The Interagency Weed Sentry Project

PROJECT REPORT

2008-2009

for

Clark County, Nevada and the Multiple Species Habitat Conservation Plan

Agency/Organization: National Park Service-Lake Mead National Recreation Area

Project Number: 2005-NPS-537-P

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EXECUTIVE SUMMARY

The goal of the Interagency Weed Sentry Project was to proactively detect incipient invasive plant populations so they could be controlled or eradicated before they negatively impacted ecosystems and species of concern. The major objectives of the Interagency Weed Sentry Project were to: (1) identify and document the presence of new exotic invasive plant species; (2) document targeted incipient populations of weeds in Clark County or vectors outside of Clark County and determine their distribution; and (3) control incipient weed populations when feasible and prioritize areas for more extensive control efforts. The measurable objectives of the Interagency Weed Sentry Project were to survey for and document the locations of invasive plant populations, treat incipient populations, and record negative weed data.

Data supplied by the Interagency Weed Sentry Project could provide land managers with a valuable tool to guide their management decisions. Knowing where new infestations were, how extensive they were and receiving recommendations on how to treat them enabled land managers to make informed decisions and control invasive plants before they became major problems.

During the biennium, members of the Public Lands Institute at the UNLV and NPS personnel have accomplished the following:

- Surveyed BLM (357 miles/2,788 acres), NPS (290 miles/2,257 acres), USFS (37 miles/243 acres) and USFWS (123 miles/861 acres) lands for weed infestations.
- Recorded 3,559 weed infestation points (each point represents a weed population which can range in size from one individual to >100,000 individuals).
- Treated invasive plant species on BLM (5,095 individuals of 14 species), NPS (44,790 individuals of 14 species), USFS (14,272 individuals of 7 species) and USFWS (1225 individuals of 8 species) lands.
- Produced trip reports and offered recommendations for weed control to BLM, NPS, USFS and USFWS land managers.
- Conducted seven special research projects, which produced presentations and publications.

INTRODUCTION

The Interagency Weed Sentry Project (henceforth Weed Sentry), was designed in 2003 to act as an early detection, rapid response program for invasive weeds on Clark County public land; specifically: National Park Service (NPS), U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and Bureau of Land Management (BLM) lands. The primary goal of the Weed Sentry was to collaborate with the aforementioned agency personnel to capture baseline information on the location and distribution of exotic plant invaders within public lands of Clark County and nearby vectors outside the county, and begin immediate control efforts on incipient populations. Preventing the introduction of invasive species is the first line of defense against invasions. However, even the best prevention efforts will not stop all invasive species introductions. Early detection and rapid response (ED&RR) efforts increase the likelihood that invasions will be addressed successfully while populations are still localized and population levels are not beyond that which can be contained and eradicated. Once populations are widely established, all that might be possible is the partial mitigation of negative impacts. In addition, the costs associated with ED&RR efforts are typically far less than those of long-term invasive species management programs (Bickmore). Weed Sentry also conducted research to help answer land manager questions about exotic plant ecology and control.

The Weed Sentry project was initiated in 2004 using funding from the Multiple Species Habitat Conservation Plan (MSHCP) and Lake Mead National Recreation Area, NPS. In 2004, surveying and data collection and storage protocols were developed and tested. By the 2005 growing season, weed surveying using the established project protocol was initiated. Weed Sentry surveying has been ongoing since then, however, this report focuses on the last two years, which were supported by MSHCP 2005 Biennium funds.

Specific objectives of Weed Sentry are to: (1) identify and document the presence of new exotic invasive plant species; (2) document targeted incipient populations of weeds in Clark County or vectors outside of Clark County and determine their distribution; and (3) control incipient weed populations when feasible and prioritize areas for more extensive control efforts. Weed Sentry data is maintained by the GIS division of the NPS. Quarterly reports and annual data transfers were provided to the county, and after each survey, specific survey results were shared with the land managing agency using a “Trip Report”. Trip Reports include information on location surveyed, weeds encountered, weed treatments conducted, and overall recommendations. Data supplied by Weed Sentry provides land managers with a valuable tool to guide their management decisions. (See appendix 1). Knowing where new infestations are, how extensive they are and receiving recommendations on how to treat infestations has helped facilitate active weed management on public lands; in turn helping land managers in make informed decisions and control invasive plants before they become large-scale, fiscally draining problems. For example, in 2007, surveyors encountered a large salt cedar at a spring on USFWS lands. We provided maps and control recommendations to the land manager, and soon after, the tree was removed. Also, in 2008, the Exotic Plant Management Team controlled a large infestation of Russian knapweed on USFS lands due to the recommendations of a Weed Sentry trip report.

At the project outset, primary measures of Weed Sentry achievement were number of miles surveyed and number of individual weeds treated. After Weed Sentry had surveyed much of the

county public lands and knew where many troublesome weed populations had established, Weed Sentry was able to follow up on high priority areas annually. Annual follow-ups on previously documented weed populations frequently became multiple days of hand- pulling tens of thousands of invasive species, and coordinating large crews to assist. Such intense weed control efforts became disconcerting because an immense amount of resources were being invested into treatment, however, there was little to no scientific information guiding control methods and timing.

While Weed Sentry was participating in extensive weed treatments there was less time remaining for additional surveys to detect incipient populations and to gain understanding as to how best control individual weed species. Then, in 2007, Lake Mead National Recreation Area (LAME) restructured their vegetation management program to include a Weed Manager who is specifically responsible for coordinating large-scale weed control efforts. Other agencies have also developed similar positions: the BLM has a Weed Management Specialist, the USFWS has a contracted Restoration/Exotic plant manager; the only agency without a specific weed position at this point is the USFS. Within the USFS, responding to Weed Sentry trip reports has been delegated to the Botanist.

Shifting the responsibility of large-scale weed control within LAME from Weed Sentry to an NPS employee allowed Weed Sentry to redistribute resources instead to implement scientifically rigorous ecological research of:

- Systems likely to be or become infested by weeds,
- Characteristics of problematic weed species, and the
- Invasibility of certain Mojave plant communities. (See appendix 4).

This information, in turn, could assist Weed Managers within all agencies with determining the best management practices for weed populations within their jurisdiction. (See appendix 3).

The first section of this report documents the methods and materials used by Weed Sentry to achieve survey goals.

The next section discusses Weed Sentry results and evidence of results in the form of weed survey accomplishments during the fiscal years 2008 and 2009 which were funded by the Clark County as part of the Multiple Species Habitat Conservation Plan. Accomplishments are discussed in the context of miles surveyed and treatments conducted within each federal land management agency, conservation management category (as deliniated by MSHCP), and ecosystem.

The next section provides an evaluation of the results by examining exotic distributions from compiled data spanning program inception in 2004 to September 2009. This section discusses county-wide trends of invasion by individual weed species. Then, the section considers trends within each land management area, highlighting weed species of special concern for each federal agency's jurisdiction.

The next section of this report discusses seven scientifically rigorous studies conducted and written entirely, or in part, by Weed Sentry Research Assistants. These are referred to as "Special Projects" within the document. Occassionally, students of the course, "Restoration Ecology" at the University of Nevada – Las Vegas,assisted with data collection for these projects. The purpose of the first study "Assessing an exotic plant surveying program in the Mojave Desert, Clark County, Nevada, USA" was to assess methods and assumptions of the Weed Sentry project, and suggest future work for advancing exotic species information systems in this region. The next study, "NPS Lake Mead National Recreation Area: *Rana onca* (rare frog) habitat surveys" was an intensive community sampling project that was conducted in conjunction with spring habitat manipulations to better support the *Rana onca*, a rare frog. An intensive plant community study, "A condition assessment of spring and seep vegetation on the Desert National Wildlife Refuge, southern Nevada" was conducted at springs in the Desert National Wildlife Refuge. Plant community sampling for this study was done in an effort to record and describe invasive and native populations at remote springs.

Two studies of the ecology of *Brassica tournefortii* were conducted; the first study, "Effects of water and distrubance on establishment of *Brassica* and native perennials" considered the effect water and disturbance has on the establishment of *Brassica tournefortii* and native annuals, and the second, "*Brassica tournefortii* competition with native annuals" explored *Brassica tournefortii's* competitive abilities. The sixth study, "Factors affecting exotic annual plant cover and richness along roadsides in the eastern Mojave Desert, USA" investigated the affects of road-type, distance from roads, and microsite type on weed establishment. This study was conducted by Weed Sentry in conjunction with personnel funded by a Joint Fire Science grant. The final study highlighted in this document, "Vegetation of grassy remnants in the Las Vegas Valley, southern Nevada" was conducted within the Las Vegas Valley with the intent of recording legacy plant community data and detecting weeds.

Finally, how the Weed Sentry project is inter-related to the agencies it supports is discussed in the conclusions, and recommendations for weed survey, monitioring and control within the county are made.

METHODS AND MATERIALS

Site selection

The team-lead coordinates survey activities with various land management agencies a minimum of once a year. (See table 1 for a list of primary agency contacts). In annual meetings with each of the federal partners, the major goal is to plan for the upcoming field season. In the developmental stages of the program, as stated in the 2004-2005 Biennium Report, this time was additionally for the transfer of information and recommendations on how to deal with emerging weed problems evident from earlier survey findings. However, during this project, trip reports were provided to agency personnel as surveys were completed. Thus, agency contacts had discussed their weed questions with Weed Sentry before the annual meeting occurred.

The Weed Sentry places a priority on coordinating with, and complementing, the management objectives of federal agencies. At survey planning meetings, agency personnel provide a list or maps of locations they would like surveyed; occasionally Weed Sentry may also suggest areas they have determined are important to survey. Survey timing is also discussed. Weed Sentry incorporates survey requests from all agencies into an annual plan of survey activities. The plan is geared toward timing surveys for peak annual plant growth of target species. Thus, surveys of lower elevation lands are generally scheduled for late winter and spring months, and higher elevation lands are scheduled during late summer and fall. Even with the annual plan, survey timing is dependent upon site visits to determine whether annual growth is occurring, and whether plants are at a stage where identification is possible. During site visits, if plants are too young to be identified to species, surveys are postponed until plants further mature. Plant growth in the desert is unpredictable due to minimal precipitation. For example, during spring 2007 there was little rain, and thus, when surveys were conducted, negative weed occurrence data was greatly confounded by the absence of rain.

For research, study sites are selected randomly, based on reported densities of weeds, or within specific ecosystems, depending upon land manager information needs. Land managers are consulted during the research planning and implementation stages to insure that study site locations are appropriate and will not interfere with their work. Depending upon the study, it may be necessary to apply for a research permit.

Table 1. List of agency contacts.

Project contacts (as of Nov 2009)	Phone	E-mail
BLM		
Nora Caplette	(702)515-5281	Nora_Caplette@blm.gov
Gayle Marrs-Smith	(702)515-5156	Gayle_Marrs-Smith@blm.gov
NPS		
Carrie Norman	(702)293-8734	Carrie_Norman@nps.gov
Kari Yanskey		Kari_Yanskey@nps.gov
USFS		
Marisa Anderson	(702)515-5409	marisaanderson@fs.fed.gov
Jennifer Brickey	(702)515-5402	jbrickey@fs.fed.us
USFWS		
Amy Sprunger	(702)879-6110	Amy_Sprunger@fws.gov

Surveys and research

There are many items necessary for conducting a weed survey, such as: a mapping-grade GPS unit (see figure 1 & 2), GPS chargers and extra batteries, back-up GPS, field notebooks, compass, The Jepson Desert Manual (Baldwin et al. 2002) and other plant identification books, topographical maps of the survey area, extra data sheets (used in the case of GPS malfunction), garbage bags for off-site disposal of incipient weed populations, and standard personal field equipment (such as water, lunch, hiking boots, etc.) (See table 2 & 3 for copies of data sheets). Additionally, at least one 4-wheel drive vehicle with off-road quality tires is needed to negotiate the backcountry roads that are surveyed. Weed Sentry vehicles put on many miles merely driving to and from survey locations in addition to the surveys themselves. In fact, the two trucks dedicated to surveying in fiscal years 2008 and 2009 accumulated an excess of 86,000 miles over the two years, and they were not the sole vehicles used for the project.

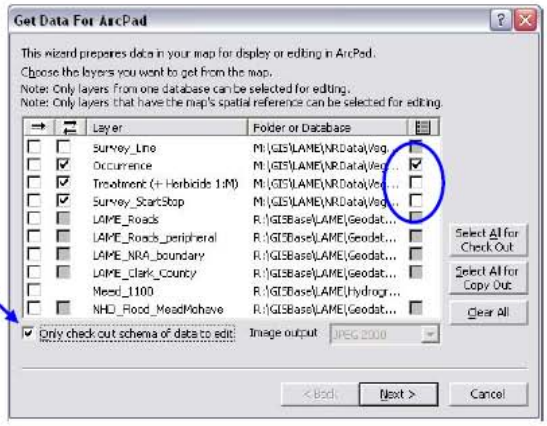
Exotic Plants Geodatabase

Check out data for ArcPad

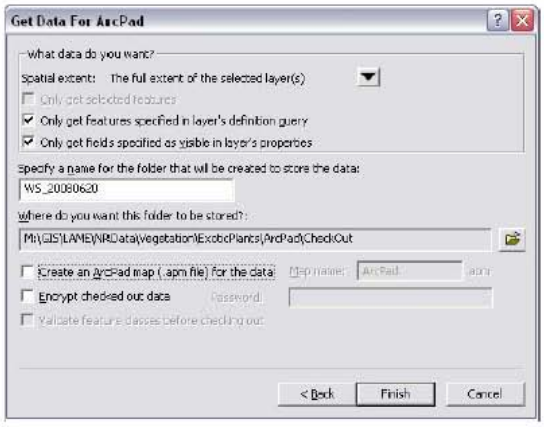
- Go to the ArcPad checkout folder: *T:\Resource\WeedSentry\ExoticPlants\ArcPad\CheckOut* and move any prior checkout folders (WS_yymmdd) to the 'Archive' folder
- Open the ArcMap project 'WeedSentry_CheckOut' from the following folder: *T:\Resource\WeedSentry\ExoticPlants\ArcMap\Projects*. The project should have Occurrence, Treatment, and Survey_StartStop displayed. These are the feature classes that will be checked out for ArcPad.
- Make sure the ArcPad Data Manager toolbar is displayed:
  View -> Toolbars -> ArcPad Data Manager
  Tools -> Extensions -> ArcPad Data Manager

- Click the "Get Data For ArcPad" button to open the wizard.
- There are two options for each layer: copy out for viewing (background data), or check out for editing.

- Select 'check out' for Occurrence, Treatment (plus the related Herbicide table), and Survey_StartStop.
- Next, check the box at the far right to select the custom form for each of the three layers. Navigate to the forms folder:
  T:\Resource\WeedSentry\ExoticPlants\ArcPad\Forms
  and select the corresponding form (.apl) for each layer.
- After you have selected the layers and forms, check the box near the bottom to check out the schema of the data for editing. This means that no existing data will be checked out, just blank copies of the layers. Then click 'Next'



- Set the spatial extent to 'The full extent of the selected layer(s)'
- For the folder that will be created to store the data, call it "WS_" plus the date the data was checked out in YYYYMMDD format.
- Set the location to save the folder as follows:
  T:\Resource\WeedSentry\ExoticPlants\ArcPad\CheckOut
- Uncheck the box for creating an ArcPad map for the data. We've encountered issues using .amp's with the new AFX file in ArcPad.
- Click 'Finish'. A window will appear with the results of the check out.

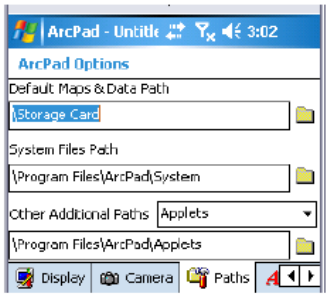


- The data is now ready to be copied to the GPS.

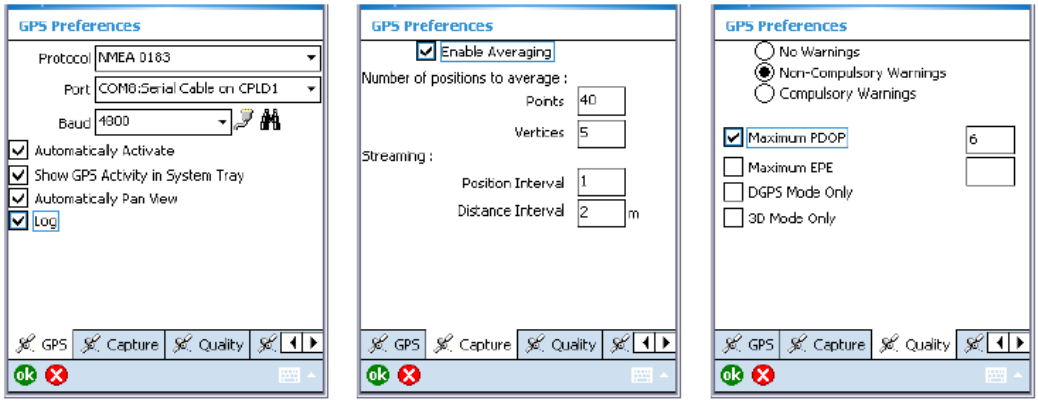
Figure 1. Steps for "checking out" data from the Weed Sentry database onto GPS units to be taken into the field.

Weed Sentry ArcPad Settings
Symbol MC-70 GPS

ArcPad Options menu:



ArcPad GPS Preferences:



ArcPad TrackLog Layer Properties

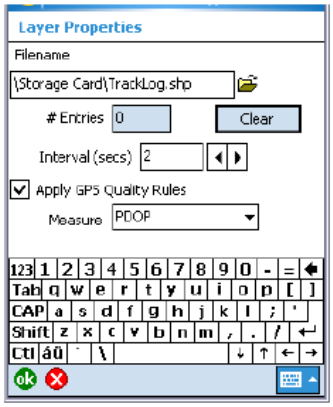


Figure 2. Settings for the Symbol MC-7094.

Weed Sentry personnel drive to the location where a survey has been requested. (See table 4 for standard safety equipment which should be in all field vehicles). Upon arriving at the survey location, surveys may be conducted by foot, vehicle, or boat. For vehicle surveys, the vehicle trip odometer is set to "0" and vehicle side mirrors pulled in for a better view of the roadside. Ideally, one person drives, watches for weed species on the left side of the vehicle, and monitors the trip odometer so that infestation points can be recorded every 0.1 mile, and a passenger monitors for weeds on the right roadside and records infestations using the GPS. If only one person is present, the road is surveyed twice, so that both roadsides can be monitored. The ability to conduct roadside surveys by vehicle is dependent upon traffic conditions. If the road is busy and speed limits are high, alternative surveying methods are used; or surveying may be deemed too dangerous to be conducted. Many of the roads on public lands in Clark County are gravel and used infrequently.

At 0.1 of a mile, all weed species encountered during the past 0.1 mile are recorded in the GPS database (combined for both roadsides if two surveyors are present), along with infestation characteristics. (See table 2 for complete data collected for each infestation). This process is repeated every 0.1 mile for the duration of the driving survey.

Determining the distance which has been surveyed (i.e. intervals for recording infestations) is more difficult for boat and hiking surveys. Generally in these types of surveys, infestation points are collected over a set amount of time, for instance every 5 minutes, or at another regular interval. If no infestations have been encountered over multiple recording intervals, generally the next infestation is recorded at the exact location it is encountered, rather than waiting for the next 0.1 of a mile or 5 minute interval to be reached before recording the new population.

Exotic plant field research can require a variety of equipment depending upon study goals. Typically, more than ten 100-m and 50-m tapes are needed to set up study plots, along with any combination of the following equipment: pin flags, PVC material to construct quadrats, meter sticks, Robel poles, clipboards, flagging, pin-flags, compasses, hand lens, camera, rake, watering can, weatherproof identification tags, plant identification books, bags to store specimens, field press, GPS unit, set of 12-inch rebar and field gear bags. Additionally, depending upon treatments being tested, a weed whacker, herbicide, hand clippers, or 5 or more person fire crews may be needed.

Table 2. Form for recording weed occurrences manually when the mapping-quality GPS unit malfunctions. This includes all of the information recorded by the GPS unit.

Place Name & Agency: Waypt. Start: Waypt. Stop:

Date:

Surveyors:

Type of Survey (i.e. paved, unpaved/graded, unpaved/4X4, trail, shoreline, etc.): Survey Side (R, L or Both):

Occurrence Data

Waypt.	Species	# of Plants	Phenology	Condition	Repr.	Acres	Cover	Dist H20	Distribution	Tmt.	# Treated	Comments

# of Plants: <10, 10-100, 101-1000, 1001-5000, 5001-10,000, 10,000-100,000, >100,000
Phenology: Dormant, Flower bud/bolting, Flowering, Immature Fruit, Leaf-out Vegetative, Mature Fruit, Seedling
Condition: Dead, Dying, Poor, Fair, Good, Excellent
Acres = Affected Area: <0.1, 0.1-0.5, 0.5-1, 1-5, >5 acres
Cover: 0-1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, >95%

Table 3. Form to record weed herbicide treatments manually.

Herbicide Treatment
Place Name: Date:
Herbicide Applicators:

Waypt.	Species	# Treated	Acres Trtd.	Herbicide	Surfactant	Dye	% used	Gallons	Wind Dir.	Start	Finish	Comments
										Wind Sp.	Wind Sp.	
										Temp	Temp	
										Time	Time	
										Wind Sp.	Wind Sp.	
										Temp	Temp	
										Time	Time	
										Wind Sp.	Wind Sp.	
										Temp	Temp	
										Time	Time	
										Wind Sp.	Wind Sp.	
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										Wind Sp.	Wind Sp.	
										Temp	Temp	
										Time	Time	
										Wind Sp.	Wind Sp.	
										Temp	Temp	
										Time	Time	

Table 4. Checklist of equipment to be kept in vehicles.

Vehicle Checklist

Every vehicle, everyday it is used, should carry the following items. Check your vehicle often and before going into backcountry to make sure it is equipped properly. If you don't have these things in your assigned vehicle, ask your supervisor where to get them, or have your supervisor purchase them for you.

____ 1. Functioning 2-way radio- This is very important.
____ 2. Potable water- enough to tide you over if you are stuck in backcountry, more during summer. About 3-5 gals would be good to keep at all times. Water leaks out, evaporates and goes bad- so check and replace often.
____ 3. First aid kit. Check to make sure kit is complete and has what is needed and medications are not dried up. Aspirin, bandages, antiseptic cream, Ace type bandage, tweezers, etc.
____ 4. Shovel. If you get stuck, this tool may be your best friend.
____ 5. Spare tire- that is not flat and is correct for the vehicle. Check the tire before you go into the backcountry.
____ 6. Correct jack and tire iron for that vehicle- check this out, they do get switched around.
____ 7. Fire extinguisher- make sure it is good.
____ 8. Latex or rubber gloves- for emergencies and handling tortoises. You may have to move or help a person who is bleeding- you do not want to do so without gloves. Also, it is best to only handle tortoises with gloves, but after doing so- throw out gloves and get a new pair.
____ 9. Radio call list and map of park should be in glove box. Also, you may want a copy of this list, first aid instructions, and how to use radio sheet from the handbook.
____ 10. Trash bags. For cleaning up field work sites and other areas of park and when you come in contact with litter in backcountry.
____ 11. Basic car supplies such as jumper cables, fuses, flares, extra windshield wipers, rag, leather gloves, etc.
____ 12. Tool kit with basic tools such as screwdrivers, crescent wrench, hammer, pliers, etc. for making on-the-spot repairs.

