic Plant Manager and may involve volunteers, contractors, and cooperators such as Nevada Conservation Corps, American Conservation Experience, or other groups or persons.

Table 5. Target locations for early detection and eradication efforts.

| Target Locations | Exotic Plant Species | Season[1] | | | | Frequency[2] |
|---|---|---|---|---|---|---|
| | | Fall | Winter | Spring | Summer | |
| Roads & trails | *Pennisetum setaceum* | | | X | X | Monthly |
| | *Tamarix aphylla* | X | X | X | | Monthly |
| | *Nicotiana glauca* | X | X | X | | Monthly |
| | *Parkinsonia aculeata* | X | X | X | | Monthly |
| | *Nerium oleander* | X | X | X | | Monthly |
| | *Brassica tournefortii* | | X | X | | Weekly |
| | *Malcolmia africana* | | | X | | Weekly |
| | *Tamarix ramosissima* | X | X | X | | Monthly |
| Rare plant habitat | *Brassica tournefortii* | | X | X | | Weekly |
| | *Malcolmia africana* | | | X | | Weekly |
| Springs/Riparian habitat | *Tamarix ramosissima* | X | X | X | | Monthly |
| | *Washingtonia filifera* | X | X | X | X | Monthly |
| | *Lepidium latifolium* | X | | X | | Weekly |
| | *Alhagi pseudalhagi* | X | | X | | Monthly |
| Shoreline | *Pennisetum setaceum* | | | X | X | Monthly |
| | *Tamarix aphylla* | X | X | | | Monthly |
| | *Nicotiana glauca* | X | X | X | | Monthly |
| | *Parkinsonia aculeata* | X | X | X | | Monthly |
| | *Nerium oleander* | X | X | X | | Monthly |
| | *Washingtonia filifera* | X | X | X | X | Monthly |
| | *Alhagi pseudalhagi* | X | | X | | Monthly |
| | *Alternanthera philoxeroides* | X | X | X | X | Monthly |
| | *Eichhornia crassipes* | X | X | X | X | Monthly |
| | *Hydrilla verticillata* | X | X | X | X | Monthly |
| | *Myriophyllum aquaticum* | X | X | X | X | Monthly |
| | *Myriophyllum spicatum* | X | X | X | X | Monthly |
| | *Vallisneria americana* | X | X | X | X | Monthly |
| | *Salvinia molesta* | X | X | X | X | Monthly |
| | *Potamogeton crispus* | X | X | X | X | Monthly |
| Developed areas | *Pennisetum setaceum* | | | X | X | Monthly |
| | *Tamarix aphylla* | X | X | | | Monthly |
| | *Tamarix ramosissima* | X | X | X | | Monthly |
| | *Nicotiana glauca* | X | X | X | | Monthly |
| | *Parkinsonia aculeata* | X | X | X | | Monthly |
| | *Nerium oleander* | X | X | X | | Monthly |
| | *Brassica tournefortii* | | X | X | | Weekly |
| Burned areas | *Lepidium latifolium* | X | | X | | Weekly |
| | *Pennisetum setaceum* | | X | X | X | Monthly |
| | *Tamarix ramosissima* | X | X | X | | Monthly |
| | *Brassica tournefortii* | | X | X | | Weekly |
| | *Malcolmia africana* | | | X | | Weekly |
| Construction Zones | *Malcolmia africana* | | | X | | Weekly |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *Tamarix ramosissima* | X | X | X | | Monthly |
| | *Brassica tournefortii* | | X | X | | Weekly |
| | *Salsola tragus* | | | X | X | Monthly |
| | *Bromus tectorum* | | X | X | | Weekly |
| | *Bromus madritensis* | | X | X | | Weekly |
| | *Schmismus spp.* | | X | X | | Weekly |

[1] Season refers to the time of year for effective survey and treatment where Fall is September through November, Winter is December through February, Spring is March through May, and Summer is June through August.
[2] Frequency refers to either weekly or monthly site visits during the season(s) indicated and is based on the typical growth rate of the species. Weekly and monthly are targets that may or may not be attainable depending on staffing.

### 6.2.2. Species Identification

If species identification is unknown or questionable, samples will be collected in the field, contained (e.g. placed in a zippered plastic bag), and taken to the Park's Botanist for identification. If positive identification cannot be made, fresh samples of the plant will be collected, contained, and sent to University of Nevada Las Vegas or another university in the NPS Cooperative Ecosystem Studies Unit for positive identification. Once a species has been verified as an exotic plant, the park's Exotic Plant Manager will analyze the species using the "The Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" protocol described in Chapter 3 and then prescribe a treatment program with the goal of eradication, if possible. If eradiation is infeasible, the goal will be containment and prevention of spread as described later in the next chapter. If it is a newly identified exotic species for the area, the Exotic Plant Manager will alert other land managers via the local Weed Management Areas and other organizations as appropriate.

### 6.2.3. Systematic Area-wide Early Detection Efforts

As exotic plants readily cross jurisdictional boundaries, early detection and eradication efforts are most effective when they are addressed on an area-wide basis across multiple land management jurisdictions. One such effort was developed to systematically address early detection and eradication on all federal lands in Clark County, Nevada, including approximately 467,000 acres of land in Lake Mead NRA. The program, known as the Weed Sentry Program, was managed by the University of Nevada-Las Vegas Public Lands institute, is primarily funded by the Southern Nevada Public Lands Management Act through the Clark County Multiple Species Habitat Conservation Program (CCMSHCP), and was in operations from 2003-2009.. The Weed Sentry program contributed much of the baseline data used in this planning document. The funding for the Interagency Weed Sentry program ended in 2009.

### *6.2.4. Targeted Early Detection*

Many exotic plants readily invade disturbed areas and for some of these species this initial site of establishment allows their populations to expand into adjacent undisturbed areas and/or be transported along vector corridors (e.g. roads) to new disturbed areas. Some disturbances are known and planned, such as construction sites, while others occur without planning, such as illegal off-road vehicle tracks and sometimes wildland fires. While the nature of the disturbance may influence the vulnerability of the site to invasion by certain species, all disturbances have the potential to foster exotic plants.

Both NPS-led construction projects as well as construction promulgated by other organizations on park lands offer an opportunity to incorporate early detection efforts into the project design. All such projects are permitted through the Park's Resource Compliance Branch. To facilitate communication and assure effective implementation of early detection surveys for exotic plants, the following process will be used:

1. Compliance Branch will initiate the process by informing Vegetation Branch Manager that a project has entered the completion/post-construction phase.
2. The Vegetation Branch Manager and Exotic Plant Manager will determine the schedule for conducting early detection surveys based on the life history of the exotic plant species anticipated in the area. In most cases, multiple surveys of the same area will be needed to detect and eradicate the exotic plants. The Vegetation Branch will inform the Compliance Branch of the survey schedule.
3. For every project area, the Vegetation Branch would supply a semi-annual summary of survey data to the Compliance Branch, including what species were found, where exotic plants were located, and what actions were taken.

For unplanned disturbances, it is difficult to have such a detailed process. The primary obstacle to undertaking early detection surveys of these areas is that the Exotic Plant Manager is often unaware that they have happened. To proactively address this communication gap, the Exotic Plant Manager will query the Fire Management Office at the end of each fire season regarding the location of fires that have occurred and will conduct post-fire exotic plant surveys as appropriate. Where exotic plant invasions in burned areas are expected to exceed management capacity, the Exotic Plant Manager will work with the Fire Management Office to prepare and submit a funding request for Wildland Fire Emergency Stabilization and Rehabilitation or Burned Area Restoration funds to be made available. For illegal off-road vehicle disturbances, the Exotic Plant Manager will query the Disturbed Land Restoration Program at least semi-annually to determine the locations of ORV trespass and similar incidents in the park and will conduct exotic plant surveys as appropriate. Currently, there are no specific funding sources to cover the costs of such surveys or treatments, although in some cases it may be possible to work with the Law Enforcement Program to pursue resource damage restitution and/or monetary damages in the legal proceedings for criminal cases.

## *6.3 Eradication*

The intent of early detection of exotic plants is to use the opportunity to eradicate incipient populations before they become well established, spread to other areas, interfere with ecological processes, and establish seed banks that will allow the species to persist after treatment. Within this context, and consistent with common usage of the word within the National Park Service integrated pest management community, eradication is defined as:

> *To bring about the elimination, complete removal, or total destruction of a pest from a defined geographic area to such an extent that the pest no longer poses a threat to other park resources and where the potential of re-infestation is preventable.*

The intent to eradicate - rather than simply contain, control, or reduce - a newly discovered incipient population of an exotic plant species may justify the use of aggressive treatment measures. Such treatments must take into account the species biology, population characteristics, geography, and other values at risk. However, these considerations must be made quickly upon discovery of an incipient population, otherwise the opportunity for eradication will effectively be lost and the population will need to be treated as an established population with containment and control as the immediate goals rather than eradication. Once evaluated, appropriate treatment options will be considered and the treatment or combination of treatments that are most likely to be successful will be applied. After treatment, the site and adjacent areas will be monitored for at least three growing seasons to assure that the eradication was successful.

## *6.4 Vascular Aquatic Plants*

This section addresses vascular exotic aquatic plants, that is, plants that require open water habitats such as Lakes Mead and Mohave. It does not address riparian or wetland plants that live in intermittently or persistently wet soils, most often associated with washes, springs, and seeps at Lake Mead NRA. It is called out separately here in the early detection and eradication chapter because as of this time there are no known aquatic exotic plant problems in the Park; however, the Park is certainly susceptible to aquatic plant invasion and it is probably just a matter of time before aquatic exotic plants are an issue in at least some locations. Furthermore, the habitat characteristics and management implications of aquatic exotic plants, as well as the treatment opportunities, are quite different than terrestrial desert exotic plants and thus they are discussed in their own subsection of this chapter.

Vascular aquatic plants will be considered in three habitat and growth forms (adapted from Cowardin 1979):

- Emergent: Erect, rooted, herbaceous plants that may be temporarily or permanently flooded at the base but do not tolerate prolonged inundation of the entire plant; e.g. bulrushes (*Scirpus* spp.).
- Floating: A non-anchored plant that floats freely in the water or on the surface; e.g. water hyacinth *(Eichhornia crassipes*, non-native) or common duckweed (*Lemna minor*, native).

- Submergent: A vascular or nonvascular plant, either rooted or non-rooted, which lies entirely beneath the water surface, except for flowering parts in some species; e.g. wild celery (*Vallisneria americana*, non-native)

Lake Mead NRA includes almost 182,000 surface acres of water, namely Lakes Mead and Mohave. Both are reservoirs created by dams that impound the Colorado River. The upper reaches of both reservoirs still exhibit some riverine characteristics, such as directional flow, while the downstream ends of both reservoirs are deepwater environments whose outflows are regulated by Hoover Dam and Davis Dam, respectively. The water levels of both lakes are controlled by the U.S. Bureau of Reclamation for the purposes of irrigation, drinking water, and power generation for communities in Arizona, Nevada, and Southern California. Lake Mead is a major flood control reservoir whose water levels fluctuate dramatically while downstream Lake Mohave is primarily a pass-through reservoir whose water levels are fairly stable. Lake Mead reservoir is currently (2011) about 120 feet below "full pool" as a result of persistent regional drought and water demands that continue to exceed supply, a condition that is likely to be exacerbated in the coming decades. Lake Mohave experiences seasonal fluctuations of about 10 feet.

Both reservoirs are essentially flooded canyons where the submerged environments range from shallowly flooded ledges near the surface (most often along shorelines but also as "islands") to waters in excess of 400 feet deep, and the transitions between shallow and deep water may be gradual or abrupt depending on bottom contours. Additionally, the sediment-laden waters of the Virgin, Muddy, and Colorado Rivers still flow as muddy river channels along the bottom of the reservoirs beneath the clear water above. These muddy rivers continue to deposit river bed load on the bottom of the reservoirs depending on current, so submerged substrates may be muddy, sandy, cobbly, or bedrock and these substrates may be oriented horizontally, vertically, or on any angle in between.

There are three major routes of introduction of exotic aquatic plants into Park waters: intentional or unintentional releases from water gardens and aquaria, transport via trailered watercraft, and wildlife mediated introductions.

- Upstream of Lake Mead lies the Grand Canyon and above that Lake Powell and the vast wildland and agricultural lands of Utah, Colorado, Arizona, and New Mexico. There are no major urban areas adjacent to the Colorado River upstream of Lake Mead; however, the rapidly growing Las Vegas metropolitan area has direct access to Lake Mead and the stormwater and wastewater effluent from the urban area drains directly to the Lake. Thus, the potential for introduction of exotic aquatic plants from water gardens and aquaria is relatively low upstream of the Park but the potential for such introductions to occur within the park is relatively high.

- Accidental introduction of exotic aquatic plants via watercraft is a strong possibility both upstream of Lake Mead as well as at Lakes Mead and Mohave due to the popularity of boating in Lake Mead NRA as well as upstream at Lake Powell in Glen Canyon NRA

and elsewhere in the Colorado River drainage. The popularity of fishing tournaments, especially those that draw contestants regionally or nationally, are a major vector for transport of invasive aquatic plants via boats, trailers, fishing equipment, and bait. Also of special concern is the potential for overland transport of aquatic plant propagules from California, which is known to host many exotic aquatic plants, and the geographic proximity to Lake Mead NRA means that trailered boats can exit infested waters in California and be launched within hours or days in Lakes Mead or Mohave by park visitors. Many aquatic plants reproduce vegetatively and the short transport time means that exotic plants from California can easily be transported on trailered boats and still be viable when they reach Park waters.

- Another route for the introduction of exotic aquatic plants into Park waters is via wildlife, specifically waterfowl and other migratory birds that may move from infested waters to Park waters and transport seeds or other propagules on their body or in their gut. Another wildlife introduction pathway involves stocked fish, a practice employed by both Nevada Department of Wildlife as well as Arizona Game and Fish Department, where fish from an infested water body or hatchery could be released into Park waters. While precautions are employed by both States, it is possible that plant seeds and other propagules might be released into park waters when fish are released.

As of 2007, there are nine known aquatic plants in Lake Mead NRA, including three exotic aquatic plant species (Bangle 2007). In addition, there is an ever growing list of exotic aquatic plant species that have been reported in other areas of the Colorado River or surrounding areas and pose an imminent threat to Park waters. These species are summarized on Table 6.

To date, none of the three known exotic species has proliferated presumably because of either unviable population sizes or less than ideal habitat conditions. However, there are substantial changes in the aquatic habitats occurring or soon to occur that may change this condition: 1) a hotter climate will likely warm the water surface, 2) drawdown of the Lake Mead reservoir will decrease pool size and potentially create more suitable submerged habitats on silt covered ledges and islands, and 3) the recent invasion of the invasive quagga mussel will alter nutrient and energy flows within both reservoirs. Because exotic aquatic plants are not yet a problem in the Park, it is very important that the prevention, early detection and eradication of exotic aquatic plants be a high priority for park managers and cooperators. Other large reservoirs have experienced substantial problems with exotic aquatics (e.g. Toledo Bend and the infestation of giant salvinia) and have found few effective treatment options due to the other values at risk in aquatic environments (e.g. public drinking water supply, irrigation water, as well as native plant and animal species). For these reasons, it is far more desirable to direct management effort at prevention as well as early detection and eradication efforts, rather than attempt containment and control of an established population.

Table 6. Aquatic vascular plants in or near Lake Mead NRA.

| Scientific Name (family) | Common Name | Habitat | Distribution |
|---|---|---|---|
| *Alternanthera philoxeroides (Ameranthaceae)* | Alligatorweed | Emergent | Alien perennial species, not reported in the park but established in several locations in southern California. |
| *Ceratophyllum demersum* (Ceratophyllaceae) | Coon's tail | Submergent | Native perennial species, widespread species not reported in park but found in other waters of the Lower Colorado River system. |
| *Eichhornia crassipes* (Pontederiaceae) | Water-hyacinth | Floating | Alien perennial species, not reported in the park but established in several locations in southern California. |
| *Elodea canadensis* (Hydrocharitaceae) | Common waterweed | Submergent | Native perennial species, common in the Park. Easily confused with *Hydrilla*. |
| *Hydrilla verticillata* (Hydrocharitaceae) | Hydrilla | Submergent | Alien perennial species, not reported in the park established in several locations in California and Arizona. Easily confused with *Elodea*. |
| *Myriophyllum aquaticum* (Haloragaceae) | Parrot feather | Submergent | Alien perennial species, not reported in the park but known to occur in Southern California in irrigation canals connected to the Colorado River. |
| *Myriophyllum spicatum* (Haloragaceae) | Eurasian watermilfoil | Submergent in water up to 20 feet deep | Alien perennial species, reported as rare in the Park. Known occurrence in other waters of the Lower Colorado River system, most notably Lake Havasu. |
| *Najas marina* (Hydrocharitaceae) | Spiny naiad | Submergent | Native annual species, common in the Park. |
| *Potamogeton crispus* (Potamogetonaceae) | Crispateleaf pondweed | Submergent | Alien perennial species, reported as uncommon in the Park. |
| *Potamogeton latifolius* (Potamogetonaceae) | Nevada pondweed | Submergent | Native perennial species, uncommon in the Park. |
| *Potamogeton pectinatus* (Potamogetonaceae) | Fennel leaf pondweed | Submergent | Native perennial species, common in the Park. |
| *Ruppia maritima* (Potamogetonaceae) | Ditchgrass | Submergent | Native perennial species, uncommon in the Park. |
| *Salvinia molesta* | Giant salvinia | Floating on still and slow moving water. | Alien perennial species, not reported in the park but found in Colorado River downstream of Park and subject of multi-agency control effort. |
| *Vallisneria americana* (Hydrocharitaceae) | Tape grass | Submergent in still and fast-flowing water. | Alien perennial species, reported as occasional in the Park. |
| *Zannichellia palustris* (Zannichelliaceae) | Horned pondweed | Submergent | Native perennial species, common in the Park. |

Early detection efforts will focus on the following search parameters:

1) Focus on boat ramps and marinas as the first point of introduction via boat equipment. Park concessioners who operate marinas should receive training regarding what species to look for in their environment.

2) Focus on urban flows, specifically Las Vegas Wash/Bay as well as the Muddy and Virgin River deltas as the point of introduction from upstream urban or agricultural waters and as locations with good growing conditions due to the increased nutrient supply generally available in these locations.

3) Focus on aquaculture activities, specifically the Lake Mead Fish Hatchery (Nevada Department of Wildlife) and Willow Beach Fish Hatchery (US Fish and Wildlife Service), because these locations serve as both an avenue for introduction as well as an avenue for export of aquatic invasive species to other water bodies.

4) Focus on stillwater environments as locations where floating aquatics tend to congregate, particularly eddies in coves and similar settings. Likewise, the waters edge all the way around the lakes are locations may harbor floating aquatics depending on wind and wave conditions. There are new models under development by various cooperators that should be reviewed to help determine areas where flow characteristics are likely to concentrate floating aquatics.

5) Focus on locations that currently support submergent native vegetation as those are locations that presumably have suitable substrate and light penetration to support plant growth, thus may be susceptible to colonization by non-native submergent species.

Once a non-native aquatic plant population is found and the species verified, the park's Exotic Plant Manager will develop a treatment plan. During the time it takes to develop and implement a treatment plan it may be necessary to enact a public use closure of the location to contain the overland spread to other water bodies via boats. The recommendation for such a closure will be taken to the Park's Management Team for consideration and implementation, if approved. Treatment will follow the flowchart in Figure 11 and will focus on eradication of incipient populations of aquatic exotic plants generally using mechanical or manual removal or the use of an aquatic label herbicide. In addition, the park's Exotic Plant Manager will alert other land managers downstream on the Colorado River via the Lower Colorado River Aquatic Invasive Species Team or other venues as appropriate.

## *6.5 Drawdown Zone*

As discussed above, the Lake Mead reservoir is shrinking and is expected to continue to do so for at least the near future. This shrinking water surface area means there is a comparable amount of newly exposed terrestrial habitat around the shoreline. Lake Mohave reservoir is a pass-through reservoir that typically only fluctuates about 10 feet in elevation per year, exposing a fringe of wet substrates usually in winter. The newly exposed substrates around both reservoirs, referred to as the "drawdown zone," are composed of rock and new soil surfaces ripe for colonization by plants – either native or non-native. The lake bottom sediment is generally finer textured than most desert soils and, with the recent invasion of quagga mussels throughout both reservoirs, it may be richer in organic materials than most desert soils. In addition, the drawdown

zone in some cases may be subjected to frequent surface disturbance caused by human activities along the shoreline as well as slightly fluctuating water levels and wave action. These soil characteristics and disturbance factors, combined with the lack of competition, may make these drawdown zones highly susceptible to invasion by exotic plant species. Of particular concern are phreatophytic species with floatable seed, such as saltcedar, because these plants have a ready seed supply left by the receding water and, once established, the root system will tap subsurface moisture. This sea of saltcedar in the drawdown zone can be witnessed in many areas of the park, such as Pearce Ferry on the far eastern boundary of the park, where lake levels dropped in 2001 exposing a large mud flat that is now hundreds of acres of dense saltcedar. In other areas, the drawdown zone has a steeper slope and presumably less soil moisture and was colonized by non-native annual plants, such as Sahara mustard, which also has a floatable seed and maintains relatively high seed viability even after weeks of submersion (Bangle et al. 2008).

Ideally, this drawdown zone would comprehensively be targeted for early detection and eradication efforts. However, the sheer spatial extent of the drawdown zone on Lake Mead alone (approximately 61,000 acres at elevation 1110 feet above sea level) makes such comprehensive treatment daunting. While there is some variation based on geology and topography, there are many miles of shoreline where the soil covered drawdown zone is 1500 to 4000 feet wide. The most efficient and cost effective treatment of such a vast area with few non-target plant species would be broadcast or aerial herbicide treatment; however, such a non-specific application method is not very viable given that the drawdown zone is immediately adjacent to the lake water, which serves as a public drinking water supply for millions of people and irrigation water for millions of acres of crop land. The drawdown zone on Lake Mohave is much smaller, but experiences annual fluctuations where it is exposed then re-inundated by lake water, thus any treatments there are in close proximity to water and will later be washed into the lake after the water rises. After careful consideration of these complications, the following strategies are proposed:

- Lake Mead: The drawdown zone of Lake Mead will be targeted for site-led treatment. That is, where exotic plant populations pose a threat to one of the site led priorities (e.g. rare plant habitat, vectors, recreational use) identified in Chapter 3, the Park's Exotic Plant Manager will prepare a prescription for treatment commensurate with the values at risk. In order to identify new infestations, the shoreline will be surveyed by boat several times per year in winter, spring, and early summer.

- Lake Mohave: The drawdown zone of Lake Mohave will be targeted for weed-led treatment where high priority species will be treated annually along the entire shoreline. The Park's Exotic Plant Manager will survey the shoreline by boat every spring, then prepare and implement treatment prescriptions. The extent of the saltcedar infestation currently exceeds our control capability, but is still considered a high priority for treatment following an overall containment strategy and control at strategic locations.

## *6.6 Adaptive Management*

In the case of early detection and eradication efforts, it is imperative that treatment effectiveness is monitored on each site. If the treatment is successful and eradication is feasible, then we need to assure that adequate human and fiscal resources are available to reach that goal and document that success for use in similar situations. If, however, the treatment is less than successful and the population is no longer functionally an incipient population but has indeed transitioned to an established population as outlined in the flowchart in Figure 12 this needs to be recognized promptly. Once a population has become established, the management direction needs to shift likewise to focus on long-term containment and control as described in Chapter 7.

