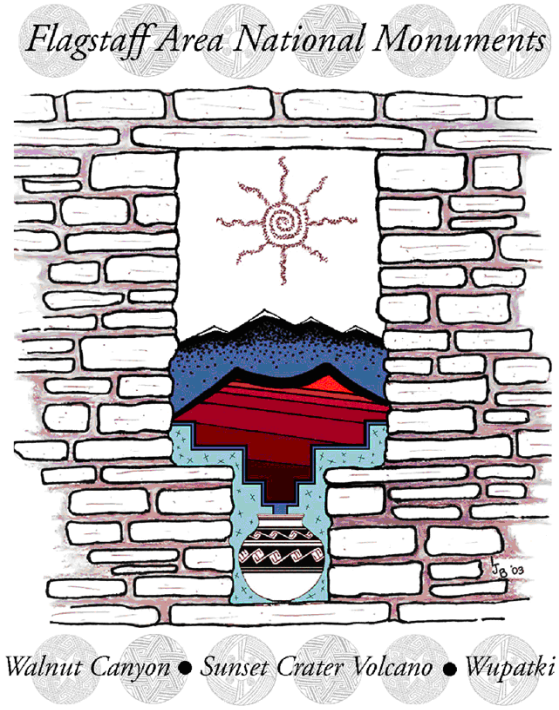
National Park Service
U.S. Department of the Interior

Flagstaff Area National Monuments

Non-Native Invasive Plant Survey and Recommendations 2003-2005

Wupatki National Monument



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I. Introduction.

The natural landscapes of our national parks are threatened by the encroachment and establishment of non-native plant species. These are species which evolved in different ecosystems, often originating on other continents, but are typically pre-adapted to the climate of the area into which they are introduced. Once they arrive within our native ecosystems, some species are unbound by the biological and ecological controls of their native ecosystems, and proliferate unchecked in a wide range of habitats. Many invasive plant species function as ruderal, pioneering plants that can easily become established in disturbed sites, such as along roadsides, farm fields, construction sites, and materials quarries. Land-uses that perturb the ground and native vegetation, such as livestock grazing and off-road driving, may exacerbate the rate of spread. Perhaps more importantly, some introduced plants can rapidly spread over areas that are subjected to natural disturbance events, such as fire and flooding.

Within National Park Service (NPS) areas in the southwestern United States, invasive plants are typically introduced and disperse along roads, trails, and developed areas. The construction of visitor use facilities may inadvertently introduce certain species or foster their spread. Although intensive land uses typically do not occur within national park areas, they often occur on adjacent lands, along with invasive plants that may spread onto NPS lands if not managed. Problem species may expand within parks in pulses after fires, flash floods, or years with wet/dry weather extremes. If highly invasive plants are not eradicated or controlled, the ecological balance of native plant communities with soil, water, and wildlife, along with their resilience after perturbation/disturbance can be irreversibly altered. Unless problem species are detected and management actions are initiated early, the eradication of the most invasive species and subsequent restoration to naturally functioning plant communities typically requires sustained efforts over large areas and long periods of time.

Many Federal regulations address nonnative plants on Federal lands, both directly and indirectly. Federal policy is derived from Acts such as the Reclamation Act of 1902, Organic Act of 1944, Federal Insecticide Fungicide and Rodenticide Act of 1947, Federal Plant Pest Act of 1957 (amended in 1994), Carson Foley Act of 1968, Federal Noxious Weed Act of 1974, Public Range Improvement act of 1978, Federal Plant Pest Act, National Invasive Species act of 1996, Plant Protection Act of 2000, and the Noxious Weed Control and Eradication Act of 2004. These regulations and policies require federal agencies to develop integrated management programs to control undesirable plants through cooperation with local and state agencies. Adherence to these policies will help maintain invasive plants within environmentally, economically, and socially tolerable levels.

NPS policy recognized the harmful effects of noxious and invasive weeds as early as 1933 (Andrascik 1996). Current NPS policy states that “management of populations of exotic plant and animal species, up to and including eradication, will be undertaken wherever such species threaten park resources or public health… . High priority will be given to the management of exotic species that have a substantial impact on park resources and that can reasonably be expected to be successfully controlled,” (USDI National Park Service 2001). The most practical management options are limited to strategically controlling targeted populations, and early detection and rapid eradication of new introductions. “Successful control employs those practices that reduce weed infestations, but do not necessarily eliminate them,” (Simmons 1985). Detailed guidance on eradicating or controlling problem species is provided by the NPS integrated pest management (IPM) policy.

Throughout this report, the term “invasive” is intended to be synonymous with other common terms such as “exotic”, “non-native”, “introduced”, and “alien”. It will be used to refer to “any species occurring in a given place as a result of direct or indirect, deliberate, or accidental actions by humans,” (USDI National Park Service 1991). This definition differentiates between changes caused by human

introductions and those occurring as a result of natural processes of plants and animals such as range expansions and succession.