Incipient population treatment
If a small infestation of a unique weed was encountered and time permited, Weed Sentry personnel used appropriate control methods, and recorded a treatment point (which included the exact number of individuals treated) on the GPS unit. (See table 2 for recording manual treatments of infestations and table 3 for recording herbicide treatments). Appropriate control methods were determined by equipment available, growth habits of the weed species, and the managing agency's preferred control methods. Early in the project, herbicide treatments were conducted over large areas of infestations, but with management restructuring at Lake Mead NRA it became infeasible for Weed Sentry to conduct herbicide treatment. If an area was large enough to require herbicide control, the Exotic Plant Management Team was contacted and provided with a report, and/or herbicide recommendations were made to the respective land manager.

Generally if a weed had already set seed before it was detected and control was deemed necessary, the controlled plants were bagged in durable trash bags and removed from the site to be disposed of elsewhere. If exotic species were controlled while they were still immature, plants were left for onsite decomposition.

Data management and QAQC
In addition to Weed Sentry's nine primary employees, Lake Mead NRA's GIS Department provides data management assistance for the project. The GIS department was responsible for programming mapping-quality GPS units with data dictionaries (standardized electronic forms) that were completed for each survey/infestation point/treatment area. In addition, they maintained the survey database and ran reports on the database. For information on quality assurance, quality control (QAQC), refer to 2005-NPS-537-P, D-2 Data Management Plan and Palmer and Landis 2002.

All information captured in the field was stored on the GPS unit and upon returning to the office, parsed into the appropriate tables in the database. (See tables 2 & 3 for specific information collected, and figure 3 for how data collected on the GPS unit is downloaded into the computer GIS (currently using Arc GIS 9.2)). The database was designed to generate layer files that are used in Arc GIS 9.x to display the data captured.

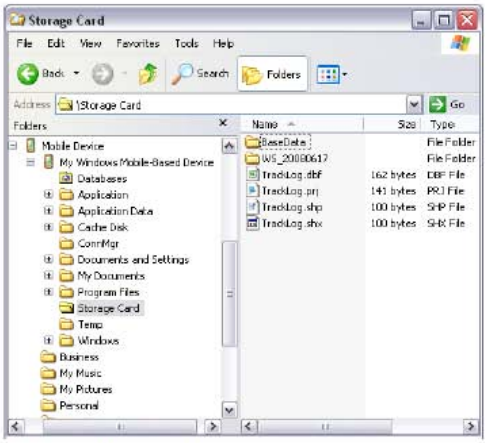
Exotic Plants Geodatabase

Download GPS Data

- Connect the MC-70 cradle to the computer via USB.
- Place the MC-70 GPS in the cradle.
- ActiveSync will start on the computer with the following warning:

- Click 'OK'. Next, a synchronization wizard will start. Click 'Cancel'. The main ActiveSync window will open.

- Click 'Explore' then navigate to \Storage Card. There will be a 'BaseData' folder, a 'WS_' followed by a date folder, and the Tracklog shapefile. The AFX file that stores exotic plants data collected in ArcPad is in the WS_date folder.
- In a separate window, navigate to the following folder on the network:
  T:\Resource\WeedSentry\ExoticPlants\ArcPad\CheckIn
- Create a new folder in the following format: 'WS_' followed by today's date 'YYYYMMDD_' and a 1 or 2 depending on which GPS was used. Example: Weed Sentry data downloaded on 6/18/08 from the 'Weed Sentry 1' GPS would be 'WS_20080618_2'
- Back to the storage card on the mobile device – Copy the AFX and tracklog files to the folder on the T: drive you just created.



- Once they have been successfully transferred to the network, delete the tracklog and WS_date folder from the storage card on the GPS. After the data has been checked in and a new AXF created, a blank tracklog and the new AFX will be transferred to the storage card

Figure 3. How to download data from the GPS unit onto the computer after a survey has been completed.

After data is downloaded, data is verified to make certain that information was recorded accurately. In ArcGIS; Occurrence, Survey_Line, Survey_StartStop_NotCheckedIn, and Treatment layers are added to a project, and attribute tables of each layer are examined for errors. Additionally, as survey lines are created by using the tracklog collected by the GPS unit, the field for "Checked in" within the "Survey_StartStop_NotCheckedIn" layer should be changed to "yes" to reflect that the survey line has been created. When the field value is changed from "no" to "yes" the points will no longer be displayed within the map view. If new locations were surveyed a new "place name" will need to be added to the Weed Sentry Survey_Line layer of the database. (See figure 4 for how to add a place name to the GIS layer). GIS programs are frequently improved and upgraded, so it is not expected that actual database management activities will remain the same for an extended period of time. Primary GPS units used in the program have been replaced; Trimble to Symbol GPS, the actual database was converted from a Microsoft Access database to one managed within ArcGIS. Thus, it is important to maintain hard copies of data, and continually upgrade all data to the newest technology so that the information gathered by Weed Sentry will not be lost over time.

Exotic Plants Geodatabase

Add New Place Names

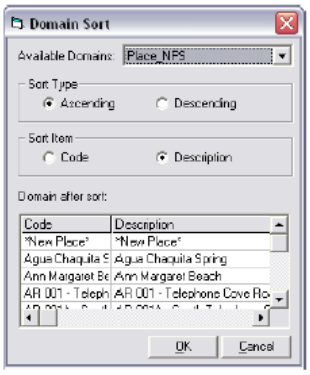
- Before starting, make sure ArcMap is not open.
- In ArcCatalog, navigate to the geodatabase: *T:\Resource\WeedSentry\ExoticPlants\Geodatabase\ExoticPlants.mdb*
- Right-click the geodatabase and select 'Properties'
- On the 'Domains' tab, select the appropriate place domain and add the new place at the bottom of the 'Coded Values' list. Be sure to add the same name under both the 'Code' and 'Description'. Click 'OK' to close the window.

Sort Place Names

- Click on the geodatabase in ArcCatalog to highlight it, then click the 'Sort a domain' tool

  (if this tool is not shown on your toolbars ask the GIS office to install it)

  Select the appropriate domain from the pick list and click 'OK'.



Update *New Place* Records in the Geodatabase

- Place names are used in the Occurrence, Survey_Line, and Treatment feature classes. Open ArcMap and add these three feature classes.
- Open the attributes for Occurrence. You do not need to be in an edit session. Select all of the *New Place* records to be updated (if there's more than one new place, only select points in one new place at a time).
- Right-click the field name ("Place") and select 'Field Calculator'. Under 'Place =' type in the new place name inside double-quotes "Like this". Check the box for 'Calculate selected records only' and click 'OK'.
- Repeat for each new place name, in each feature class.

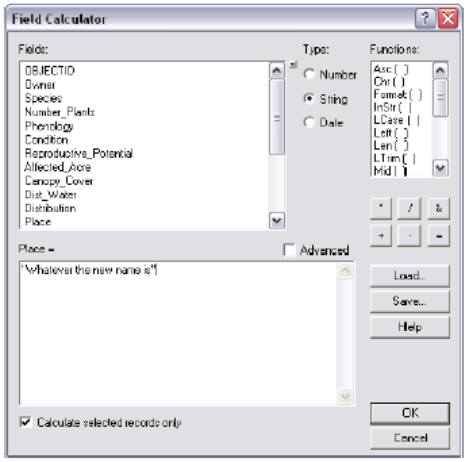


Figure 4. How to add a place name to the Geodatabase when a new area has been surveyed.

RESULTS AND EVIDENCE OF RESULTS

During 2008 and 2009, more than 800 linear miles and 6,000 acres were surveyed for exotic incipient weed populations. Surveys were primarily conducted within Clark County; however, since federal agency lands cross county and state borders, Weed Sentry surveys included lands adjacent to Clark County which were suspected to be potential weed vectors. (See table 5 and figure 5). Surveys were conducted by automobile, foot and boat. Although surveys were primarily conducted along present day roadways and established hiking trails, other areas such as historic roadways, cattle trails, shorelines, within washes and in the case of USFS lands, within forest-thinning treatment areas, were also surveyed using the Weed Sentry protocol. (See appendix 4).

Along with recording 3,319 individual infestation points, more than 65,000 individual exotic plants were controlled by Weed Sentry. An infestation point was recorded to represent an entire population of an exotic species. Thus, there could be 4 infestation points recorded, 1 of the points could represent a population of one individual, another could be 10,000 -100,000 individuals, etc. On the other hand, records of the number of individuals controlled are actual quantities, the exact number of, for example, dandelions hand-pulled by Weed Sentry. So if 10 dandelions were pulled, that would be the number that would be recorded (See tables 6-9). With exception to a large *Tribulus terrestris* infestation that was controlled by herbicide, all weeds were controlled during 2008 & 2009 by hand-pulling, and either left for on-site compost, or if mature seeds were present, bagged and disposed of off-site.

Fourteen weed species were controlled on BLM lands. (See table 6). 2,900 *Tribulus terrestris*, 910 *Bromus diandrus* and more than 100 *Brassica tournefortii, Chorispora tenella, Descurainia sophia, Hordeum* spp., *Sisymbrium altissimum* and *Sisymbrium irio* were hand-pulled.

On NPS lands, fourteen weed species were controlled. (See table 7). The majority of the 42,441 *Brassica tournefortii* that were controlled occurred at a sandy rare plant site on Lake Mead. In addition, 834 *Avena fatua*, 704 *Malcolmia africana*, 332 *Bromus diandrus*, and more than 100 *Hordeum* spp, *Sisymbrium irio* and *Tribulus terrestris* were controlled on NPS lands.

On USFS lands, seven weed species were controlled. (See table 8). The majority of the 14,113 *Tribulus terrestris* were controlled along Kyle Canyon road by spot treatment with a backpack herbicide spray. In addition, more than 50 *Melilotus officinalis* and *Salsola tragus;* along with small populations of *Medicago sativa, Melilotus alba, Sonchus asper* and *Verbascum thapsus* were hand-pulled on USFS lands.

On USFWS lands, eight weed species were controlled. (See table 9). Small populations of *Brassica tournefortii, Chorsipora tenella, Hordeum* spp., *Salsola tragus, Sisymbrium irio, Tamarix ramosissima* and *Tribulus terrestris* were hand-pulled. In addition, more than 1,000 *Malcolmia africana* were controlled along Mormon Well Road, just east of the turnoff to Sawmill Trail.

Table 5. Miles and acres surveyed within each federal land management agency during 2008 and 2009.

Agency	Miles	Acres
BLM	357	2,788
NPS	290	2,257
USFS	37	243
USFWS	123	861
Total	807	6,149

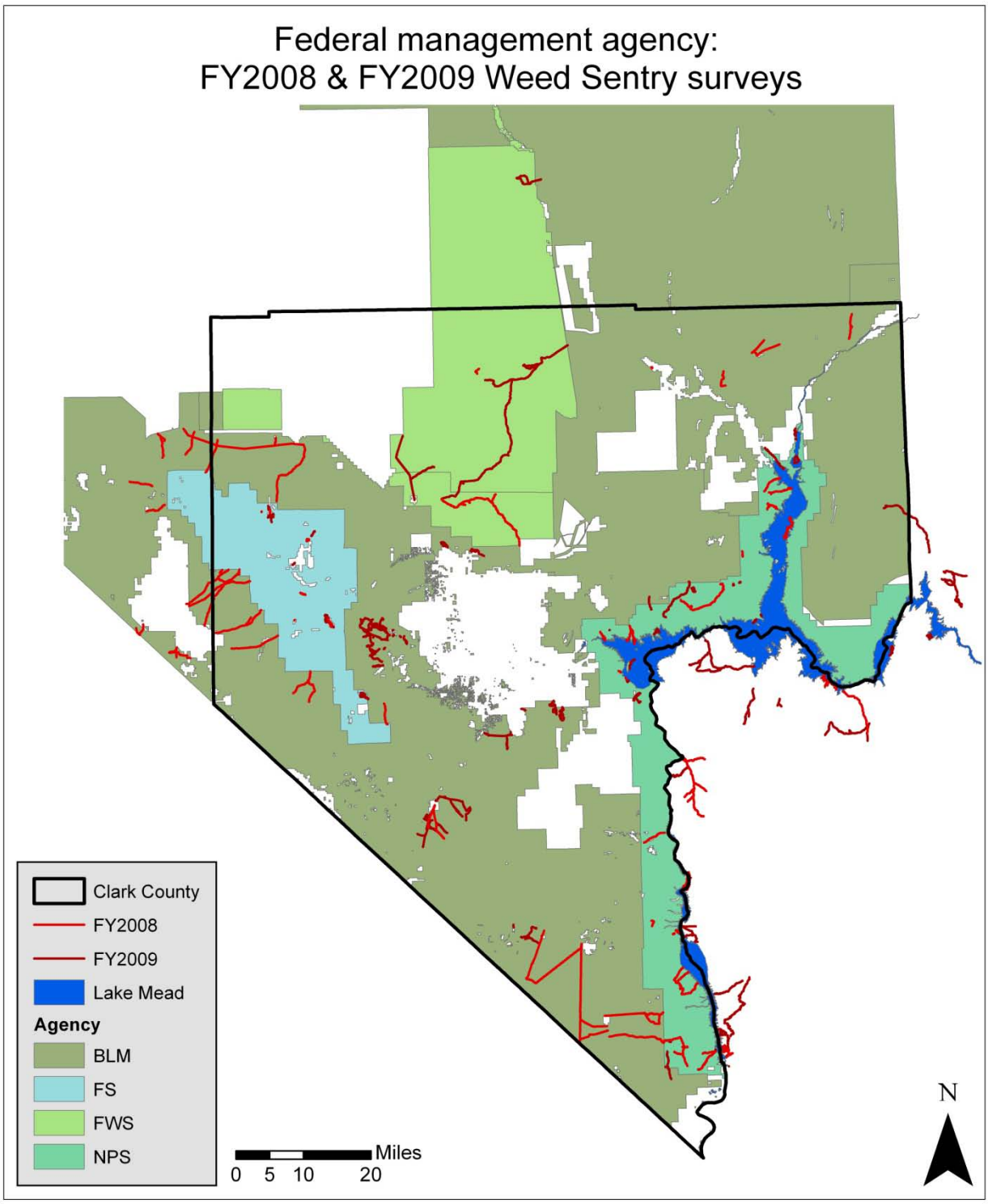


Figure 5. Map of surveys conducted during FY2008 & FY2009 within each federal land management agency. Bureau of Land Management (BLM), Forest Service (FS), Fish and Wildlife Service (USFWS) and National Park Service (NPS).

Table 6. Number of individuals of each exotic species that were controlled on BLM lands during 2008 and 2009.

Species	Individuals
Brassica tournefortii	150
Bromus diandrus	910
Chorispora tenella	210
Descurainia sophia	199
Halogeton glomeratus	21
Hordeum spp.	237
Malcolmia africana	81
Salsola tragus	48
Sisymbrium altissimum	160
Sisymbrium irio	170
Sisymbrium orientale	6
Solanum elaegnifolium	1
Tribulus terrestris	2,900
Triticum aestivum	2
Total	5,095

Table 7. Number of individuals of each exotic species that were controlled on Lake Mead NRA lands during 2008 and 2009.

Species	Individuals
Avena fatua	834
Brassica tournefortii	42,441
Bromus diandrus	332
Hirschfeldia incana	1
Hordeum spp.	104
Parkinsonia aculeata	5
Pennisetum setaceum	57
Malcolmia africana	704
Melilotus indica	5
Sisymbrium altissimum	4
Sisymbrium irio	173
Sisymbrium orientale	10
Tamarix ramosissima	18
Tribulus terrestris	102
Total	44,790

Table 8. Number of individuals of each exotic species that were controlled on USFS lands during 2008 and 2009.

Species	Individuals
Medicago sativa	1
Melilotus alba	1
Melilotus officinalis	75
Salsola tragus	67
Sonchus asper	14
Tribulus terrestris	14,113
Verbascum thapsus	1
Total	14,272

Table 9. Number of individuals of each species controlled within the USFWS boundaries during 2008 and 2009.

Species	Individuals
Brassica tournefortii	24
Chorispora tenella	4
Hordeum murinum	43
Malcolmia africana	1,106
Salsola tragus	20
Sisymbrium irio	7
Tamarix ramosissima	1
Tribulus terrestris	20
Total	1,225

Conservation management categories

During 2008 and 2009, seventy-two percent of Weed Sentry survey miles were conducted within designated Clark County Multiple Habitat Conservation Plan conservation management categories. Of these, more than fifty-eight percent of survey miles were within intensively managed areas. (See table 10 and figure 6).

Table 10. Miles and acres surveyed within each MSHCP management category during 2008 and 2009. Designations include: intensively managed areas (IMA), less intensively managed areas (LIMA), multiple use management areas (MUMA) and unmanaged areas (UMA).

Category	Miles	Acres
IMA	342	2,599
LIMA	65	432
MUMA	158	1,137
UMA	22	158

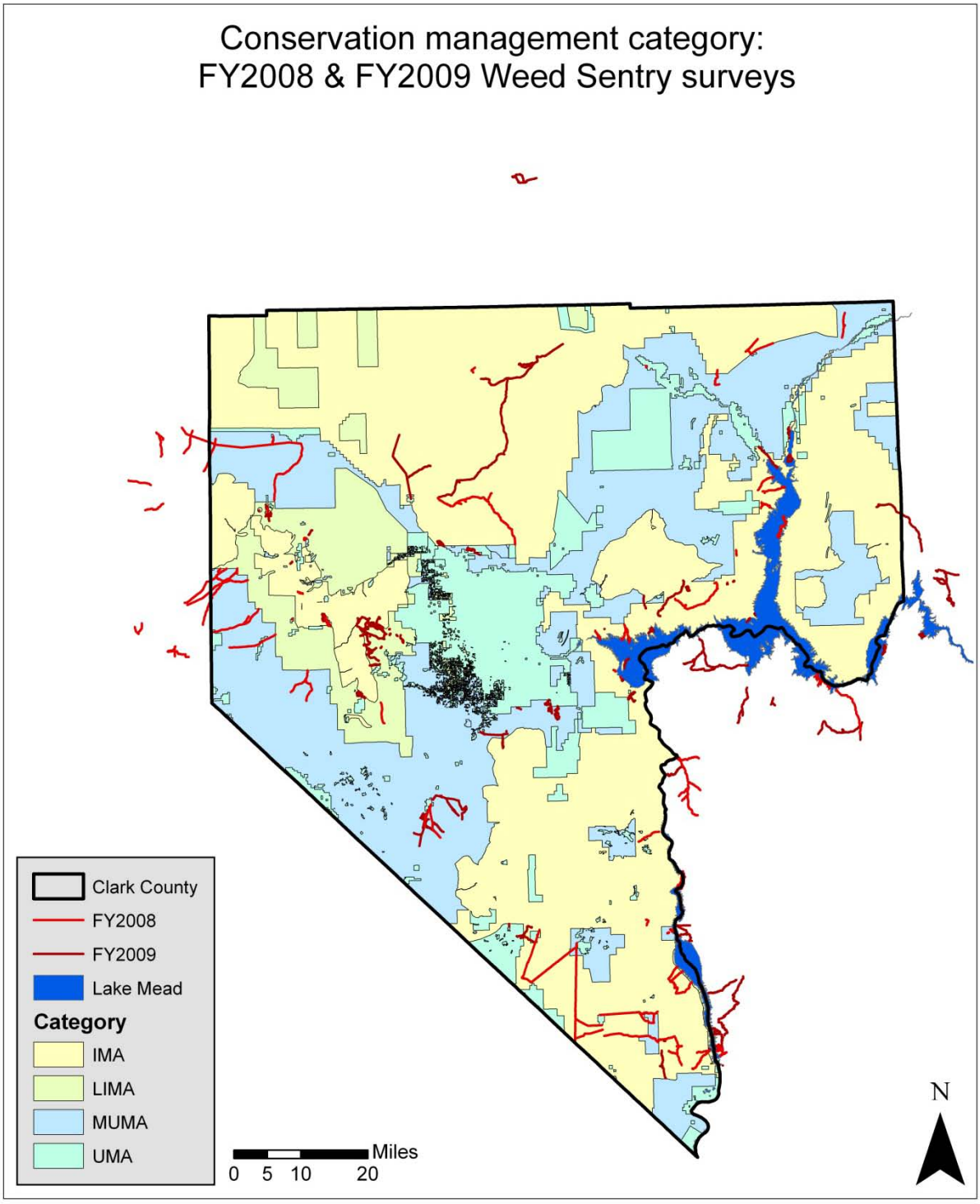


Figure 6. Map of surveys conducted during FY2008 & FY2009 within Clark County management categories as determined by the Multiple Species Habitat Conservation Plan.

Clark County ecosystems

The Clark County Multiple Species Habitat Conservation Plan has divided the county into 10 ecosystems, 9 of which have had at least one mile surveyed during the biennium. (See table 11, figure 7). Weed Sentry surveying did not occur in the ecosystem designated "alpine". According to the Plan, the majority of Clark County, more than 3 million acres, is composed of Mojave desert scrub. Weed sentry surveyed more than 2,000 acres of Mojave desert scrub, more than 1,000 acres of blackbrush ecosystem, and more than 100 acres of pinyon-juniper, sagebrush and salt desert scrub.

Table 11. Miles and acres surveyed by Weed Sentry within each Clark County ecosystem during 2008 and 2009, along with the total acres each ecosystem occupies.