# Chapter 7: Control and Containment of Established Populations

## *7.1 Introduction to Control and Containment of Established Populations*

This chapter specifically addresses Exotic Plant Management Program Objective 4: Contain and, if possible, eradicate established exotic plant populations. This chapter focuses on priority species and sites to be treated using various integrated pest management methods and tools to contain and reduce established weed populations.

The basic tenants of integrated pest management as described in Chapter 4 require that the approach to established populations be

- based on knowledge of the species and it's environment,
- be cost effective,
- prevent unacceptable levels of pest damage,
- while posing the least possible risk to people, resources, and the environment.

For our purposes, an established population is defined as a "reproducing population of a given invasive species that persists over time without human intervention." Established populations can be perennial species where the individual plants persist from year to year, or a biennial or annual species where the individual plants are short lived but the seed production and site conditions are such that the population re-establishes itself in the same area year after year. In either case, an established population is by definition persistent and as a result will likely require repeated effort to manage.

The aim of containment is to restrict the spread of an exotic species and to contain the population in a defined geographic location. The treatment methods may be chemical, mechanical, biological, or cultural, but the work is focused on the edges of the population to thwart it's expansion. Species most likely to be successfully contained are those that spread slowly over short distances and those populations surrounded by unsuitable habitat whereby they are spatially confined. If containment of an exotic species is successful, habitats and native species beyond its borders are safeguarded against the impacts caused by the exotic species. A species contained in a given area requires diligent effort to maintain the control measures at the border coupled with prevention measures to guard against its spread to new areas (Whitttenberg and Cock 2005).

Control focuses on the long-term reduction in density and abundance of an exotic species in a given population below an acceptable threshold. The economic and ecological harm caused by the species under this threshold is considered acceptable. The weakened state of the invasive species allows native species to re-establish (either naturally or through human intervention) and they may even further diminish the abundance of the exotic species. In rare cases, the effective

control of exotic species coupled with active restoration of native species may lead to the local eradication of the exotic species (Whitttenberg and Cock 2005).

In practice, containment and control are often used in sequence. Typically the first focus is on containment of the exotic plant population so that it is not spreading to new areas, then to reduce its population size within the infested area below a level where its negative impacts can be tolerated. What that threshold or level of infestation is will depend on site- and species- specific factors. For example, where the impact of the exotic plant is a 1- to -1 displacement of the native plant species the threshold might be a level where the native plant species are able to maintain a population size that is considered viable. However, where the impact of the exotic plant is to increase the flammability of a plant community the threshold would be that the spacing between the exotic plants is wide enough to impair its ability to carry fire under typical conditions. Site specific and biological knowledge are necessary to define a meaningful threshold for a given treatment area commensurate with other resource management goals.

## *7.2 Treatment Approaches and Methods*

Treatment approaches and methods were discussed in detail in Chapter 4 and are only highlighted here for quick reference and to elaborate their role in containment and control of established populations.

Cultural treatments are practices that promote the growth of desirable plants and reduce the opportunities for exotic plants to grow. Cultural treatment methods involve manipulating treatment areas to present exotic plants with effective native competitors. In the case of established populations, the most commonly used cultural treatment is restoration of native species after treatment and removal of most of the exotic species.

Manual and mechanical treatments involve physical damage to or removal of part or all of the plant. Manual treatments involve physically damaging or removing exotic plants through non-mechanical means (e.g. hand pulling). Mechanical treatments involve the use of tools to remove or physically damage exotic plants (e.g. chainsaws). Both treatments are commonly used in containment and control of established populations, most notably as hand-pulling for low densities of annual species and as part of an integrated pest management strategy using both mechanical and chemical treatments (e.g. cut-stump treatment of woody species).

Biological treatments (aka biocontrol) involve the use of biocontrol agents that are “natural enemies” (including insects and microorganisms) to reduce the abundance of an exotic plant. These biocontrol agents that limit the growth or reproduction of exotic plants or in some cases may damage the plant in ways that make it susceptible to other pathogens. Biological control may be a highly cost effective, long-term solution for controlling some exotic species that are too widespread for control by other means. Biological control is best suited for infestations of a single, dominant exotic plant species that is not closely related to other native plant species and thus is a valuable control treatment for established populations. Biocontrol does not eliminate the

exotic plant population, but may be an important part of an integrated pest management strategy that involves a dramatic reduction in the exotic plant by biocontrol agents, then chemical or mechanical removal of the few remaining plants, followed by restoration of native plant species, and long-term monitoring of the site. Where the native plant community lacks resilience and/or active site restoration is not undertaken to establish native perennial species, the biocontrol treatment may allow for the establishment of other exotic plants to occupy the site as the target plant fades out from successful biocontrol (Wilson and McCaffrey 1999). There are few biocontrol agents available for the exotic species that have been identified as priorities at Lake Mead, but the very short list (Table 2) does include Tamarisk leaf beetle (Diorahbda elongata) which has been introduced upstream of the park for saltcedar control and is expected to impact the saltcedar stands in Lake Mead NRA in the near future. There are very specific requirements that must be met for the use of biocontrol in the National Park Service (see flowchart in Figure 14).

Chemical treatments involve applying herbicides as prescribed by their labels, using a variety of application methods. Herbicides are most effective for treating monotypic stands of a single exotic plant species in areas where desirable plants are scarce or absent and where pulling or cutting is not feasible. Spot treatments with herbicides are also very effective at treating scattered individual weeds within desirable vegetation or environmentally sensitive areas. There are a variety of application methods and chemical formulations for specific exotic species and site conditions (see Table 3). Herbicides are commonly used as part of a two phase cut-stump strategy for woody species that includes first the cutting of the tree (top kill) followed immediately by the application of herbicide to the cut stump for transference to the roots (root kill). There are very specific requirements that must be met for the use of herbicides in the National Park Service (see flowchart in Figure 13).

Prescribed fire involves developing a burn plan and intentionally igniting a fire under controlled conditions to meet specific objectives, including the decrease of exotic plant species and/or to increase the vigor of native plant species. As there are very few fire-dependent native species in the Mojave Desert, the most likely use of prescribed fire is to decrease exotic species. The approved Lake Mead Fire Management Plan (2004) provides for the use of prescribed fire to control invasive exotic plant species. To date prescribed fire treatments have been limited to saltcedar as part of an integrated pest management strategy where fire is applied first to reduce density, followed by chemical treatment, often followed by restoration. With the anticipated arrival of tamarisk beetle in the Park's riparian habitats, there may be an opportunity to use fire in a new integrated pest management strategy where the defoliated and stressed trees left by the beetles are then treated by prescribed fire to remove the standing dead biomass, prior to restoring the site to native species.

## *7.3 Labor Sources for Large Scale Control Projects*

Treatment of established populations by any means other than biological control will almost certainly need a great deal more labor input than the Park's Exotic Plant Manager. In these

situations, a work crew appropriate to the task will be required. Several labor sources that have successfully been used for large treatments at Lake Mead are discussed below, but additional labor sources may become available in the future.

### 7.3.1. Exotic Plant Management Team

The Lake Mead Exotic Plant Management Team (EPMT) has been in existence since 2001 and is one of 17 Exotic Plant Management Teams serving the National Park Service. While there has been some variation in crew size and geographic scope from year to year, the crew generally consists of 20 people with five overhead positions. The Lake Mead EPMT is duty stationed at Boulder City, Nevada with Lake Mead NRA and assists parks and other public land management agencies with large-scale weed treatment projects throughout a five state area.

The Lake Mead EPMT can be scheduled to assist with any large-scale weed management project but most often focuses on exotic woody species, specifically saltcedar. They are available to work on any weed species any time of the year. This crew has highly skilled and well-equipped sawyers and is completely self-contained making them the ideal choice for backcountry shoreline and spring sites. The large crew is generally available from November through April, with a much smaller crew available the remainder of the year. Lake Mead EPMT annual work plan is set in September with approximately four to eight weeks per year allocated to Lake Mead NRA, although there are some opportunities to use additional time if funds are available.

### 7.3.2. Other Crews

Other crews, such as Nevada Conservation Corps (NCC) and American Conservation Experience (ACE), have been used successfully for large scale weed control projects at Lake Mead. There is a lot of variation in skill level, availability, and cost from program to program and year to year, but these crews are a reasonable and cost-effective option for large scale weed control efforts.

### 7.3.3. Volunteers

Volunteers, either in groups or individually, have been successfully used for weed control projects at Lake Mead for many years. Volunteers are especially well suited for easily accessible sites and exotic species that can be effectively treated by hand-pulling. Ideally, volunteer efforts should be organized as part of an event (e.g. Earth Day, National Public Lands Day, Boy Scout field trip, etc.) that includes education as well as work. Effective management of volunteers requires close coordination with the Lake Mead Volunteer Coordinator and reasonable expectations, including the provision of all necessary tools and equipment by the NPS, relatively short work days, and on-site supervision by an NPS representative for the duration of the project. Because of the close proximity of Lake Mead NRA to urban populations, the availability of volunteers is good and the use of their labor to control exotic plants is expected to continue and even increase as other funding sources diminish and the needs increase.

## *7.4 Priorities*

The priority for containment and control of established populations can be either weed-led or site-led and the prioritization strategy and outcomes were discussed in Chapter 4 of this document.

At site-led priority locations, the Exotic Plant Manager and the Botanist or Hydrologist will work collaboratively to develop a treatment strategy that focuses on protection of the values at risk at that location.

Weed-led priorities apply in most areas of Lake Mead NRA. The highest priority species are addressed below in treatment prescriptions specific to that species. Species are listed in alphabetical rather than priority order.

## 7.4.1. Prescription for *Acroptilon repens* (Russian knapweed)

***Acroptilon repens***
**(Russian knapweed)**

RANKING: Nevada Noxious Weed List-B, Arizona Noxious Weed List-Regulated and Prohibited, Cal-EPPC ranking-Moderate, Lake Mead National Recreation Area ranking-High

THREATS: It is difficult to establish native perennial grass in dense stands of Russian knapweed. The deep roots of Russian knapweed allow the plant to reach water resources that natives cannot reach. Russian knapweed exhibits allelopathic characteristics.

MANAGEMENT OPTIONS:

**No Action:** Russian knapweed is an aggressive colonizer, if left untreated it has the potential to dominate a disturbed area. A dense stand of Russian knapweed has the potential to increase the fire frequency of an area as well as crowd out native vegetation.

**Mechanical Control:** Hand pulling is not suitable for Russian knapweed control because it has very deep roots and will break off to form new plants.

**Chemical Control:** Chemical control is the most successful, however, repeat treatments are necessary. Optimum treatment is winter foliar application during plant senescence using ¼ oz per gallon of aminopyralid or broadcast according to label rates. In aquatic environments, use 1% aquatic imazapyr foliar spot treatment during any phonological stage. Other herbicide options include picloram, chlorosulfuron, metsulfuron methyl, 2, 4-D.

**Cultural Control:** Maintaining a healthy native plant community will help keep Russian knapweed from invading. Seeding native perennial grasses into disturbed areas where Russian knapweed has the potential to infest. Fire will cause rapid regeneration of Russian knapweed and increase the density of the infestation.

**Biological Control:** A nematode forms galls on Russian knapweed which reduces plant vigor. A gall-forming mite is also used to control Russian knapweed. There are different fungus species that attack Russian knapweed leaves, stems, and the crown of the plant.

RECOMMENDATIONS:

**Monitoring:** Infestations should be monitored once a month up to 3 months after an infestation is treated to ensure that the control methods were successful.

Reference: www.wa.gov, www.tncweeds.ucdavis.edu, www.cdfa.ca.gov, Beck et al, Brooks/Matchett/Deuser; Renz/Beck/Brooks/Deuser

## 7.4.2. Prescription for *Alhagi pseudalhagi* (camelthorn)

***Alhagi pseudalhagi***
**(Camelthorn)**

RANKING: Nevada Noxious Weed List-A, Arizona Noxious Weed List-Regulated and Prohibited, Cal-EPPC ranking-Moderate, Lake Mead National Recreation Area ranking-High

THREATS: Upstream of Lake Mead NRA are dense infestations of camelthorn. This will only keep re-infesting Lake Mead NRA. Camelthorn has a rapid and aggressive growth habit which out-competes native vegetation. Dense stands are impenetrable because of its spiny stems, making it difficult for animals or people to reach water sources.

MANAGEMENT OPTIONS

**No Action:** If no action is taken then camelthorn will rapidly invade river banks, resulting in habitat loss of native plants, birds, and animals.

**Mechanical Control:** This method is not recommended due to the extensive root system. If root fragments were left in the ground the plant would resprout.

**Chemical Control:** This is the preferred method. Camelthorn spreads vegetatively through rhizomes, therefore a systemic herbicide is needed to ensure control. Optimum treatment is a fall spot foliar terrestrial and aquatic treatment during green leaf out stage using 1% imazapyr. Alternatively, the above mixture can be applied anytime the plant is green and lush.

**Cultural Control:** Camelthorn will invade disturbed areas. Maintaining a healthy native plant community will help keep camelthorn out.

**Biological Control:** No biological control is known in the United States at this time. However, cattle and sheep will graze on Camelthorn. The seeds will pass through the animal's digestive tract and can start a new infestation.

RECOMMENDATIONS

**Monitoring:** Camelthorn infestations should be monitored on a minimum of twice a year, Novemeber and March/April. This is the optimum time to chemically control camelthorn.

Reference: Bossard et al. 2000, (Renz/Deuser)

### 7.4.3. Prescription for *Arundo donax* (giant reed)

***Arundo donax***
**(Giant Reed)**

RANKING: Nevada Noxious Weed List-A, Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: Its vigorous growth displaces native plant species. Giant Reed is readily flammable throughout much of the year, increasing the susceptibility of riparian corridors to fire. Large stands can significantly increase water loss from underground aquifers in semiarid regions due to high evapotranspiration rate, which is many times greater than that of native riparian vegetation. Unlike native vegetation, giant reed provides little shading for the in-stream habitat, leading to increased water temperatures and reduced habitat quality for aquatic wildlife. Giant reed reduces habitat for wildlife, including the Least Bell's vireo, a federally endangered bird.

MANAGEMENT OPTIONS

**No Action:** If an infestation is along a river corridor and no action is taken then giant reed will most likely invade the shoreline. It is very difficult to eradicate once established.

**Mechanical Control:** Repeated mowing may be effective but in some cases re-growth from root fragments can occur. Hand-pulling is effective with new plants less than six feet in height, but care must be taken that all rhizome material is removed.

**Chemical Control:** This method is preferred because any type of cutting to giant reed stalks could potentially produce new plants. Optimum treatment is foliar application of 1% imazapyr with 5% glyphosate plus surfactants to complete coverage of green leaves. Alternative treatments include 5% glyphosate foliar spray and cut stump/stubble with10% imazapyr or 50% glyphosate.

**Cultural Control:** Prescribed fire removes the biomass, but does not kill the rhizomes.

**Biological Control:** No biological control agents have been approved by the USDA at this time. There have been observations of invertebrates and caterpillars feeding on giant reed.

RECOMMENDATIONS

**Monitoring:** Giant reed is highly invasive. Once a treatment method is chosen, monitoring of the infestation should take place once a month until 100% mortality is reached.

Reference: Bossard et al. 2000; Swearingen et al. 2002; DiTomaso and Healy 2003, www.nps.gov

## 7.4.4. Prescription for *Bromus rubens* (red brome)

***Bromus rubens***
**(red brome)**

RANKING: Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: Red brome will out compete with native grasses and increase fire frequency which results in the loss of native perennial plants.

MANAGEMENT OPTIONS

**No Action:** Red brome will invade the interspaces of the desert landscape which will in turn decrease plant diversity for wildlife and increase fire loads.

**Mechanical Control:** Hand pulling red brome can be effective in small populations.

**Chemical Control:** Herbicide applications are more effective on large populations. Optimum treatment is post-emergent spot foliar application of early growth/leaf stage with 1% glyphosate, pre-emergent treatment with imazapic using 3-6 ounces per acre, or a combination pre-post treatment using imazapic and glyphosate mixture.

**Cultural Control:** Prescribed fires will only increase the density of red brome. Maintaining a healthy native plant ecosystem will decrease the invasion of red brome.

**Biological Control:** There are biological controls for cheatgrass, but literature doesn't state any for red brome.

RECOMMENDATIONS:

**Monitoring:** Red brome is not controlled at Lake Mead NRA because it is too widespread; however, possible treatment could be implemented in site-led priority areas.

Reference:

## 7.4.5. Prescription for *Bromus tectorum* (cheatgrass)

***Bromus tectorum***
**(cheatgrass)**

RANKING: Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: Cheatgrass will out compete with native grasses and increase fire frequency which results in the loss of native perennial plants.

MANAGEMENT OPTIONS

**No Action:** Cheatgrass will invade the interspaces of the desert landscape which will in turn decrease plant diversity for wildlife and increase fire loads.

**Mechanical Control:** Hand pulling is effective, but is only feasible in small areas.

**Chemical Control:** Herbicide applications are more effective on large infestations. Optimum treatment is post-emergent spot foliar application of early growth/leaf stage with 1% glyphosate, pre-emergent treatment with imazapic using 3-6 ounces per acre, or a combination pre-post treatment using imazapic and glyphosate mixture.

**Cultural Control:** Prescribed fire will only increase the density of cheat grass.

**Biological Control:** There are a few biological controls available. Soil bacteria which cause crown rot may be a possible biological control. Black fingers of death is a fungus that kills cheatgrass seeds.

RECOMMENDATIONS:

**Monitoring:** Cheatgrass is not currently being treated at Lake Mead; however, treatments could be implemented in site led priority areas.

Reference: www.npwrc.usgs.gov

## 7.4.6. Prescription for *Brassica tournefortii* (Sahara mustard)

***Brassica tournefortii***
**(Sahara Mustard)**

RANKING: Nevada Noxious Weed List-B, Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: Dense stands of Sahara mustard will suppress native annual vegetation. It monopolizes available soil moisture as it builds canopy and matures seed long before many native species.

MANAGEMENT OPTIONS

**No Action:** If no action is taken then Sahara mustard has the potential to invade undisturbed desert and displace native vegetation.

**Mechanical Control:** Hand-pulling is a successful method of control. Bag mature seed pods and dispose of them properly.

**Chemical Control:** Research is ongoing as to which type of herbicide is best for controlling Sahara mustard at different phonological stages without harming surrounding native vegetation.

**Cultural Control:** Cleaning employee vehicles and construction vehicles is an important practice to implement.

**Biological Control:** No known biological control at this time. It will be difficult to find a biological control that will attack only Sahara mustard and not damage food crops. Burros will graze on Sahara mustard, but they do not seem to significantly reduce the infestation.

RECOMMENDATIONS

**Monitoring:** Sahara mustard can have multiple generations in a growing season. Monitoring should be done once a month until April (the end of Sahara mustard's annual cycle) to ensure successful control.

Reference: Bossard et al. 2000

## 7.4.7. Prescription for *Centaurea melitensis* (Malta starthistle)

***Centaurea melitensis***
**(Malta starthistle)**

RANKING: Nevada Noxious Weed List-A, Cal-EPPC ranking-Moderate, Lake Mead National Recreation Area ranking-High

THREATS: Malta starthistle displaces native plants and animals, threatening natural ecosystems. Long-term ingestion by horses can also be harmful.

MANAGEMENT OPTIONS

**No Action:** Malta starthistle is an annual plant that does not appear to spread very fast; however once established it may displace native vegetation.

**Mechanical Control:** Malta starthistle can be hand-pulled with good success and this is the preferred method for small infestations. If there are mature seed heads on the plant be sure to bag them.

**Chemical Control:** Malta starthistle can be treated with herbicides using a spot foliar application of ¼ ounce per gallon of aminopyralid before seed development. Alternatively, these other herbicides can be used in foliar application prior to seed development: glyphosate, 2, 4-D, dicamba and 2, 4-D, imazapyr, chlorosulfuron, or metsulfuron methyl.

**Cultural Control:** Grazing and mowing can prevent seed production and control infestations, but these methods are not feasible at Lake Mead. Prevent Malta starthistle from becoming established by maintaining a healthy native plant community. Keep livestock out of infested areas and avoid driving through infestations. Use weed free hay for stock operations.

**Biological Control:** None known at this time. However, a beetle was inadvertently introduced into California that destroys mature seed heads.

RECOMMENDATIONS

**Monitoring:** If mechanical control was implemented then there should be a yearly monitoring schedule, but if a chemical control was implemented then monitoring should occur once a month after chemical application up to 3 months.

Reference: Bossard et al. 2000

## 7.4.8. Prescription for *Convolvulus arvensis* (Bindweed)

***Convolvulus arvensis***
**(Field Bindweed)**

RANKING: Arizona Noxious Weed List-Regulated and Prohibited, Cal-EPPC ranking-Evaluated, Lake Mead National Recreation Area ranking-High

THREATS: Field bindweed has an extensive root system. It is primarily a threat to agricultural fields. Currently it is only found at Overton Wildlife Management Area in Lake Mead NRA. Field bindweed is on the Lake Mead NRA high priority list because it is on the Arizona noxious weed list.

MANAGEMENT OPTIONS

**No Action:** Field bindweed does not have a high potential to naturalize at Lake Mead NRA because the majority of the habitat at Lake Mead NRA is not conducive for bindweed. It is only found at OWMA where it spreads on agricultural land.

**Mechanical Control:** Due to field bindweeds extensive root system this method should not be implemented.

**Chemical Control:** Most effective method by using a systemic herbicide that will penetrate to the roots. These herbicides applied prior to seed development are known to be effective: glyphosate, 2, 4-D, dicamba and 2, 4-D, imazapyr, chlorsulfuron, or metsulfuron methyl.

**Cultural Control:** Practice early detection and maintain a healthy native plant community.

**Biological Control:** The field bindweed moth defoliates bindweed plants by consuming both leaves and flower buds. An eriophyid mite causes gall formation along the midribs of the leaves, petioles, and stem tips, stunting the plant and reducing seed production.

RECOMMENDATIONS

**Monitoring:** Disturbed areas surrounding field bindweed infestations should be monitored once a year to ensure that the infestation is not spreading to other parts of the park.

Reference: www.colorado.gov

## 7.4.9. Prescription for *Helianthus ciliaris* (Texas blueweed)

***Helianthus ciliaris***
**(Texas blueweed)**

RANKING: Arizona Noxious Weed List-Regulated and Prohibited, Lake Mead National Recreation Area ranking-High

THREATS: Texas blueweed is more of an agricultural weed. It will quickly establish and spread in disturbed areas and in cultivated fields. Texas blueweed is on the Lake Mead NRA high ranking list because it is on the Arizona noxious weed list.

MANAGEMENT OPTIONS

**No Action:** Texas blueweed has not been invasive in the areas where it is found, it is primarily an agricultural weed. It is unlikely that Texas blueweed will naturalize at Lake Mead NRA, however monitoring of these infestations is important to be sure it doesn't naturalize.

**Mechanical Control:** Due to the rhizomatous structure of the roots it is not recommended to hand pull the plants. Any fragments left in the ground may grow in to new plants.

**Chemical Control:** Literature states that glyphosate, 2, 4-D, dicamba, clopyralid, and picloram will effectively control Texas blueweed.

**Cultural Control:** Maintain a healthy native plant community. Planting perennial grasses around a Texas blueweed infestation may provide competition.

**Biological Control:** There is no known biological control available. Texas blueweed is resistant to the sunflower beetle and the carrot beetle.

RECOMMENDATIONS

**Monitoring:** Monitor infestations on an annual basis to assess the size of the infestation and to ensure there are no new infestations.