II. Project Area.

Wupatki National Monument (Wupatki) covers approximately 35,400 acres (14,325 hectares) of Colorado Plateau semiarid grassland and shrub land environment located approximately 35 miles (56.33 kilometers) northeast of Flagstaff, Arizona. Wupatki's elevation ranges from 4,200 ft. to 5,600 ft. (1,281 m to 1,707 m) and contains a diverse array of topographical features, geological characteristics, and hydrological regimes creating a wide range of habitats sustaining many distinct vegetation communities. Wupatki's geology and soils provide diverse substrates for a wide array of plant communities, including arid grassland, one-seed juniper woodland, mixed grassland-shrubland, sparsely vegetated badlands, volcanic cinder dune, ephemeral drainage, and riparian vegetation (Bateman 1976, Hansen et al. 2004). While the varied habitats harbor a diverse native flora, many areas are sparsely vegetated and/or dominated by natural aeolian and fluvial depositional processes or frequent fire regimes, which perturb soil and vegetation, and may favor the establishment of invasive plants over native early succession plants. At least 29 invasive plant species are known to occur in the monument (Batemen et al. 1976, Kearny 1960, Epple 1995, Howery 2001, Whitson et al. 2001, SWEPIC 2005). The General Management Plan for Wupatki National Monument (USDI National Park Service 2002) identifies a set of mission goals for the monument, including maintaining the biotic integrity of natural systems. The exclusion of invasive exotic plant species is one of the listed actions for achieving this goal.

III. Prior Camelthorn and Tamarisk Management Efforts at Wupatki.

As part of this project, Mark Brehl reviewed available files, maps, and other gray literature in the Flagstaff Area National Monuments' Archive Collection or on file with the Natural Resource Program. Camelthorn and tamarisk were present in Wupatki as least as early as 1976, as they were included on the earliest known plant inventory and flora for the monument (Bateman 1976). Tamarisk very likely occurred earlier along the Little Colorado River, but less is known about the emigration of camelthorn. Efforts to locate, map and control tamarisk and camelthorn populations in the park were conducted between 1983 and 1988 by Steve Cinnamon, Resource Management Specialist at Wupatki. Cinnamon's project records (1983, 1987) include maps, field logs, notes, correspondence, and a final report on camelthorn and tamarisk eradication at Wupatki.

In 1983, Cinnamon hand-sketched camelthorn and tamarisk populations on a set of 1:24,000 USGS topographic quadrangle maps with an interpretive key for both species. These maps provide some level of baseline distribution or cover information, but it is uncertain whether he surveyed all available habitats at the time they were prepared. Also in 1983, Cinnamon measured pre-treatment camelthorn densities with plant stem counts in eight, 30 x 30 meter (0.3 hectare) plots. Six plots were sited in the Black Falls area, near the confluence of Deadman Wash and the Little Colorado River. Another plot was sited in upper Deadman Wash, near where it is crossed by the Scenic Loop Road. The last was near Heiser Spring. Cinnamon reported an average of 9,344 green stems per 0.3 hectare for the eight plots. The highest density was in the Black Falls Plot #2 with 22,838 green stems per 0.3 hectare, and the lowest in the Upper Deadman Wash Plot with 1,286 green stems per 0.3 hectare.

During May 2005, efforts were made to relocate all eight plots as part of this project. Four were relocated. The plots were often in or near active channels of the ephemeral drainage system. Only one plot still had wooden stakes delineating all four plot corners. Another three had stakes that had been pulled, washed out, or rotted and laying on the surface, thus marking only the approximate

corners. The remaining four plots could not be located and the corner stakes are presumed to have been washed away or buried by fluvial deposits.

Experimental tamarisk and camelthorn eradication treatments by Cinnamon included combined mechanical and chemical methods to achieve the most desired results. Mechanical methods used included the use of Pulaskis and Sandvics for frill treatments; chainsaws and weed eaters for cut-stump treatments; winches for pulling up stumps and roots, and covering with Hypalon pond liners to remove, or prepare plants for herbicide application. Most cut material was pilled and burned on site. Tamarisk treatments included cut-stump and frill followed immediately by herbicide application. Tamarisk re-growth was treated with foliar herbicide application. Camelthorn was treated with foliar spraying and cut stump methods followed by herbicide application. Herbicides used included Arsenal (Imazapyr), Hyvar_X (Bromacil), Roundup (Glyphosate), Weedone 170 (2, 4-DP + 2, 4-D), Tordon RTU (Picloram) and Garlon 3A (Triclopyr). Blazon Dye was also used to help indicate herbicide application coverage as well as several un-named surfactants to increase herbicide effectiveness. Treatments occurred from early spring to late fall and included multiple treatments of re-growth within a season.