Ecosystem	Miles	Acres	Tot acres*
Blackbrush	144	1,074	824,700
Bristlecone pine	2	10	15,800
Desert aquatic	5	39	16,900
Mesquite/Catclaw	8	55	21,700
Mixed conifer	2	9	56,400
Mojave desert scrub	319	2,343	3,273,100
Pinyon-juniper	42	306	277,800
Sagebrush	17	137	134,600
Salt desert scrub	23	157	190,700

*As stated in Clark County Multiple Species Habitat Conservation Plan and Environmental Impact Statement (09/00)

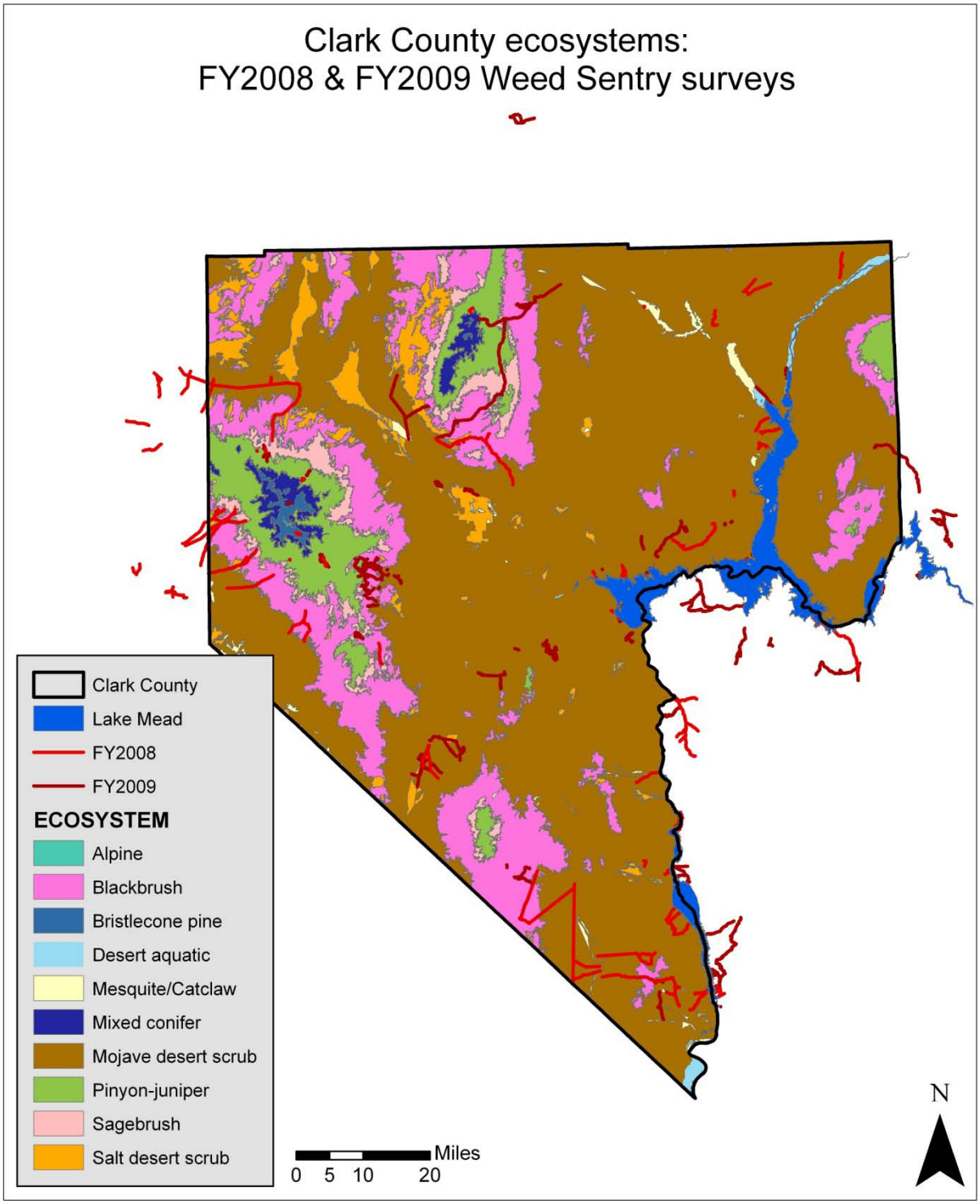


Figure 7. Map of surveys conducted during FY2008 & FY2009 within generalized Clark County ecosystems as designated by the Multiple Species Habitat Conservation Plan.

EVALUATION/ DISCUSSION OF RESULTS

Specific objectives of Weed Sentry are to: (1) identify and document the presence of new exotic invasive plant species; (2) document targeted incipient populations of weeds in Clark County or vectors outside of Clark County and determine their distribution; and (3) control incipient weed populations when feasible and prioritize areas for more extensive control efforts.

Weed Sentry has been conducting surveys since 2004. Dr. Elizabeth Powell originally developed the concept of the early detection, rapid response weed survey project, and Josh Hoines assisted with shaping initial survey protocols. Although this document is a final report for the current 2008-2009 project, the discussion of results is based on the compiled information that has been gathered over the past six years, from 2004 to 2009. Analyses will not consider year to year weed population differences, as there are significant confounding factors preventing these comparisons. For example, fluctuations in weed populations are most likely a product of annual precipitation variability and not necessarily indicative of the *eradication* of the weed species. Additionally, surveys were conducted by a variety of individuals over the years, and individual records could be influenced by the surveyer's experience-level and attention to detail. Trends will be explored by considering the complete (i.e. 2004-2009) distribution of exotic plant species in tandem with geographical features. Considering the spatial distribution of recorded infestations will enable us to hypothesize the potential extent of invasion by particular species and families. In addition, considering the ecosystem where an exotic predominately is recorded can suggest preferred-habitat characteristics. This will suggest to managers where certain weed species may establish in the future, and advise which species are not yet wide-spread and could be controlled with minimal resource expenditures.

Over the course of the Weed Sentry project, the approach used by the team leads to record weed presence evolved. In addition, occurrence records for certain species are deflated due to team-lead survey approaches, and land manager data requests. For example, *Salsola tragus* is a wide-spread weed, and over time, NPS and USFWS land managers suggested it was not necessary to continue recording infestations. USFS, which manages higher elevation lands, however, did want the invasive recorded. Then, when the team lead changed halfway through the biennium, recording the presence of *Salsola tragus* resumed. In another example, the presence of *Tamarix ramosissima* was not recorded along Lake Mead (due to its nearly continuous abundance), but at springs and other water features off the lake, members of family Tamariaceae were recorded, and if possible, immediately controlled. These caveats aside, quantifiable analyses of Weed Sentry data and statistical analyses of survey records are not possible nor appropriate with the type of data collected.

County-wide trends

Nearly 16,000 infestation points composing 81 different weed species have been recorded by Weed Sentry during the six-field-season duration of the project. (See table 12). Infestation points represent a *population* of an exotic species, rather than an individual which is shown in the previous tables of the number of exotic individuals controlled. The majority of infestations recorded have been exotic species from the families Brassicaceae (mustards), Asteraceae (daisies) and Poaceae (grasses). (See table 13).

County-wide trends can best be explained when considering the ecosystem each invasive species is predominately distributed in. Weed establishment crosses conservation management category boundaries and agency boundaries, but could possibly be limited by ecosystem conditions such as elevation and moisture levels. (See figure 8).

Bromus tectorum was a top invader; in fact, 24% of weed occurrence records were identified as *Bromus tectorum.* (See figure 9). Recorded occurrences of *Bromus inermis* were restricted to within the Spring Mountains.

Many of the most commonly recorded invaders were of the Brassicaceae Family. (See figures 10 & 11). Each genera had unique distributions through the Weed Sentry project area. *Brassica tournefortii* was most densely recorded along the eastern border of Clark County (within and near Lake Mead NRA). However, this species was also recorded throughout much of the county, and appears to have the ability to grow at higher elevations and in a variety of ecosystems. *Brassica tournefortii* may have the ability to infest much of the county in high densities.

Another mustard, *Descurainia sophia*, was most commonly found in the higher elevation western region (USFS Spring Mountains). *Malcolmia africana* predominately occurred in the northern half of the county, and *Sisymbrium irio* appears nearly evenly distributed throughout the county. (See appendix 1 for more information on *Malcolmia africana* distribution characteristics). *Lepidium latifolium* was only found within Lake Mead NRA near water and is limited by water availability. Another Brassicaceae, *Chorispora tenella* was most commonly found in upper elevations. (See figure 11).

Species within the Fabaceae Family appear to be restricted in their distributions. (See figure 12). Although there were 64 *Parkinsonia aculeata* records and 59 *Melilotus officinalis* records, *Parkinsonia aculeata* was only encountered within Lake Mead NRA (often within established camping areas), and *Melilotus officinalis* was mainly recorded in the Spring Mountains, and within established camping areas with above average water availability within Lake Mead NRA.

Recorded occurrences of Family Arecaceae (the palm family) were restricted to within Lake Mead, and along the Virgin River corridor. (See figure 13). These may have been historically planted, and their removal is currently controversial within the National Park Service.

Fourteen plant species had only one occurrence record. (See figure 14). These species should generally be high priority for control because they are not yet widespread through the county, making control more cost effective and the potential for eradication more likely. Twelve plant species were recorded either 2, 3 or 4 times. (See figure 15). These species also have limited distributions and should be carefully considered for high priority control status.

Table 12. Number of infestation points recorded for each exotic species. *Bromus madritensis*, *Erodium cicutarium*, *Salsola tragus*, *Tamarix ramosissima* were not consistently recorded.

Species	Common name	# Occ.
Brassica tournefortii	Sahara mustard	5,041
Bromus tectorum	cheatgrass	3,748
Malcomia africana	African mustard	1,290
Sisymbrium irio	London rocket	783
Descurainia sophia	herb sophia	527
Tamarix ramosissima	salt cedar	520
Sisymbrium orientale	Indian hedgemustard	432
Bromus trinii	Chilean chess	368
Salsola tragus	Russian thistle	340
Bromus diandrus	ripgut brome	265
Sisymbrium altissimum	tall tumblemustard	256
Pennisetum setaceum	crimson fountaingrass	176
Tamarix aphylla	Athel tamarisk	168
Nicotiana glauca	tree tobacco	161
Marrubium vulgare	horehound	134
Hordeum vulgare	common barley	131
Hordeum murinum	mouse barley	124
Tribulus terrestris	punctureVine	122
Elaeagnus angustifolia	Russian olive	120
Unknown		119
Lepidium latifolium	broadleaved pepperweed	105
Nerium oleander	oleander	94
Taraxacum officinale	dandelion	90
Verbascum thapsus	mullein	82
Bromus madritensis	red brome	76
Parkinsonia aculeata	Jerusalem thorn	64
Melilotus officinalis	yellow sweetclover	59
Washingtonia filifera	California fan palm	53
Ulmus pumila	Siberian elm	52
Agropyron cristatiforme	crested wheatgrass	50
Chenopodium album	lambsquarters	47
Grindelia squarrosa	curlycup gumweed	43
Erodium cicutarium	redstem stork's bill	39
Melilotus alba	white sweetclover	39
Robinia pseudoacacia	black locust	39
Verbena bracteata	bigbract verbena	39
Ranunculus testiculatus	curveseed butterwort	33
Acroptilon repens	Russian knapweed	30
Chorispora tenella	crossflower	24
Solanum elaeagnifolium	silverleaf nightshade	23
Eragrostis cilianensis	stinkgrass	22

Species	Common name	# Occ.
Bromus inermis	smooth brome	19
Centaurea melitensis	Maltese star-thistle	18
Chenopodium berlandieri	pitseed goosefoot	18
Polypogon monspeliensis	rabbitsfoot grass	16
Polygonum aviculare	prostrate knotweed	11
Tragopogon dubius	yellow salsify	11
Phoenix dactylifera	date palm	9
Halogeton glomeratus	saltlover	8
Lolium perenne	perennial ryegrass	8
Arundo donax	giant reed	7
Hirschfeldia incana	shortpod mustard	6
Sonchus asper	spiny sowthistle	6
Triticum aestivum	common wheat	6
Avena fatua	wild oat	5
Sonchus oleraceus	common sowthistle	5
Echinochloa crus-galli	barnyardgrass	4
Melilotus indica	yellow sweetclover	4
Alhagi pseudalhagi	camelthorn	3
Hordeum marinum	seaside barley	3
Medicago sativa	alfalfa	3
Veronica anagallis-aquatica	water speedwell	3
Bassia hyssopifolia	fivehorn smotherweed	2
Lactuca serriola	prickly lettuce	2
Peganum harmala	African rue	2
Plantago major	common plantain	2
Rubus discolor	Himalayan blackberry	2
Sorghum halepense	Johnsongrass	2
Agrostis stolonifera L	creeping bentgrass	1
Amaranthus albus	prostrate pigweed	1
Convolvulus arvensis	field bindweed	1
Cynodon dactylon	Bermudagrass	1
Gnaphalium luteoalbum	Jersey cudweed	1
Malva neglecta	common mallow	1
Malva parviflora	cheeseweed mallow	1
Paspalum dilatatum	dallisgrass	1
Poa annua	annual bluegrass	1
Portulaca oleracea	little hogweed	1
Potamogeton crispus	curly pondweed	1
Solanum rostratum	buffalobur nightshade	1
Sorghum sp.	sorghum	1
Vitex agnus-castus	lilac chastetree	1
TOTAL		15,928

Table 13. Number of exotic species within each plant family.

# of exotic species	Family
1	Amaranthaceae
1	Apocynaceae
2	Arecaceae
11	Asteraceae
8	Brassicaceae
5	Chenopodiaceae
1	Convolvulaceae
1	Elaeagnaceae
7	Fabaceae
1	Geraniaceae
1	Lamiaceae
2	Malvaceae
2	Plantaginaceae
23	Poaceae
2	Polygonaceae
1	Portulacaceae
1	Potamogetonaceae
1	Ranunculaceae
1	Rosaceae
2	Scrophulariaceae
3	Solanaceae
2	Tamricaceae
1	Ulmaceae
2	Verbenaceae
2	Zygophyllaceae

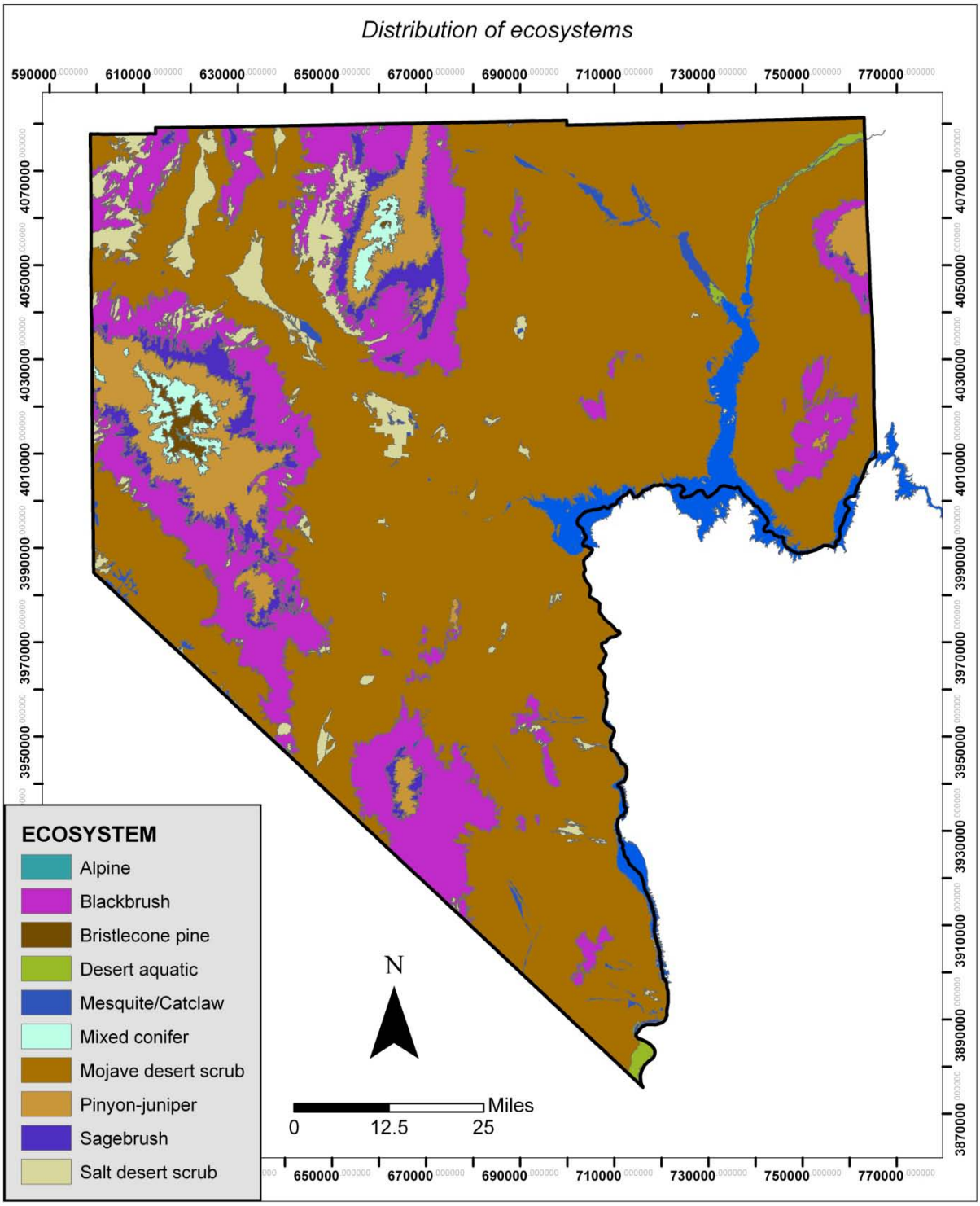


Figure 8. Distribution of ecosystems within Clark County, Nevada, USA.

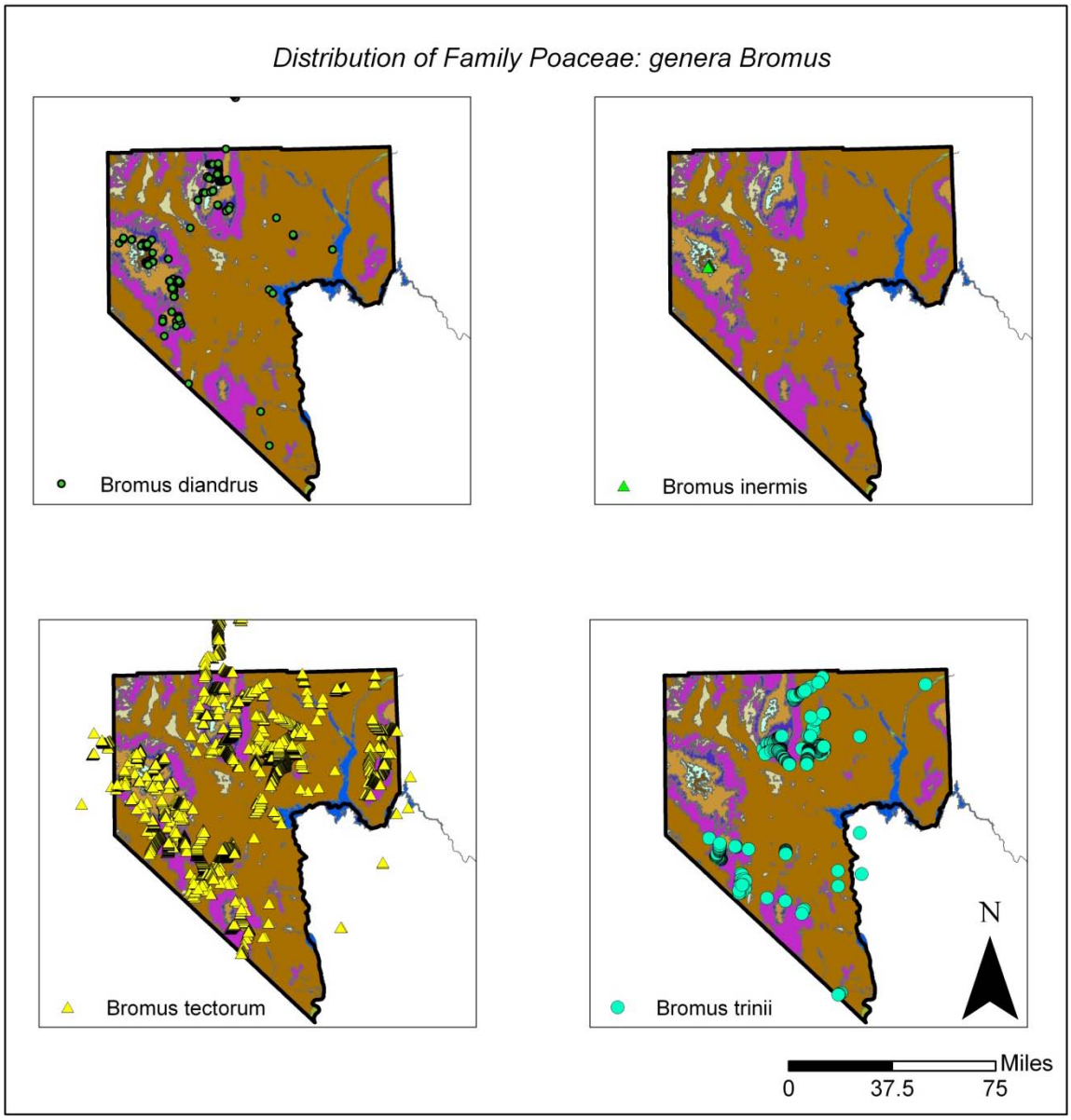


Figure 9. Distribution of four species of *Bromus* within the Poaceae Family; *Bromus diandrus, Bromus inermis, Bromus tectorum* and *Bromus trinii. Bromus madritensis* ssp. rubens is not shown because it was not consistently recorded throughout the Weed Sentry project surveys due to how common it is.

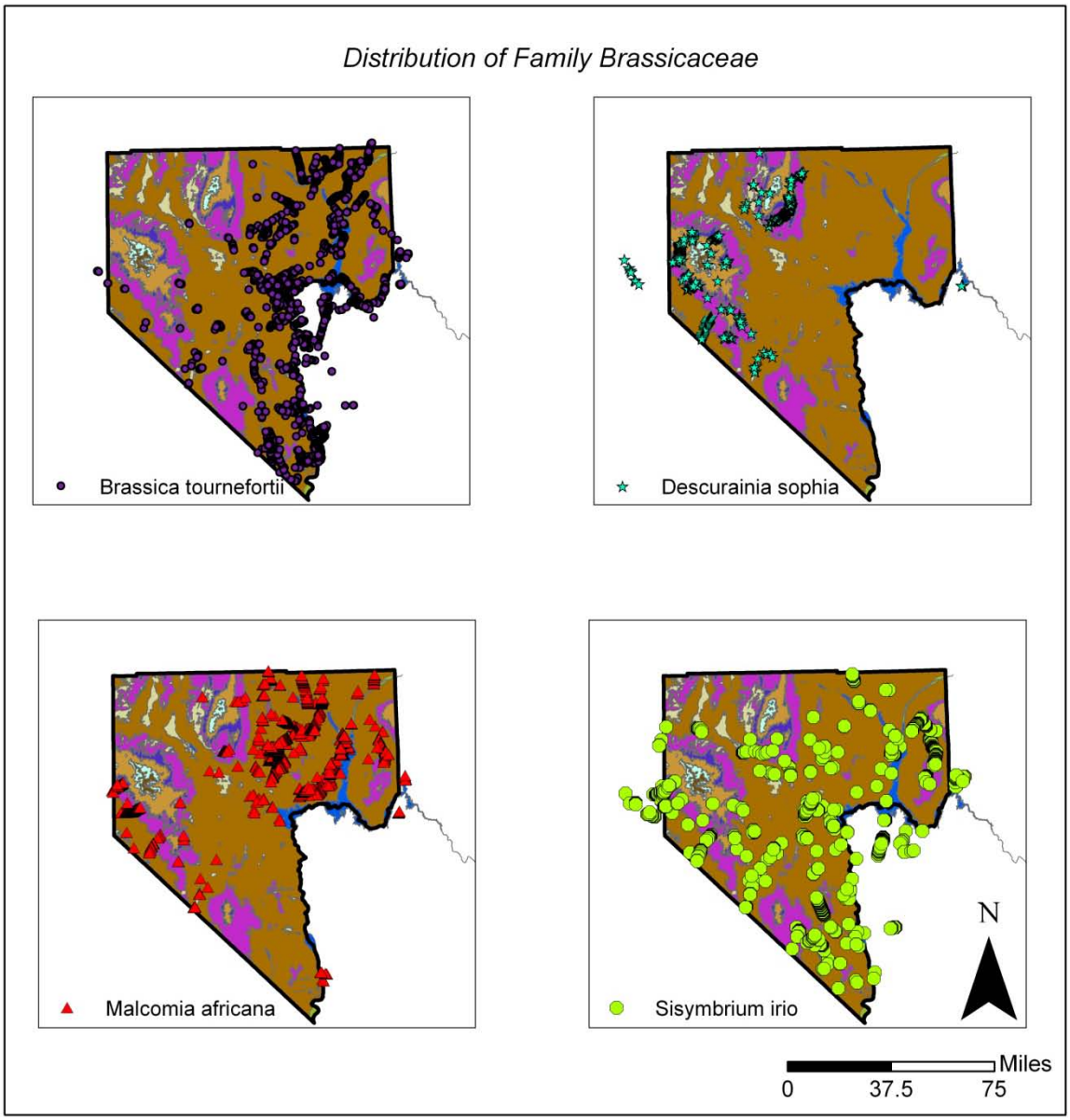


Figure 10. Map of occurrence of top invaders of Family Brassicaceae; *Brassica tourneforii, Descurainia sophia, Malcolmia africana* and *Sisymbrium irio*.