Reference: www.nwcb.wa.gov

### 7.4.10. Prescription for *Lepidium latifolium* (Perennial pepperweed)

***Lepidium latifolium***
**(Perennial pepperweed)**

RANKING: Nevada noxious weed list-C, Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: Plants are highly competitive and typically form dense colonies that displace native vegetation and wildlife.

MANAGEMENT OPTIONS

**No Action:** Left untreated Perennial pepperweed may dominate a river system and displace native vegetation.

**Mechanical Control:** Perennial pepperweed regenerates quickly from roots left in the soil or from fragments and thus making mechanical control not a viable option.

**Chemical Control:** This is the preferred option because a systemic herbicide that reaches the roots will kill the plant. Metsulfuron, imazapyr, chlorsulfuron, and 2, 4-D are herbicides that will control perennial pepperweed effectively.

**Cultural Control:** Prescribed fire is not effective in controlling Perennial pepperweed because the fuel loads in infestations of this plant are inadequate to sustain burns. A fire can burn through an infestation and stimulate plant growth.

**Biological Control:** Goats appear to tolerate heavy consumption of fresh plants, and cows, under some situations, will also graze the foliage. However, there have been reports of horses becoming ill after being fed contaminated hay, possibly due to the ability of perennial pepperweed to accumulate nitrates. A biological control with insects or fungi is highly unlikely because of risks to man important crop plants that are members of the mustard family. No biological controls are implemented here at Lake Mead NRA.

RECOMMENDATIONS

**Monitoring:** Infestations of Perennial pepperweed should be monitored after a fall treatment (October/November) and a spring treatment (March/April) to ensure control method success.

Reference: DiTomaso and Healy 2003; Bossard et al. 2000, www.nps.gov

## 7.4.11. Prescription for *Medicago polymorpha* (Bur-clover)

***Medicago polymorpha***
**(Bur-clover)**

RANKING: Arizona Noxious Weed List-Regulated and Prohibited, Cal-EPPC ranking-Low, Lake Mead National Recreation Area ranking-High

THREATS: Bur-clover is not an invasive weed and is primarily only found in disturbed grazed areas. Bur-clover falls in to the high priority list because it is on the Arizona noxious weed list.

MANAGEMENT OPTIONS

**No Action:** Bur-clover is primarily an agricultural weed that does not seem to naturalize at Lake Mead NRA.

**Mechanical Control:** Hand pulling plants may control small populations as long as all the roots were removed.

**Chemical Control:** No known chemicals have been listed in the literature, but glyphosate may be an options of control.

**Cultural Control:** Maintain healthy native plant community.

**Biological Control:** No known biological control.

RECOMMENDATIONS

**Monitoring:** Monitoring once a year (February/March) is recommended to ensure the infestations don't expand.

Reference:

## 7.4.12. Prescription for *Myriophyllum spicatum* (Eurasian milfoil)

***Myriophyllum spicatum***
**(Eurasian milfoil)**

RANKING: Nevada noxious weed list-A, Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: It can form large, floating mats of vegetation on the surface of lakes, rivers and other water bodies, preventing light penetration for native aquatic plants and impeding water traffic. The mats inhibit recreational use of waterways for boating, swimming, and fishing. An infestation of Eurasian milfoil can also provide habitat for mosquitoes.

MANAGEMENT OPTIONS

**No Action:** Taking a no action stance on Eurasian milfoil could devastate the aquatic ecosystem.

**Mechanical Control:** Large harvesting equipment can be used to mechanically remove milfoil in larger areas; a sturdy hand rake can be used for smaller areas. Physical barriers can also be a means of control.

**Chemical Control:** Aquatic herbicides can be used to control Eurasian milfoil. Literature suggests fluridone, diquat, copper, endothall, and 2, 4-D to control Eurasian milfoil.

**Cultural Control:** Manipulation of water level to reduce light penetration is currently being implemented at Lake Mead NRA. The small infestation is located in Black Canyon where seasonal water fluctuations occur.

**Biological Control:** There are no known biological controls available at this time. A North American weevil, *Eurhychiopsis lecontei*, feeds on Eurasian milfoil in the midwestern United States. The fungus *Mycoleptodiscus terrestris* is also being researched as a potential biocontrol agent.

RECOMMENDATIONS

**Monitoring:** Potential impacts to existing native aquatic species should be evaluated carefully before and after implementing any of the control techniques. Monitor shallow areas around the lake to prevent further spread of Eurasian milfoil once a year.

Reference: Swearingen et al. 2002; Bossard et al. 2000, www.dnr.wi.gov, www.plants.ifas.ufl.edu

## 7.4.13. Prescription for *Pennisetum setaceum* (fountain grass)

***Pennisetum setaceum***
**(Fountain grass)**

RANKING: Nevada noxious weed list-C, Cal-EPPC ranking-Moderate, Lake Mead National Recreation Area ranking-High

THREATS: Fountain grass is well adapted to fire, and plants can recover to pre-burn density, even increase in density, following a burn. Fountain grass increases fuel loads, which increases the intensity and spread of fire and results in severe damage to native species that are not fire adapted or are adapted to less extreme fire regimes. Fires fueled by fountain grass impact ground-nesting birds and terrestrial animals as well. Thick infestations of fountain grass interfere with regeneration of native plant species.

MANAGEMENT OPTIONS

**No Action:** Not controlling infestations of fountain grass would result in a monoculture of this perennial grass, especially along shorelines at Lake Mead NRA. This could make the shorelines of Lake Mead NRA more susceptible to fire.

**Mechanical Control:** Manually digging up fountain grass can be successful if all the roots are removed. Cutting off seed heads and bagging them can also prevent further fountain grass recruitment for the season, but the perennial plants will persist and eventually re-seed.

**Chemical Control:** Herbicides have been proven to be very successful in controlling fountain grass. Optimum treatment is foliar application of 5% glyphosate to complete coverage anytime during green lush leaves prior to seed development. Alternatively 5% glyphosate can be applied anytime during any phenological stage to complete coverage.

**Cultural Control:** Fountain grass is a perennial that re-sprouts post-fire, prescribed fire will increase the infestation of fountain grass and is not recommended as a control option.

**Biological Control:** No biological control is known and there probably won't be any due to valuable forage grasses possibly being affected as well. Burros and livestock will browse on fountain grass, but this does not control it.

RECOMMENDATIONS

**Monitoring:** Fountain grass seeds stay in the seed bank for many years. Yearly monitoring of infestations will facilitate in the eradication of fountain grass. April to May is the optimum months to capture the new generation of fountain grass.

Reference: Boussard et al. 2000

## 7.4.14. Prescription for *Phoenix dactylifera* (date palm)

***Phoenix dactylifera***
**(date palm)**

RANKING: Cal-EPPC ranking-nominated, Lake Mead National Recreation Area ranking-high

THREATS: Date palms will crowd out native vegetation in riparian spring ecosystems. It is vital to keep a healthy balance of natives in a riparian spring to support wildlife in and among the springs.

MANAGEMENT OPTIONS

**No Action:** Date palms if left alone have the potential to infest a riparian spring.

**Mechanical Control:** Small date palms can be hand pulled. Larger palms must be cut down with a chainsaw. However, a date palm will resprout and must be sprayed with herbicide.

**Chemical Control:** Treatment options include cut stump with 50% glyphosate, drill holes into core every 6 inches around diameter and fill with 50% glyphosate, and foliar application of 5-10% glyphosate with surfactant to all fronds.

**Cultural Control:** Maintaining a diverse native vegetation component in riparian springs around Lake Mead NRA will impede the invasion of date palms to this fragile system.

**Biological Control:** No biological control is currently being used at Lake Mead.

RECOMMENDATIONS:

**Monitoring:** Date palms were originally planted as landscape plants and have been naturalizing. Monitoring efforts should be focused on areas where date palms currently exist. Date palms are perennial and can be monitored anytime of the year.

Reference:

## 7.4.15. Prescription for *Solanum elaeagnifolium* (Silverleaf nightshade)

***Solanum elaeagnifolium***
**(Silverleaf nightshade)**

RANKING: Nevada noxious weed list-B, Cal-EPPC ranking-Evaluated, Lake Mead National Recreation Area ranking-High

THREATS: Silverleaf nightshade is a threat primarily to pastures and agricultural fields. Silverleaf nightshade spreads by rhizomes and by seeds allowing it to infest large areas. It is on the Lake Mead NRA high priority list because it is on the Nevada noxious weeds list.

MANAGEMENT OPTIONS

**No Action:** Silverleaf nightshade occurs in small numbers throughout Lake Mead NRA. It is primarily an agricultural weed, but should still be treated as a potential threat to the ecosystem at Lake Mead NRA.

**Mechanical Control:** Silverleaf nightshade has a very deep root system thus making mechanical control very ineffective.

**Chemical Control:** A systemic herbicide that can reach the deep root system is much more effective than a contact herbicide. Literature suggests glyphosate, 2, 4-D, picloram, dicamba, and triclopyr to control silverleaf nightshade.

**Cultural Control:** Maintain a healthy native plant community.

**Biological Control:** There is no known biological control for silverleaf nightshade. Researchers are working on possible nematodes that are host specific to silverleaf nightshade. There is concern for the agricultural crops that biological controls might affect.

RECOMMENDATIONS:

**Monitoring:** Silverleaf nightshade infestations should be monitored on an annual basis. The plant flowers from May to September. If chemical control is implemented then monitoring should be done more frequently to ensure proper control effectiveness. Seeds will remain in the soil for many years.

Reference: www.cdfa.ca.gov

## 7.4.16. Prescription for *Sorghum halepense* (Johnson's grass)

***Sorghum halepense***
**(Johnson's grass)**

RANKING: Nevada noxious weed list-C, Lake Mead National Recreation Area ranking-High

THREATS: Johnson's grass grows in disturbed areas and wet areas. Fire will allow Johnson grass to regenerate from seed. It reproduces through rhizomes making it very difficult to control. Johnson's grass is more of an agricultural weed that causes economic losses. In a wildland situation, Johnson's grass does have the characteristics of being invasive.

MANAGEMENT OPTIONS;

**No Action:** Johnson's grass if left untreated has the potential to overcrowd native grasses. It is primarily an agricultural weed, but should be treated as a potential invasive weed.

**Mechanical Control:** Not very effective unless one can dig up all the roots.

**Chemical Control:** Most effective method due to its underground root structure. Literature states that glyphosate and 2, 4-D are effective herbicides in controlling Johnson's grass.

**Cultural Control:** Minimize disturbance in areas to prevent Johnson's grass from being introduced.

**Biological Control:** Biological control is problematic because any control agents that kill Johnson grass will also kill crop grasses such as corn. Several biological controls are being researched. A smut has had success in controlling Johnson's grass in the southeastern U.S. as well as a natural fungal pathogen.

RECOMMENDATIONS:

**Monitoring:** Johnson's grass infestations should be monitored every year to ensure that the infestation has not spread. It flowers from June to November.

**Reference:** www.fs.fed.us, www.missouriplants.com

## 7.4.17. Prescription for *Tamarix aphylla* (Athel)

***Tamarix aphylla***
**(Athel)**

RANKING: Cal-EPPC ranking-Low, Lake Mead National Recreation Area ranking-High

THREATS: The soil salinity underneath an athel decreases native plant germination. Athel hybridizes with saltcedar producing another invasive tamarisk species with unknown qualities.

MANAGEMENT OPTIONS

**No Action:** Athel would continue to spread around the shoreline as well as hybridizing with saltcedar if left untreated.

**Mechanical Control:** Athel will reproduce through vegetative processes, making it very difficult to handpull. Cutting down a tree must be followed by a chemical treatment because it will resprout.

**Chemical Control:** The same treatments used for *Tamarix ramosissima* can be used on Athel. The current method is hack and squirt or girdle circumference used with the following herbicides: 20% ester triclopyr with 80% JLB Basal Oil (only during temperatures less than 75 degrees F due to volitization) or 10% imazapyr with water and no temperature restrictions

**Cultural Control:** Athel is no longer being used in landscaping in the park and is being removed from landscaped areas.

**Biological Control:** No biological control is available at this time, but the tamarisk beetle might feed sporadically on Athel.

RECOMMENDATIONS:

**Monitoring:** Any control efforts should be monitored on a yearly basis in the spring for any resprouts.

Reference:

## 7.4.18. Prescription for *Tamarix ramosissima* (Saltcedar) and Tamarix spp.

***Tamarix ramosissima amd Tamarix spp.***
**(Saltcedar and Hybrid Tamarix)**

RANKING: Nevada noxious weed list-C, Cal-EPPC ranking-High, Lake Mead National Recreation Area ranking-High

THREATS: Salts concentrate in the leaves of saltcedar and leaf litter can both increase soil salinity beyond the tolerance of native species and can increase fire frequency. Saltcedar displaces native riparian species. Saltcedar also has a high evapotranspiration rate and can locally affect groundwater supplies and channelize river systems that typically meander.

MANAGEMENT OPTIONS

**No Action:** A monoculture of saltcedar will form in moist soil if no action is taken. This could destroy any riparian system.

**Mechanical Control:** Seedlings can be hand pulled and tossed on to a dry place. More mature trees can be cut then treated with chemical.

**Chemical Control:** Chemical control is very effective on this species and various application methods and chemicals can be used in specific field conditions. Cut stump: 20% ester triclopyr with 80% JLB Basal Oil only during temperatures less than 75 degrees F due to volitization or 10% imazapyr with water and no temperature restrictions or 50% amine triclopyr with water and no temperature restrictions. Low Volume Basal Spray: 20% ester triclopyr with 80% JLB Basal Oil only during temperatures less than 75 degrees F due to volitization. Foliar: 1% imazapyr complete coverage, during full leaf out and optimum in the fall prior to dormancy transition.

**Cultural Control:** Maintain intact riparian plant communities that may resist invasion. Prescribed fire will aide in the control of heavy infestations to remove the biomass, but a followup with chemical control will be needed for any resprouts.

**Biological Control:** The tamarisk beetle has been released in the Colorado River system and the Virgin River drainage and will likely affect shoreline populations at Lake Mead NRA.

RECOMMENDATIONS

**Monitoring:** Infestations should be monitored once a quarter for resprouts. Once the beetles start defoliating saltcedar trees in the park secondary invasion will need to be monitored in those areas once a year.

Reference:

## 7.4.19. Prescription for *Tribulus terrestris* (Puncturevine)

***Tribulus terrestris***
**(Puncturevine)**

RANKING: Nevada noxious weed list-C, Arizona Noxious Weed List-Regulated and Prohibited, Lake Mead National Recreation Area ranking-High

THREATS: Puncturevine grows in disturbed areas. Typically found in campgrounds, developed areas, and drawdown zones around the lake. It is not invasive, but the thorny seeds can cause problems for visitors and wildlife. The seeds can get lodged in the feet of wildlife resulting in potential injury or infection. Visitors can have the same affect if they step on the seeds with their bare feet. Puncturevine seeds can last up to 20 years in the seed bank.

MANAGEMENT OPTIONS

**No Action:** If no action is taken then the infestations will likely stay where they are. With lowering lake levels the infestations may spread, but only into the disturbed areas. Puncturevine has not escaped into natural areas.

**Mechanical Control:** Hand pulling the plant is very effective. If there are seeds on the plant then it must be bagged and disposed of properly. If there are only flowers or leaves on the plant then it can be discarded on the ground to decompose.

**Chemical Control:** Literature states that 2,4-D, glyphosate, chlorosulfuron, imazapyr, paraquat, and dicamba are effective on puncturevine; however, Lake Mead doesn't have many infestations and hand pulling is easier and more cost effective.

**Cultural Control:** No cultural practices have been applied here at Lake Mead NRA, but in the future we could promote a healthy native component amongst all the disturbed areas around the park to keep out weeds.

**Biological Control:** No biological control is used on puncturevine at Lake Mead NRA. California has introduced the stem weevil and the seed weevil to help control puncturevine.

RECOMMENDATIONS

**Monitoring:** Return during May to August to the areas where control has been implemented to see if new plants have generated.

Reference: www.cdfa.ca.gov

## 7.5 Post-treatment Restoration

For many sites with established weed populations, the propagules of native plant species may be insufficient to provide for natural reestablishment of native plant communities, thus leaving the site vulnerable to re-invasion by the same exotic species or new invasions by other exotic species. In these cases, it may be necessary to actively revegetate the site. The decision to revegetate must consider direct costs (seedbed preparation, seed or plant materials, follow-up management), indirect costs (risk of failure), and benefits (wildlife habitat, soil conservation). Revegetation efforts should focus on sites and methods with the greatest potential for increasing net benefits in the shortest amount of time (Jacobs et al. 1999).

Obviously cost is an important consideration for post-treatment restoration. But funds either will or will not be available depending of the vagaries of funding sources and political will. In addition to cost, there are several other factors to be considered when determining the appropriateness of active restoration as part of a weed treatment strategy at Lake Mead NRA. Each of these factors will be discussed in turn in the following subsections.

### 7.5.1. Likelihood of Success

The Mojave Desert is the harshest of North American deserts, defined by little precipitation and significant water loss due to evaporation (MacKay 2003). Lake Mead NRA lies in the eastern Mojave, an area characterized by a bimodal precipitation pattern where most of the moisture occurs as winter rains, but in many years, thunderstorms driven by the Southwestern monsoon brings localized intense rainfall during late summer. The Mojave Desert environment presents many difficulties for plants, including temperature extremes, salty soils, and, most of all, lack of water (MacKay 2003). As a result of adaptation to this harsh landscape, many native and exotic species have evolved specific characteristics that must be considered in developing restoration plans.

Many native and exotic plant species found in the Mojave Desert are annual plants that complete their lifecycle in one growing season, typically spring. Other species have developed episodic recruitment mechanisms where they only set seed, or the seed only germinates, when specific soil moisture and/or temperature thresholds are met. Some heat-tolerant plants, called $C_4$ plants, use an enzyme for photosynthesis that is very efficient at high temperatures giving them a competitive advantage over the less efficient $C_3$ plants. Still other plants have developed specific metabolic or anatomical adaptations to site-specific soil characteristics, such as the salt-tolerant halophytes and the gypsum-loving gypsophiles. Thus the species-specific characteristics of the desired plant species as well as the potential invasive species must be considered along with the site characteristics which may give one species an advantage over the other.

When determining the appropriateness of active restoration, consideration must be given to the ability to either work with these species-specific and site-specific limitations or find ways to overcome these limitations in order the effort to be successful. Some considerations might include:

- species selection appropriate to soil type, elevation and aspect
- expected germination rates under field conditions for the desired species
- seed dormancy mechanisms of desired species and ability to control the conditions necessary to induce germination
- seeding rates (lb/acre) or seedling spacing necessary to establish a dense enough population to resist invasion by exotic species
- timing of seed application or seedling out planting in relation to available soil moisture and potential for seed/seedling loss due to erosion

### 7.5.2. Availability of Appropriate Plant Materials

Restoration plans must also consider the availability of appropriate plant materials. Not only is species selection important, but NPS policy (NPS 2006) also requires that the genetic type used in restoration most nearly approximates the extirpated genetic type. That is, the seed or seedlings should be propagated from local plants. The Lake Mead Native Plant Nursery is able to produce seed or seedlings of local genotypes of many Lake Mead species, but only for relatively small scale restoration projects. Larger projects require several years of advance planning in order to contract for propagule increase in an off-site facility, or in a very few cases, suitable seed may be available from commercial sources.

### 7.5.3. Site or Soil Preparation Needs

Some exotic plant species alter the soil and thus make restoration of native plants more difficult unless the soil condition is remediated. One such example is allelopathic species that produce chemicals to inhibit the growth of competing plants, such as some knapweed species (Centaurea spp.). Another example is plant species that concentrate certain minerals in the soil near their roots. For example, the extremely high transpiration rates of saltcedar combined with the accumulation of their high salt content leaf cast increases the salinity of the soils where they grow. In long-established populations of saltcedar, the high salt content of the soil may be beyond the tolerance of some native riparian vegetation and the soil may need to be remediated in some way prior to out planting of native cottonwood or willow, or species selection for the site should consider using native species that are more salt tolerant, such as *Atriplex* species.

Post-treatment restoration efforts will be documented at Lake Mead. Preference will be given to passive restoration (e.g. promoting or assisting natural recovery) but active restoration (e.g. site medication, planting, etc.) may be used in some cases where the potential for natural recovery is considered low. Table 7 is an example restoration strategy that demonstrates some of the biotic and abiotic factors and implementation steps that might be used in a restoration project.

Table 7. Text box showing factors considered and an example restoration strategy**.**

**Matrix:** Site specific abiotic and biotic factors to consider when developing a restoration strategy (J. Hoines, Southern Nevada Interagency Restoration Coordinator, personal communication, April 2008)

| | | ABIOTIC FACTORS | | | |
|---|---|---|---|---|---|
| | | **Site Precipitation** | **Flooding Regime** | **Soil Salinity** | **Fire Regime** |
| | **Site characteristics** | < 5 inches annually | Minimal flooding due to channelization | High salinity | Burns annually |
| **BIOTIC FACTORS (e.g. species)** | **Salt cedar** | Invasive riparian plant, precipitation does not directly influence plant demographics | Deep rooted and once established does not need to be near water. Increases Channelization | Highly tolerant of saline soils | Fire adapted and alters the fire regime to increase fire intensity and frequency. |
| | **Willow** | Native riparian plant, precipitation does not directly influence plant demographics | Riparian plant adapted for colonizing sand bars and other disturbed riparian habitats | Low salinity tolerance | Low- to moderate-severity fires top-kills young stems. Mature trees probably survive such fires. Severe fires sometimes kill willows by completely removing soil organic layers and charring the roots. If root crow survives, it resprouts vigorously after fire. |
| | **Arrowweed** | May need normal precipitation to germinate and grow | Forms dense stands and may recover well from roots after disturbance | Grows on soils from moderate to low salt concentrations | Forms dense stands and re-sprouts vigorously after disturbance, including low to moderate intensity fire. Early post-fire colonizer in moist soils. |
| | **Quail bush** | Grows on saline benches, may need precipitation for germination. | Early native colonizer of saline soils. Can be used to keep out invasives until natural flooding event occurs | Grows well on saline soils | If plant and soil moisture are high, some plants survive fire. Seeds prolifically following low-intensity and infrequent fires. |
| | **Mesquite** | Requires precipitation throughout early stages of life cycle | Phreatophytic plant typically found on benches above active water may require flooding for dispersal, scarification, and germination. | Grows on moderate to low salinity soils | Moderate to high severity fires top kills young trees, most older trees have thick bark and survive occasional fire. Re-sprouts after fire, especially where root system is well established and water table is accessible. Declines with increased fire intensity and frequency. |

Restoration strategy based on the information considered in the matrix above:

1) control/eradicate salt cedar
2) Allow water course to assume natural characteristics (i.e meandering)
3) Revegetate saline benches with salt tolerant species, quail bush etc.
4) Revegetate low salinity benches with native phreatophytes i.e. mesquites
    a. Supplemental watering until roots reach water table (1-3yrs)
5) Revegetate sand/silt bars with willows and arrowweed
6) Retreat site for exotics on cyclic maintenance schedule
7) Monitor site recovery (vegetation, soils, etc…) to advise future management interventions if necessary

## *7.6 Adaptive Management*

For containment and control of established populations, the assumption is that multiple treatments will be needed on a given site. As such, these situations offer a prime opportunity to learn what is successful and what is less than successful on a given population, and apply that knowledge directly to that same population the next time it is treated. This improves treatment effectiveness as well as maximizes time, effort, and funds expended to control a population. To capitalize on this learning opportunity, it is important that treatment effectiveness is monitored to determine what treatments work and what did not, and that information is systematically documented. Less than successful treatments should be evaluated using best professional judgment to determine, if possible, why and to what extent the treatment failed (e.g. incomplete application, wrong phenological condition, etc.) and identify possible improvements to the treatment strategy.

# Chapter 8: Data Management, Monitoring, and Research

## *8.1 Introduction to Data Management, Monitoring, and Research*

This chapter specifically addresses Exotic Plant Management Program Objective 1: The exotic plant management program operates within a framework of adaptive management where research and monitoring are used to systematically evaluate actions and outcomes for the purpose of improving management actions.

## *8.2 Data Management*

Detailed and accurate record keeping are a fundamental part of the Lake Mead NRA Exotic Plant Management Program. Record keeping provides a historical record of activities and provides a means to compare results and improve future exotic plant management efforts.

Data management systems are dynamic as the software and network capability continue to increase and GPS technologies evolve. This dynamic situation is tempered by the reality that government agencies, including the National Park Service, tend to make transitions slowly and unevenly which often results in data gaps and sometimes legacy data that does not transition. Additionally, different funding sources and partner organizations may have their own data standards that must be met. Rather than try to address these issues by prescribing a specific data structure or platform which will quickly become outdated, this plan sets the sidebars for weed related data collection and management at Lake Mead NRA for the life of this plan.

### 8.2.1. Exotic Plant Mapping

The park will map exotic plant population distributions based on the North American Weed Management Association standards.

The mission of the North American Weed Management Association (NAWMA) is to provide education, regulatory direction, professional improvement, and environmental awareness to preserve and protect our natural resources from the degrading impacts of exotic, invasive noxious weeds. NAWMA is a network of public and private professional Exotic Plant Managers who are involved in implementing any phase of a county, municipal, district, state, provincial or federal noxious weed law. This organization has developed the North American Invasive Plant Mapping Standards (2002), which was endorsed by the Federal Interagency Committee for the Management of Noxious and Exotic Weeds and approved by multiple partners, including the National Park Service as well as the states of Arizona and Nevada. Consequently, these are the most widely recognized weed mapping standards that are relevant to Lake Mead NRA and will represent the minimum standards for the park's exotic plant management program. The use of these standards will increase our ability to share information across jurisdictional boundaries.

The complete NAWMA mapping standard as it currently exists is included in Appendix C. There are two standards for two applications: 1) Inventory and Monitoring Standard to record presence of weeds; and 2) Survey Standard to record absence of weeds. The required fields are listed here in Table 8 for reference.

Table 8. Required fields for the North American Weed Management Association mapping standard.

| Inventory and Monitoring Standards | Survey Standards |
|---|---|
| Collection Date | Area Surveyed |
| Examiner | Type of survey |
| Plant Name | Date of Survey |
| Common Name | Location |
| Plant Code | Quad Number |
| Infested Area | Quad Name |
| Gross Area | |
| Canopy Cover | |
| Ownership | |
| Source of the Data | |
| Country | |
| State or Province | |
| County or Municipality | |
| Hydrologic Unit Code | |
| Location | |
| Quad Number | |
| Quad Name | |

It is anticipated that these standards will be updated periodically and the updated NAWMA standard will then become the minimum for Lake Mead NRA. In the event that NAWMA as an organization is dissolved, the park will seek a new minimum data standard that is widely used by its interagency partners and that has been endorsed by the Federal Interagency Committee for the Management of Noxious and Exotic Weeds.

### 8.2.2. Treatment Recording

All exotic plant treatments in Lake Mead NRA, regardless of who undertakes the treatment, will be recorded. Starting in FY2009, the data standard and platform will be the Alien Plant Control and Management Database (APCAM). This database tracks acres treated, monitored, inventoried, etc. as well as the specifics of control methods used on a per species basis. Treatments accomplished by the Lake Mead EPMT in Lake Mead NRA have been consistently recorded in this database since 2002, but legacy data has also been entered as far back as 1996. The Park's Exotic Plant Manager will assure that all treatments, even those done by someone other than EPMT, are also recorded in APCAM.

APCAM is the database used by the Exotic Plant Management Teams (EPMTs) in the National Park Service and software support is available through the National Park Service's Natural Resource Program Center. The Park's Exotic Plant Manager will be responsible for maintaining,

populating, and periodically updating the APCAM database and software as recommended in the APCAM User Guide.

### 8.2.3. Quality Assurance/Quality Control

Data cleaning of both the weed map and APCAM databases will be done routinely using summary statistics, random sampling of data lines, and similar methods.

As staffing is available, the Park's Exotic Plant Manager will conduct quality control and quality assurance measures as outlined by Stohlgren et al. 2002:

> "Quality control and quality assurance are important to evaluate observer accuracy and spatial bias for the "minimum-standard" NAWMA polygon. The stratified-random design and purposive sampling design can be used to assess the spatial bias of NAWMA records. To evaluate observer bias and accuracy (taxonomy and location), a random subset of minimum standard polygons must be assessed by an independent field crew. The "audit" crew verifies the taxonomy and spatial location accuracy of the polygon. If the accuracy is low, additional audit polygons are necessary. The recorder's data should be noted as "validated" in the metadata, and the level of accuracy should be noted separately for taxonomy and location, with the sample site noted."

The Park's QA/QC strategy will annually target 5% of the recorded observations. Those observations will be revisited to verify species identification, population perimeter, and population characterization. In addition, a similar strategy will be used for QA/QC of treatments recorded in APCAM.

### 8.2.4. Metadata and Data Sharing

In compliance with the Federal Geographic Data Committee (FGDC) metadata standards, GIS and GPS data files will include metadata. Geospatial data will be made available as requested to local cooperators and will be served through NPS Data Store (online at http://science.nature.nps.gov/nrdata) as well as other federally sponsored geospatial data sharing programs developed under the auspices of the National Spatial Data Infrastructure program. The Park's GIS and Data Management Program will prepare and upload the data as required.

Data collected under specific task agreements and/or supported by various funding sources may have additional reporting standards that will be followed. The Park's Exotic Plant Manager will generally be responsible for those deliverables.

### 8.2.5. Annual Reporting

Annual reports are prepared and submitted according to NPS procedures. All reports will be prepared by the Park's Exotic Plant Manager and approved by the Park's Vegetation Manager prior to submission. Currently, the following reporting requirements are in effect throughout the National Park Service:

- Biological Control: An annual report will be submitted to the Regional IPM Coordinator by March 15 each year. The report will include:
    - Biological control agent common name and scientific name
    - Permit # (if transported across state lines)
    - Target exotic plant common name and scientific name
    - Date and time of release
    - Weather conditions during release
    - Description and location of release site
    - Estimated size of exotic plant infestation
    - Number of biological control agents released

- Chemical Control: The pesticide use logs maintained throughout the year will be compiled annually and submitted in the intranet-based NPS pesticide use reporting system by March 15 each year for the previous calendar year. The report will include the following information for each approved pesticide:
    - Date and time of application
    - Name, location, and estimated area of treatment site
    - Brand name of the material or materials used, including formulation
    - USEPA registration number of materials used
    - The mix rate of material used
    - The amount of material used
    - Name(s) of pesticide applicator(s)
    - General weather conditions, including wind speed

In addition, to these annual database entries for biological and chemical control, the Park's Exotic Plant Manager will prepare an annual report for the Chief of Resource Management in narrative form that will include a summary of: noteworthy events of the year such as major accomplishments, significant changes in exotic plant populations, and changes in program management; total acres of infested lands within the park (based on NAWMA compliant database), along with a discussion of trends, distributions, etc; total acres treated in the park by various means (as recorded in APCAM); funds expended by the Exotic Plant Management Program and source of those dollars; and discussion of partnerships, collaborators, and outreach activities.

In addition, quarterly reports are prepared four times per year that summarize weed management accomplishments during that time frame. The requirements regarding content and level of detail included in the quarterly reports vary by funding source. The quarterly reports will be prepared as required and archived with the other Exotic Plant Management Program files and data.

### 8.2.6. Redundancy

Computer and server hard drives fail and paper copies get misfiled or destroyed. As such, all exotic plant mapping and treatment records will be kept in at least two locations, ideally one electronic version on a network server that is backed up regularly and one paper version in a file cabinet. The Exotic Plant Manager is responsible for managing these records according to the NPS Records Management Guidelines.

### 8.2.7. Records Management and Archives

Electronic and paper documents will be maintained according to the standards established in the park's Records Plan, and future updated versions thereof. The park maintains an archive, managed by the Branch of Cultural Resources. The park follows the NPS DO-19, *Records Disposition Schedule*, as well as the *NPS Museum Handbook* chapter on *Archives.* Resource archives are retained in perpetuity in order to maintain an admin history to document decisions that have been made regarding stewardship of resources.

At least annually, important paper and electronic records will be identified by the Park's Exotic Plant Manager for inclusion in the Park Archive. After discussion with the Park's Archivist or Cultural Resource Manager, the records will be submitted for accession to the archive.

## *8.3 Monitoring*

Monitoring is the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective (Elzinga et al. 1998). Detection of a change or trend may trigger a management action, or it may generate a new line of inquiry. Monitoring is often done by sampling the same sites over time, and these sites may be a subset of the sites sampled for the initial inventory.

Within this Lake Mead NRA Exotic Plant Management Plan, "survey" is not considered part of "monitoring" but rather a separate effort with different objectives. Early detection is addressed as a survey effort in Chapter 5.

### 8.3.1 Relationship of Park-led Monitoring and the Mojave Network Inventory and Monitoring Program

An exotic plant monitoring framework will be developed to assess the effectiveness of exotic plant treatments, detect non-target and secondary impacts caused by treatments, and assess the overall status and trends of priority exotic plant species park-wide. In some cases, treatment effectiveness monitoring may include research components where different treatment methods are compared side-by-side in order to inform the day to day decisions made by the park's Exotic

Plant Manager. The park-led monitoring effort will be compatible with the large scale monitoring efforts being developed throughout the Mojave Desert parks by the NPS's Mojave Network Inventory and Monitoring Program (MOJN I&M), but the park-led monitoring program will be geared toward collecting information on a spatial and temporal scale appropriate to inform day-to-day exotic plant management decisions at Lake Mead. A monitoring plan, complete with protocols and standard operating procedures will be developed as an appendix to this Plan after the I&M Invasive Species Monitoring Protocol is available for consideration in 2010.

It is anticipated that the I&M monitoring effort will focus on long-term vegetation status and trends at a landscape scale. Such information will be important to informing exotic plant management effort at the park. In particular, the monitoring report of a species "naturalizing" in the park away from the disturbed areas should be considered in the re-evaluation of that species for management priority. Similarly, the status and trend of invasive species beyond treated areas is important in separating treatment effectiveness from larger-scale trends in distribution or abundance of a given weed species.

### 8.3.2. Interim Qualitative Monitoring Strategy

The Lake Mead NRA exotic plant management monitoring effort will focus on management-oriented objectives not adequately addressed in the I&M monitoring effort. Below are listed some monitoring questions and elements that such monitoring objectives are likely to focus on:

- Based on site-specific characteristics, how effective are treatments, including manual, chemical, and biological controls as well as post-treatment restoration?
    - includes both "as designed" and "as implemented" measures in order to determine the absolute effectiveness of a prescribed treatment (e.g. "as designed") as well as the influence of human-error or less-than-desirable field conditions ("as implemented")
- How effective are prevention measures at intercepting vectors of invasion?
    - includes an estimate of what weed species and how frequently they are intercepted from entering the park by implementation of the prescribed prevention measures
    - in cooperation with the Lake Mead NRA Interpretation Division, it may also include a measure of education effectiveness in cooperation with the Interpretation Division
    - should also include any documented "failures" whereby exotic plants are known to have become established in an area that was subject to our prevention measures
- What are the impacts of treatments to non-target organisms and/or ecological processes?
    - includes both direct and indirect impacts
- Are secondary invasions following treatment?
    - ideally, this includes an estimate of other variables that may influence secondary invasions (e.g. site productivity, soil characteristics, propagule strength, etc.)

    - this should also include consideration of what are the mechanisms that trigger secondary invasion (e.g. changes in resource availability, disturbed soils as a result of treatment, etc)
- In what ways are exotic plants impacting other park values (e.g. other resources, visitor use, etc) and are there ways to minimize or mitigate those impacts?

Eventually, the I&M invasive species protocol will be developed and then compatible, quantitative park-led monitoring protocols will be developed. In the interim, qualitative information will be documented and used by the Exotic Plant Manager to inform future decisions consistent with the principles of adaptive management. Information collected will also be shared as appropriate with the Mojave Network I&M protocol development work group to identify practical considerations in the development of a quantitative monitoring protocol.

Until quantitative protocols are developed, the following qualitative monitoring standards will be used at Lake Mead NRA:

1) Interim Strategy for Treatment Effectiveness Monitoring: At least 25% of treated sites will be revisited for at least 3 growing seasons to monitor the effectiveness of the treatment. Ideally, the selected sites should be digitally photographed prior to treatment, immediately post-treatment, and at each follow-up visit. The revisit and any re-treatment will be captured in APCAM. In addition, the evaluator will make notes of the following during each follow-up visit:

- Is there any indication in the project documentation or in the field that the initial treatment was implemented in ways other than designed (e.g. equipment failure, missed plants during application, weather too hot for maximum effectiveness)? If so, identify those factors and the influence they may have had on treatment effectiveness.
- Is there any indication that non-target organisms or ecological processes have been affected by the treatment? If so, what was affected and in what ways?
- Are there any new exotic plant species established in the treated area or have other exotic plant species increased in abundance after treatment? If so, what species and what changes can be observed? Is there an apparent spatial relationship with other site characteristics (e.g. species X becoming established in the wash but not the upland areas)?
- Are there any indications that other park values have been impacted positively or negatively by the treatment? If so, what values have been impacted in what ways? What are the indicators of the observed impact?

2) Interim Strategy for Prevention Effectiveness Monitoring: As feasible, at least 10 samples per year will be collected from incoming construction equipment by Compliance Monitors. All soil and plant particles will be scraped off and collected from a single piece of equipment. Under the direction of the Park's Vegetation Manager, the sample will be grown-out in the plant nursery to determine the species and relative abundance of viable propagules that were intercepted by

implementation of the contract condition requiring inspection and cleaning of incoming equipment.

### 8.3.3. Remote Sensing

Remote sensing is a complex science and art that has many practical applications for land management, including the detection of invasive species in natural areas. Definitions are many, but a good description that is useful for our purposes is offered by Barry Rice of The Nature Conservancy's Global Invasive Species Team (Rice 2004):

> Remote sensing is the practice of obtaining data on a target, using distantly placed detection devices. Such devices, often mounted in aircraft or satellites, may detect radiation at a number of wavelengths in order to infer characteristics of the emitting or reflecting object. The characteristics that can be learned about an object include surface temperature, composition, structure, and size.

As Lake Mead is approximately 1.5 million acres, much of which is difficult to access on the ground, remote sensing offers a valuable tool for detecting and monitoring exotic plants. However, the usefulness of remote sensing products to these purposes varies by plant species, time of year, purpose, and type of imagery. Also, remote sensing is a rapidly evolving field, with new satellites launched and new sensors developed frequently, thus while remote sensing has some limited utility to desert exotic plant management now, it will likely have more usefulness in the future. Table 9 briefly summarizes some current remote sensing applications for exotic plant management that may be relevant to Lake Mead NRA.

Table 9. Summary of some remote sensing applications for high priority exotic plant species at Lake Mead NRA as of 2007.

| Species | Image Type | Data Collection | Application | Reference |
|---|---|---|---|---|
| *Arundo donax* | Color infrared aerial photography & videography[a]<br>AVIRIS hyperspectral imagery[b] | Summer and fall | detection and monitoring | Everitt 2004[a]<br>Dipietro 2002[b] |
| *Bromus* spp. & *Schismus* spp. | Multitemporal Landsat 5 TM and MODIS imagery | March | Limited use for monitoring due to difficulty distinguishing invasive annual grasses from other desert annuals | Peterson 2006 |
| *Tamarix* spp. | Natural color aerial digital photography and hyperspectral imagery | Growing season | monitoring | Laes and Maus 2006 |

The Park will continue to engage with various collaborators working to develop useful remote sensing applications for a wide-range of resource management issues, including exotic plant management. As appropriate the Park will foster improvement in the utility of remote sensing by

serving as test sites for new applications with due consideration of other park values and subject to standard permitting and environmental compliance procedures.

## *8.4 Program Evaluation*

Ecology is a young and dynamic science generating an almost constant flow of new knowledge and information available to inform resource management. Additionally, the adaptive management concept requires that management actions be systematically evaluated and the lessons learned be incorporated into future management decisions and/or actions. Also, the very nature of the Mojave Desert ecosystem is dynamic, especially in response to precipitation and other climate variables, which results in sometimes spectacular changes in weed species abundance and distribution. As a result, the Lake Mead Weed Program will be re-evaluated and updated on a regular basis as indicated below.

### 8.4.1 Species List

As new species are discovered or reported in the surrounding area, they will be added to the species list and evaluated and prioritized according to the process outlined in Chapter 3 and Appendix D. At least annually the Exotic Plant Manager will review the list for completeness and make changes or additions as warranted.

Every five years, the Exotic Plant Manager will review the entire species list and each species' evaluation for accuracy. In addition the noxious weed lists for Nevada, Arizona, and California will be reviewed and those ratings will be added/updated in the Lake Mead priority list. Information will be updated as necessary and the LAKE priority will be re-evaluated.

### 8.4.2 Treatments

Every five years, following the review of species priorities discussed in section 8.4.1, the Exotic Plant Manager will review/write treatment prescriptions for all high priority species to incorporate new information learned at Lake Mead as well as reported in the literature. As appropriate, statistical methods will be used to analyze treatment data in APCAM to determine common variables in successful and unsuccessful treatments at Lake Mead NRA. In addition, this review will focus on new biological controls as well as new chemicals and application methods.

This review will also include literature search for new management methods, including remote sensing as that field continues to grow rapidly driven by rapid advancements in imaging and geospatial technology.

### 8.4.3 Work Flow Planning

The annual work plan in Chapter 9 will be updated by the Exotic Plant Manager during the summer prior to each fiscal year and submitted to the Vegetation Manager for approval. Additionally, the Exotic Plant Manager will work with cooperators, such as the Exotic Plant Management Team, to identify and schedule weed management tasks in Lake Mead NRA in their annual work plans.

A five-year work plan will be developed to outline longer-term projects and/or exotic plant management efforts that build upon each other (e.g. treatment, site restoration, monitoring, etc.). The five-year plan will be broken down by fiscal year and will identify cooperators and either confirmed or possible funding sources for each component. The five-year plan will "roll-forward" each year so that there is always a plan that covers the next five fiscal years. The five-year plan will be used to prioritize and strategize funding proposals for out-years, but will remain flexible enough to accommodate short-notice funding opportunities and management needs.

## *8.5 Research Needs*

Research is the methodical investigation into a subject in order to discover facts, to establish or revise a theory, or to develop a plan of action based on the facts discovered (Encarta Dictionary online). As such, research is an inherent component of the Lake Mead Exotic Plant Management Program and is fundamental to the concept of adaptive management. The systematic collection of information and testing of theories provide for the new knowledge necessary to advance the goals of the exotic plant management program. There is much we do not know about the Mojave Desert ecosystems and their exotic plant invaders. Likewise there is much we wish we knew about treatment effectiveness and unintended consequences of exotic plant management actions or inactions. The result is almost limitless opportunities for both basic and applied research in the field of exotic plant biology and management at Lake Mead NRA.

All research at Lake Mead NRA, including research focused on exotic plants, requires a NPS Research and Collecting Permit to be issued by the park. Consistent with NPS policy, research will be encouraged and facilitated and permit conditions will be put in place to protect park resources, visitors, and operations.

Exotic plant research needs can be expected to vary over time. To facilitate applied research to address resource management needs, the Exotic Plant Manager will update as needed the list of research needs and make this information available to the research community in appropriate ways (e.g. posting on the NPS Research and Collecting Permit website). In some cases, NPS or NPS-sponsored funds may also be made available to researchers to address priority research needs. There is an ongoing need for autecological investigations into the life history and ecological impacts of exotic plant species as well as the potential range of effective treatments. In addition, topical research needs have also been identified (Table 10).

Table 10. Topical research needs identified at Lake Mead NRA in 2008

| Research Topic | Timing |
|---|---|
| What is the influence of roads (paved, unpaved, and illegal) in facilitating the invasion of exotic plants into undisturbed areas? And, how do edaphic and anthropogenic factors increase or decrease the invasibility? | Not time sensitive |
| As lake levels continue to drop, what is the fate of exotic plant invasions in the drawdown zone? | Somewhat time sensitive |
| What remote sensing techniques may be effectively utilized for early detection of priority exotic plants? What are their applications and limitations? | Not time sensitive |
| How are exotic plant invasions responding to climate change? | Somewhat time sensitive |
| How might the arrival of the tamarisk beetle biocontrol agent be incorporated into an integrated pest management strategy for wide scale reduction in tamarisk while minimizing the negative impacts to native species (especially endangered riparian bird species)? | Highly time sensitive |

## *8.6 Adaptive Management*

Data management, monitoring, and research are fundamental to adaptive management, thus corresponding with the Monitoring and Evaluation steps in the adaptive management process (Figure 7). The systematic collection of information provides the means by which to evaluate the successful and less-than-successful management decisions and thus incorporate that knowledge into future decisions.

# Chapter 9: Work Plan

## *9.1 Monthly tasks*

There are operational and administrative tasks to be completed monthly in the Lake Mead Weed Management Program in order to fulfill the requirements of this Exotic Plant Management Plan. These tasks have been generally identified in Table 11 to serve as a guideline. However, it is anticipated that some of these tasks will be revised in response to changes in administrative requirements and field conditions. Inter-annual variation in weed distribution and abundance at Lake Mead NRA may be greatly influenced by a variety of factors, including:

- weather, above average fall or winter precipitation often results in a dramatic increase in spring annual species;
- lake elevation on Lake Mead and to a lesser extent Lake Mohave, which will increase or decrease the newly exposed "drawdown" zone that is susceptible to invasion;
- human disturbances such as illegal off-road vehicle trails and construction zones;
- and, natural disturbance events, such as fires, floods, and other stochastic events.