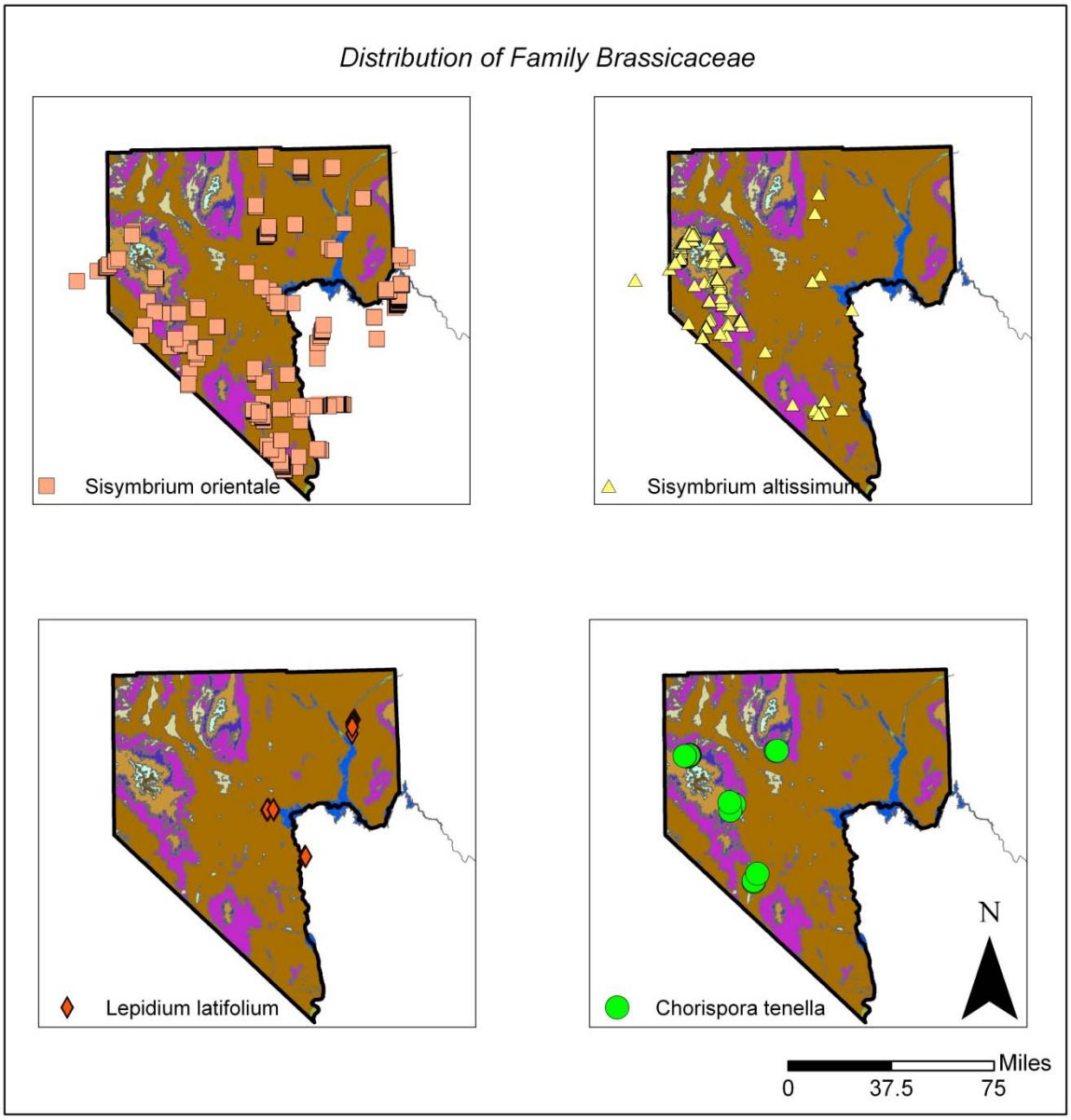


Figure 11. Map of occurrences of less frequently recorded species within the Brassicaceae family.

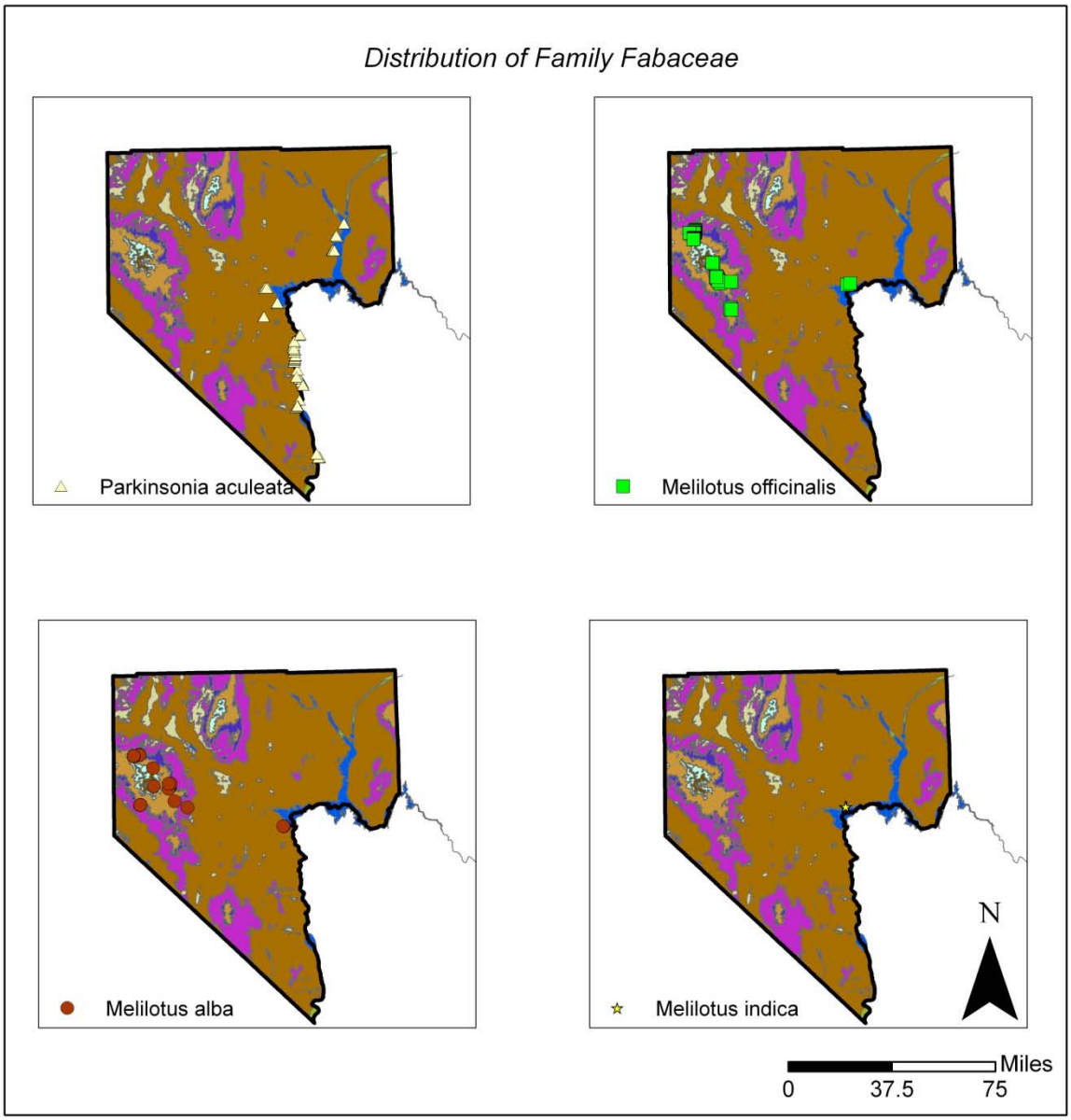


Figure 12. Distribution of select Fabaceae families throughout Clark County. *Parkinsonia aculeata, Melilotus officinalis, Melilotus alba, and Melilotus indica* were the most frequently recorded Fabaceae species. Only four infestations of *M. indica* were recorded, all in the Lake Mead Callville Bay area. These may have been a different *Melilotus* as specimens were too immature to make a positive identification.

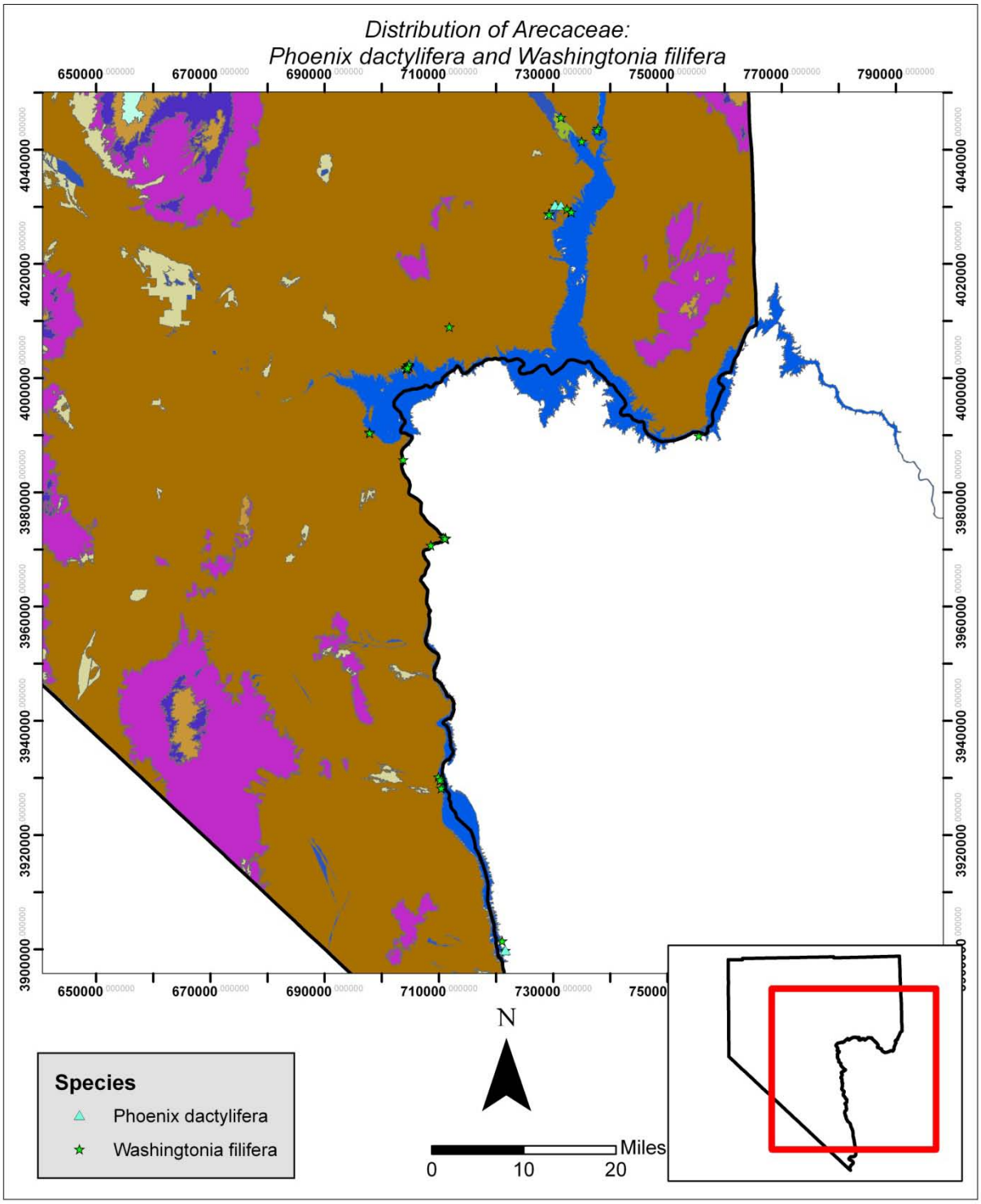


Figure 13. Distribution of *Phoenix dactylifera* and *Washingtonia filifera*. These Arecaceae were only recorded on NPS lands.

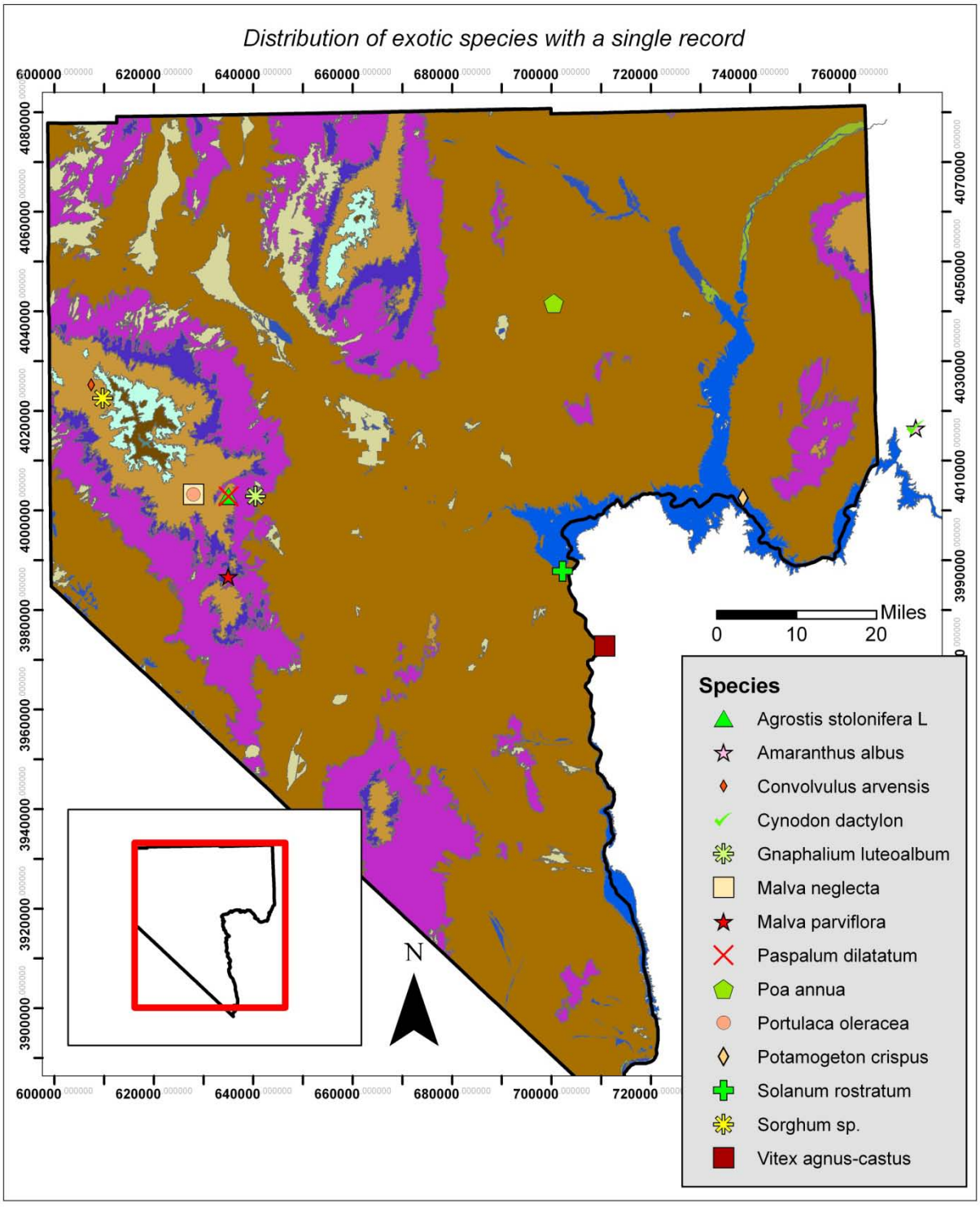


Figure 14. Locations of the fourteen species that were only recorded a single time.

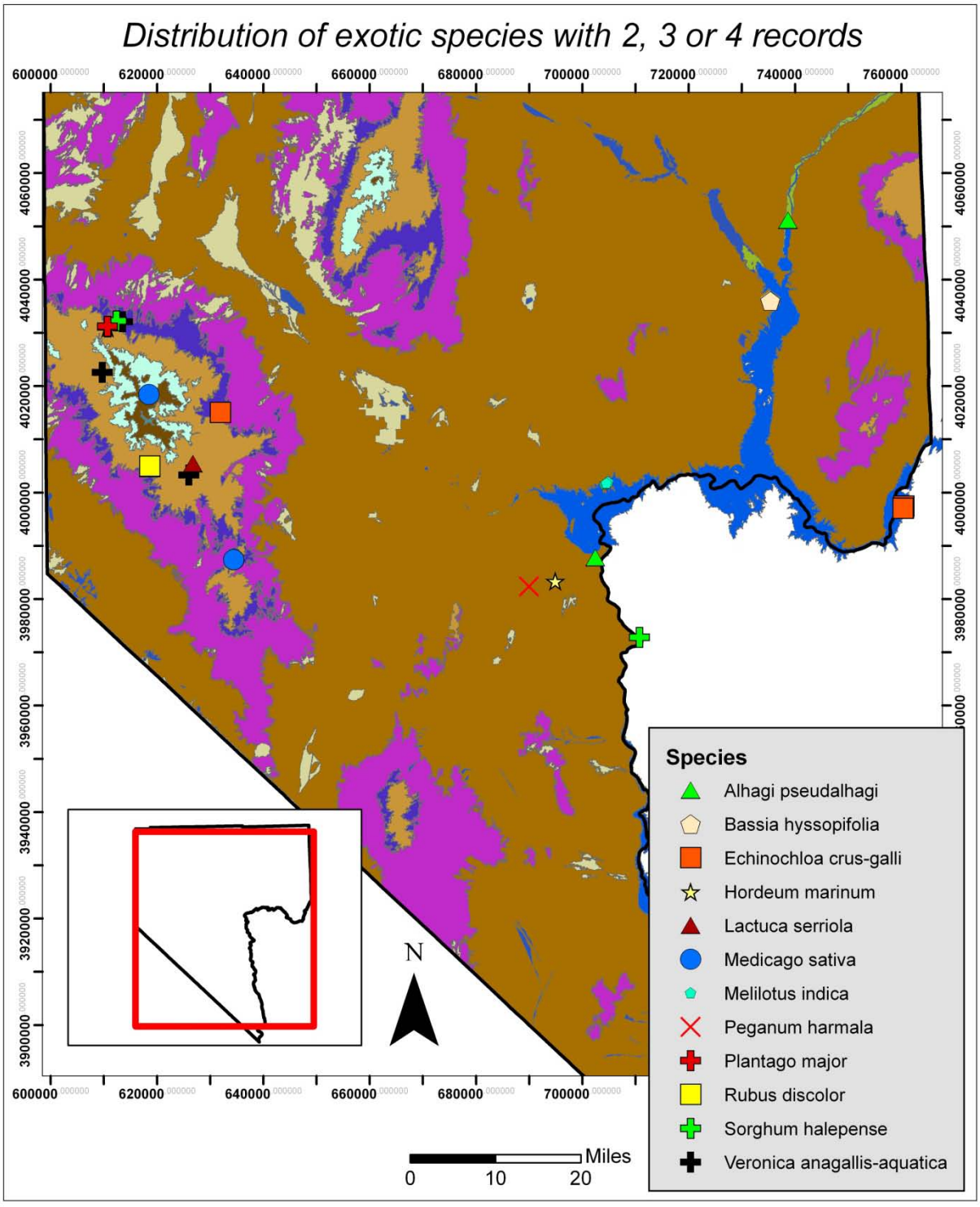


Figure 15. Locations of the twelve species that were recorded 2, 3, or 4 times.

Federal management agency

Assisting federal public land managers within Clark County with pro-active weed detection and control has required periodic re-surveying of certain federal lands. Each year, surveys were conducted on lands managed by each of the four management agencies (BLM, NPS, USFS, USFWS). (See figure 16).

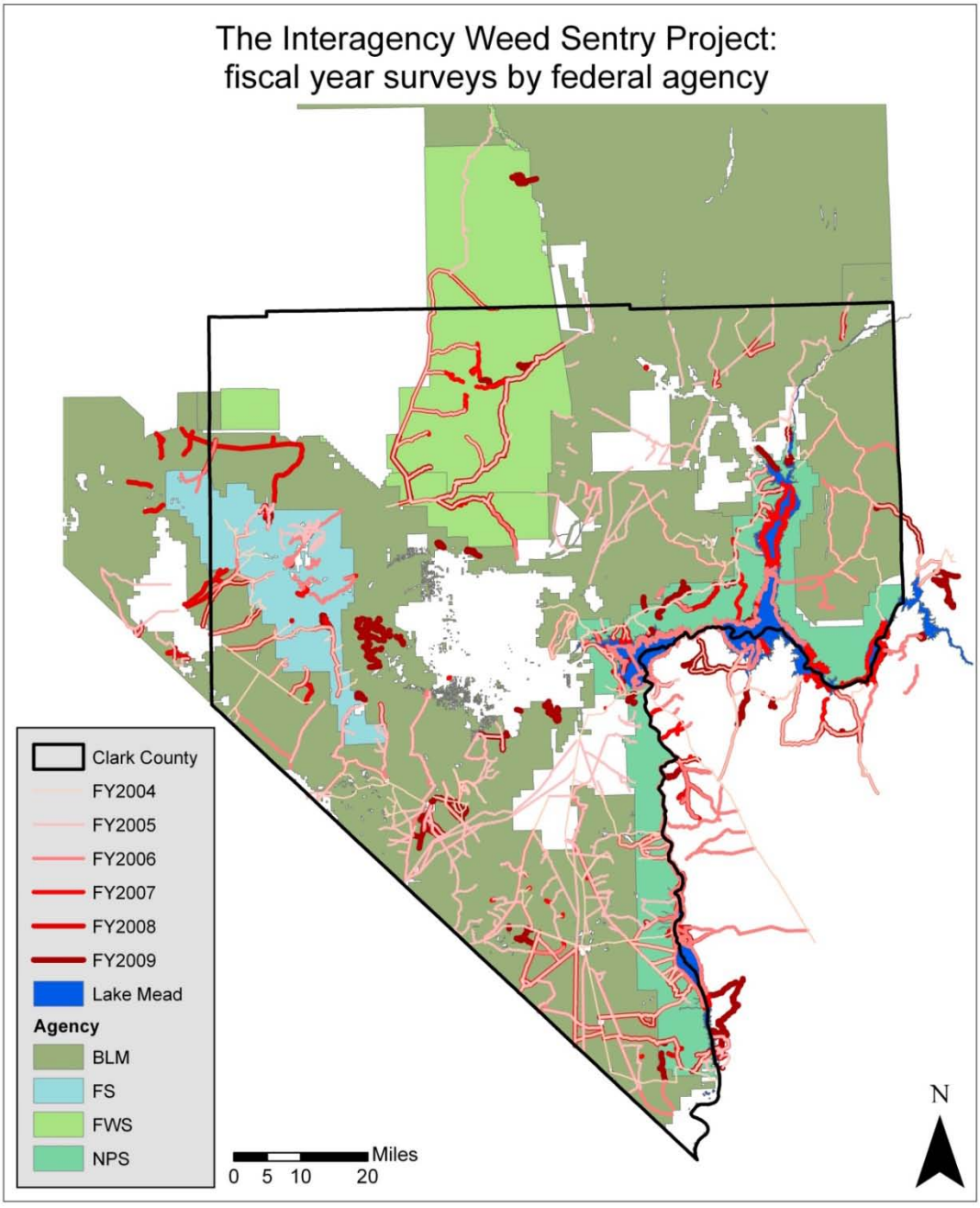


Figure 16. Map of survey lines (by fiscal year) indicating areas which were surveyed on each management agency's land.

Trends in BLM lands

More than 7,000 weed infestation points composed of 43 exotic plant species have been recorded on BLM lands from 2004-2009. (See table 14 and figures 17 – 20). Some of areas were surveyed multiple times over the course of six years. *Bromus tectorum* and *Brassica tournefortii* infestation points have been the most frequently recorded exotics, with each being recorded more than 2,000 times. Controlling these species is going to require extensive research and novel approaches.

Exotic species that compose few of the infestation points on BLM lands should be carefully considered for control efforts. These species may have the potential to be controlled with little investment of resources, and if not controlled, may be up and coming noxious weeds. These species with just 1-2 recorded infestation points include: *Agrostis stolonifera, Alhagi pseudalhagi, Avena fatua, Gnaphalium luteoalbum, Hirschfeldia incana, Lolium perenne, Melilotus officinalis, Parkinsonia aculeata, Paspalum dilatatum, Peganum harmala, Poa annua, Ranunculus testiculatus* and *Taraxacum officinale.*

The BLM has incorporated the aforementioned information into Red Rock NCA treatment plans for 2009-2011 to address the infestations reported at Willow Springs, Pine Creek, Calico Basin Drive, parking areas, and trails. From the evidence submitted in the Weed Sentry reports, managers have seen the need for consistent action, and have increased commitment for treatments of weeds and incorporating more monitoring as a routine part of program duties (Nora Caplette, personal communication).

Table 14. Species identity and number of infestation points recorded on BLM lands from 2004-2009. *Erodium cicutarium* and *Salsola tragus* were not consistently recorded throughout the Weed Sentry project; occurrence numbers of these species are deflated.

Species	Total infestation
Acroptilon repens	20
Agropyron cristatiforme	2
Agrostis stolonifera	1
Alhagi pseudalhagi	1
Arundo donax	3
Avena fatua	2
Brassica tournefortii	2,021
Bromus diandrus	55
Bromus tectorum	2,049
Bromus trinii	199
Centaurea melitensis	5
Chorispora tenella	6
Descurainia sophia	154
Erodium cicutarium	37
Gnaphalium luteoalbum	1
Grindelia squarrosa	24
Halogeton glomeratus	8
Hirschfeldia incana	1
Hordeum spp	97
Hordeum vulgare	127
Lepidium latifolium	16
Lolium perenne	1

Species	Total infestation
Malcolmia africana	863
Marrubium vulgare	24
Melilotus alba	6
Melilotus officinalis	1
Parkinsonia aculeata	2
Paspalum dilatatum	1
Peganum harmala	2
Pennisetum setaceum	5
Poa annua	1
Polypogon monspeliensis	4
Ranunculus testiculatus	1
Salsola tragus	179
Sisymbrium altissimum	100
Sisymbrium irio	570
Sisymbrium orientale	306
Solanum elaeagnifolium	22
Tamarix aphylla	4
Tamarix ramosissima	298
Taraxacum officiniale	2
Tribulus terrestris	19
Triticum aestivum	6
Unknown	18
TOTAL	7,264

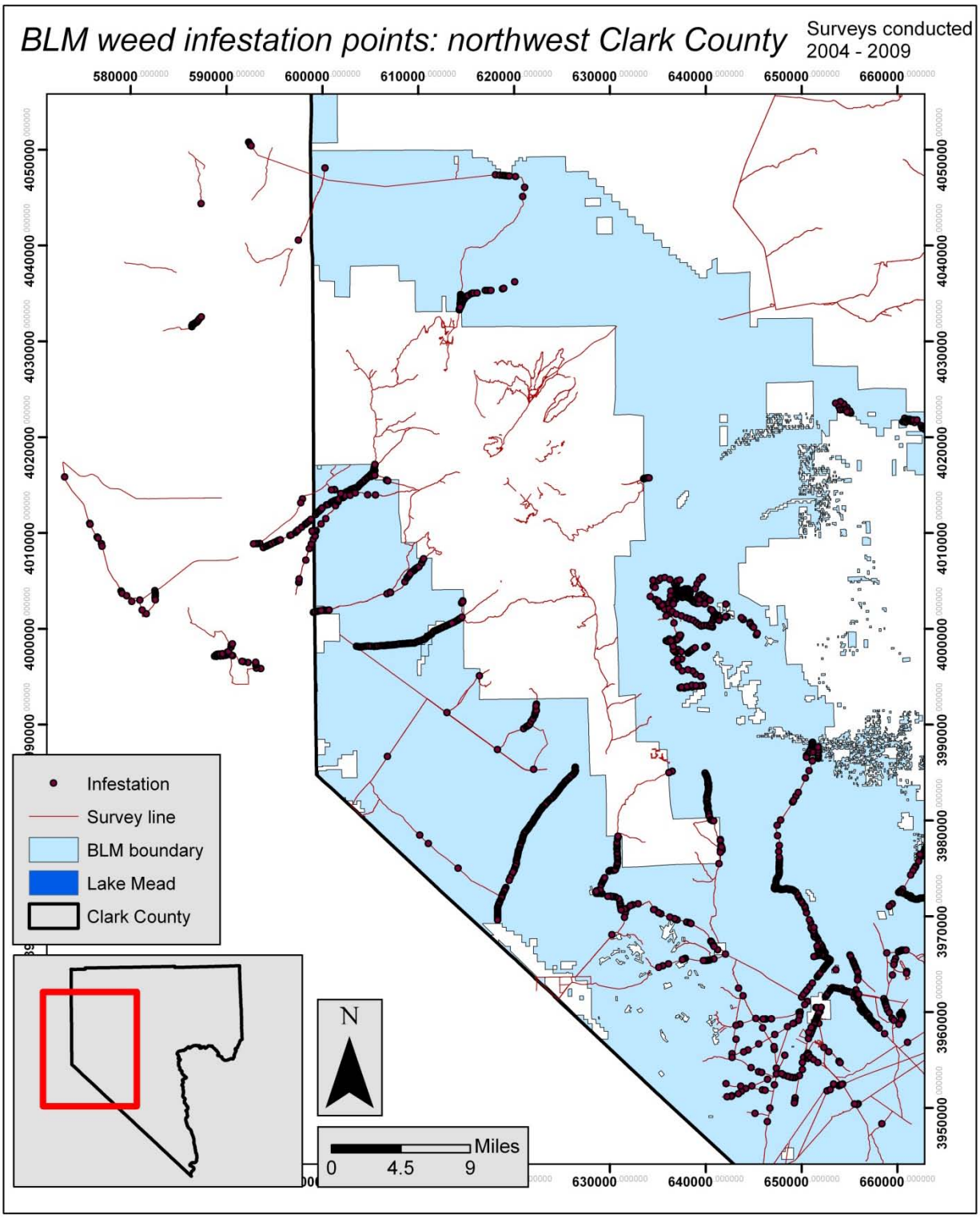


Figure 17. Distribution of infestation points on BLM lands in the northwestern survey area. Survey lines with no infestation points indicate there were no weed species detected in those BLM areas.

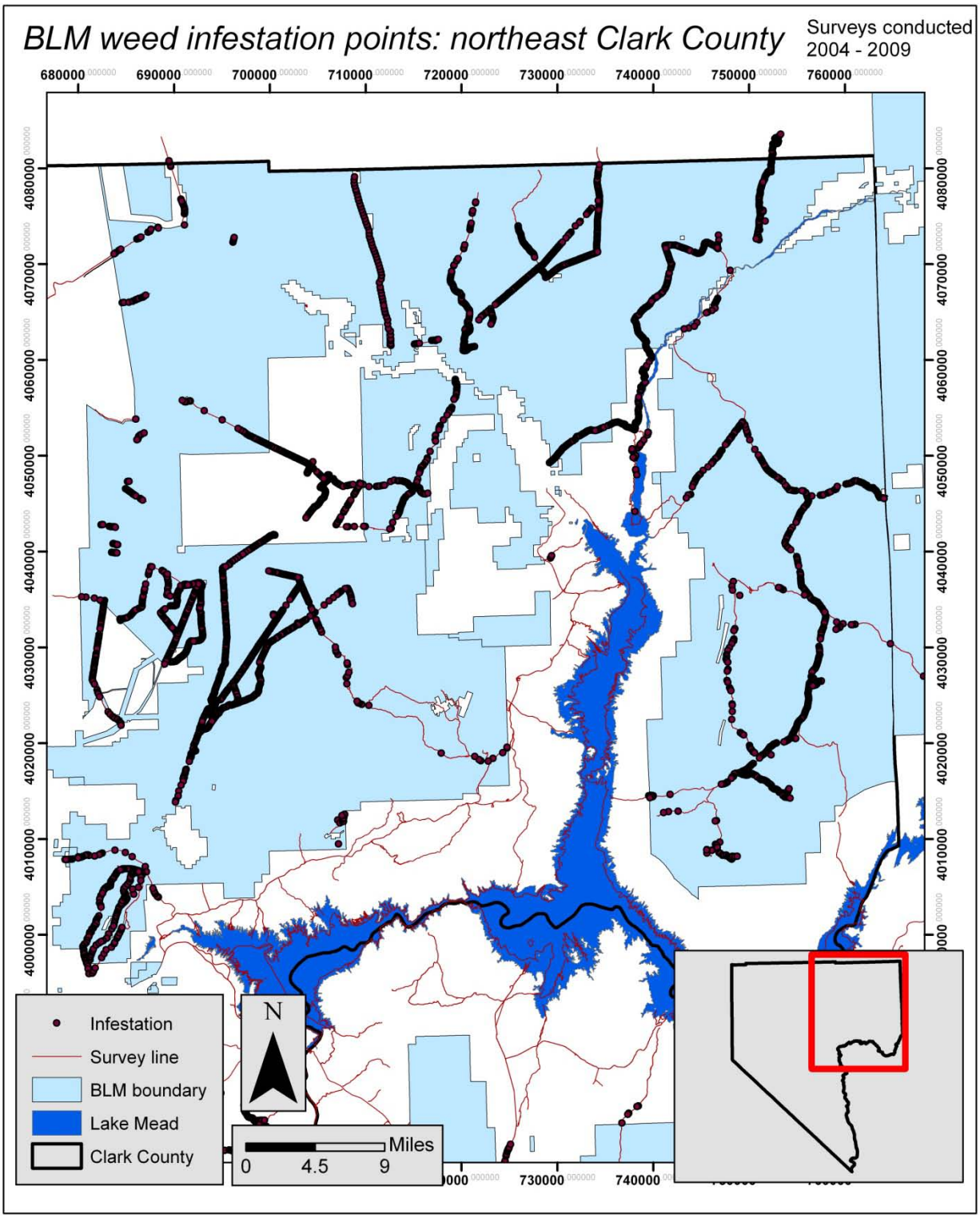


Figure 18. Distribution of infestation points on BLM lands in the northeastern survey area. Survey lines with no infestation points indicate there were no weed species detected in those BLM areas.

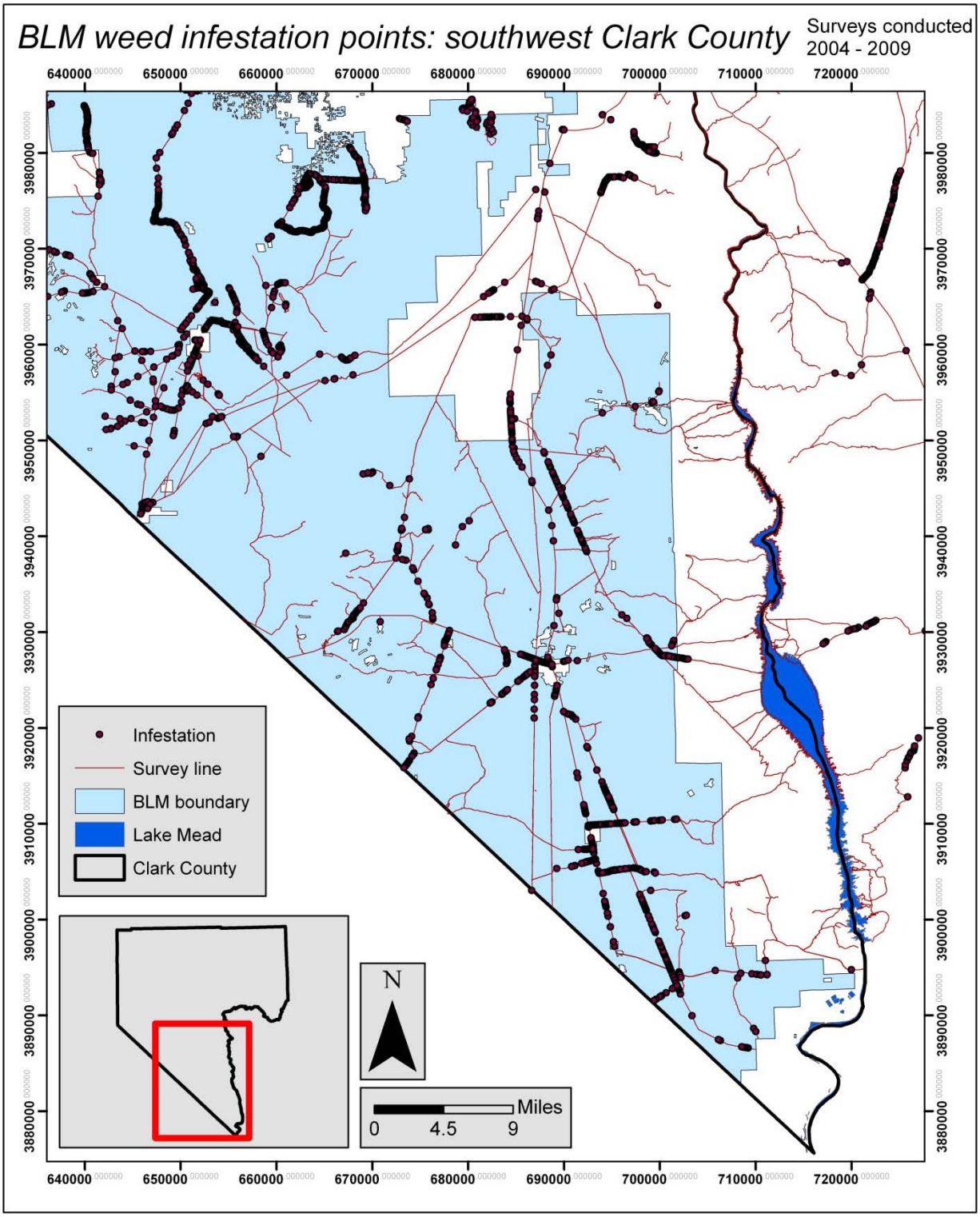


Figure 19. Distribution of infestation points on BLM lands in the southwestern survey area. Survey lines with no infestation points indicate there were no weed species detected in those BLM areas.

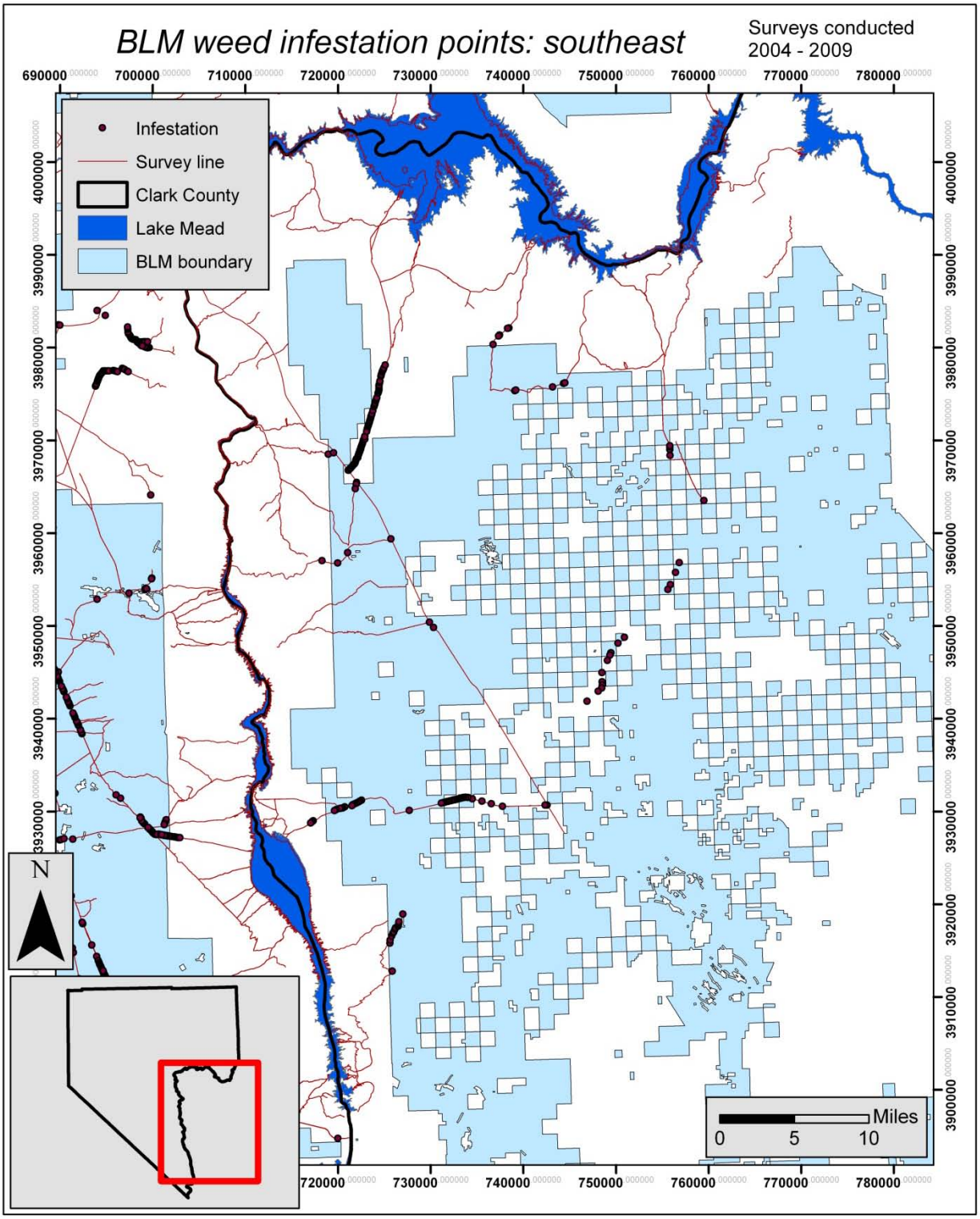


Figure 20. Distribution of infestation points on BLM lands in the southeastern survey area. Survey lines with no infestation points indicate there were no weed species detected in those BLM areas.

Trends in NPS lands

Nearly 5,000 infestation points composing 43 exotic species have been recorded on NPS lands in Clark County, Nevada and surrounding counties and states. (See table 15 and figures 21 – 23. Note that infestations that appear to be in water are actually located along the receded shoreline or on islands.) *Brassica tournefortii* had by far the greatest number of recorded infestation points with over 3,000 records, composing 61% of the records collected in NPS lands. Another Brassicaceae, *Malcolmia africana* had the next greatest number of infestation point records, with 385 records. Palms, *Phoenix dactylifera* and *Washingtonia filifera* were only recorded on NPS lands. Many of these are believed to be purposefully planted and can not be controlled without prior review and Cultural Resource approval. (See figure 13).

Alhagi pseudalhagi, Amaranthus albus, Arundo donax, Avena fatua, Bassia hyssopifolia, Bromus trinii, Cynodon dactylon, Marrubium vulgare, Melilotus officinalis, Potamogeton crispus, Sisymbrium altissimum, Solanum elaegnifolium, Solanum rostratum, Sonchus asper, and *Sorghum halepense* had two or fewer recorded infestation points on NPS lands. The Weed Sentry recommended that these species should be carefully considered for further control efforts. It is the practice of the NPS Weed Manager to consider park-designated priority levels for weed species, and aforementioned species that are determined "high priority" will be controlled immediately upon being reported (Carrie Norman, personal communication).

Table 15. Species identity and number of infestation points recorded on NPS lands from 2004-2009. Due to their prevalence, *Bromus madritensis, Erodium cicutarium, Salsola tragus* and *Tamarix ramosissima* were not consistently recorded. Thus, numbers for these four species are deflated.