Table 11. Overview of operational and administrative tasks for the Lake Mead NRA Exotic Plant Management Program

| Month | Task | Responsible Party |
|---|---|---|
| **January** | | |
| *Administrative* | Depending on weed conditions and funding availability, hire SCA's for 3 months during peak winter annual weed control or 2 seasonal park employees for a 1039 appointment (October to April) | Exotic Plant Manager |
| | SNRT meeting [1] | Exotic Plant Manager |
| | Prepare and submit NPS Pesticide Use Proposal forms for the year | Exotic Plant Manager |
| *Operational* | Winter annual weed control - primarily *Brassica tournefortii* control | Exotic Plant Manager, biotechs, contractors |
| | Monitor and evaluate any weed control for effectiveness | Exotic Plant Manager |
| | Early detection surveys | Weed Sentry |
| **February** | | |
| *Administrative* | Prepare educational materials on weeds found at Lake Mead NRA for the National Invasive Weed Awareness Week (typically the last week of February), distribute educational materials to park employees, volunteers, and cooperators | Exotic Plant Manager |
| *Operational* | Winter annual weed control - primarily *Brassica tournefortii* control | Exotic Plant Manager, biotechs, contractors |
| | Monitor and evaluate any weed control for effectiveness | Exotic Plant Manager |
| | Early detection surveys | Exotic Plant Manager, biotechs, volunteers |
| **March** | | |
| *Administrative* | Prepare 2nd quarterly report, due at the end of the month | Exotic Plant Manager |
| | SNRT meeting [1] | Exotic Plant Manager |
| *Operational* | Perennial weed control on Lake Mead and Mohave shorelines – | Exotic Plant Manager, |

| | | |
|---|---|---|
| | primarily *Nerium oleander*, *Washingtonia filifera*, *Parkinsonia aculeata*, and *Pennisetum setaceum* | biotechs, contractors, cooperators |
| | Winter annual weed control - primarily *Brassica tournefortii* control | Exotic Plant Manager, biotechs, contractors, cooperators |
| | Monitor and evaluate any weed control for effectiveness | Exotic Plant Manager |
| | Early detection surveys | Exotic Plant Manager, biotechs, volunteers |
| **April** | | |
| *Operational* | Perennial weed control on Lake Mead and Mohave shorelines – primarily *Nerium oleander*, *Washingtonia filifera*, *Parkinsonia aculeata*, and *Pennisetum setaceum* | Exotic Plant Manager, biotechs, contractors, cooperators |
| | Control work on perennial rhizomatous weeds – primarily *Lepidium latifolium* at Las Vegas Wash and Willow Beach Fish Hatchery and *Alhagi pseudalhagi* control at Grand Wash Bay | Exotic Plant Manager, biotechs, contractors, cooperators |
| | Winter annual weed control - primarily *Brassica tournefortii* control in site-led priority areas | Exotic Plant Manager, biotechs, contractors, cooperators |
| | Monitor and evaluate any weed control for effectiveness | Exotic Plant Manager |
| | Early detection surveys | Exotic Plant Manager, biotechs, volunteers |
| **May** | | |
| *Administrative* | SNRT meeting[1] | Exotic Plant Manager |
| *Operational* | Perennial weed control on Lake Mead and Mohave shorelines – primarily *Nerium oleander*, *Washingtonia filifera*, *Parkinsonia aculeata*, and *Pennisetum setaceum* | Exotic Plant Manager, biotechs, contractors, cooperators |
| | Monitor and evaluate any weed control for effectiveness | Exotic Plant Manager |
| **June** | | |
| *Administrative* | Prepare 3rd quarterly report, due at the end of the month | Exotic Plant Manager |
| | CEU's for Arizona Pesticide Applicators Certification | Exotic Plant Manager |
| | Schedule work crews for winter annual weed control (Nevada Conservation Corp) | Exotic Plant Manager |
| *Operational* | Survey riparian areas for weeds, work to be completed in the fall or winter by Exotic Plant Manager or Lake Mead EPMT | Exotic Plant Manager |
| **July** | | |
| *Administrative* | Trainings/Conferences | Exotic Plant Manager |
| | SNRT meeting [1] | Exotic Plant Manager |
| | Develop work priorities for upcoming field season | Exotic Plant Manager |
| | Annual Lake Mead work plan meeting with Lake Mead EPMT and other cooperators | Exotic Plant Manager, cooperators |
| *Operational* | Survey any areas that recently burned | Exotic Plant Manager |
| **August** | | |
| *Administrative* | Trainings/Conferences | Exotic Plant Manager |
| | Evaluate any new potential weeds using the Cal-IPC criteria | Exotic Plant Manager |
| | Update priority list of weeds | Exotic Plant Manager |
| | Inventory herbicide and application equipment | Exotic Plant Manager |
| | Purchase herbicide and equipment needed for upcoming field season | Exotic Plant Manager |
| | Inventory and update MSDS and Labels for herbicides | Exotic Plant Manager |
| *Operational* | Survey target areas for summer annual weeds | Exotic Plant Manager |
| | Survey any areas that recently burned | Exotic Plant Manager |

| | | |
|---|---|---|
| **September** | | |
| *Administrative* | Prepare 4th quarterly report, due at the end of the month | Exotic Plant Manager |
| | Trainings/Conferences (Cal-IPC Symposium) | Exotic Plant Manager |
| | SNRT meeting [1] | Exotic Plant Manager |
| | Review new literature on existing weeds and update priority list if necessary | Exotic Plant Manager |
| | Provide Lake Mead EPMT with treatment needs within the park for their annual work plan | Exotic Plant Manager |
| *Operational* | Survey washes for annual weed emergence after monsoon season | Exotic Plant Manager |
| | Generate priority areas for Weed Sentry to focus on next fiscal year | Exotic Plant Manager |
| **October** | | |
| *Administrative* | Inventory and order personal protective equipment (Nitrile gloves, heavy duty garbage bags, any tools needed) if necessary | Exotic Plant Manager |
| | Nevada Pesticide Certification or Recertification (if needed) | Exotic Plant Manager, biotechs |
| | Arizona Pesticide Certification (if needed) | Exotic Plant Manager, biotechs |
| | Conduct weed awareness training for new employees and cooperators | Exotic Plant Manager |
| *Operational* | Control work on perennial rhizomatous weeds – primarily *Lepidium latifolium* - at Las Vegas Wash and Willow Beach Fish Hatchery. | Exotic Plant Manager |
| | Nevada Conservation Corp starts project work in the park | Exotic Plant Manager, cooperators |
| **November** | | |
| *Administrative* | SNRT meeting [1] | Exotic Plant Manager |
| *Operational* | Perennial weed control on Lake Mead and Mohave shorelines, primarily *Tamarix ramosissima*, *Tamarix aphylla*, and *Nicotiana glauca* | Exotic Plant Manager |
| | Monitor infestations of perennial rhizomatous weeds, primarily *Alhagi pseudalhagi*, at the Hoover Dam checkpoint (Nevada side) and Grand Wash Bay | Exotic Plant Manager |
| **December** | | |
| *Administrative* | Prepare 1st quarterly report, due at the end of the month | Exotic Plant Manager |
| | Pesticide Use Report forms due | Exotic Plant Manager |
| *Operational* | Possible winter annual weed control if there was a wet year, primarily *Brassica tournefortii* control | Exotic Plant Manager |
| | Early detection surveys | Exotic Plant Manager, biotechs, volunteers |

[1] Southern Nevada Restoration Team (SNRT) meetings are held the third Thursday of every other month. These meetings allow the Exotic Plant Manager to update the other 3 federal agencies (USFWS, USFS, and BLM) on what has been happening at Lake Mead NRA concerning weeds and to identify cross-jurisdictional opportunities for weed control.

## *9.2 Work Plans*

An annual work plan will be prepared by the Exotic Plant Manager during the summer prior to each fiscal year and submitted to the Vegetation Manager for approval. Additionally, the Exotic Plant Manager will work with cooperators, such as the Exotic Plant Management Team, to identify and schedule weed management tasks in Lake Mead NRA in their annual work plans.

A rolling five-year work plan has been prepared to identify longer-term projects and/or exotic plant management efforts that build upon each other (e.g. treatment, site restoration, monitoring, etc.). The five-year plan will "roll-forward" each year so that there is always a plan that covers the next five fiscal years. The five-year plan will be used to prioritize and strategize funding proposals for out-years, but will remain flexible enough to accommodate short-notice funding opportunities and management needs. The first five years are included in the tables below.

Table 12. Proposed projects for FY2011

| FY2011 Projects | Areas Implemented | Cost Estimate |
|---|---|---|
| Athel monitoring | 388 miles of Lake Mead Shoreline | 4 pp for 20 person EPMT crew = $160k |
| Fountain grass maintenance | 130 miles of Lake Mohave shoreline: Cottonwood Cove south to Davis Dam | 2 GS-09 for 4 pp = $20k + $10k for travel and supplies |
| Sahara mustard control: handpulling or spraying (Dec-April) + evaluate treatment effectiveness to date | All Site-led priorities areas | monitoring = $20k + removal 6 pp for 10 person crew = $120k[1] |
| Survey park for new weeds | target areas from Tables 5 and 6 | $25k minimum |
| Camelthorn control: spraying (Nov-Mar) | Grand Wash Bay, areas along river corridor east of South cove to park border | 1 pp for 10 person crew = $25k |
| Perennial pepperweed control: spraying (Nov-April) | Las Vegas Wash, Willow Beach | 1 pp for 2 people = $5k |
| Tree tobacco monitoring (Nov-April) | 388 miles of Lake Mead Shoreline | 2 pp for 4 people = $20k |
| Tamarisk control and maintenance: multiple methods (Nov-April) | Site-led priority 4 sites (springs) | $75k for new treatment at North Pipe Spring |
| multi-species control with multiple methods at site-led priority 1 sites for protection of rare plants | Sandy Cove, Lime Cove, Glory Hole, Kline Hole, Overton Beach Road, Middle Point, Ebony Cove, St. Thomas, Overton Beach Road, Blue Point, Stewarts's Point, Valley of Fire, Echo Wash, Pinto Valley north, Pinto Valley south, Callville Wash north, Big Gyp Hills | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |

Table 13. Proposed projects for FY2012

| FY 2012 Projects | Areas Implemented | Cost Estimate |
|---|---|---|
| Athel monitoring | 388 miles of Lake Mead shoreline | 4pp for 4 person EPMT crew = $40k |
| Fountain grass maintenance | 130 miles of Lake Mohave shoreline: Cottonwood Cove south to Davis Dam | 2 GS-09 for 3 pp = $15k + $8k for travel and supplies |
| Sahara mustard control: handpulling or spraying (Dec-April) | All Site-led priorities areas | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |
| Survey park for new weeds | target areas from Tables 5 and 6 | $25k minimum |
| Camelthorn control: spraying (Nov-Mar) | Grand Wash Bay, areas along river corridor east of South cove to park border | 1 pp for 10 person crew = $25k |
| Perennial pepperweed control: spraying (Nov-April) | Las Vegas Wash, Willow Beach | 1 pp for 2 people = $5k |
| Tree tobacco monitoring (Nov-April) | 388 miles of Lake Mead Shoreline | 2 pp for 4 people = $20k |
| Tamarisk control and maintenance: multiple methods (Nov-April) | Site-led priority 4 sites (springs) | $30k for maintenance of existing treatments |
| multi-species control with multiple methods at site-led priority 1 sites for protection of rare plants | Sandy Cove, Lime Cove, Glory Hole, Kline Hole, Overton Beach Road, Middle Point, Ebony Cove, St. Thomas, Overton Beach Road, Blue Point, Stewarts's Point, Valley of Fire, Echo Wash, Pinto Valley north, Pinto Valley south, Callville Wash north, Big Gyp Hills | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |

Table 14. Proposed projects for FY2013

| FY 2013 Projects | Areas Implemented | Cost Estimate |
|---|---|---|
| Athel monitoring | 388 miles of Lake Mead shoreline | 4pp for 4 person EPMT crew = $40k |
| Fountain grass maintenance | 130 miles of Lake Mohave shoreline: Cottonwood Cove south to Davis Dam | 2 GS-09 for 3 pp = $20k + $8k for travel and supplies |
| Sahara mustard control: handpulling or spraying (Dec-April) | All Site-led priorities areas | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |
| Survey park for new weeds | target areas from Tables 5 and 6 | $25k minimum |
| Camelthorn control: spraying (Nov-Mar) | Grand Wash Bay, areas along river corridor east of South cove to park border | 1 pp for 10 person crew = $25k |
| Perennial pepperweed control: spraying (Nov-April) | Las Vegas Wash, Willow Beach | 1 pp for 2 people = $5k |
| Tree tobacco monitoring (Nov-April) | 388 miles of Lake Mead Shoreline | 2 pp for 4 people = $20k |
| Tamarisk control and maintenance: multiple methods (Nov-April) | Site-led priority 4 sites (springs) | $30k for maintenance of existing treatments + $75k for new treatments at Black Canyon Spring |
| multi-species control with multiple methods at site-led priority 1 sites for protection of rare plants | Sandy Cove, Lime Cove, Glory Hole, Kline Hole, Overton Beach Road, Middle Point, Ebony Cove, St. Thomas, Overton Beach Road, Blue Point, Stewarts's Point, Valley of Fire, Echo Wash, Pinto Valley north, Pinto Valley south, Callville Wash north, Big Gyp Hills | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |

Table 15. Proposed projects for FY2014

| FY 2014 Projects | Areas Implemented | Cost Estimate |
|---|---|---|
| Athel monitoring | 388 miles of Lake Mead shoreline | 4pp for 4 person EPMT crew = $40k |
| Fountain grass maintenance | 130 miles of Lake Mohave shoreline: Cottonwood Cove south to Davis Dam | 2 GS-09 for 4 pp = $20k + $10k for travel and supplies |
| Sahara mustard removal: handpulling or spraying (Dec-April) | All Site-led priorities areas | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |
| Weed Plan Update: Reassess weed ranking list and any other deletions or additions to the weed plan | NA | GS-9 x 2pp = $5k |
| Camelthorn control: spraying (Nov-Mar) | Grand Wash Bay, areas along river corridor east of South cove to park border | 1 pp for 10 person crew = $25k |
| Perennial pepperweed control: spraying (Nov-April) | Las Vegas Wash, Willow Beach | 1 pp for 2 people = $5k |
| Tree tobacco monitoring (Nov-April) | 388 miles of Lake Mead Shoreline | 2 pp for 4 people = $20k |
| Tamarisk control and maintenance: multiple methods (Nov-April) | Site-led priority 4 sites (springs) | $30k for maintenance of existing treatments |
| multi-species control with multiple methods at site-led priority 1 sites for protection of rare plants | Sandy Cove, Lime Cove, Glory Hole, Kline Hole, Overton Beach Road, Middle Point, Ebony Cove, St. Thomas, Overton Beach Road, Blue Point, Stewarts's Point, Valley of Fire, Echo Wash, Pinto Valley north, Pinto Valley south, Callville Wash north, Big Gyp Hills | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |

Table 16. Proposed projects for FY2015

| FY 2014 Projects | Areas Implemented | Cost Estimate |
|---|---|---|
| Athel monitoring | 388 miles of Lake Mead shoreline | 4pp for 4 person EPMT crew = $40k |
| Fountain grass maintenance | 130 miles of Lake Mohave shoreline: Cottonwood Cove south to Davis Dam | 2 GS-09 for 4 pp = $20k + $10k for travel and supplies |
| Sahara mustard removal: handpulling or spraying (Dec-April) | All Site-led priorities areas | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |
| Weed Plan Update: Reassess weed ranking list and any other deletions or additions to the weed plan | NA | GS-9 x 2pp = $5k |
| Camelthorn control: spraying (Nov-Mar) | Grand Wash Bay, areas along river corridor east of South cove to park border | 1 pp for 10 person crew = $25k |
| Perennial pepperweed control: spraying (Nov-April) | Las Vegas Wash, Willow Beach | 1 pp for 2 people = $5k |
| Tree tobacco monitoring (Nov-April) | 388 miles of Lake Mead Shoreline | 2 pp for 4 people = $20k |
| Tamarisk control and maintenance: multiple methods (Nov-April) | Site-led priority 4 sites (springs) | $75k for new treatments in Lower Grapevine |
| multi-species control with multiple methods at site-led priority 1 sites for protection of rare plants | Sandy Cove, Lime Cove, Glory Hole, Kline Hole, Overton Beach Road, Middle Point, Ebony Cove, St. Thomas, Overton Beach Road, Blue Point, Stewarts's Point, Valley of Fire, Echo Wash, Pinto Valley north, Pinto Valley south, Callville Wash north, Big Gyp Hills | monitoring = $10k + removal 6 pp for 10 person crew = $120k[1] |

# Chapter 10: Cooperators and Preparers

## *10.1 Cooperators*

Several organizations and individuals outside of the National Park Service were consulted on the development of this plan and many will be vital partners in its implementation.

The Public Lands Institute (PLI) at the University of Nevada, Las Vegas, specializes in education, research, and community engagement projects related to public land management and stewardship. They are a formal partner to the National Park Service for a variety of research and management tasks associated with exotic plant management.

The Clark County Multiple Species Habitat Conservation Plan (MSHCP) Weed Working Group (WWG) is made up of representatives from several agencies and weeds management groups. The WWG reports quarterly to provide information, issues and recommendations concerning on-going project updates, inventory, mapping and prioritization of funding of research and weeds related conservation actions. The on-the-ground activities and effectiveness monitoring are intended to control and/or eradicate plants that negatively impact or threaten the viability of the habitat of the 78 covered species in the MSHCP.

Lower Colorado River Aquatic Invasive Species Team shared their experiences with salvinia management and helping to formulate the aquatic invasive weed strategies presented in this plan.

## *10.2 Preparers*

This document was prepared under the leadership of the Alice C. Newton, Lake Mead Vegetation Program Manager. Primary authors were Sandee Dingman, Natural Resource Specialist, and Carrie Norman, Exotic Plant Manager, both at Lake Mead NRA. Some text in the background section was retained from earlier drafts prepared under contract by botanist Elizabeth Powell formerly of the University of Nevada - Las Vegas (UNLV).

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## *10.3 Technical Reviewers*

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# Chapter 11: References, Acronyms and Glossary

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## *11.2 Acronyms*

| | |
|---|---|
| APCAM | Alien Plant Control and Monitoring |
| APHIS | Animal and Plant Health Inspection Service |
| BLM | Bureau of Land Management |
| CCMSHCP | Clark County Multiple Species Habitat Conservation Program |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| DOI | Department of the Interior |
| EA | Environmental Assessment |
| EPMT | Exotic Plant Management Team |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| IPM | Integrated Pest Management |
| LAKE | Lake Mead National Recreation Area |
| NAWMA | North American Weed Management Association |
| NEPA | National Environmental Policy Act |
| NPS | National Park Service |
| PL | Public Law |
| PLI | Public Land Institute |
| SNPLMA | Southern Nevada Public Lands Management Act |
| SNRT | Southern Nevada Restoration Team |
| UNLV | University of Nevada - Las Vegas |
| USC | United States Code |
| USFWS | United States Fish and Wildlife Service |
| USFS | United States Forest Service |

## *11.3 Glossary*

**Adaptive Management:** Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error process' process, but rather emphasizes learning while doing. Adaptive management does not represent a end in itself, but rather a means to more effective decision and enhanced benefits. Its true measure is in how well it heals meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders. (Williams et al. 2007)
**Alien:** Same as exotic and non-native. A species that is not native to the region in which it is growing.
**Annual:** Completes life cycle in one growing season, not woody.
**Biennial:** Completes life cycle in two growing seasons, not woody.
**Common: S**pecies is often found in proper habitat in Lake Mead NRA (Bangle 2007).
**Control:** Efforts aimed on the long-term reduction in density and abundance of an exotic species in a given population below an acceptable threshold
**$C_3$ Plant:** A plant that uses $C_3$ photosynthesis: a form of photosynthesis in which $CO_2$ is captured by RuBP carboxylase/oxygenase and the first stable product is a three-carbon compound (Gurevitch et al. 2002).
**$C_4$ Plant:** A plant that uses $C_4$ photosynthesis: a form of photosynthesis in which $CO_2$ is captured by PEP carboxylase and the first stable product is a four-carbon compound (Gurevitch et al. 2002).
**Disturbed:** Areas or regions that are not in their natural state. Areas that have been disrupted or changed in some form or manner either by people or by natural events.
**Dormancy:** A special condition of arrested growth in which the plant and such plant parts as buds and seeds do not begin to grow without special environmental cues. The requirement for such cues, which include cold exposure and a suitable photoperiod, prevents the breaking of dormancy during superficially favorable growing conditions. (Raven et al. 1981).
**Edaphic:** describes the effect of soil characteristics, especially chemical or physical properties, on plants and animals (Encarta Dictionary online).
**Emergent:** Erect, rooted, herbaceous plants that may be temporarily or permanently flooded at the base but do not tolerate prolonged inundation of the entire plant (adapted from Cowardin 1979).
**Eradication:** to bring about the elimination, complete removal, or total destruction of a pest from a defined geographic area to such an extent that the pest no longer poses a threat to other park resources and where the potential of re-infestation is preventable.
**Established Population:** A reproducing population of a given invasive species that persists over time without human intervention.
**Exotic:** Same as alien and non-native. A species that is not native to the region in which it is growing.

**Floating plant:** A non-anchored plant that floats freely in the water or on the surface (adapted from Cowardin 1979).
**Germination:** The beginning or resumption of growth by a spore, seed, bud, or other structure (Raven et al. 1981).
**Genotype:** An individual's DNA sequence (Gurevitch et al. 2002).
**Granivore:** Seed-eating animal (Gurevitch et al. 2002), typically ants and rodents in the Mojave Desert
**Gypsophile:** A plant living in soil high in gypsum content.
**Halophyte:** A plant that lives in saline soil (Gurevitch et al. 2002)
**Heterozygosity:** The condition of having two different alleles at the same locus on homologous chromosomes (Raven et al. 1981).
**Incipient invasive**: A plant that could become invasive- or that is naturalizing and is likely to become invasive in the future.
**Invasive:** a species that is capable of naturalizing in undisturbed, natural areas and is capable of competing with native species for niche.
**Maintenance:** In context of weed management, maintenance of a treated area entails re-visting sites where reinvasion of the treated species is considered likely (often due to a continuous source of propagules or a long-lived seedbank) whereby the same site is re-visited multiple times to treat or re-treat the target species.
**Monitoring:** collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective (Elzinga et al. 1998). In context of weed management, monitoring is often done after a treatment where the likelihood of re-invasion by the treated species is low but the site still warrants a re-visit to detect and treat any re-sprout or new germination.
**Native:** Indigenous to the region. A species that has evolved in the region in which it is found growing.
**Natural:** Areas or regions that have not been disturbed by the agency of humans.
**Naturalized, naturalizing:** A species that is non-native to the region but is well established and reproducing independent of human care in either waste places, disturbed, or natural areas.
**Niche:** The total of all factors and interactions that define the place or position of a particular species in its ecosystem. Niche includes the species use of both the abiotic and biotic environment and its interactions with that environment and other organisms in it.
**Non-native:** Same as alien and exotic. A species that is not native to the region. It has evolved elsewhere in the world and has spread to the region either naturally or thru the agency of people. Frequently non-native is taken to mean that plants have been moved to new regions by or in association with humans and not by natural dispersal.
**Noxious weed:** A nuisance plant species that causes significant economic damage. Noxious is a legal term with a legal definition for each state or county. Noxious is used to describe plants that are nuisance species that are recognized as such by a state or country. Often a species may be highly invasive and widespread nuisance and not be declared a noxious weed of a particular state because it is not considered controllable. Noxious weeds are typically defined as species which can be controlled. Therefore, highly invasive species that are widespread may not be listed as noxious weeds in all states in which they are a nuisance.
**Occasional:** Species may be found in proper habitat in Lake Mead NRA (Bangle 2007).