Species	Total infestation
Alhagi pseudalhagi	2
Amaranthus albus	1
Arundo donax	2
Avena fatua	2
Bassia hyssopifolia	2
Brassica tournefortii	3,009
Bromus diandrus	6
Bromus madritensis	10
Bromus tectorum	22
Bromus trinii	2
Centaurea melitensis	11
Cynodon dactylon	1
Descurainia sophia	4
Echinochloa crus-galli	3
Erodium cicutarium	2
Hirschfelda incana	5
Hordeum spp.	21
Lepidium latifolium	89
Malcolmia africana	385
Marrubium vulgare	2
Melilotus alba	4
Melilotus indica	4

Species	Total infestation
Melilotus officinalis	2
Nerium oleander	94
Nicotiana glauca	161
Parkinsonia aculeata	62
Pennisetum setaceum	171
Phoenix dactylifera	9
Polypogon monspeliensis	7
Potamogeton crispus	1
Salsola tragus	52
Sisymbrium altissimum	1
Sisymbrium irio	186
Sisymbrium orientale	116
Solanum elaegnifolium	1
Solanum rostratum	1
Sonchus asper	1
Sonchus oleraceus	3
Sorghum halepense	1
Tamarix aphylla	164
Tamarix ramosissima	207
Tribulus terrestris	16
Unknown	12
Washingtonia filifera	53
TOTAL	4,910

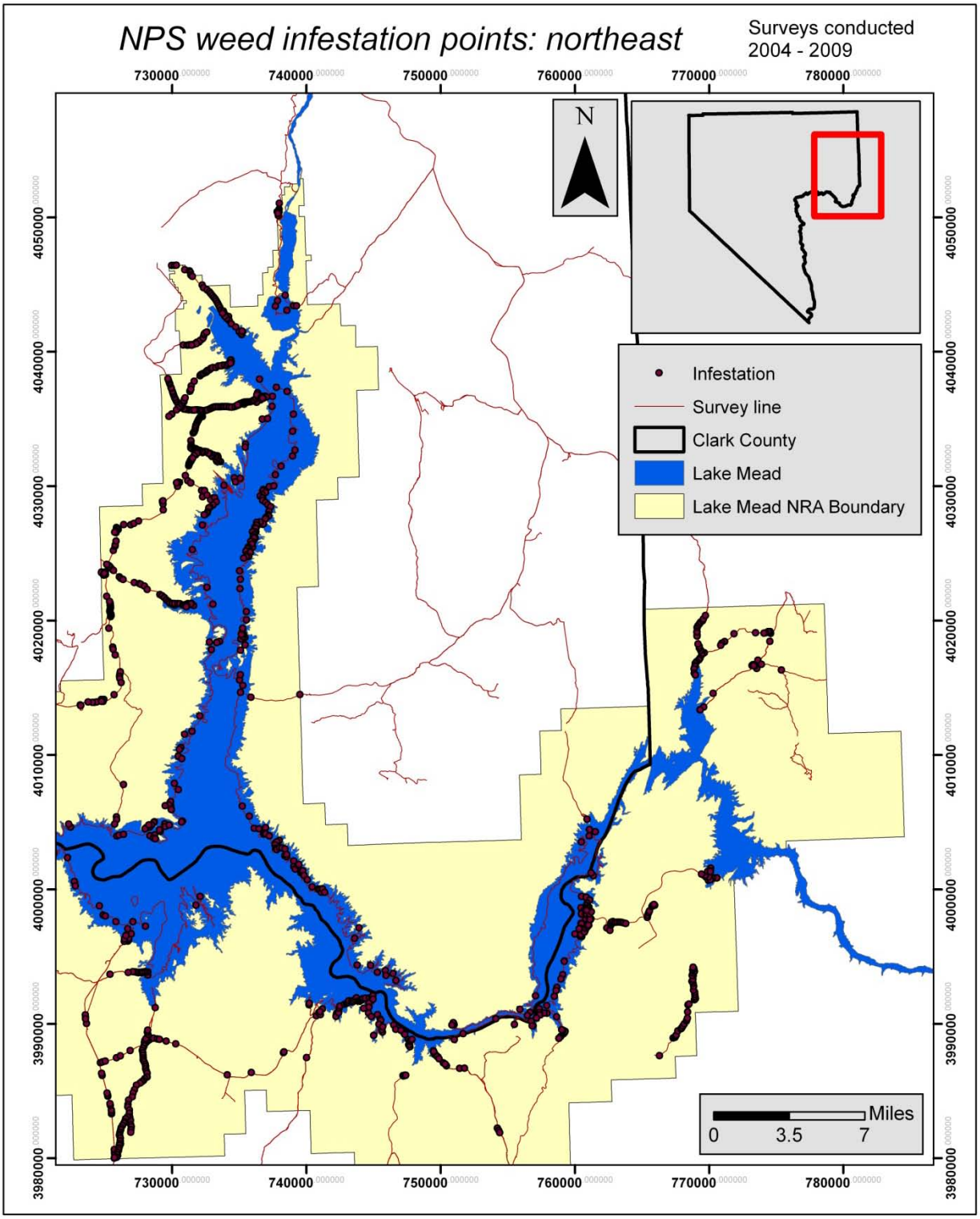


Figure 21. Distribution of infestation points on NPS lands in the northeastern survey area.

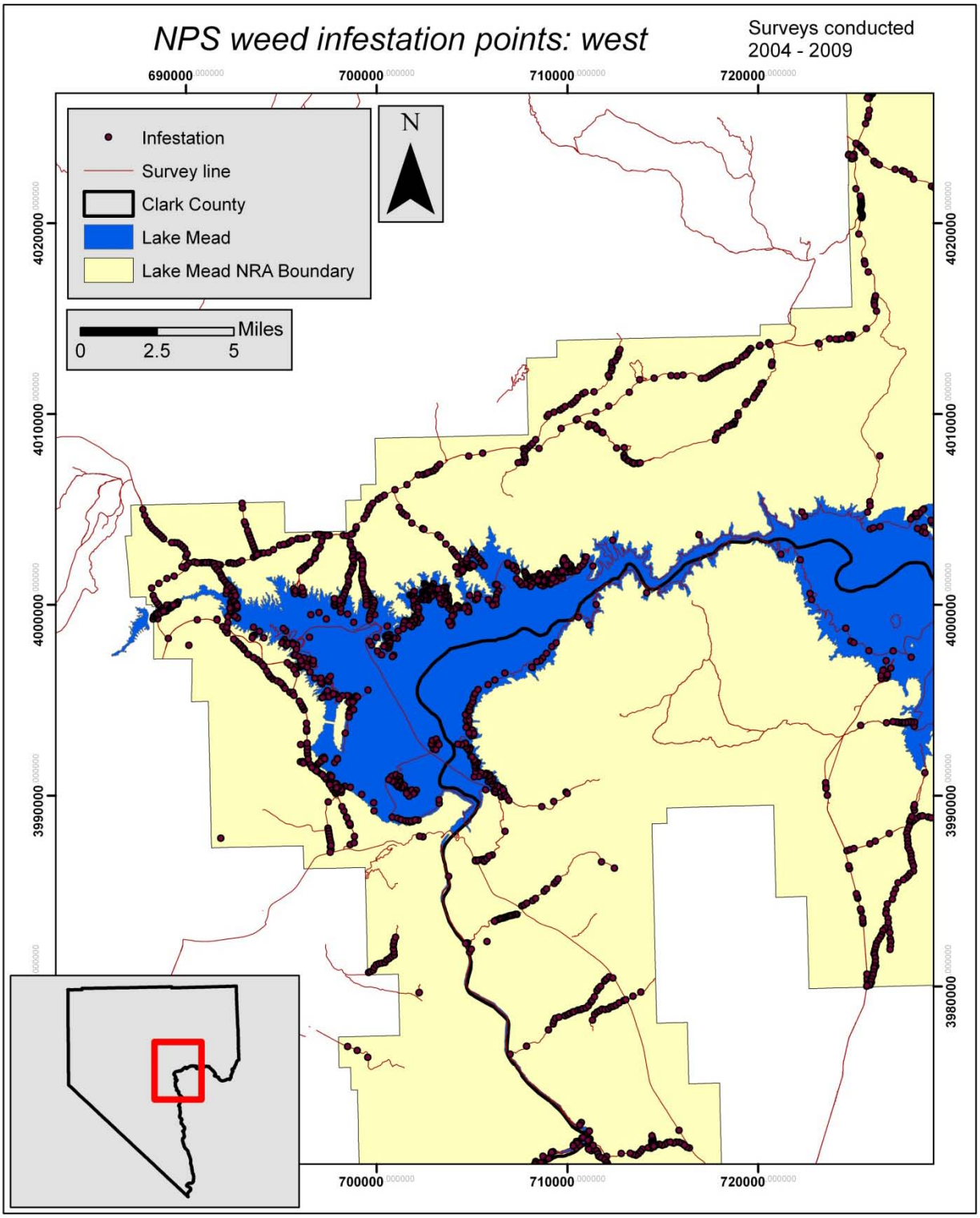


Figure 22. Distribution of infestation points on NPS lands in the western survey area.

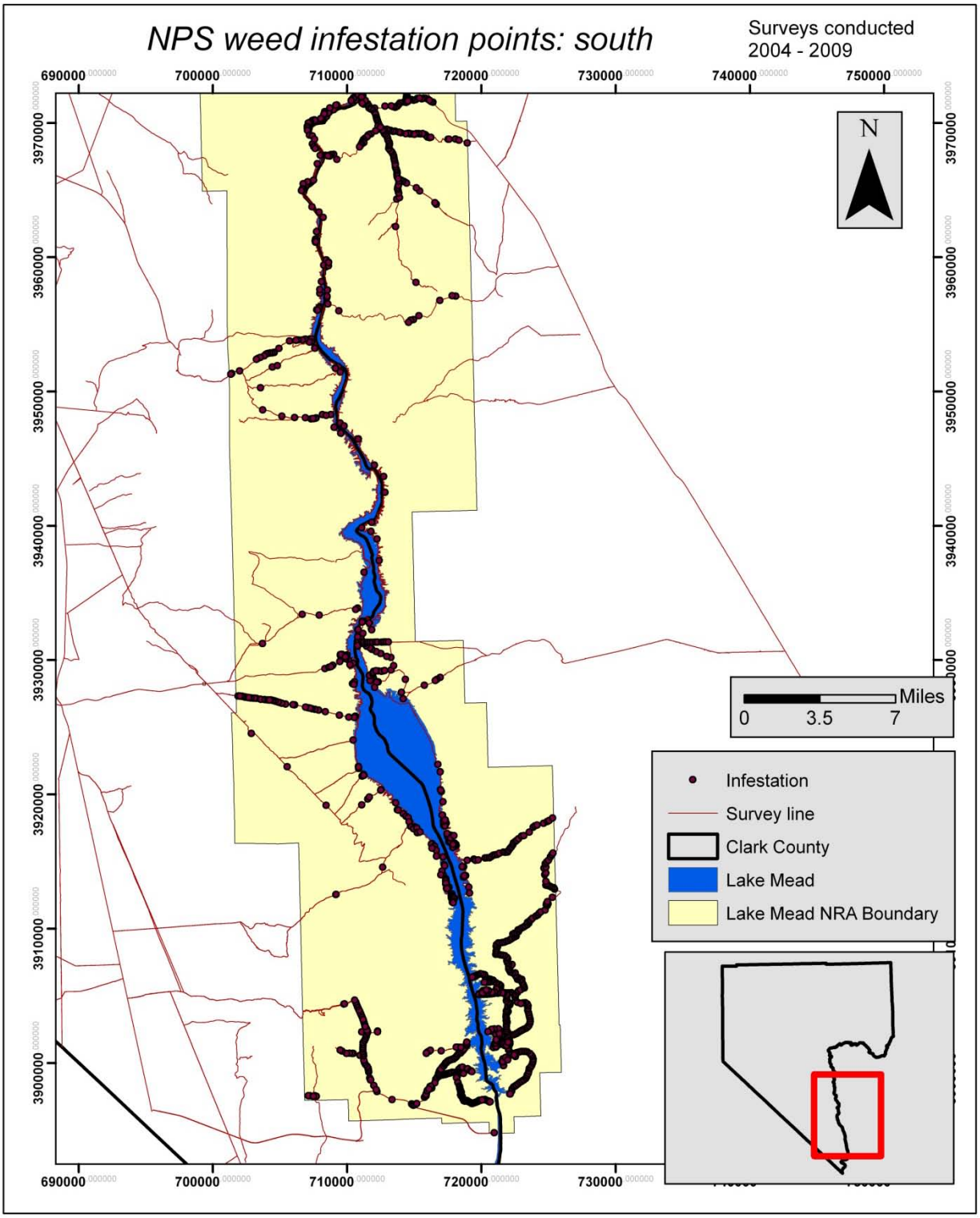


Figure 23. Distribution of infestation points on NPS lands in the southern survey area.

Trends in USFS lands

From 2004 to 2009, 1,847 infestations composing 48 exotic plant species were recorded on USFS lands. (See table 16 and figure 24). *Bromus tectorum* was recorded most frequently, with 604 infestations recorded over the six year survey period. Other species that were frequently recorded (more than 100 infestations) were *Bromus diandrus, Descurainia sophia, Marrubium vulgare,*and *Sisymbrium altissimum.* Weed Sentry works with land managers to survey land that will assist manager information needs. Survey requests by Forest Service land managers were frequently geared toward supplementing federally mandated monitoring.

Avena fatua, Convolvulus arvensis, Echinochloa crus-galli, Elaeagnus angustifolia, Malva neglecta, Malva parviflora, Plantago major, Portulaca oleracea, Rubus discolor, Sonchus oleraceus, Sorghum halepense, Sorghum spp., and *Ulmus pumila* are 13 species that had two or fewer infestation points recorded. These should be carefully considered for high priority control efforts. To date, the Forest Service has not yet read trip reports submitted by Weed Sentry and thus has not taken any action regarding recommendations (Marisa Anderson, email 01/06/2010).

Weed Sentry was able to pinpoint some highly invaded areas for USFS managers. (See appendix 1 for these areas).

Table 16. Species identity and number of recorded infestations on USFS lands from 2004-2009.

Species	Total infestation
Acroptilon repens	9
Agropyron cristatiforme	48
Arundo donax	2
Avena fatua	1
Bromus diandrus	100
Bromus inermis	19
Bromus tectorum	604
Bromus trinii	9
Chenopodium berlandieri	18
Chorispora tenella	14
Convolvulus arvensis	1
Descurainia sophia	106
Echinochloa crus-galli	1
Elaeagnus angustifolia	1
Eragrostis cilianensis	22
Grindelia squarrosa	19
Hordeum spp.	6
Hordeum vulgare	4
Lactuca serriola	2
Lolium perenne	7
Malva neglecta	1
Malva parviflora	1
Marrubium vulgare	102
Medicago sativa	3
Melilotus alba	29

Species	Total infestation
Melilotus officinalis	56
Plantago major	2
Polygonum aviculare	11
Polypogon monspeliensis	2
Portulaca oleracea	1
Ranunculus testiculatus	23
Rubus discolor	2
Salsola tragus	56
Sisymbrium altissimum	155
Sisymbrium irio	5
Sisymbrium orientale	10
Sonchus asper	5
Sonchus oleraceus	2
Sorghum halepense	1
Sorghum spp.	1
Tamarix ramosissima	3
Taraxacum officinale	82
Tragopogon dubius	11
Tribulus terrestris	85
Ulmus pumila	1
Unknown	81
Verbascum thapsus	81
Verbena bracteata	39
Veronica anagallis-aquatica	3
TOTAL	1,847

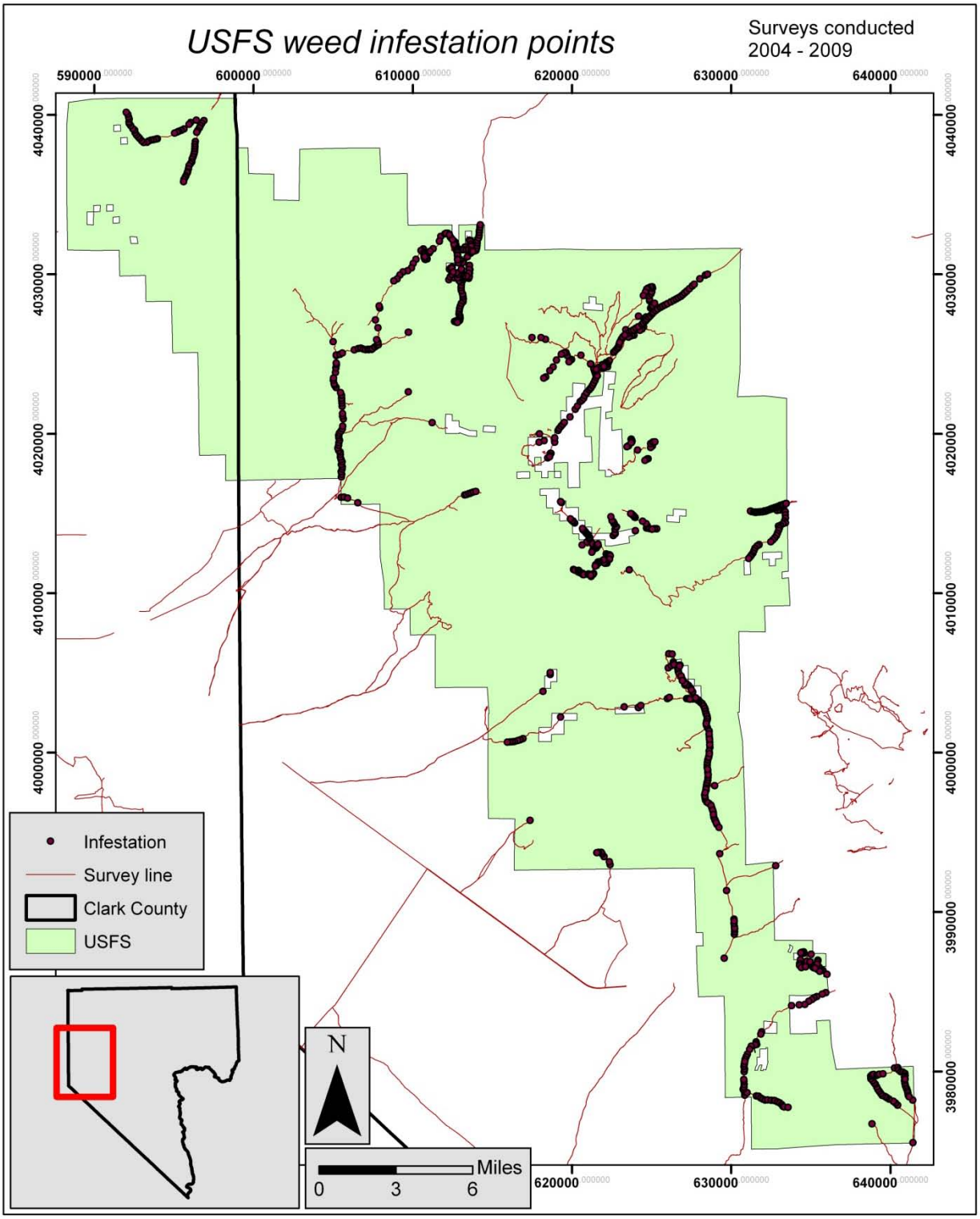


Figure 24. Distribution of infestation points on USFS lands.

Trends in USFWS lands

There were three USFWS land holdings surveyed by Weed Sentry. The largest, most extensively surveyed was Desert National Wildlife Refuge. Additionally, the Willow Beach Fish Hatchery and Moapa Valley National Wildlife Refuge were surveyed.

Three invasive species have been recorded at Willow Beach Fish Hatchery. (See table 17). When the fish hatchery was surveyed in 2005, a single *Vitex agnus-castus* individual was the sole invasive species encountered. Later, in 2007, small populations of two different invasives were recorded; *Brassica tournefortii* (10-100 individuals) and *Tribulus terrestris* (<10).

Moapa Valley National Wildlife Refuge was surveyed by Weed Sentry in 2007, and at that time a large infestation of *Malcolmia africana* (1000-5000 individuals), along with *Centaurea melitensis* (100-1000) and a small population of *Tribulus terrestris* (10-100), were encountered. (See table 18).

There were a total of 2,017 weed infestation points composing 20 plant species recorded between 2004 and 2009 within USFWS Desert National Wildlife Refuge. (See table 19 and figure 25). Over half of the points that were collected were *Bromus tectorum* (1,073 recorded occurences). More than 100 infestation points of each: *Descurainia sophia*, *Bromus trinii*, and *Elaeagnus angustifolia* were recorded. More than 10% of the infestations recorded at Desert National Wildlife Refuge were located in the small area around the headquarters and visitor center, Corn Creek. (See figure 26).

Forty-two *Malcolmia africana* infestation points were recorded throughout Desert National Wildlife Refuge. (See figure 27). If not aggressively controlled, this species has a high likelihood of further spread. Until the 2009 survey, this invasive was not recorded along Mormon Well Road. Mormon Well Road was surveyed annually from 2004-2009, excluding 2008. In 2009, when *Malcolmia africana* was initially detected along Mormon Well Road, there were already five infestation areas, two of which contained an estimated 100-1,000 individuals, three of which contained 10-100 individuals.

The USFWS Refuge Manager has used this information to help focus management priorities and it will also act as a base from which the new restoration/exotic plant staff can begin work (Amy Sprunger, personal communication).

Table 17. Recorded infestations at Willow Beach Fish Hatchery.

Species	Total infestation
Brassica tournefortii	1
Tribulus terrestris	1
Vitex agnus-castus	1

Table 18. Infestations recorded at Moapa restoration area.

Species	Total infestation
Centaurea melitensis	1
Malcolmia africana	1
Tribulus terrestris	1

Table 19. The identity and number of infestations recorded at Desert National Wildlife Refuge from 2004-2009. Occurences of *Salsola tragus* were not consistently recorded within USFWS lands every year, thus, numbers of recorded occurrences are deflated.