**Perennial:** Living more than two growing seasons.
**Pernicious:** Refers to a plant species that is difficult to control once established. Spreads rapidly and/or has features that prevent rapid and easy control, such as deep rhizomes, ability to sucker, resprouting, thorns, herbicide resistance, etc.
**Photoperiod:** Duration and timing of day and night (Raven et al. 1981)
**Propagule:** A seed or other dispersal structure, such as a seed cluster (Gurevitch et al. 2002).
**Rare:** Only a few occurrences within Lake Mead NRA (Bangle 2007).
**Recruitment:** The influx of new individuals entering a population each year as a result of reproduction or immigration.
**Remote Sensing:** The practice of obtaining data on a target, using distantly placed detection devices. Such devices, often mounted in aircraft or satellites, may detect radiation at a number of wavelengths in order to infer characteristics of the emitting or reflecting object. The characteristics that can be learned about an object include surface temperature, composition, structure, and size. (Rice 2004)
**Research:** The methodical investigation into a subject in order to discover facts, to establish or revise a theory, or to develop a plan of action based on the facts discovered (Encarta Dictionary online).
**Restoration:** Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Society for Ecological Restoration International Science & Policy Working Group 2004).
**Rhizomes/Rhizomatous**: An underground stem/A plant bearing such structures. Rhizomes differ from roots by having meristematic tissue that allows species to reproduce from the rhizome or a portion thereof. Rhizomes are typically capable of producing both roots and aboveground stems from nodes, or centers of meristematic tissue. The rhizomes may also act as storage tissue for nutrients, allowing the above ground portions of the plant to be nourished during times of stress. Rhizomatous plants are often difficult to kill due to the action of the rhizome in protecting, replacing, and reproducing the above ground portion of the plant.
**Seed:** An embryonic sporophyte embedded in a female gametophyte and covered with one or more integuments derived from the maternal sporophyte (Gurevitch et al. 2002). A structure formed by the maturation of the ovule of seed plants following fertilization (Raven et al. 1981).
**Seed bank:** The seeds buried in the soil, can refer to either a single species or an entire community (Gurevitch et al. 2002).
**Seedling:** A young sporophyte developing from a germinating seed (Raven et al. 1981).
**Survey:** Within the context of invasive plants, an effort to find invasive plants and estimate their abundance or status. Such efforts may be repeated over time, but each survey is generally independent of previous efforts. (Geissler and Welch 2007)
**Submergent:** A vascular or nonvascular plant, either rooted or nonrooted, which lies entirely beneath the water surface, except for flowering parts in some species (adapted from Cowardin 1979).
**Treatment:** to act upon a pest with the lowest risk, most effective approach feasible to reduce its impact or spread. Integrated pest management approaches to be considered include: no action; biological, cultural, physical, chemical or a combination of one or more of these approaches.
**Uncommon:** Species is not often found in proper habitat in Lake Mead NRA (Bangle 2007).

**Weed:** A nuisance species of plant. A plant that is growing in an area in which it is not desired. The term is often used interchangeably for non-native, or invasive plant species. Term is also sometimes used for native species that are nuisance species in gardens or rangelands.
**Wildlands**: Areas or regions that have flora and fauna still in their natural state.

# Appendices

Appendix A: NPS IPM process

Appendix B: Safety Considerations

Appendix C: NAWMA Mapping Standards

Appendix D: Weed Prioritization by Species

# Appendix A: Integrated Pest Management in the NPS

Except where noted, the information in this appendix is excerpted in May 2008 from the National Park Service's Integrated Pest Management Program website at http://www.nature.nps.gov/biology/ipm. It has been reformatted for this document but the content remains unchanged.

## *A1.0 Overview*

The National Park Service implements a nationwide Integrated Pest Management (IPM) Program to reduce risks to the public, park resources, and the environment from pests and pest-related management strategies.

### A1.1 What is Integrated Pest Management or IPM?

IPM is a science-based, decision making process that coordinates knowledge of pest biology, the environment and available technology to prevent unacceptable levels of pest damage, by cost-effective means, while posing the least possible risk to people, resources and the environment.

### A1.2 What is a Pest?

Pests, as defined by National Park Service policy, are living organisms that interfere with the purpose or management objective of a specific site within a park, or that jeopardize human health or safety.

### A1.3 IPM History in the National Park Service (NPS)

The National Park Service began implementing IPM in 1979 when a Presidential Memorandum issued by President Carter directed all federal agencies to adopt an IPM approach in all procurement and regulatory policies and pest management activities.

Today the NPS IPM Program employs one servicewide and nine regional IPM coordinators skilled in the principles of IPM to provide guidance and technical assistance to park managers addressing pest issues. Pests are investigated and managed on a case by case basis with management strategies tailored to the specific characteristics of the individual site and pest biology. Pest management plans are prepared to address both short and long term pest management solutions.

## *A2.0 IPM Process*

The NPS as well as the US Fish and Wildlife Service implement an 11 Step Process for Developing and Implementing an Integrated Pest Management Strategy. This process is suitable when addressing any pest situation. The eleven steps are listed below (version November 2006).

1. Describe your site management objectives and establish short and long term priorities.

2. Build consensus with stakeholders, occupants, decision makers and technical experts (ongoing).

3. Document decisions and maintain records.

4. Know your resource (site description and ecology).

5. Know your pest. Identify the potential pest species, understand their biology and conditions conducive to supporting them (air, water, food, shelter, temperature and light).

6. Monitor pests, pathways, and human and environmental factors, including population levels and phenological data.

7. Establish "injury thresholds," the point at which no additional damage or pest presence can be tolerated. This is the action threshold at which a pest management action will be implemented through an approved IPM strategy.

8. Review available tools and best management practices. Develop a management strategy specific to your site and identified pest(s). Tools can include: 1) no action, 2) physical, 3) mechanical), 4) cultural, 5) biological, and 6) chemical management.

9. Define responsibilities and implement the lowest risk, most effective strategy, in accordance with applicable laws, regulations, and policies.

10. Evaluate results; determine if objectives have been achieved; modify strategy if necessary.

11. Education and provide outreach. Continue the learning cycle. Return to Step 1.

The National IPM Road Map also provides guidance and support to all citizens as well as federal agencies when managing pest species. This document is available on line at http://www.northeastipm.org/whatis_ipmroadmap.pdf.

## *A3.0 IPM Administration in the NPS*

### A3.1 Pesticide Use Proposals

Any employee wanting to use a pesticide in the park will submit a pesticide use proposal to the IPM coordinator. The IPM coordinator will enter the information into a database which will then get reviewed by the regional IPM coordinator. Once the regional IPM coordinator concurs with the use of the proposed pesticide the park IPM coordinator will inform the employee that it is alright to use the particular pesticide. Pesticide use proposals should be submitted to the park IPM coordinator by October 1 for use starting in January, or they can be submitted whenever the pest problem arises.

### A3.2 Pesticide Use Logs

The amount of pesticides used in the previous year throughout the park is sent to the IPM coordinator by April 30.The amount of pesticide used is then entered in the database records for each pesticide proposal.

## *A4.0 IPM Law and Policy*

Federal agencies are directed by Title 7 (136r-1) Federal Insecticide Fungicide Rodenticide Act to implement an IPM approach in procurement and pest management strategies. Title 7 USC 136r-1 Federal Fungicide Insecticide and Rodenticide Act states: "The Secretary of Agriculture, in cooperation with the Administrator, shall implement research, demonstration, and education programs to support adoption of Integrated Pest Management. Integrated Pest Management is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. The Secretary of Agriculture and the Administrator shall make information on Integrated Pest Management widely available to pesticide users, including Federal agencies. Federal agencies shall use Integrated Pest Management techniques in carrying out pest management activities and shall promote Integrated Pest Management through procurement and regulatory policies and other activities".

Policy guidance is provided by National Park Service Management Policies, Section 4.4.5 (2006) and the Department of Interior, Departmental Manual part 517, Integrated Pest Management (November 2006).

# Appendix B: Safety Considerations

## *B1. Introduction*

Exotic plant management activities have many inherent risks to human health and safety: exposure to herbicide as well as hazards of the outdoor environment such as extreme heat, dehydration, cold, uneven terrain, unstable surfaces, flash floods, rock falls, rattlesnakes, biting insects, plants with spines and thorns. In addition, the large geographic area of Lake Mead NRA as well as the remoteness of many work sites introduce additional hazards as a result of long distance driving, 4x4 vehicle operation, all-terrain vehicle (ATV) use, and boat operations for shoreline and aquatic weeds.

However, most of these risks can be mitigated if comprehensive safety guidelines (or protocols) by consistently followed. The purpose of this appendix is to outline safety guidelines for weed management activities to ensure the safety of workers and the public.

### B1.1 Responsibilities

It is the responsibility of the Lake Mead Exotic Plant Manager to ensure that these safety guidelines are effectively communicated to all persons undertaking weed management activities in Lake Mead NRA. Where possible, these safety guidelines should be incorporated into contracts and other legal or administrative instruments in writing, but ultimately it is more important to ensure that they are effectively communicated through whatever means is most effective for the situation (e.g. safety orientation in person, written documents, verbal instructions, etc). It is also the responsibility of the Exotic Plant Manager to update this information periodically as weed management practices change and/or new safety technologies become available.

It is the responsibility of the weed crew supervisor on-site (e.g. Weed Sentry Lead, Nevada Conservation Crew Leader, Exotic Plant Management Team Crew Boss or Squad Boss) to monitor their workers compliance with these safety measures and take immediate corrective action in the event of non-compliance.

Finally, it is the responsibility of individual weed management workers to understand and implement these safety guidelines. If guidelines are not thoroughly understood it is the responsibility of the worker to communicate their lack of understanding through their chain of command so that additional information or clarification can be provided prior to undertaking weed management work.

### B1.2 Exposure

When considering human health risks related to weed management activities, the frequency and duration of exposure of the worker to the hazard is an important risk factor. Some health risks are the result of acute exposure to the hazard while others are the result of chronic exposure over time.

## *B2. Training and Certification*

Exotic Plant Manager maintains pesticide applicators certifications in Arizona and Nevada. Arizona pesticide applicator's license expires every calendar year, but one can get continuing education unit credits for renewal instead of taking the exam again. Nevada pesticide applicator's license expires every three years. As provided for under state law in both Arizona and Nevada, non-certified applicators can apply herbicide under the direct control of a certified applicator.

All certified pesticide applicators must meet the training requirements of the state. All non-certified pesticide applicators working in the park under the direction of a certified applicator must complete in-park training that includes the following information:

- The purpose of the treatment (e.g. what species is being treated, by what method, and why)
- Label and MSDS highlights, particularly those pertaining to environmental and human health risks. (Copies of the label and MSDS may be provided as appropriate.)
- Target species identification as well as distinguishing characteristics of any similar non-target species.
- Instruction for safe and effective use of personal protective equipment.
- Instruction in application equipment use, including loading, priming, calibration, and clean-up.
- Instruction in mixing, storage, and transportation of herbicide.
- Reporting of herbicide use, including use of GPS and data dictionary.

There is no prescribed format for this training and it should be appropriate to the situation. In some cases, that may be a formal presentation to an incoming work crew or it may be one-on-one demonstration for a new volunteer.

It is the responsibility of the Exotic Plant Manager to assure that all pesticide applicators working in the park have knowledge of the information identified in the bullets above. Under no circumstances, should a non-certified applicator use herbicide in the park without adequate instruction and supervision.

## *B3. Herbicide Storage and Use*

### B3.1 Herbicide Purchase

NPS 77 allows NPS personnel to purchase the amount of pesticide (herbicide is a specific type of pesticide that works on plants) authorized for use during the year of approval. Larger amounts can be purchased only when the smallest amount available for purchase is larger than the amount necessary for the project. If an approved pesticide is unavailable, any substitutions with different active ingredients will require approval through the same pesticide use request and approval process.

### B3.2 Herbicide Storage

Herbicide storage facilities must be locked, fireproof, and ventilated; proper warning signs must be posted. Pesticides must be stored separately from all other substances, and the directions provided on the labeling must be followed. In addition, each type of pesticide must be stored on separate shelves. Any structure used for storage of pesticides should be posted, and copies of labels, material safety data sheets (MSDSs), and inventories should be inside the herbicide shed as well as in the Exotic Plant Managers office. The door of the storage facility should be labeled with the National Fire Protection Association (NFPA) symbol showing the highest rating in each category based on the ratings of the chemicals stored within. Likewise, tank mixes should be labeled with the trade name, concentration, surfactant and dye (if any), date of mix, and the NFPA hazard symbol for that chemical.

Herbicide containers and herbicide contaminated materials (e.g. soiled PPE and pesticide application equipment) should never be transported or stored inside the cab or passenger compartment of a vehicle. These items should also never be stored in containers used for food preparation or other food service purposes.

### B3.3 Disposal of Herbicides

Only the amount of herbicide required for the treatment area should be mixed to limit the amount of excess pesticide generated during treatment. However, remaining quantities of mixed herbicide and any rinsate from the container or spray equipment may be applied to the treatment area. If herbicides cannot be disposed of in this manner, they may be given to another agency or disposed of according to state laws and regulations. Donation of surplus chemicals should be documented and records kept for 3 years.

## B3.4 Pesticide Safety

Copies of the label and MSDSs should be at the site where pesticides are being applied. In addition to the safety of the applier, the safety of park visitors and others not involved with the application of pesticides must be considered. Many pesticide labels specify the minimum periods before unprotected individuals may enter treated areas, or they specify that treated areas must be posted. If the label specifies a reentry period, treated areas must be posted with signs warning visitors and others not to enter the treated area. The signs should indicate that the area has been treated with a pesticide, what materials were used, and the name and telephone number of a contact person.

# *B4. Personal Protective Equipment*

## B4.1 Herbicide Application

Minimize Herbicide Contact and Exposure During Application

- All weed management workers mixing or applying herbicide are required to wear all personal protective equipment (PPE) listed on the chemical labels for the chemicals in use, including the herbicide, surfactant, dyes, and other additives. In addition, workers are encouraged to wear additional personal protective equipment such as wearing full face shields on top of goggles to protect themselves from splash or spray.
- All personal protective equipment should be fitted to the person in order to provide effective protection. Depending on the formulation of the pesticide, the applicator should use a respirator approved for the type of pesticide being applied. Respirator use must comply with the park's respirator plan and should be fit-tested according to the manufacturers instructions. Respiratory protection is most important in enclosed spaces or when the applicator will be exposed to pesticides for a long time.
- Dusts, concentrates, and fine sprays have the highest risk of causing pesticide exposure.
- Prior to each use all PPE, even new PPE, should be visually inspected and replaced if there are any holes, tears, rips, or other indications that would indicate the barrier between the worker and the chemical is compromised.
- Replace gloves often. Wash and dry hands before putting on gloves. Wash gloves before removing them.
- Wash hands thoroughly before eating, drinking, using tobacco products, or going to the bathroom.
- Cuff gloves if pesticide is expected to run up the sleeves. Tuck sleeves of a long sleeve shirt into gloves.

Personal Clean-Up after Herbicide Use

- Wash gloves and footwear (if possible) with detergent and water before removing them.
- Change clothing and put clothes used during application in a plastic box or bag, and keep contaminated clothing away from children and pets.

- Use a mild liquid detergent and warm water to wash your hands, forearms, face, and any other body parts that may have been exposed to pesticides.
- Take a warm shower and wash your hair and body at the end of the work day.

Laundry

- Do not wash work clothing and personal protective equipment in the same wash water with the family laundry.
- Handle unwashed items with care and wash your hands after loading the machine. Wash in plenty of water for dilution and agitation. If using a washing machine, use heavy-duty liquid detergent in hot water for the wash cycles. After washing the clothes, run the washer through one complete cycle with detergent and hot water, but no clothing, to clean the machine.
- Hang items to dry if possible in plenty of fresh air. Do not hang in living areas. Using a clothes dryer is acceptable, but over time the machine may become contaminated with pesticide residues.
- If you have chemical-resistant items, follow the manufacturer's washing instructions. Wash boots and gloves with hot water and liquid detergent. Wash twice, once outside and once inside. Air-dry boots and gloves and allow to dry completely prior to next use.

## B4.2 Other Weed Management Activities

Other weed management activities that do not involve herbicide also pose risks which can be mitigated with the use of personal protective equipment.

Chainsaws: This is a high risk activity and strict adherence to the job hazard analysis is required. Standard PPE generally includes use of goggles/safety glasses, hard hats, leather gloves, hearing protection, saw chaps, long sleeves, long pants, and heavy duty cut-resistant or leather boots.

Hand pulling: Leather gloves and long sleeves should be worn to protect hands and arms from plants with irritating sap or thorns.

Other cutting tools: PPE will depend on the nature of the tool, but generally should include eye protection, gloves, and boots.

## B4.3 Transportation: Driving, Hiking, and Boating

Automobile Driving: All personnel are required to wear seatbelts in all vehicles equipped with seatbelts.

ATV/UTV operation: The following standard personal protective equipment is required at all times for ATV/UTV operation, including loading and unloading, except as modified for

industrial use applications. All PPE must be fitted to the operator, inspected by the operator prior to each use, and non-serviceable items must be immediately reported to the Supervisor for replacement.

- Helmet:
    - ATV operators shall wear a full or three-quarter face motorcycle helmet with chin strap properly secured. The helmet shall meet requirements of the Department of Transportation (DOT), ANSI Z90.1 standard, or Snell Memorial Foundation (SMF) standards. Helmets shall be replaced as recommended by their manufacturer or sooner if a helmet is involved in an impact related accident.
    - UTV operators shall wear a helmet as described above or may wear a hard hat provided a cab/brush cage is permanently installed on the vehicle. Hard hat shall meet requirements of NFPA 1977 and ANSI Z89.1 standards. Hard hat shall be replaced as recommended by their manufacturer or sooner if the hard hat is involved in an impact related accident.
- Sturdy Gloves
    - ATV/UTV operators shall wear gloves appropriate to the task, environmental conditions, and weather.
- Long pants and long-sleeved shirt or jacket.
    - No exceptions are granted for extreme heat conditions.
- Footwear:
    - ATV: sturdy over-the-ankle boots with incised heels to help prevent the operator's feet from slipping off the footrests.
    - UTV: sturdy shoes that cover the toes and heel and have a sturdy, slip resistant sole.
- Eye protection:
    - Face shield, safety glasses, goggles, or sunglasses.
    - Eye protection must meet the VESC8, V8, or ANSI Z87.1 standard for impact resistance. Off-the-shelf sunglasses are not acceptable!
- PPE for Pesticide/Herbicide Application:
    - OHV Pesticide Application - Applicators shall wear a helmet as described in IV.A.3 above (not hard hats). The helmet shall be equipped with a removable, washable liner.
    - Nitrile gloves are to be worn during spray operations, replacing riding gloves.
    - To protect the applicator from chemical exposure and for safe operation of the ATV/UTV impervious boots with fiberglass shank in the sole will be worn or impervious boots may be worn over leather riding boots.
    - Follow pesticide label instructions for other personal protective equipment, as specified.

Hiking: sturdy footwear (e.g. boots) and sun protection (e.g. hat) are generally required.

Boating: All personnel working on a boat and are required to wear personal flotation devices (e.g. life vest) fitted to the person and appropriate to the size of the watercraft and boating conditions. Eye protection is also strongly recommended.

## *B5. Emergency Response and Reporting*

### B5.1 Accidents

Herbicide Exposure

Herbicide applicators must have easy access to emergency decontamination and first aid kits whenever they are applying herbicides, even if they are out in the field. All applicators should have access to an eyewash kit and at least 2 gallons of clean water. Decontamination kits are available from many suppliers or can be assembled independently. Rubber buckets or tubs with tight sealing lids are convenient for homemade kits and should include:

1. Two (or more) 1 gallon containers filled with potable water.
2. Eyewash kits or eyewash bottles with buffered isotonic eyewash.
3. Hand or body soap.
4. Paper or other disposable towels.
5. A heavyduty plastic bag or bucket with lid to contain contaminated items.
6. A map and directions to the nearest medical facilities.

Procedures For Handling A Spill

- Consult the pesticide container label and appropriate MSDS to determine response and safety protocol.
- Report the spill as warranted by information provided on the pesticide container label and MSDS.
- Wear appropriate PPE to handle a spill. Carry spill response kit at all times and be familiar with its contents.
- To prevent the spill from spreading, emergency supplies on hand should include:
    - shovel
    - empty containers
    - hoses and hose clamps or duct tape
    - plastic tarp, sheeting, or heavy plastic bags
    - caulking/sealant
    - spare screws/nuts/bolts
    - absorbent material
    - miscellaneous tools
- Methods for stopping/containing spills:
    - Prevent additional spillage first.
    - If in a building or a pickup bed, use absorbent material to soak up liquid.
    - If on the ground, use the shovel and scrape earth to form dikes to contain the liquid.
    - Use plastic sheeting and absorbent material if it will help.
    - Flag the area of spill to indicate parameters.
    - As soon as the spill is contained, contact the Exotic Plant Manager who will determine whether the spill meets the legal criterion as a reportable spill and make the appropriate contacts.

- Methods for collection of spilled pesticides and materials:
    - If not in contact with soil, collect spilled liquids with absorbent material and put into heavy plastic bags or empty containers; tag container indicating contents.
    - If in contact with the soil, collect liquids with absorbent material; gather all material, including soil that came into contact with the spilled pesticides, and put into empty containers; tag the container indicating contents.
    - Secure used spill response materials and contact the parks Environmental Management Officer to make arrangements for proper disposal.

Emergency Numbers

Pesticide Poison Information: 800- 732- 2200
National Response Center: 800- 424- 8802
CHEMTREC: 800- 424- 9300

## B5.2 Reporting Requirements

Herbicide related accidents requiring immediate medical assistance should be relayed via dispatch. Once the immediate medical concerns are addressed, the accident should be reported to the Exotic Plant Manager and the Supervisor of the employee(s) involved. The Exotic Plant Manager and/or Supervisor will make the appropriate entries into SMIS, notify the Park Safety Officer, and facilitate any investigations that may be warranted.

The requirement to report a chemical spill is based on the potential harm to human health or the environment from the spill (EPA). National Response Center is the federal point of contact for reporting oil and chemical spills.

# *B6. Job Hazard Analyses*

Job Hazard Analyses are prepared and regularly updated to cover the following tasks:

- Chainsaw use during removal of invasive weeds
- Swamping during removal of invasive weeds
- Herbicide mixing and application during invasive weed removal
- Trailer use
- Working in a desert environment during invasive weed removal

As these are living documents, they are not included in this appendix but the most current version will continue to be accessible on the Lake Mead server at:
T:\Resource\Weed Manager\JHA

## *B7. Operational Risk Management*

All overnight backcountry work or complex projects will require a written Operations Plan, consistent with the principles of Operational Risk Management. The exact format and requirements will follow the most current park standard, but will generally include a situation analysis, hazard identification and mitigation, and a communication plan.

The Operations Plan should be prepared in advance, approved by Program Supervisor, and discussed with all participants at the beginning of the project or trip.

# Appendix C: NAWMA Mapping Standards

These standards are updated periodically and should be cross-referenced back to the source at http://www.nawma.org. The information presented here is current as of May 2008. It has been reformatted to fit this document, but the content remains unaltered.

Approved by:
North American Weed Management Association on May 7, 2002

Endorsed by:
Federal Interagency Committee for the Management of Noxious and Exotic Weeds

## *C1.0 Introduction*

The efforts to control invasive plants have often been described as a war on weeds. By many estimates, we are losing this war. In order to be more effective, many Exotic Plant Managers are adopting a more strategic approach. One of the most overlooked, and often most critical determinant of who wins a war is the intelligence gathered prior to any action occurring on the field. The same holds true for improving the efficiency and success of invasive weed management.

## C1.1 The Benefits of Invasive Species Inventories

With limited budgets for weed management, it can seem hard to justify spending money on weed inventories or maps. Wouldn't that money be better spent toward actual weed management? The best justification can be found in Steve Dewey's brochure, Noxious Weeds: A Biological Wildfire. Dewey applies wildfire management principles to invasive weed management. When fighting fires, the first priority is to contain the fire and extinguish spot fires outside the perimeter of the fire. Trying to fight a wildfire without any idea of its size, direction of spread, rate of spread, and other relevant information, would jeopardize the lives of the fire fighters. Correspondingly, trying to manage an invasive weed infestation without similar information jeopardizes the efficiency of control efforts and wastes time and money. With maps or inventory information, a strategy focused on removing new and isolated infestations and containing the principle infestation can be developed, the same principle used for wildfires. Once contained, the size of the infestation is reduced, working from the outside in.