Species	Total infestation
Brassica tournefortii	11
Bromus diandrus	104
Bromus tectorum	1,073
Bromus trinii	158
Centaurea melitensis	1
Chenopodium album	47
Chorispora tenella	2
Descurainia sophia	263
Elaeagnus angustifolia	119
Hordeum murinum	3
Malcolmia africana	41
Marrubium vulgare	3
Polypogon monspeliensis	3
Robinia pseudoacacia	39
Salsola tragus	53
Sisymbrium irio	22
Tamarix ramosissima	12
Taraxacum officinalis	4
Ulmus pumila	51
Unknown	8
TOTAL	2,017

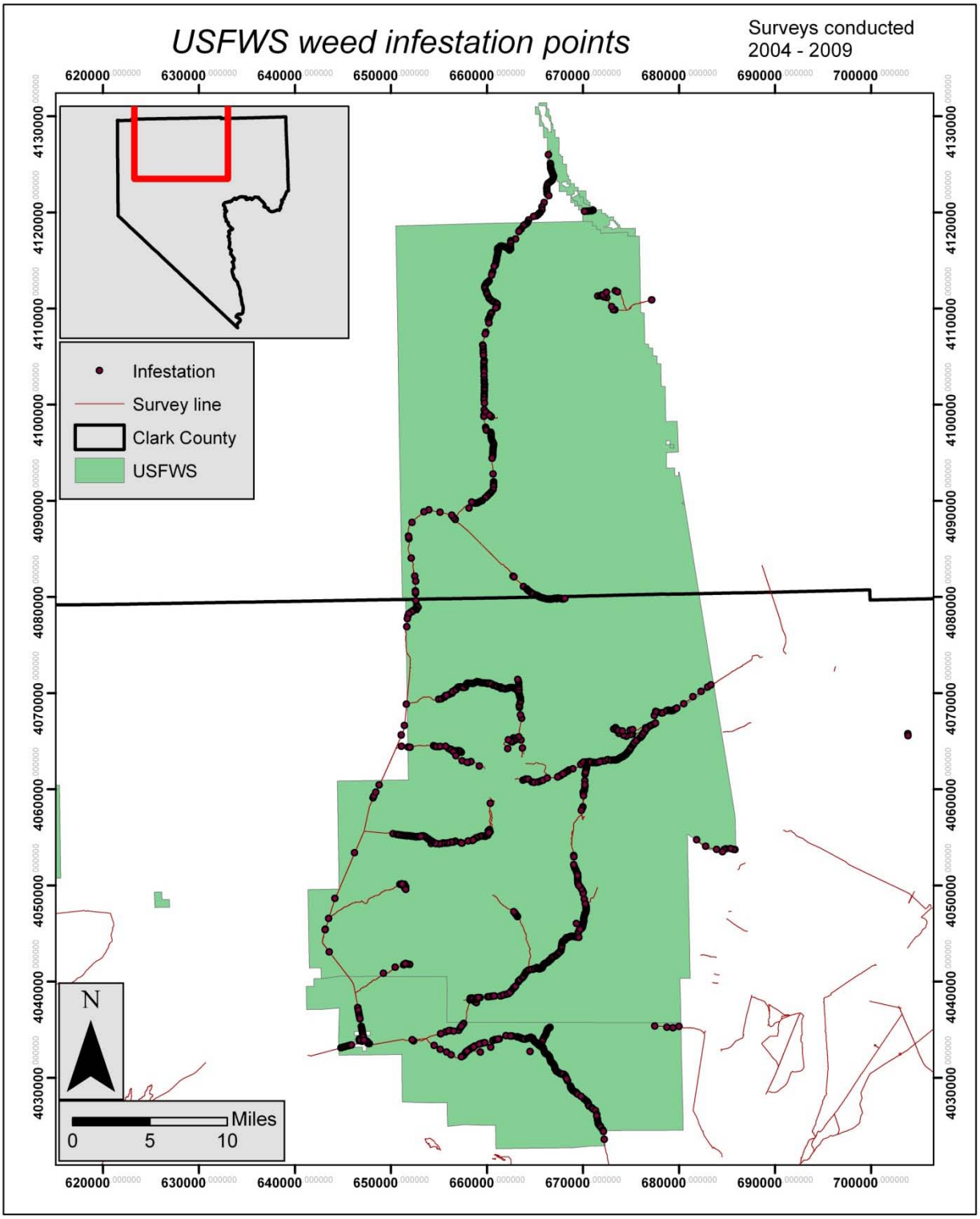


Figure 25. Distribution of infestation points at USFWS Desert National Wildlife Refuge.

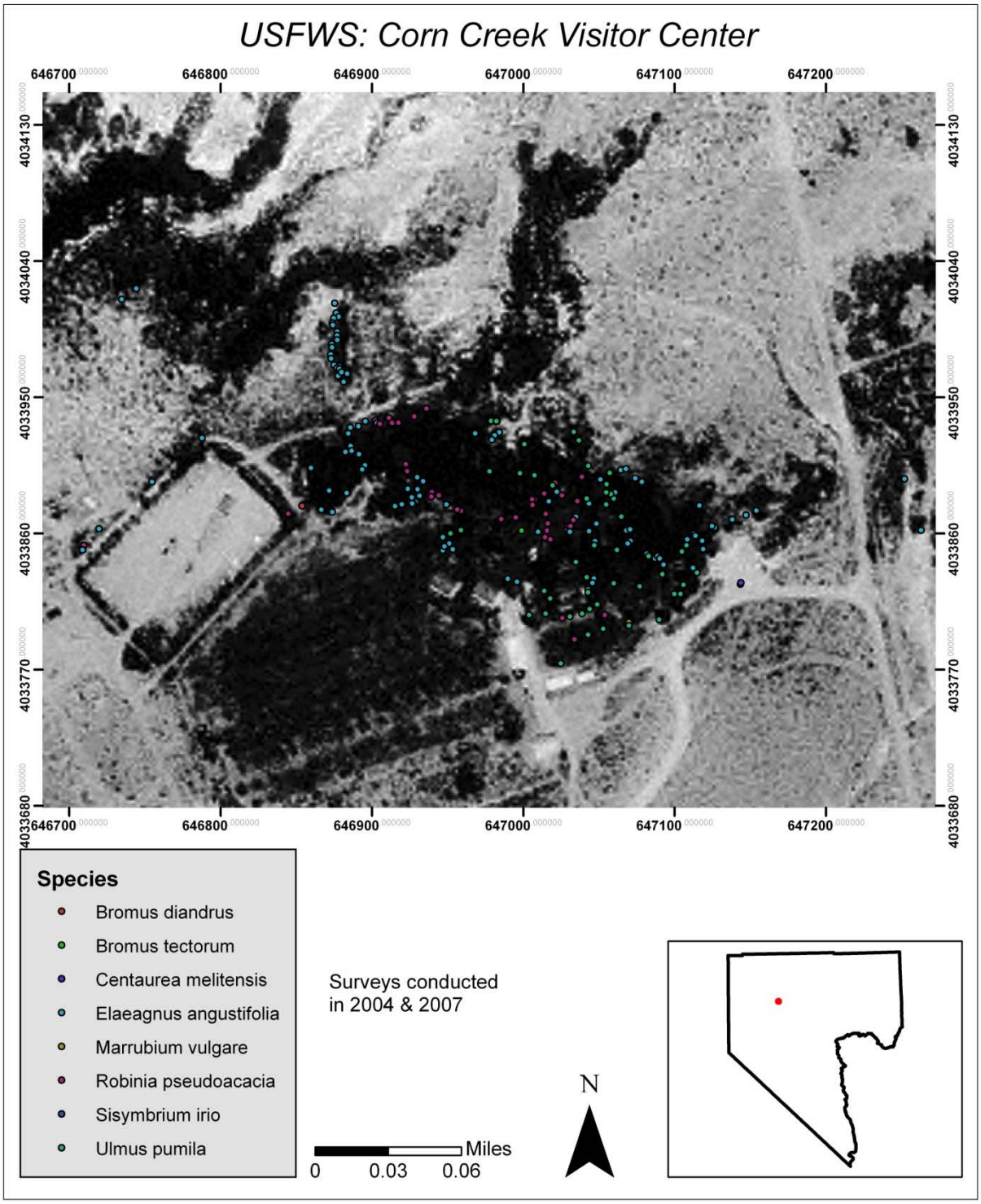


Figure 26. Distribution of infestation points on USFWS land (Corn Creek Visitor Center).

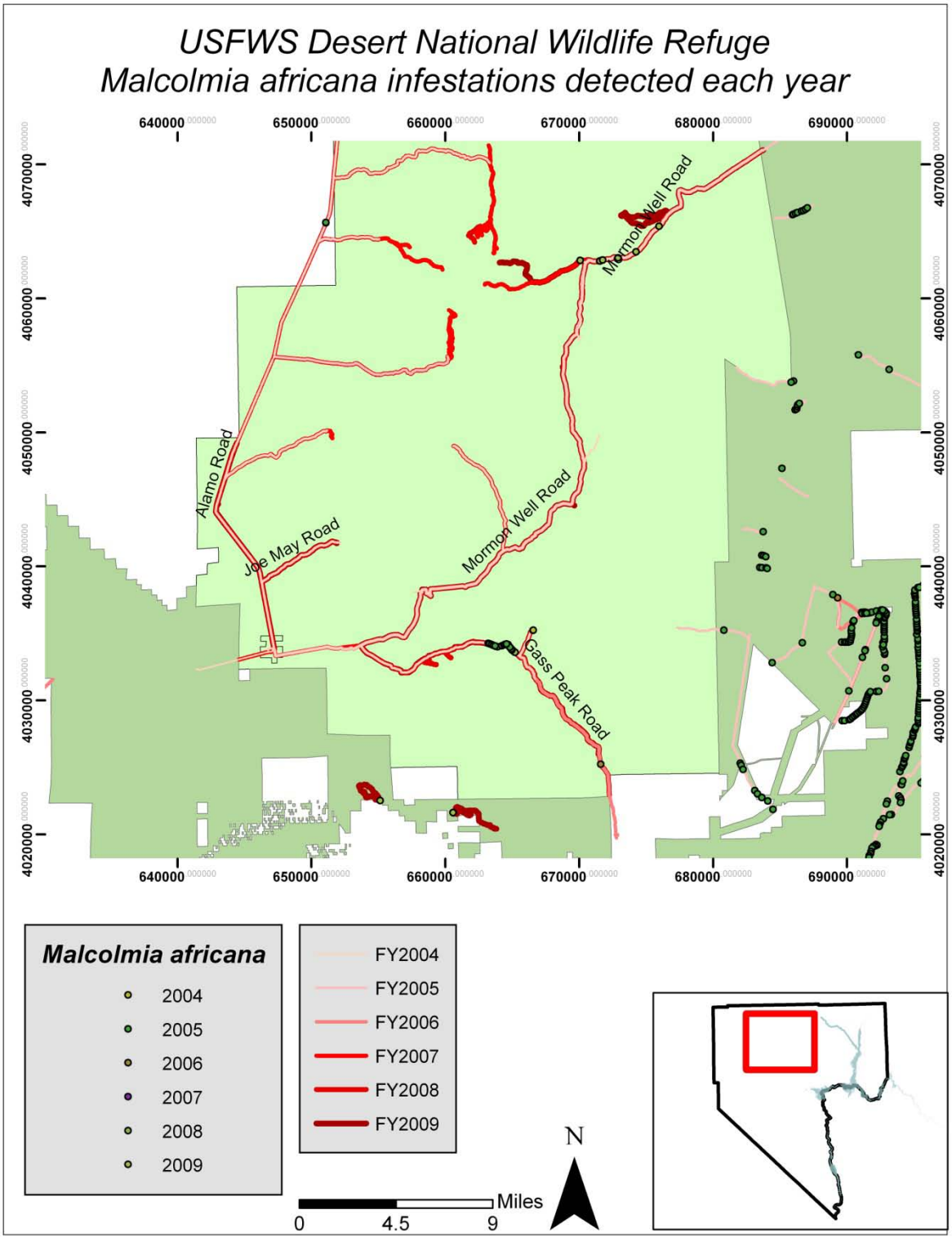


Figure 27. Distribution of 42 recorded *Malcolmia africana* infestation points at Desert National Wildlife Refuge.

SPECIAL PROJECTS

Assessing an exotic plant surveying program in the Mojave Desert, Clark County, Nevada, USA

We report the first 3 years of exotic species survey data collected by Weed Sentry, assess methods and assumptions of the program, and suggest future work for advancing exotic species information systems in this region. (See Appendix 4).

We totaled the number of kilometers of roadsides, trails, or shorelines on which exotic species were detected in each soil taxonomic unit and computed the average number of species occurrences per kilometer in each soil type. Soils classified as "badlands" were included. We descriptively assessed relationships between species occurrences and soil types, elevation, and the presence or absence of gypsum (defined as soils containing >5% gypsum in the upper 15 cm of soil according to the published soil surveys). To evaluate which soil types may be most infested, we calculated the mean number of species occurrences per kilometer surveyed for each soil type.

Occurrences of several of the 15 most frequently encountered species (of 43 total survey species) were related to elevation. For example, the only detected occurrences of *Nicotiana glauca* and *Lepidium latifolium* were below 915 m, while *Sisymbrium altissimum* (tumblemustard), *Bromus diandrus* (ripgut brome), and D*escurainia sophia* (herb sophia) exhibited their most occurrences/km at elevations above 1,830 m. Other species, such as *Hordeum vulgare*, *Sisymbrium orientale*, and *Bromus tectorum* occurred across a broader range of elevations. With an average of 1.3–1.6 occurrences/km, *Brassica tournefortii* was the most frequently detected species below 915 m elevation. It is important to note that the nearly ubiquitous *Bromus rubens* and *Schismus* spp. were not surveyed and thus are not included in species frequency rankings.

Few relationships between soil types and exotic species distributions were evident. *Malcolmia africana* was an exception to the trend of species in our data set showing little relationship to the coarse-scale soil survey. This annual forb occurred on more than twice as many gypsum soil types than expected based on its distribution among all soil types. *Malcolmia africana* is not restricted to gypsum soils, as we recorded it in 50 non-gypsum soil types.

While this program has provided an initial assessment of the landscape-scale distribution of exotic species along transportation corridors, evaluations of both the survey methods and the effectiveness of treating incipient populations are needed. An exotic plant information system most useful to resource managers will likely include integrating planning oriented coarse-scale surveys, more detailed monitoring of targeted locations, and research on species life histories, community invasibility, and treatment effectiveness.

A manuscript was published from this work.

- Abella, S.R., J.E. Spencer, J. Hoines, and C. Nazarchyk. 2009. Assessing an exotic plant surveying program in the Mojave Desert, Clark County, Nevada, USA. Environmental Monitoring and Assessment 151:221-230.

NPS Lake Mead National Recreation Area: *Rana onca* (rare frog) habitat surveys

We conducted detailed vegetation sampling at Rogers and Blue Point Springs within Lake Mead National Recreation Area to monitor plant species richness, species-specific foliar cover and height, and plant community biomass through time in treatment and control areas using a standard-plot approach. (See appendices 6 & 7). A major purpose of this monitoring was to address concerns that vegetation modifications may allow the encroachment and spread of noxious non-native plants into manipulated areas. The monitoring allows continuous assessments of the effects of these vegetation manipulations on species composition, and provides estimates of re-growth rates of emergent species in order to evaluate how often vegetation manipulations will be needed to maintain more open habitats for frogs.

In total, 28 plant species were observed across the two spring sites over the course of the monitoring. Treatments had very little effect on which species were present. Species that were present before the cutting or burning treatments were generally present in the last set of observations as well. However, there were five species that were observed in pre-treatment observations and not recorded thereafter: *Acacia greggii* and *Baccharis salicifolia*, both at Rogers Spring, and *Heliotrope curassavicum, Suaeda moquinii,* and *Tamarisk ramosissima* at Blue Point Spring. Each of these observations was a single recording on an edge plot at very low abundances. Three native species, *Lythrum californicum, Muhlenbergia asperifolia,* and *Prosopsis glandulosa*, were seen at Rogers Spring after treatments that were not observed there before. *Lythrum californicum* was a new observation for that region of the park and verified by park contract botanist Dianne Bangle. Note that no new exotic species established in treatment areas.

The presence and absence of individual species was consistent pre and post-treatment. Overall, while the physical manipulation had an immediate effect on the abundance of nearly all species, after one year post-treatment, nearly all species aside from *Cladium californica* (hereafter referred to as *Cladium)* recovered to post-treatment abundances. While *Cladium* took longer to re-establish, abundance of the species is so great and the species forms such dense stands that the treatments we established in *Cladium*-dominated habitats were not enough to make habitats suitable for frog re-establishment.

Our work shows that the types of manipulations employed generally avoid negative effects of significant drops in species richness and diversity, and no dominant species were eliminated from the systems. The vegetative community composition remains consistent, even recently after treatments. Abundances of species that recover are essentially the same abundances as pretreatment observations. Additionally, no invasive exotic species established in the systems post-treatment. The vegetation manipulations of cutting and burning do not have a negative effect on plant community composition, and communities are able to recover to pre-treatment abundances and composition within two years.

Research findings were orally presented at the Lower Colorado River Basin riparian revegetation workshop.

- Engel, C., J.R. Jaeger, and S. Abella. Vegetation responses to attempted habitat restoration for the relict leopard frog: study design and preliminary results. Oral presentation at the Lower Colorado River Basin riparian revegetation workshop, Southern Nevada Water Authority and Las Vegas Wash Coordination Committee, Las Vegas Springs Preserve, Las Vegas, NV. 7 May 2008.

A condition assessment of spring and seep vegetation on the Desert National Wildlife Refuge, southern Nevada

Our study's goals were to: document current plant communities associated with desert and dryland forest springs and seeps (in comparison with nearby uplands) and to detect and quantify exotic plant invasions. (See appendix 7).

From June to October 2007, we sampled twelve springs (five high-elevation and seven low-elevation) within DNWR for surrounding plant community composition. We sampled a gradient of vegetation from immediately within the spring to upland (20 m away). We recorded the plant community composition and the percent cover each species composed of each quadrat.

A total of eighty-four understory species were identified during sampling. Average understory species richness per quadrat ranged from 2 species/m^2 at Upper White Blotch Spring (a low-elevation spring), to 5.4 species/m^2 at Wiregrass Spring (a high-elevation spring). Total site richness within 24, 1-m^2 quadrats ranged from 7 to 26. Linear regression of species richness and distance from spring within individual sites indicated that Wiregrass and White Spot Springs were the only springs that showed significant differences across the 20-m gradient. (See figure 28). Wiregrass showed a significant decrease in species richness as the distance from the spring increased ($R^2 = 0.46$, $n = 24$). At Wiregrass, average species richness ranged from 5.3 species/m^2 near the spring (0 to 2 m), to 3.4 species/m^2 further from the spring (10 to 20 m). On the other hand, species richness at White Spot significantly increased along with increases in the distance from the spring ($R^2 = 0.42$, $n = 24$). At White Spot, the average species richness near the spring (0 to 2 m) was 2.3 species/m^2, whereas further from the spring (10 to 20 m), richness was 3.5 species/m^2.

Tamarix ramosissima was encountered during sampling at White Spot. Exotic species were encountered at all low elevation springs. There were no exotics detected at four out of five high elevation springs (Bootleg, Perkins, Shalecut and Yellowjacket). Of sites where exotic species were detected, an average of 13% of total species richness was composed of exotics and ranged from 22% (White Spot), to 5% (Lower White Blotch).

Over all sites, only 4% of the total cover we sampled was exotic. White Spot Spring contained the greatest proportion of cover by exotics (17%). Linear regression of exotic cover and site elevation indicated that there were no relationships between the two. Additionally, linear regression of site-wide native and exotic richness and cover showed no relationships.

Since the time of the study, both *Tamarix ramosissima* individuals encountered during the study were treated by land managers. Some of the other exotic species that were detected such as *Bromus rubens* and *Bromus tectorum* are much wider spread, and will be more challenging to manage. The standing dead of these grasses have the potential to greatly change the face of the landscape due to increased fire frequencies. Since these grasses were not found at the four

spring sites with no access trail, it is important to continue to minimize traffic to these areas to prevent future introductions.

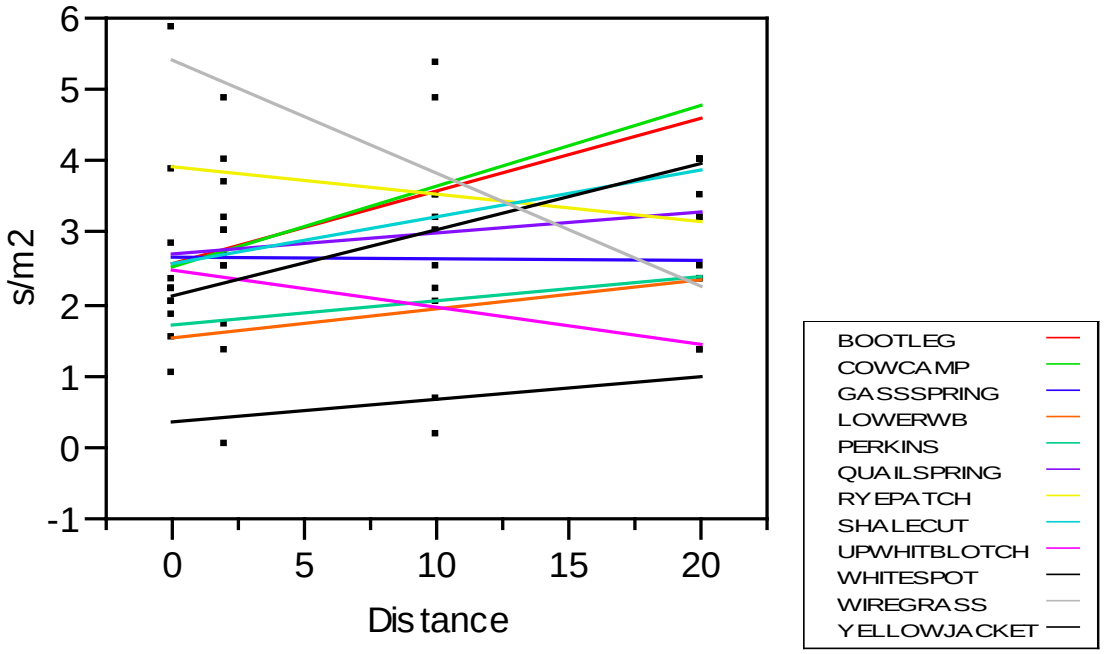


Figure 28. Diagram of changes in species richness at each spring over a gradient of 20 m. Only two springs exhibited a significant change in species richness over the gradient.

Research findings were orally presented at the Lower Colorado River Basin riparian revegetation workshop.

- Craig, J., S. Abella, J. Spencer, and A. Sprunger. The invasibility of riparian and upland areas surrounding springs at Desert National Wildlife Refuge. Oral presentation at the Lower Colorado River Basin riparian revegetation workshop, Southern Nevada Water Authority and Las Vegas Wash Coordination Committee, Las Vegas Springs Preserve, Las Vegas, NV. 7 May 2008.
- Manuscript in progress.

Effects of water and disturbance on establishment of *Brassica* and native annuals

Over the years Weed Sentry personnel noticed the stark variation in *Brassica tournefortii* population extent from year to year. Desert weather variability from year to year was a supposed culprit, but knowing more about the dynamics of *Brassica tournefortii* with native annuals would help ascertain whether population sizes were negatively impacting natives. (It is possible that *Brassica tournefortii* was not competing with natives or reducing native population sizes).

Habitat modification (i.e., disturbance) and resource availability have been identified as possible mechanisms that facilitate plant invasions. In the eastern Mojave Desert, habitat disturbance has increased due to increased human population, and water is considered to be the main limiting resource in arid ecosystems. To elucidate the effects of soil disturbance and water on plant invasions, we created experimental patches that varied in levels of soil disturbance and resource availability (i.e., water) in a fully crossed factorial field experiment, and documented responses of native and non-native winter annuals. (See appendix 8). Our treatments had no effects on the density (plants/m^2) of the non-native herb, *Brassica tournefortii*. However, water and soil disturbance positively influenced plant height and consequently the number of siliques. Density (plants/m^2) of the non-native Mediterranean grass (*Schismus* spp.) increased in watered and disturbed plots during both years of the study. Native winter annual density (plants/m^2) in watered and disturbed plots increased in 2009 but not in 2008. These results suggest that the establishment of non-native annual grasses in arid systems can be influenced both by the state of the invaded habitat and by the level of resource availability.

Research findings were presented in posters at Ecological Society of America 2008 and the Natural Areas Association Meeting.