In addition to enabling Exotic Plant Managers to prioritize which part of an infestation to treat first, the use of invasive weed inventories can increase the efficiency of almost any method of weed management. Combining weed inventories with other layers of information, such as soil types and water table depths, helps Exotic Plant Managers select the most safe and effective herbicide for a location. By utilizing weed inventories to help with biological management of noxious weeds, distribution of the control agents can be optimized. Inventory information can be used to help plan volunteer weed pulling efforts. Invasive species inventories will not kill weeds, but are an invaluable planning tool to help get the most out of limited weed management dollars.

Inventories can also be useful in the planning phases of management efforts, maps and inventory information are critical to monitoring efforts. No matter what tool is used to manage weeds, monitoring should be done to evaluate the effectiveness and make sure the area has not been re-infested. Many of the invasive plant species have a seed viability extending past what realistically can be committed to memory. There are many county weed supervisors who know by heart where every weed infestation in their county is located. Should anything happen to these people, the epitaph on their headstone could read, "Here lays the county's entire weed inventory". By putting this information onto paper maps or into computer databases, weed

management efforts can continue past the duration of a particular person's career.

The information gleaned from invasive weed inventories can also be used to help fit weed management into the larger picture of maintaining the health and integrity of an ecosystem. Currently, invasive species are the second largest contributor to native species becoming threatened and endangered species. Invasive weed inventories provide the data necessary to further quantify impacts of invasive weeds on native ecosystems.

One of the most important benefits of weed inventories lies in their use as a tool for generating awareness. If a picture is worth a thousand words, a map is worth at least that many. Whether the audience is county commissioners, state legislators, congressmen, special interest groups, or the general public, being able to tie the problem back to their area of interest dramatically increases their receptiveness and interest in the problem.

When invasive species awareness projects are discussed, the need for heightened awareness among elected officials is almost always mentioned. Obviously, it's important for the people who control the funds for managing public lands to understand one of the biggest threats to the health of those public lands. Even among weed scientists and other invasive species experts, there is uncertainty about the exact size of the problem we are facing. It is estimated that an additional 5000 acres of public land in the west are infested each day by invasive weeds. However, it can be incredibly difficult to find figures showing the acreage of infestation for a specific national forest or national park. Finding infested acreage figures for areas that span jurisdictional boundaries, such as a county or watershed, can be even more difficult. Without inventory information it is almost impossible to provide policy makers with realistic figures on what types and amounts of resources are necessary to combat invasive species successfully.

This effort should be supported and encouraged by elected officials for several reasons. First, it will provide better policy-making information. Resources and money can be allocated according to the severity of infestations in an area. Second, it improves the ability to predict spread and implement appropriate prevention measures before infestations require costly management programs. Lastly, making it easy for agencies to share inventory information instead of different agencies collecting the same data over and over reduces costs.

## C1.2 Coordinated Mapping

The benefits of weed inventories laid out in the previous section are nothing new to Exotic Plant Managers. In fact, most Exotic Plant Managers already use some form of weed inventory. The various forms range in complexity from simple stick pens in maps hanging on the wall of their office to GIS based inventories on a computer.

The reason for NAWMA's effort to create the minimum standards outlined in this document is to increase the ability to share information. This effort is not intended to create a single database, but rather to create minimum standards so that all information being collected is compatible. Furthermore, these are intended to be the minimum standards. The standards address the most basic information necessary to compare invasive species problems across tribal, county, state,

national, and even international borders.

This minimum level of information is not intended to discourage individual counties, agencies, or other entities from collecting additional information. For example, inventories done for research purposes will collect a whole range of information not mentioned in these standards, such as soil type, a description of the vegetative community being invaded, and perhaps the slope of the site. The research objectives would determine the amount of additional information needed. If the researcher is not using a standardized inventory protocol, then the information collected is useful only to the research project. By using these standards, the information collected for the research project could be incorporated with inventories serving other purposes, thereby widening the usefulness of the collected information. By collecting similar information that can be shared across the nation, more money is made available to treatment efforts instead of duplicated inventories done on the same weed infestations.

## C1.3 Who Should Use These Standards?

These standards were designed to be compatible with most existing invasive species inventories. Their purpose is not to add another level of work to Exotic Plant Managers, but to lighten their workload by making it possible to share information across boundaries. Of course, for the full benefit of the standards to be realized, everyone involved in weed management needs to adopt the standards.

Realizing that the most critical part of standards lies in their acceptance, these standards were developed with consultation from a wide range of representation from those involved in invasive species issues. Hopefully, any concerns that you have with these standards were addressed in the review process. Every effort was made to make these standards as user friendly as possible, while still providing information that is essential at every level of weed management form the site of the infestation to national and international levels. NAWMA sincerely hopes that you will find these standards to be useful and adopt them as the minimum standard for your invasive species inventories.

## *C2.0 Inventory and Monitoring Standards*

This chapter describes the basic information necessary to inventory and monitor invasive plant populations. These data and mapping standards have been agreed to by a group of weed professionals and scientists and represent the minimum or core information necessary to characterize a weed infestation.

There are three basic elements of a weed inventory: what is the weed; where is it located; and finally how large is the infestation. This chapter contains the data fields that are required to satisfy these basic inventory elements. A sample field form is located in Appendix F or can be obtained at the NAWMA web site, www.NAWMA.org. In many instances you may wish to collect additional information about the site and the environment that the weeds inhabit; such other plants in the area, elevation, aspect and soils. Some suggestions for additional information are located in the following chapter.

This chapter is organized into basic data fields. Each of the data field/subject area is divided into the following subheadings:

**Data Field Name**: This is name that will appear on the inventory form and on requests for information between agencies, states and weed management areas. It will be name that is used to share like information between users. It will provide common vocabulary for sharing information.

**Definition**: Provides a description and explanation of the data field.

**Why it is Useful**? Describes why this information may be important and how it will be useful in describing weed infestations.

**Core Element**: This tells you whether this is a core or required data field. Some data elements are very common and useful for weed inventories but will not be required for the information sharing; these will be called optional fields. Only required fields will be used for integrating and sharing information across ownerships.

**Coding**: Describes the proper way information should be entered

**Data Value:** This tells you whether the field is made up of numbers, numeric. The field can also be made up of text or a combination of text and numbers, called alphanumeric. The number sequence that follows indicates how many digits (field width) and decimal points are allowed in the field.

**Example**: Provides a sample of the proper coding.

## C2.1 Field Name: Collection Date

**Definition:** The date the weed infestation was observed in the field. It does not refer to the date information was entered into the computer.

**Why is it useful:** This field tells you when the inventory was conducted. It provides information on the time of year plants were observed. A weed infestation may look very different in the spring of the year or in the fall of the year after flowering and seed formation. This field also tells you how old your information is; last month, last year, or ten years ago. These cues will help you decide how reliable the information is and whether a follow-up visit to the site may be warranted. Changes in the size and density of a weed population from one visit to the next form the basis of monitoring.

**Core Element:** Yes, this is a required field.

**Coding:** Enter the date where YYYY equals the four digits or numbers of the year (2002), mm equals the two digit representation of the month (10) and dd stands for the two digit representation for the day of the month (03). The date will be in the following format yyyymmdd.

**Data Value:** Numeric (8,0)

**Example:** A knapweed site was visited on October 3, 2002. You would record:
Collection date: 20021003

## C2.2 Field Name: Examiner

**Definition:** The individual who collected the information in the field, at the site of the infestation.

**Why is it useful:** This is useful information when several individuals may have contributed to an inventory. Within a countyor a Weed Management Area, private landowners, the public, road crews, county agents, scout troops and government employees may all have contributed to the survey. A name allows the person compiling the inventory to verify and correct any questions on the information.

**Core Element:** Optional, this is useful at the field office level but is not a core element and will not shared between entities.

**Coding:** Enter the full name of the individual who collected the data.

**Data Value:** Alphanumeric (50,0)
**Example**: **Examiner:** Ronald J. Weed

## C2.3 Field Name(s): Genus, Species, Intra specific (optional), Authority

**Definition:** These fields will contain the scientific or species name of the weed. The scientific name consists of the genus name followed by the species name, in Latin. Some plants are further classified into subspecies or variety. Lastly, the individual who first classified the plant and assigned the scientific name is called the authority.

**Why is it useful?** Scientific names are in Latin and can be intimidating and cumbersome to learn, but they have a decided advantage over common names. These Latin, scientific names provide a universal code or language for naming plants, so people all over the world will use the same name. Even when the name changes due to new discoveries or new information, a trail of synonyms or conserved names is retained so the plant can still be identified. Scientific names also show how groups of plants are related.

**Core Element:** Genus and species are required elements. Subspecies and authority are optional.

**Coding:** Enter the Genus and species name as it appears in either your plant key, the PLANTS Database (http://plants.usda.gov/plants/index.html) or from the tables that appear in Appendix A.

**Data Value(s): Genus:** Alphanumeric (2,0) **Species:** Alphanumeric (30,0), **Intraspecific:** Alphanumeric (30,0) **Authority:** Alphanumeric (20,0)

**Example:** The scientific name for yellow star thistle is: Centaurea soltitialis L. You would record: **Genus:** Centaurea **Species**: soltitialis **Authority:** L.

## C2.4 Field Name: Common name

**Definition:** The English or Spanish name for the plant.

**Why is it useful:** These are the weed names most commonly used in conversation. They are often descriptive like yellow star thistle and are always in the spoken language of the country. The common names are easy to pronounce and remember. Unfortunately, there is no consistency in common names and there may be several regional names for the same plant. Conversely, the same name may refer to several different plants.

**Core Element:** This is an optional field; common names will not be part of the core data elements. There will be continuing attempts by the Weed Science Society of America, the Plants database and others to list all of the known common names for each species. These efforts will allow an easy crosswalk between the commonly used and the scientific name.

**Coding:** Enter the common name as it appears your plant field guide, the name you have been

taught or from the table that appears in Appendix A.

**Data Value:** Alphanumeric (25,0?)

**Example:** One of the common names for: Centaurea biebersteinii is spotted knapweed, you would record: Common Name: Spotted Knapweed

## C2.5 Field Name: Plant Code

**Definition:** 3-10 digit codes for scientific names.

**Why is it useful:** Plant codes are useful, short cut method for recording plant names in the field. There are many different coding systems in use. Many use some combination of the first two or three letters of the genus and species names. Unfortunately, there have been so many different codes developed over the years it is difficult to agree on a single system, therefore we will continue to rely on the full scientific name for identifying the weed name.
Within the United States, the PLANTS database is attempting to bring consistency to coding plant names. Use of codes from the PLANTS database are highly encouraged. PLANTS is maintained and operated by the United States Department of Agriculture. Tables are available from PLANTS database that will convert these plant codes back to the full scientific name. The Integrated Taxonomic Information System (ITIS), a joint effort between Canada, the United States and Mexico may also be a useful source of plant codes in the future.

**Core Element:** This is an optional field.

**Coding:** There are no standardized codes for this data field. The codes used in the PLANTS database can be found at: http://plants.usda.gov/plants/index.html.

**Data Value:** Alphanumeric (8,0)

**Example:** The PLANTS database code for Yellow starthistle, Centaurea soltitialis would be as follows:

**Plant Code:** CENSOL

## C2.6 Field Name(s): Infested Area, Unit of Measure

**Definition:** Area of land containing one weed species. An infested area of land is defined by drawing a line around the actual perimeter of the infestation as defined by the canopy cover of the plants, excluding areas not infested. Areas containing only occasional weed plants per acre do not equal one acre infested. Generally, the smallest area of infestation mapped will be 1/10th (.10) of an acre or 0.04 hectares.

It is highly recommended that only a single weed species be entered for each infested area.

These standards will be applied across North America. Canada and Mexico commonly use hectares to measure land. In the United States acres are the common land measure. Since acres and hectares are not equivalent, it is important to know which system was used to measure the infestation. This field is called the Unit of Measure.

**Why is it useful:** An area of weeds can be defined in many ways and there is little consistency between individuals, counties, states and countries. Is an acre of weeds one weed plant in an acre, an acre covered with weeds or all the lands threatened with invasion from an existing infestation? This definition provides a consistent and common method of describing weed populations. This is the data field that will be used to sum and report weed acres across all ownerships.

**Core Element:** Both Infested Area and Unit of Measure are required fields.

**Coding:** Infested Area: Enter the number of acres/hectares Unit of Measure:
Enter hectares or acres

**Data Value:** Infested Area: Numeric (9,2) Unit of Measure:
Alphanumeric (9,0)

**Example:** A 1.6-hectare infestation of oxeye daisy (Chrysanthemum leucanthemum L.) was found outside Vancouver, BC. **Infested Area:** 1.6 **Unit of Measure:** hectares

## C2.7 Field Name: Gross Area, Unit of Measure

**Definition:** This field is intended to show general location and population information. Like Infested Area it is the area of land occupied by a weed species. Unlike Infested Area, the area is defined by drawing a line around the general perimeter of the infestation not the canopy cover of the plants. The gross area may contain significant parcels of land that are not occupied by weeds.

Gross area is used in describing large infestations. When a value is entered for gross area, the assumption is that the area within the perimeter of the weed population (area perimeter) is an estimate or the product of calculating the area within a described perimeter. It is not a measured value. If a value for Gross Area is entered a value for Infested Area must still be entered. The value for Infested Area is derived from estimating the actual or percentage of land occupied by weed plants.

**Why is it Useful?** It is useful in describing large infestations or discontinuous infestations on the landscape. For larger weed populations it is very time consuming to plot the actual perimeter of the weed population. The increase in accuracy of plotting individual plants may not be enough to compensate for the increase in cost or manpower. An estimate of land area may be sufficient to meet the inventory and treatment requirements.

**Core Element:** This is an optional field. A value for Gross Area and Unit of Measure must both be entered. If a value is entered under Gross Area a value must also be entered under infested area.

**Coding:** Gross Area: Enter the number of acres/hectares
Unit of Measure: Enter hectares or acres

**Example:** A large spotted knapweed infestation is in the West Fork drainage. By driving around the area and looking at aerial photos the weed population is an approximate gross area of 600 acres. There are significant portion of the area that are not infested. It is estimated that approximately 40% of the area is actually occupied, or an estimated 240 acres infested. The value entered in Gross Area is 600 and value entered in Infested Area is 240. .

**Gross Area**: 600 **Unit of Measure:** acres
Infested Area**: 240**
**Unit of Measure**: acres

## C2.8 Field Name: Canopy Cover

**Definition:** Canopy cover will be estimated as a percent of the ground, covered by foliage of a particular weed species. Cover will be recorded as a numeric value. If inventory procedures includes the use of cover classes such as the Greater Yellowstone Area, 10 point codes, Daubenmire codes the mid point of the cover class will be entered as the cover value.

**Why is it Useful?** Canopy cover is a way to estimate the amount or severity of a weed infestation. Area tells you the extent of the population across the landscape. Canopy cover tells how that weed dominates the vegetation within that area. The greater the canopy cover the more the weeds there are. It is a monitoring tool, providing information on the changes in weed population from year to year.

**Core Element:** This is a required field

**Coding:** This field is percent canopy cover and therefore only numbers are an appropriate entry. The field should not exceed 3 digits or numbers. If you are using a cover classes like the Greater Yellowstone Area, 10-point class codes or the Daubenmire cover class codes; enter the mid point of the cover class. There are some examples of these cover classes and the mid point conversion located in Appendix B.

**Data Value:** Numeric (3,1)

**Example:**

**Canopy Cover:** 14

## C2.9 Field Name: National Ownership

**Definition:** The ownership of the land where the infestation is located. Ownership will consist of two, tiered groups. The first tier, National Ownership, will identify broad categories of land ownership, such as federal, provincial, state, county, city and private lands. Codes are available for the various federal agencies and should be entered here. Individual private landowners will not be identified.

Individual state and provincial land management agencies will not be coded in this field. The second ownership field, Local Ownership is reserved for these codes and is described in the following section.

**Why is it useful?** This field allows information to be grouped or displayed by broad ownership

patterns.

**Core Element:** This is a required field

**Coding:** Record one of the codes listed in Appendix C

**Data Value:** Alphanumeric (8,0)

**Example:** Bureau of Land Management

**National Ownership:** BLM

Canadian Park Service

**National Ownership:** CPS

## C2.10 Field Name: Local Ownership

**Definition:** This second ownership field is reserved for state and local users. There is no consistency in the naming of state and provincial agencies, nor is there consistency in which branch of government manages these lands. It would therefore be difficult to create useful coding conventions for these entities at this time. This field will be available to regional or local entities to define and establish useful codes.

It is also important to maintain the confidentiality for private landowners. The names, addresses and other like information of private individuals; landowners or corporations will not be part of any common data set.

**Why is it useful?** This field has been requested by and is most useful to state, county and local entities. It will allow information to be grouped by state agencies or local entities like weed management associations.

**Core Element:** This is an optional field

**Coding:** Codes for this field will be determined at the local level

**Data Value:** Alphanumeric (10,0)

**Example:** Montana Department of Fish, Wildlife and Parks **Local Ownership:** MTDFWP; Alberta Sustainable Resource Development (Public Lands) **Local Ownership:** ABSRD

## C2.11 Field Name: Source of the Data

**Definition:** This field refers to the owner or manager of the data. This may be a different person or entity from the landowner or the person who collected the data. It may be an office manager or a database specialist. This entity that will be responsible for answering questions about the data or be responsible for data requests.

**Why is it useful?** This provides a contact point for questions about the data and a means to consolidate and coordinate requests for information. This field bridges the gap between the folks that are collecting the information and those that will be managing the data.

**Core Element:** Required

**Coding:** This field using the same coding system as for national ownership, described in a previous section.

**Data Value:** Alphanumeric (5,0)

**Example:** Banff National Park has been mapping invasive plants. In databasing the inventory information the Canadian Park Service was entered as the data source**.** Joseph P. Knapson has been given the task of preparing a map showing the spread of Yellow Star Thistle across North America. Joseph finds a record for star thistle north west of Calgary, Alberta. All other information indicates that the farthest north yellow starthistle has been located was in Montana. He would like to validate this finding. Information in the Data_Source field tells him, he should contact Banff National Park and confirm this observation. **Source of Data:** CPS

## C2.12 Field Name: Country

**Definition:** The nation or country in which the infestation is located. Separate records or mapping polygons will be created for infestations that cross international boundaries.

**Why is it Useful?** This information will facilitate the free exchange of information across international boundaries. Information can be separated or summed based on national affiliations. Statistics on acres of weeds or acres of an individual weed species can easily be obtained. It will result in information such as acres of spotted knapweed in Canada.

**Core Element:** Required

**Coding:** Enter the two-digit code for the country. These are the same as postal codes.

**Data Value:** Alphanumeric (6,0)

**Example:** An African rue infestation was found on the Sonoran desert in northern Mexico. The information would be entered as follows: **Country:** MX

## C2.13 Field Name: State_Province

**Definition:** The state or province where the infestation is located.

**Why it is useful?** This allows the infestation to be located in a geographic area. It also allows the easy and quick summation of information on weeds at the state or provincial level.

**Core Element:** This is a required field and must be completed for each infestation or data record.

**Coding:** This field will use the standard postal codes, which is a two-letter abbreviation for the state or province. A complete list of codes is located in Appendix D.

**Data Value:** Alphanumeric (2,0)

**Example:** A dalmation toadflax (Linaria dalmatica (L.) infestation is found outside Vancouver, British Columbia. **State or Province:** BC

## C2.14 Field Name: County_Muncipality

**Definition:** The county (US, Mexico and Canada) or municipality (Canada) where the infestation is located. **Why is it Useful?** This allows the infestation to be located in a local geographic area. It also allows the easy and quick summation of information on weeds at the county or municipality level.

**Core Element:** This is a required field for all inventories.

**Coding:** In the United States these are three digit numeric codes, called FIPS. A complete list of county codes is located in Appendix E. Examples of codes from Canada and Mexico are yet to be obtained.

**Data Value:** Alphanumeric (5,0) (Canada??)

**Example:** There is an infestation in Humboldt County, Nevada. **County:** 013

## C2.15 Field Name: HUC_ Number

**Definition**: The Hydrological Unit Code or HUC number is a unique number assigned to the 2,000 major watersheds in the United States and Puerto Rico. The United States Geological Survey (USGS) has divided the all the water systems in the US into watersheds using the following system.
**1st Level** -The first division is into 21 major regions.
**2nd Level** -The 21 major regions are further subdivided in 222 subregions
**3rd Level** - The 222 sub regions are further subdivided into 352 accounting units or basins
**4th Level –** The 352 basins are further subdivided into 2000 cataloging units or subbasins
**5th Level –** USGS only maintains a numbering system for levels 1-4. Local areas often subdivide 4th level subbasins into watersheds.
**6th Level –** Local areas often further subdivide 5th Level watersheds into subwatersheds.
For more information on HUC see http://water.usgs.gov/GIS/huc.html.

**Why is it Useful?** Aquatic invasive plants move quickly in streams and rivers. An infestation from a single site can quickly infest an entire watershed. The polygon and point location system to locate weed populations at upland or terrestrial sites does not easily apply itself to aquatic organisms moving in riverine systems. Mapping based on hydrologic boundaries is a more useful way to display these infestations.

**Core Element:** This is a required field only for aquatic species that are found in streams and rivers. It is an optional field for all terrestrial weed infestations and for aquatic infestation found in lakes and ponds.

**Coding:** Each hydrologic unit, region, subregion, basin, subbasin, watershed and subwatershed are represented by a two-digit code for a possible total of twelve digits. USGS maintains a standards nationwide coding for only the first four levels; region, subregion, basin and subbasin. You can locate your area and the appropriate code at: http://www.epa.gov/win/address.html

**Data Value:** Numeric (12, 0)

**Example:** An infestation a Eurasian water milfoil is located in the South Fork of the Salmon River. Using USGS standards, the local area has further subdivided this subbasin into the watershed, East Fork of the South Fork of the Salmon River. In this case the HUC number would be as follows: **HUC_Number:** 1706220804

## C2.16 Data Field(s): Legal, Latitude and Longitude (Lat-Longs), Universal Transverse Mercators (UTMs)

**Definition:** The location of an infestation will refer to the center of the infestation or the center of the polygon, which defines it. Today location can be described using a variety of tools; any of the following methods may be used; legal; metes and bounds; Lat-Longs, and; UTMs.

**Why is it useful?** Location information is essential for invasive species mapping. It allows weed sites to be located on a map, be plotted across landscapes and allows users to relocate a site.

**Core Element:** Location is a required field. There are four acceptable methods; the user can chose any one of the methods described below. If GIS is used to locate the polygons, the user must also create a data field and enter the center location information for the center of the polygon.

**Coding:** Use the coding conventions for the chosen location. The designations behind a data field indicate whether or not a field is required for the individual method.