- Suazo, A.A., J.E. Spencer, and S.R. Abella. Responses of Sahara mustard (Brassica tournefortii) to water addition and soil disturbance manipulations. Poster presentation at the 35th Natural Areas Association conference, Nashville, TN. 15 October 2008.
- Suazo, A.A., J.E. Spencer, and S.R. Abella. Response of Sahara mustard (Brassica tournefortii) to soil disturbance and water addition in the eastern Mojave Desert. Poster presentation at the Ecological Society of America 93rd annual meeting, Milwaukee, WI. 6 August 2008.
- Manuscript in progress.

Brassica tournefortii competition with native annuals

Our objective was to investigate the relationship between exotic invasive species *Brassica tournefortii* and the abundance of native annual and perennial species.

This monitoring was conducted along a hillside adjacent to the landfill that is located just west of the Lake Mead NRA native plant nursery. Along this hillside, *Brassica tournefortii* density was greater at the base of the hill than at the top of the hill. Therefore, the site could be used as a gradient study. Many species of native annuals (and a few native perennial species) also established readily at this site.

Sampling occurred in early April, 2007, at the time of peak annual species abundance and peak flowering. We established four, 100-m transects perpendicular to the slope of the hill and each 10 m apart. We collected density (number of individuals of each species per quadrat) and cover data for each species with 1 m^2 subplots placed every 5 m (starting with 0 and ending at 95 m along the transect), thereby sampling 20 subplots per transect. Values for cover were categorized where 1 = 0-1%, 2 = 1–5%, 3 = 5–15%, 4 = 15–25%, 5 = 25–35%, 6 = 35–50%, 7 = 50–75%, 8 = 75–95%, 9 = 95%- 100%.

Cover values (%) were assigned to each observation as the midpoint of the range of the assigned cover class. Importance values were calculated for each observation by summing the % cover for each species with the density of that species per subplot. Multiple regression analyses were performed on the importance values to examine relationships between *Brassica tournefortii* and all other species recorded at the site.

The only relationships between *Brassica tournefortii* and any native species were negative relationships between *Brassica tournefortii* and the most abundant of native species, *Phacelia fremontii*. (See figure 29). Additionally, there also appeared to be a weak negative relationship between *Brassica tournefortii* and *Encelia farinosa*. (See figure 30). The only other exotic species, *Schismus arabica*, had uniform distribution across the site with no relationships with any of the native species or with *Brassica tournefortii*.

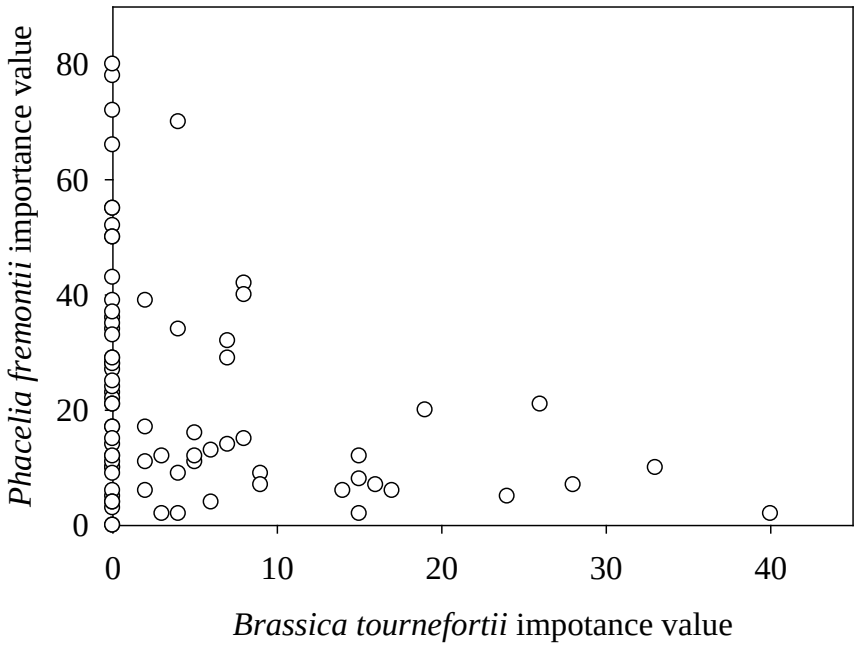


Figure 29. The relationship between the abundance of *Brassica tournefortii* and *Phacelia fremontii.*

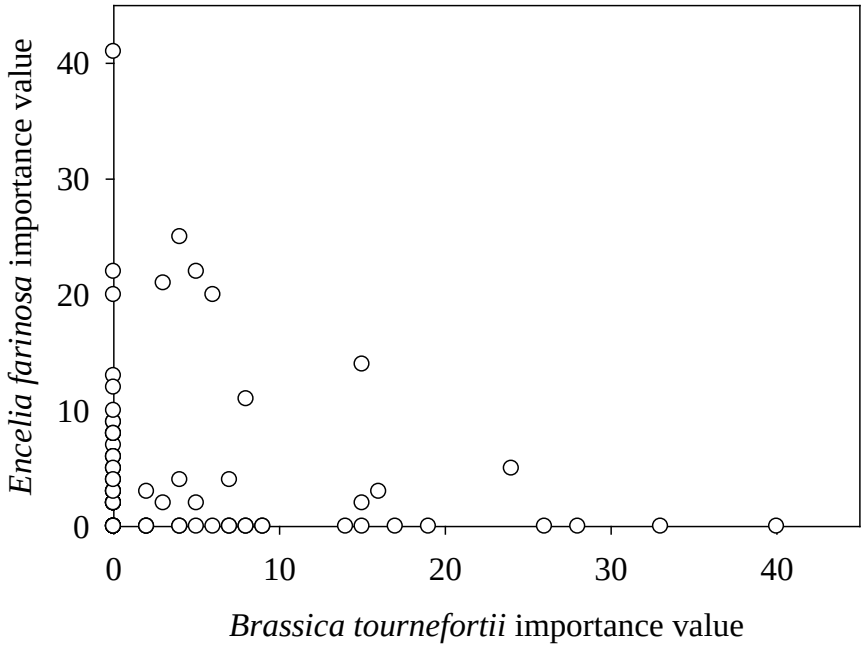


Figure 30. The relationship between abundance of *Brassica tournefortii* and *Encelia farinosa*.

Factors affecting exotic annual plant cover and richness along roadsides in the eastern Mojave Desert, USA

We evaluated the cover and richness of exotic plants relative to road type (gravel or paved) and distance from roads in the eastern Mojave Desert where exotic annual species are increasing the flammability of the desert. (See appendix 9). Exotic and native annual plant cover and richness were sampled from five to 45 meters from roads in three prevalent microsite types for this system: *Larrea tridentata* microsites, *Ambrosia dumosa* microsites, and interspaces between shrubs.

We identified 64 annual plant species, and six of these (9.4%) were exotics. The exotic species encountered were *Schismus* species, *Bromus rubens, Erodium cicutarium, Brassica tournefortii, Sisymbrium irio*, and *Malcolmia africana. Schismus* spp. occurred most frequently (12 of 12 sites) of any exotic followed by *Erodium cicutarium* (7 of 12 sites). Combined, these two species accounted for 82% of all exotic occurrences at the microsite level. *Brassica tournefortii* occurred at four sites while *Bromus rubens, Malcolmia africana* and *Sisymbrium irio* each occurred at two sites.

Both natives and exotics varied by microsite, where annual plant cover was higher under shrubs than in interspaces. We observed no other significant main or two-way effects in the ANOVA involving overall cover of exotics and natives. There was a significant three-way interaction among road type, microsite, and distance for natives but not exotics.

Microsite was the most important factor affecting species richness. The richness in interspaces appeared to trend lower further from the road, while the shrub microsites did not show this general trend. There was an apparent interaction between microsite and plant origin, as richness of natives was highest under *Ambrosia dumosa* compared to *Larrea tridentata* and interspaces; richness of exotics was high under both shrub species. The differences between natives and exotics should be interpreted cautiously because of the limited number of exotic species (six) compared to natives (58).

Our results suggest that native and exotic species are quite similar in cover and richness patterns with respect to roads and microsites. We found little evidence to suggest that proximity to the road edge dictates the richness or cover of native or exotic plant species. Thus, the invasibility of areas at 45 m from the road appear to be similar to those at 5 m. There were some slight differences in overall native compared to exotic plant cover relative to the species of shrub involved in creating the microsite, but the general patterns were identical. The three confamilial groups that were available for analysis supported the conclusions from the grouped native and exotic species, where we observed little distinction in distribution based on plant origin.

Research findings were presented at the multiple conferences and a manuscript is in press.

- Craig, D.J., J.E. Craig, S.R. Abella and C.H. Vanier. *In press*. Factors affecting exotic annual plant cover and richness along roadsides in the eastern Mojave Desert, USA. Journal of Arid Environments.
- Craig, D.J., J.E. Craig, and S.R. Abella. Road corridor surveys alone may not reliably detect extent of exotic annual plant distributions. Poster presentation at the 2009 George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites, Portland, OR. 3 March 2009.
- Craig, D.J., J.E. Craig, and S.R. Abella. Implications for management prioritization of exotic annual weed monitoring near roadsides in the eastern Mojave Desert, USA. Poster presentation at the Wildfires and Invasive Plants in American Deserts conference, Reno, NV. 9 December 2008.
- Craig, D.J., J.E. Craig, and S.R. Abella. Exotic annual plant invasions and their relationships to roads and native perennial species in the Mojave Desert, southwestern USA. Poster presentation at the 35th Natural Areas Association conference, Nashville, TN. 15 October 2008.

Vegetation of grassy remnants in the Las Vegas Valley, southern Nevada

We sampled four privately held sites in the southwestern Las Vegas Valley that contained unique assemblages of native grasses and that we were able to obtain permission to sample. (See appendix 10). We established one sample plot in the center of each site to reduce edge effects on these small sites as much as possible. Plots were 50 m × 50 m (0.25 ha) at sites 1-3 and 30 m × 30 m (0.09 ha) at the smaller site 4 that would not accommodate a larger plot. We mapped individuals of three native shrub species (catclaw, creosote, and Mojave yucca) to the nearest meter using x, y coordinates within plots. We sampled sites 1-3 in December 2006 or January 2007, and site 4 in February 2008. In each cell, we recorded species rooted in the cell and categorized their cover using Peet et al.'s (1998) cover classes.

Based on the results of our site surveys, density of the three mapped shrubs at sites 1-3 ranged from 52-124/ha (average = 85) for catclaw, 8-32/ha (average = 20) for Mojave yucca, and 168-456/ha (average = 291) for creosote. Catclaw probably has higher moisture requirements and tended to occupy the washes, but scattered individuals also occurred on adjacent uplands. The fourth site had 578 creosote/ha, but did not contain catclaw or Mojave yucca.

Richness of native species per 0.01 ha ranged from 5-22 species, with natives comprising 62-94% of the total richness per 0.01 ha. (See figure 31). Richness tended to be higher in washes, but several sections of the uplands contained richness equal or greater to the washes. The total number of species occurring on 0.25-ha plots at sites 1-3 was 38, 39, and 42, and 28 species occurred on the 0.09-ha plot at site 4. We found a grand total of 73 species on all plots.

All four sites were dominated by native shrubs and perennial grasses, with smaller components of cacti and native and exotic forbs and annual grasses. White bursage, Nevada jointfir (*Ephedra nevadensis*), creosote, and littleleaf ratany (*Krameria erecta*) overall were the most frequently occurring shrubs, with catclaw also occurring at ≥ 40% frequency at three sites. Two to four cactus species occurred per site, although these occurrences were scattered typically at < 10% frequency. Perennial forbs were not abundant overall, with desert trumpet being the most frequent species at all four sites followed by broom snakeweed exhibiting 60-80% frequency at two sites.

The grass and catclaw-mesquite communities described in this study are rare and do not occupy extensive areas of the Mojave Desert. Native perennial grasses and other species in these and other native Mojave Desert communities may be suitable for establishment in areas such as urban parks, golf courses, and those benefitting from desert landscaping. Attempts could be made to create elsewhere habitats that have been lost in Las Vegas Valley, although creation of communities where they did not exist before may raise ethical issues and may not be fully ecologically feasible. In our view, great opportunities exist for at least partly maintaining the legacy of rich Las Vegas vegetation through strategic protection of remnants or incorporating remnants into developments, salvaging material, and conducting documented studies of past and present vegetation to record this unique resource.

A manuscript has been published from this work. (See appendix 10).

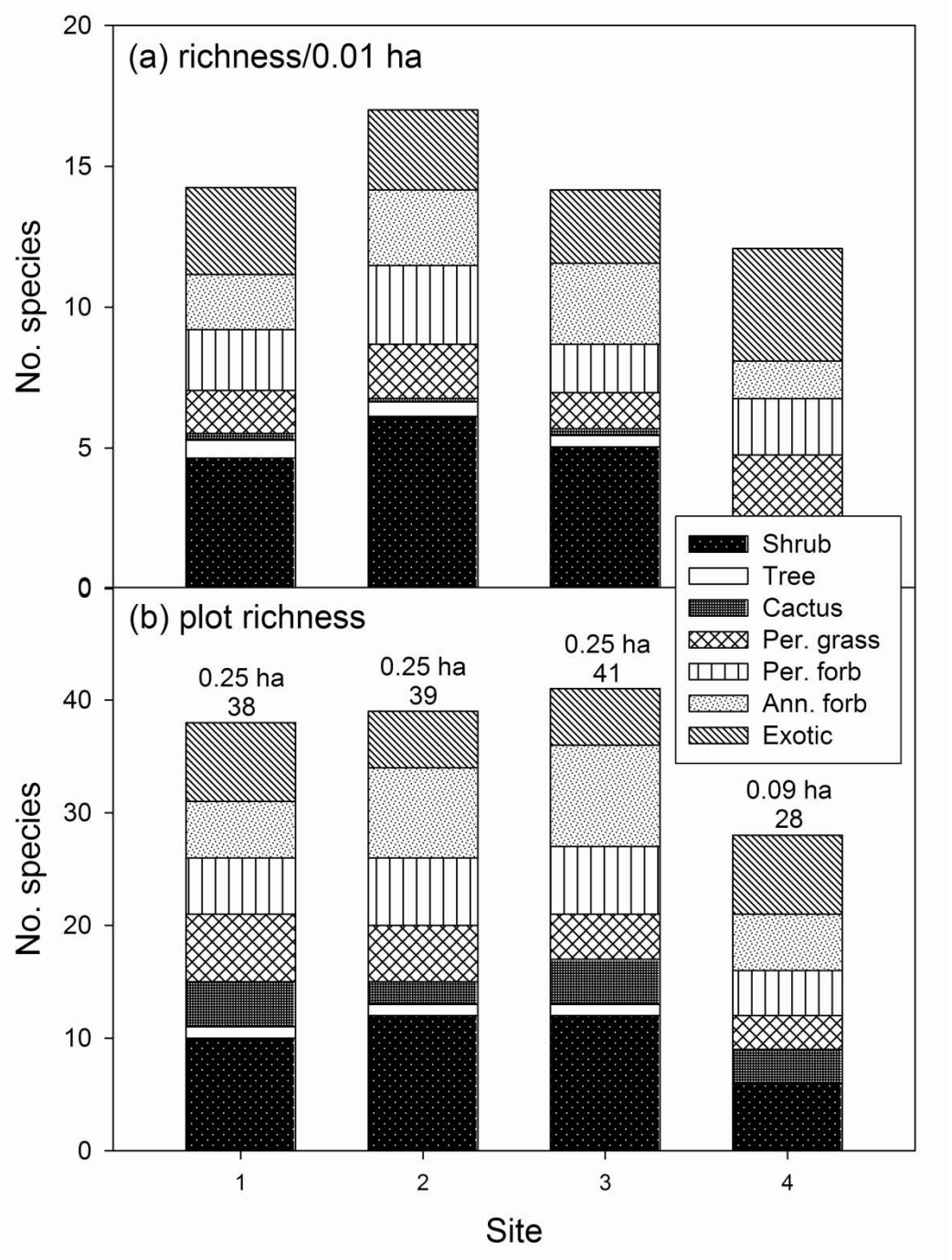


Figure 31. Plant species richness of exotic species and by growth form for native species for four sites in the Las Vegas Valley, southern Nevada.

CONCLUSION

County-wide infestations

Most of the recorded infestations within Clark County are composed of the families Brassicaceae (mustards), Asteraceae (daisies) and Poaceae (grasses). A top invader with 24% of weed occurrence records, was the grass *Bromus tectorum.*

Beyond *Bromus,* many of the most commonly recorded invaders were of the Brassicaceae Family. Each genera had unique distributions through the Weed Sentry project area. *Brassica tournefortii* was most densely recorded along the eastern border of Clark County (within and near Lake Mead NRA). However, this species was also recorded throughout much of the county, and appears to have the ability to grow at higher elevations and in a variety of ecosystems. *Brassica tournefortii* may have the ability to infest much of the county in high densities.

Descurainia sophia was most commonly found in the higher elevation western region (USFS Spring Mountains). *Malcolmia africana* predominately occurred in the northern half of the county, and *Sisymbrium irio* appears nearly evenly distributed throughout the county. *Lepidium latifolium* was only found within Lake Mead NRA near water and is limited by water availability. Another Brassicaceae, *Chorispora tenella* was most commonly found in upper elevations.

Species within the Fabaceae Family appear to be restricted in their distributions. Although there were 64 *Parkinsonia aculeata* infestation records and 59 *Melilotus officinalis* records, *Parkinsonia aculeata* was only encountered within Lake Mead NRA (often within established camping areas), and *Melilotus officinalis* was mainly recorded in the Spring Mountains, and within established camping areas with above average water availability within Lake Mead NRA.

Recorded occurrences of Family Arecaceae (the palm family) were restricted to within Lake Mead, and along the Virgin River corridor.

Information utilization

Ultimately, the individual agencies: BLM, NPS, USFS and USFWS are responsible for tactics and intensity of weed control and monitoring on lands within their jurisdiction. Weed Sentry offered assistance by surveying the vast acres each agency manages and detecting weed populations; but individual agencies dictated how weeds could be controlled and the level in which information provided by Weed Sentry was used.

The Weed Management Specialist for the BLM has greatly valued and utilized the information provided by Weed Sentry:

> "The reports submitted from the Weed Sentry Program at UNLV have provided invaluable information in both site specific surveys and in recording district wide trends. The

information submitted in these professional reports include detailed locations, maps, species listings, and actions performed by the Sentries in achieving what weed control was possible in their brief visit by hand pulling.

I highly value the recommendations included in the report, which provides an overall assessment of the vegetation and highlights priority actions that are practical in addressing infestation risks and level of investment for treatments. This information is utilized for weed program development in choosing survey priorities and treatment activities. For example, the 2008 Weed Sentry Reports included several sites within the Red Rock NCA. The BLM has incorporated treatment plans in 2009-2011 to address the infestations reported at Willow Springs, Pine Creek, Calico Basin Drive, parking areas, and trails. From the evidence submitted in the Weed Sentry reports, managers have seen the need for consistent action, and have increased commitment for treatments of weeds and incorporating more monitoring as a routine part of program duties.

Another action taken from Weed Sentry reporting is the incorporation of new weed populations into the national weed mapping system, which is launching this year in Nevada under the acronym NISIMS (National Invasive Specie Information Management System). The historical GIS data gathered from the UNLV program is in process of submission to this database which will become the universal repository for national weed data amongst federal agencies and any participating states.

I give my sincerest thanks to Jill Craig and the Sentry Program which works independently to perform excellent science and reporting for the greater good." – Nora Caplette, Weed Management Specialist, BLM

In the case of USFS, there is not a dedicated weed manager. Agency contacts are not able to immediately act on Weed Sentry recommendations (for example, Trip Reports submitted to USFS contacts in September still have not been read by personnel in authority to arrange weed control).

Recently at USFWS there was a contractor hired for restoration and exotic plant management. Refuge Manager Amy Sprunger stated that the Trip Reports and surveys by Weed Sentry have provided a foundation from which the new employee can begin to work. USFWS personnel wouldn't have been able to cover so much ground, especially backcountry springs of the Sheep Range, and information Weed Sentry has provided regarding these areas was invaluable.

The NPS has a dedicated Weed Manager. Weed Manager Carrie Norman stated that she uses Trip Reports by comparing species reported by Weed Sentry to the park's priority status rating, and if species reported are high priority she immediately controls them as they are reported.

RECOMMENDATIONS

During the six years of surveying by Weed Sentry, *Bromus spp.* and mustards from the Family Brassicaceae were by far the most widespread and frequently encountered. These species are so extensively distributed that traditional control methods are no longer fiscally feasible. The competitiveness of mustards should be tested to determine the level of threat they pose on native rare plants. In addition, research on both *Bromus tectorum* and a variety of species of Brassicaceae is needed to ascertain life history characteristics and determine the best management practices for these species. *Bromus madritensis* ssp. Rubens has become so widespread managers are no longer interested in occurrence records. However, it is a fact that this, along with other *Bromus spp.,* are contributing to altered fire regimes and changing desert systems in ways still not entirely understood. Research is needed to test novel methods of control for this fire-prone exotic that blankets a large portion of Clark County.

Beyond the aforementioned widespread, nearly ubiquitous, troublesome grasses and mustards, it is recommended that agencies place immediate priority for control on species that had few records. These species may be eradicated with the least time and energy investment.

In order to prevent exotic species from invading unchecked it is important that surveying and monitoring of public lands is continued. As was evident with the large *Malcolmia africana* infestation that established at Desert National Wildlife Refuge after one year of surveying was omitted, it is important to maintain a vigilant defense against exotic species. If possible, agencies should aim to survey for weeds in areas and during years with normal to high precipitation levels. Surveying in drought years has not been practical for Weed Sentry since invasive species often failed to germinate in these conditions but remained in the seedbank to establish later when precipitation occurred.

Agency-specific weed control recommendations are a regular part of each Trip Report submitted by Weed Sentry after each survey. Recommendations made during the FY2008 – FY2009 survey seasons can be reviewed in the Trip Reports included in Appendix 1.

ACKNOWLEDGEMENTS

The original concept of Weed Sentry is a product of Dr. Elizabeth Powell. Josh Hoines assisted with the initial survey protocol development. Over the six years the Weed Sentry has been detecting and eradicating weeds in Clark County, surveying has been coordinated by Josh Hoines, Carrie Norman and Jessica Spencer. Additionally, Kashmira Asnani, Lindsay Chiquoine, Teague Embrey, Cayenne Engel, Tiffany Finke, James Fitzgerald, Jen Frey, Kate Prengaman, Chris Roberts, Sarah Schmid and Alex Suazo have assisted with surveying.

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Vanessa Truitt, Joseph Hutcheson, and Mark Sappington have programmed GPS units, managed GIS data, kept GPS units running and the Weed Sentry informed of how to properly use them. During earlier stages of the program, Stacey Crowe provided GIS and GPS support. Vanessa Truitt also created Appendix 2, and ran countless data reports to assist with developing this final report.

Jessica Spencer created Tables 2 & 3 of this document, Carrie Norman created Table 4 and Vanessa Truitt created Figures 1-4.

Sharon Altman of the UNLV provided editing and comments for this report.

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