**Legal Location:**
**Data Field:** ¼, ¼, ¼, ¼, (optional)
**Data Value:** alphanumeric (2)
**Data Field:** ¼, ¼, ¼, (optional),
**Data Value(s):** alphanumeric (2)
**Data Field**: ¼, ¼ section (optional)
**Data Value(s):** alphanumeric (2)
**Data Field**: ¼ section (optional)
**Data Value(s):** Alphanumeric (2)
**Data Field**: Section (required)
**Data Value(s):** Numeric (2)
**Data Field**: Township (required)
**Data Value(s):** alphanumeric (6,1)
**Data Field**: Range (required)
**Data Value(s):** alphanumeric (6,1)
**Data Element:** Meridian (required)
**Data Value(s):** alphanumeric (20)

**Example:** An infestation is located along trail in southwest Idaho at NW, NE Section 13, T3N, R2E **Legal Location: ¼, ¼, ¼, ¼: ¼, ¼, ¼, ¼, ¼: NW ¼: NE Section:** 13 **Township:** 03 N **Range:** 02E **Meridian:** Boise. An infestation of musk thistle is found in the Province of Alberta in the northwest ¼ of Section 2, Township 26, Range 28, west of the 4$^{th}$ meridian. It would be coded as follows: **Legal Location: ¼, ¼, ¼, ¼: ¼, ¼, ¼, ¼, ¼: ¼:** NW **Section:** 02 **Township:** 26 **Range:** 28

**Meridian:** W04

**Metes and Bounds**

**Data Element**: Metes and Bounds
**Data Value(s):** Comment field 200+ characters

**Example:** The same Idaho weed infestation is located using metes and bounds. Metes and bounds is a written description of the boundaries of the site. It is the system often used to describe property boundaries or in the eastern half of the United States where section, townships and ranges have not been described.

**Comment Field:** Proceed in a NE direction for 100 yards, turn SW for 20 feet …and thence back to the …

**Latitude and Longitude**

**Data Field:** Datum (required)
**Data Value(s):** Alphanumeric (15)
**Data Field**: Latitude Degrees (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Latitude Minutes (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Longitude Seconds (required)
**Data Value(s):** Numeric (2,2)
**Data Field**: Latitude Direction (required)
**Data Value(s):** N (all sites in North America are in the North (N) Latitudes Alphanumeric (1)
**Data Field**: Longitude Degrees (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Longitude Minutes (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Longitude Seconds (required)
**Data Value(s):** Numeric (2,2)
**Data Field**: Longitude Direction (required)
**Data Value(s):** (All sites in North America are West (W) of Greenwich

**Example:** The same Idaho infestation is located using Lat/Longs

| **Latitude/Longitude** | | **Datum** NAD 1927 Conus | | |
|---|---|---|---|---|
| **Latitude:** | **Degrees** 4 3 | **Minutes** 3 5 | **Seconds** 6. 9 | **Direction**: N |
| **Longitude:** | **Degrees** 1 1 6 | **Minutes** __ 9 | **Seconds** _4 9. 0 | **Direction:** W |

**Universal TransMercator**

**UTM Data Field**: UTM Zone (required)

**Data Value(s):** Alphanumeric (5)
**Data Field**: UTM_Datum (required)
**Data Value(s):** Numeric (4,2)
**Data Field**: UTM Easting (required)
**Data Value(s):** Numeric (8,2)
**Data Field**: UTM Northing (required)
**Data Value(s):** Numeric (10,2)

**Example:** This same infestation in Idaho is described using UTMs **UTM: UTM Datum Zone** 1 1 **UTM Year** 1 9 2 7 **UTM Easting** 5 6 7 5 0 3. 6 **UTM Northing** 4 8 2 7 8 6 7. 7

## C2.17 Field Name: Quad Number

**Definition:** This is the identification number, which appears on the corner of the quadrangle (quad) map. In the United States this refers to maps published by the United States Geological Survey (USGS). In Canada these maps are part of the National Topographic System maintained by Geological Survey of Canada

**Why is it useful?** Quad is an abbreviated name for quadrangle. Quad maps are readily available from USGS, GSC, sporting good stores and other government offices. They show roads, lakes streams and other natural features. Quads are also topographic maps depicting elevations across the landscape. Quads are often available at the NAWMA International Data mapping standard scale of 1:24,000, making them a good base for weed mapping. They also provide a useful link to GIS, since the coordinates for latitude and longitude can be derived from the maps. It is an also an easy way to locate an infestation and its surrounding area on a map.
In Canada a very similar system is used. Showing topography, roads trails, water systems and other man made systems. These maps are available in at the NAWMA International Data mapping standard scales For Canada of 1:20,000 and 1:50,000 in Canada. These maps are available as both paper maps an their electronic equivalent from the National Topographic Data Base (NTDB).

**Core Element:** This is an optional field

**Coding:** This is a combination of numbers and letters found on each Quad map.

**Data Value:** Alphanumeric (15,0)

**Example:** An infestation is found at Papose Creek in southwest Montana. The infestation is located on the Hilgard Peak Quad. **Quad_Number:** 44111-H4-TF-024. An infestation of dalmation toadflax is found at Seven Persons in southeast Alberta. The infestation was located on the Seven Persons quad with the following identification number. **Quad_Number:** 072E15.

## C2.18 Field Name: Quad Name

**Definition:** This is the name that appears on the quadrangle map. It often refers to a prominent geographic feature, town or identifiable point in the area.

**Why is it useful?** See Quad Number in the previous section.

**Core Element:** This is an optional field

**Coding:** The is an optional field

**Data Value:** Alphanumeric (40,0)

**Example:** An infestation is located in Madison County, Montana. The local weed district has plotted the dalmation toadflax (Linaria dalmatica) infestation on the Hilgard Peak quad map.
**Quad_Name:** Hilgard Peak, Montana

# *C3.0 Survey Standards*

Surveying or mapping for invasive plants can be an expensive and time-consuming activity. It is important to know where and when surveys have occurred, even if no invasive plants were found. Information on the absence of weeds can be as valuable as information on the presence of weeds. For these reasons a number of organizations would like to track areas that have been surveyed and record information related to the survey. This chapter on survey standards is entirely optional and is not part of the international data standards for inventory and monitoring of invasive plants but offers guidelines for consistent collection of this information. The following set of data fields are related only to weed surveys.

## C3.1 Field Name: Area_Surveyed

**Definition:** The field refers to the entire land area that was surveyed for weeds, whether weeds were found or not. Information will be recorded in two data fields, the Area surveyed and a Unit of Measure.

**Why is it useful**? These fields record information on the extent, or the total area that was surveyed. It allows landowners and land managers to maintain records or the areas that have been looked at/surveyed for weeds and those areas where no surveys have occurred.

**Core Element:** This is not a required field.

**Coding:** Area Surveyed: Enter the number of acres/hectares surveyed. Unit of Measure: Enter hectares or acres

**Data Value:** Area Surveyed: Numeric (9,2)

**Unit of Measure:** Alphanumeric (9,0)

**Example:** In the summer of 2000 Jasper National Park completed surveys in and around park headquarters facilities. The 1,750 hectare survey revealed that no weeds were present. **Area Surveyed**: 1750 **Unit of Measure:** Hectares

## C3.2 Field Name: Type_of_Survey

**Definition:** This field refers to the survey method. At his time only two survey methods are recognized, observed and remote. Observation refers to surveys that were conducted by direct observation or visiting the site of infestation. The observations can be made in many ways helicopters, vehicles, horseback or on foot. The second option is remote sensing. This refers to any survey that was conducting by using aerial photography, satellite imagery or any method where the infestation was not directly observed.

**Why is it useful:** Information in this field tells you how the survey was conducted. It can give you information on the relative reliability of the survey. Surveys taken via remote sensing may be relatively accurate but may not give you good site specific information. It tells you whether someone actually was at the site of the infestation and directly observed such things as the species present and the extent of the infestation.

**Core Element:** This is an optional field

**Coding:** Enter the type of survey.

**Data Value:** Alphanumeric (50,0)

**Example:** Type of Survey: remote

## C3.3 Field Name: Survey Begin Date

**Definition:** This field refers to the date the survey was started. It does not refer to the date that information was entered into the database.

**Why is it useful:** This field tells you when the survey was conducted. It provides information on the time of year plants were observed. A weed infestation may look very different in the spring of the year or in the fall of the year after flowering and seed formation. Surveys conducted at certain times of year may not reveal certain plants that have already dried up or have yet to emerge in the spring. This field also tells you how old your information is; last month, last year,

or ten years ago. These cues will help you decide how reliable the information is and whether a follow-up survey may be warranted.

**Core Element:** This is an optional field

**Coding:** Enter the date where YYYY equals the four digits or numbers of the year (2001), mm equals the two digit representation of the month (04) and dd stands for the two digit representation for the day of the month (12). The date will be in the following format yyyymmdd.

**Data Value:** Numeric (8,0)

**Example:** A survey of northwest Harney County, Oregon was begun in the spring of 1999. **Survey Date:** 19990412

## C3.4 Field Name: Survey Completion Date

**Definition:** This field refers to the date the survey was completed. It does not refer to the date that information was entered into the database.

**Why is it useful:** This field tells you when the survey was concluded. It provides information on the time of year plants were observed. The combination of the Survey start Date and the Completion Date tell you how long the survey book to complete and over what season(s) of the year the inventory occurred. A weed infestation may look very different in the spring of the year or in the fall of the year after flowering and seed formation. Surveys conducted at certain times of year may not reveal certain plants that have already dried up or have not yet emerged in the spring. This field also tells you how old your information is; last month, last year, or ten years ago. These cues will help you decide how reliable the information is and whether a follow-up survey may be warranted.

**Core Element:** This is an optional field

**Coding:** Enter the date where YYYY equals the four digits or numbers of the year (2002), mm equals the two digit representation of the month (07) and dd stands for the two digit representation for the day of the month (23). The date will be in the following format yyyymmdd.

**Data Value:** Numeric (8,0)

**Example:** The Harney County survey was completed in July of the same year, 1999. **Survey Date:** 19990723

## C3.5 Data Field(s): Legal, Latitude and Longitude (Lat-Longs), Universal Transverse Mercators (UTMs)

**Definition:** The location of a survey will refer to the center of the polygon, which defines it. Today location can be described using a variety of tools; any of the following methods may be used; legal; metes and bounds; Lat-Longs, and; UTMs.

**Why is it useful?** Location information is essential to identify where the survey has occurred. It allows the survey to be located on a map, be plotted across landscapes and allows users to relocate the survey.

**Core Element:** There are four acceptable methods, the user can chose any one of the following methods. If GIS is used to locate the polygons, the user must also create a data field and enter the center location information for the center of the polygon.

**Coding:** Use any of the coding conventions listed below.

**Legal Location**:
**Data Field:** ¼, ¼, ¼, ¼, (optional)
**Data Value:** alphanumeric (2)
**Data Field:** ¼, ¼, ¼, (optional),
**Data Value(s):** alphanumeric (2)
**Data Field**: ¼, ¼ section (optional)
**Data Value(s):** alphanumeric (2)
**Data Field**: ¼ section (optional)
**Data Value(s):** Alphanumeric (2)
**Data Field**: Section (required)
**Data Value(s):** Numeric (2)
**Data Field**: Township (required)
**Data Value(s):** alphanumeric (6,1)
**Data Field**: Range (required)
**Data Value(s):** alphanumeric (6,1)
**Data Element:** Meridian (required)
**Data Value(s):** alphanumeric (20)

**Example:** An infestation is located along trail in southwest Idaho at NW, NE Section 13, T3N, R2E. **Legal Location: ¼, ¼, ¼, ¼: ¼, ¼, ¼, ¼, ¼: NW ¼: NE Section:** 13 **Township:** 03 N **Range:** 02E **Meridian:** Boise. An infestation of musk thistle is found in the Province of Alberta in the northwest ¼ of Section 2, Township 26, Range 28, west of the 4$^{th}$ meridian. It would be coded as follows: **Legal Location: ¼, ¼, ¼, ¼: ¼, ¼, ¼, ¼, ¼: ¼: NW Section:** 02 **Township:** 26 **Range:** 28 **Meridian:** W04.

**Metes and Bounds**

**Data Element**: Metes and Bounds

**Data Value(s):** Comment field 200+ characters

**Example:** The same Idaho weed infestation is located using metes and bounds. Metes and bounds is a written description of the boundaries of the site. It is the system often used to describe property boundaries or in the eastern half of the United States where section, townships and ranges have not been described. **Comment Field:** Proceed in a NE direction

**Latitude and Longitude**
**Data Field:** Datum (required)
**Data Value(s):** Alphanumeric (15)
**Data Field**: Latitude Degrees (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Latitude Minutes (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Longitude Seconds (required)
**Data Value(s):** Numeric (2,2)
**Data Field**: Latitude Direction (required)
**Data Value(s):** N (all sites in North America are in the North (N) Latitudes Alphanumeric (1)
**Data Field**: Longitude Degrees (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Longitude Minutes (required)
**Data Value(s):** Numeric (2,0)
**Data Field**: Longitude Seconds (required)
**Data Value(s):** Numeric (2,2)
**Data Field**: Longitude Direction (required)
**Data Value(s):** (All sites in North America are West (W) of Greenwich

**Example:** The same Idaho infestation is located using Lat/Longs

| **Latitude/Longitude** | | **Datum** NAD 1927 Conus | | |
|---|---|---|---|---|
| **Latitude:** | **Degrees** 4 3 | **Minutes** 3 5 | **Seconds** 6. 9 | **Direction**: N |
| **Longitude:** | **Degrees** 1 1 6 | **Minutes** __ 9 | **Seconds** _4 9. 0 | **Direction:** W |

**Universal Transverse Mercator (UTM)**

**Data Field**: UTM Zone (required)
**Data Value(s):** Alphanumeric (5)
**Data Field**: UTM Datum (required)
**Data Value(s):** Numeric (4,2)
**Data Field**: UTM Easting (required)
**Data Value(s):** Numeric (8,2)
**Data Field**: UTM Northing (required)

**Data Value(s):** Numeric (10,2)

**Example:** This same infestation in Idaho is described using UTMs **UTM: UTM Datum Zone** 1 1 **UTM Year** 1 9 2 7 **UTM Easting** 5 6 7 5 0 3. 6 **UTM Northing** 4 8 2 7 8 6 7. 7

## C3.6 Field Name: Quad Number

**Definition:** This is the identification number, which appears on the corner of the quadrangle (quad) map. In the United States this refers to maps published by the United States Geological Survey (USGS). In Canada these maps are part of the National Topographic System maintained by Geological Survey of Canada

**Why is it useful?** Quad is an abbreviated name for quadrangle. Quad maps are readily available from USGS (need Canadian equivalent), sporting good stores and other government offices. They show roads, lakes streams and other natural features. Quads are also topographic maps depicting elevations across the landscape. Quads are often available at the NAWMA International Data mapping standard scale of 1:24,000, making them a good base for weed mapping. They also provide a useful link to GIS, since the coordinates for latitude and longitude can be derived from the maps. It is an also an easy way to locate an infestation and its surrounding area on a map.

**Core Element:** This is an optional field

**Coding:** This is a combination of numbers and letters found on each Quad map.

**Data Value:** Alphanumeric (15,0)

**Example:** An infestation is found at Papose Creek in southwest Montana. The infestation is located on the Hilgard Peak Quad, **Quad_Number:** 44111-H4-TF-024
An infestation of Dalmatian toadflax is found near Seven Persons in southeast Alberta. The infestation was located on the Seven Persons quad, with the following identification number, Quad_Number: 072E15

## C3.7 Field Name: Quad Name

**Definition:** This is the name that appears on the quadrangle map. It often refers to a prominent geographic feature, town or identifiable point in the area.

**Why is it useful?** See Quad Number in the previous section.

**Core Element:** This is an optional field

**Coding:** The is an optional field

**Data Value:** Alphanumeric (40,0)

**Example:** An infestation is located in Madison County, Montana. The local weed district has plotted the Dalmatian toadflax (Linaria dalmatica) infestation on the Hilgard Peak quad map. **Quad_Name:** Hilgard Peak, Montana

## *C4.0 Glossary of Terms used in NAWMA Mapping Standards*

**Attributes:** The information used to describe a map feature.

**Collection Date**: The date the weed infestation was observed in the field. It does not refer to the date information was entered into the computer.

**Compass**: A device for determining directions by means of a magnetic needle or group of needles turning freely on a pivot and pointing to the magnetic north.

**Contour line**: A line on a map connecting points that are the same elevation above mean sea level.

**Datum:** A model of the earth's shape. Geodetic datums define the size and shape of the earth and the origin and orientation of the coordinate system used to map the earth.

**Declination** (specifically Magnetic Declination): The angle that represents the difference in direction between magnetic north and true north. Declination will vary from place to place and through time. A compass needle aligns itself with the magnetic forces of the earth where as most maps indicate true north.

**Features:** Objects represented on maps. Usually, points, lines, and areas. Points are often symbolized.

**GIS (Geographic Information System):** A computerized system for the collection, storage, management, retrieval, changing, modeling, analysis and display of spatial data used to create a representation of the real world.

**GPS (Global Positioning System):** A global navigation system based on a system of high orbiting satellites. The GPS receiver uses at least 4 satellites to compute position.

**Gross Area**: This field is intended to show general location and population information. Like

Infested Area it is the area of land occupied by a weed species. Unlike Infested Area, the area is defined by drawing a line around the general perimeter of the infestation not the canopy cover of the plants. The gross area may contain significant parcels of land that are not occupied by weeds.

Gross area is used in describing large infestations. When a value is entered for gross area, the assumption is that the area within the perimeter of the weed population (area perimeter) is an estimate or the product of calculating the area within a described perimeter. It is not a measured value. If a value for Gross Area is entered a value for Infested Area must still be entered. The value for Infested Area is derived from estimating the actual or percentage of land occupied by weed plants.

**Infested Areas**: Area of land containing one or more weed species. An infested area of land is defined by drawing a line around the actual perimeter of the infestation as defined by the canopy cover of the plants, excluding areas not infested. Areas containing only occasional weed plants per acre do not equal one acre infested. Generally, the smallest area of infestation mapped will be 1/10th (.10) of an acre or 0.04 hectares.

**Latitude:** The angular distance (distance measured in degrees) north or south of the equator. Latitude is 0 degrees at the equator, 90 degrees at the north pole and – 90 degrees at the south pole. Latitude is also described by direction north or south of the equator instead of + or -.

**Longitude:** The angular distance (distance measured in degrees) east or west of the prime meridian. Longitude is 00 at the prime meridian, and is measured + 180 going east and –180 going west. Longitude is also described by direction east or west of the prime meridian instead of + or -.

**Map:** A general representation of the real world.

**Meridian:** A meridian is one half of a great circle on the globe connecting all points of equal longitude; all meridians connect at the North and South poles. The Prime meridian is the reference meridian for latitude and longitude. For UTM designations, each UTM zone has a central meridian from which Eastings are measured. For the Township and Range System (PLSS), the principal meridians are selected north-south lines from which land was divided into parcels.

**Partial Township:** A block of the Public Lands Survey System that is less than 36 miles square created to compensate for the error created by the curvature of the earth.

**Prime Meridian:** A great circle passing through the north and south pole and through Greenwich, England. Its longitude is 0 degrees.

**Public Lands Survey System** (Township and Range System): The Public Lands Survey System

(PLSS) was proposed as an aid to parceling out for sale the public land west of Pennsylvania. The PLSS system divides land into parcels based upon selected north-south lines called principal meridians and east-west lines called base lines. The north-south meridians, though perpendicular to the base lines, had to be adjusted periodically to counteract the effects of the curvature of the earth. The result of this system is a pattern of nearly square blocks, called townships, laid out in horizontal tiers north and south of the base lines. Townships are generally 36 square miles but because of the adjustments made to compensate for the curvature of the earth, partial townships were designated. A township is generally represented by a township and range designation from the principal meridian. Range: The location of the Township east or west of the principal meridian of the Public Lands Survey System.

**Scale:** The ratio between distance as measured on the earth and the same distance as measured on a map, globe, or other representation of the earth.

**Section:** One (1) mile square (640 acre blocks) divisions of a township. There are 36 sections in each township.

**Topographic Map:** A map that displays both the horizontal and vertical positions of the features represented. It uses contours or other symbols to represent mountains, valleys, and plains.

**Township:** The primary block of the Public Lands Survey System. Generally, an area of 6 miles on a side (36 square miles). (See Partial Township) Also, the north/south location designation of the PLSS blocks.

**Universal Transverse Mercator** (UTM) Coordinate System: UTM Coordinate System defines two dimensional, horizontal positions using a grid system. The UTM grid is divided into UTM zones that designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude. Each zone has a central meridian.

## *C5.0 2007 Addendum to the NAWMA Mapping Standards*

Addendum to the NAWMA mapping standards as suggested by the mapping standards committee and passed by the NAMWA board at the September 24, 2007 meeting.

1. Under **Latitude and Longitude** (in separate fields for degree, minutes, seconds)
Data Field: Longitude Seconds (required)
    Data Value(s): Numeric (2, 2)
Should be
    Data Value(s): Numeric (3, 2) (To accommodate the 3 spaces such as 108)

2. Under **Plant Name**
    Genus: Alphanumeric (2, 0)

Should be
    Genus: Alphanumeric (20, 0)

3. The addition of longitude and latitude in decimal degrees as a location option.

**Latitude and Longitude – Decimal Degrees**

**Data Field:** Datum (required)
**Data Value(s):** Alphanumeric (15)
Suggested field name: Datum

**Data Field**: Latitude Decimal Degrees (required)
**Data Value(s):** Numeric (10,8)
Make the number + (positive) if it is in the North direction
Suggested field name: Latitude

**Data Field**: Longitude Decimal Degrees (required)
**Data Value(s):** Numeric (11,8)
Make the number – (negative) if it is in the West direction
Suggested field name: Longitude

**Example:** An infestation is located using Lat/Longs.

**Datum:** WGS 1984
Latitude: 43.123456787
Longitude: -108.12345678

Under the Infest Area Definition replace the sentence

“Generally, the smallest area of infestation mapped will be 1/10th (.10) of an acre or 0.04 hectares.”

With the following:

“If the area of the infestation was not recorded a default size of 1/10th (.10) of an acre or 0.04 hectares will be used.”

# Appendix D: Weed Prioritization by Species

All known exotic plant species in Lake Mead NRA were evaluated using the "The Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" (Warner et al. 2003). This product was developed by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association for use in California, Arizona, and Nevada. It ranks each plant's level of threat to the ecological health of wildlands through evaluation of its ecological impact, ability to invade natural vegetation communities, and current extent of its invasion using a Plant Assessment Form. A verbal description of each of the list categories follows. These categories correspond directly to the overall criteria scores that derive from the responses to individual criteria questions and section scores. Accordingly, the individual questions and section scoring matrices have been designed to appropriately weigh the ecological impacts, invasiveness, and ecological distribution of each species, conveying a synopsis of these factors through categorical groupings. A review of the questions and the completed Plant Assessment Forms for each species provides the most detailed and comprehensive explanation for the inclusion of a particular species within a category. The categories are defined as follows:

- High: These species have severe ecological impacts on ecosystems, plant and animal communities, and vegetational structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. These species are usually widely distributed ecologically, both among and within ecosystems.
- Medium: These species have substantial and apparent – but generally not severe – ecological impacts on ecosystems, plant and animal communities, and vegetation structure. Their reproductive biology is conducive to moderate to high rates of dispersal, though establishment is generally dependent on ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
- Low: The ecological impacts of these species are minor. Their reproductive biology and other invasiveness attributes result in low to moderate rates of invasion. Ecological amplitude and distribution are generally limited but these species may be locally persistent and problematic.
- Alert: This is an additional designation for some species in either the high or medium category, but whose current ecological amplitude and distribution are limited. The designation alerts managers to species that are capable of rapidly invading unexploited ecosystems, based on initial, localized observations, and on observed ecological behavior in similar ecosystems elsewhere.
- Evaluated but not listed: In general, this designation is for species for which information is currently inadequate to respond with certainty to the minimum number of criteria questions or for which the sum effects of ecological impacts, invasiveness, and ecological amplitude and distribution fall below the threshold for listing.
- Nominated: The designation is for species that were nominated for review, but not evaluated because either they are not known to escape into wildlands or there was a lack of sufficient information to complete an assessment.