Cinnamon determined the most effective method was the stump cut method using 100% solution of Tordon RTU (Picloram) which showed no re-growth. Cut stump treatments of Tamarisk treated with a 2% Roundup (Glyphosate) solution and covered with Hypalon showed no re-growth though this method is not feasible for large populations. The next most effective treatment was a cut–stump treatment using Garlon 3A which proved 85-92% effective. Foliar application of a combination of Arsenal and Garlon 3A showed 80-90% success after several weeks, though no monitoring information is given for subsequent years. A summary of Cinnamon's final report on camelthorn and tamarisk eradication at Wupatki was included in the Proceedings of Tamarisk Conference (1987). His conclusions regarding the effectiveness of treatments are vague and only detail short term success. Summaries of yearly weed management activities are described for 1983-1988 but no precise statistics or details of treatment methods are provided. Field logs of daily activities are available for review and may be used to determine timing, frequency, methods and areas treated.

Beginning in 1999, the vegetation at Wupatki was inventoried and mapped as part of the U.S. Geological Survey-National Park Service Vegetation Mapping Program (Hansen et al. 2004). The team of investigators used vegetation sampling and analysis to classify plant associations according to the National Vegetation Classification (NVC) standards. In addition, aerial photo interpretation, field reconnaissance, and ground-truthing methods were used to map the vegetation, corresponding to the NVC associations as closely as possible. The vegetation map was developed as GIS data. The vegetation classification yielded 24 alliances, 23 associations, three provisional associations, one local assemblage and one barren class. Vegetation "alliance" is the second finest level in the NVC hierarchy, corresponding with what ecologists call a plant "community" or foresters call a forest "type" or "stand". Alliances are based on the dominant overstory species. Within alliances, associations represent the finest level of the NVC hierarchy, and are determined according to dominant understory plant species. Provisional associations and local assemblages lack sufficient data to be included in the current NVC database, and need additional documentation across their range to determine whether they are common or unique to Wupatki. The team was able to map a total of 26 vegetation cover classes, two based on geomorphology, and seven others based on Anderson's Level II land-use classification system. Twenty-four map classes correspond directly with the NVC classification system (i.e. contain only one association). Four were too intermixed to be discerned on aerial photography, and therefore were mapped as "complexes" of multiple associations.

On the Hansen et al. GIS data, the Little Colorado River Invasive Riparian Shrubland is the predominant cover class along the Little Colorado River corridor, also extending up the mouths of major tributary drainages such as Deadman Wash and Antelope Wash. This map class covers approximately

0.22% of the monument at 76.6 acres (31 hectares). It falls within the Camelthorn Semi-Natural Shrubland Alliance and the Tamarisk Temporarily Flooded Shrubland Alliance. NVC associations include a provisional camelthorn association, the invasive tamarisk association, and the native coyote willow association. They occur in a tightly woven mosaic that is photometrically indistinguishable and thus they are combined into a single class based on landform rather than plant cover. Dominant shrubs include camelthorn and tamarisk with little understory vegetation. Associated species at Wupatki include broom snakeweed (*Gutierrezia sarothrae* [Pursh] Britt. & Rusby), Southern goldenbush (*Isocoma pluriflora* [Torr. & Gray] Greene), Western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Löve) and narrowleaf willow (*Salix exigua* Nutt.). Based upon field plots, species diversity within the camelthorn alliance is relatively high with 17 species; however five of these are exotic non-native plants. Within the tamarisk alliance, species diversity ranged from one species in homogenous stands of tamarisk, to areas of more diverse riparian vegetation containing up to 12 species.

In September 2000, the National Park Service Geological Resource Division assisted with disturbed land restoration planning for several abandoned materials quarries at Wupatki (Greco et al. 2001). These areas, formerly used for road construction materials and other park purposes, have resulted in surface disturbances which accelerate erosion, detract from the aesthetic landscape of the monument and in some cases threaten nearby archeological resources. Greco et al.'s report states, "Along the Little Colorado River, surface disturbances from borrow pits have created habitats for exotic plant species which threaten nearby riparian environments." Of the twelve borrow pits that were inspected, three harbored invasive plants. All three sites are located in the riparian/ephemeral drainage system. Both camelthorn and tamarisk were found together in two abandoned borrow pits near the Little Colorado River. Another borrow pit in a small order tributary to Deadman Wash near the Scenic Loop Road contains a single small tamarisk. Other more obscure invasive plants may also be present at some of these sites but were not detected during the survey. The compacted soil, pooling water and active erosion present at these sites provide habitat conditions which may favor the establishment of invasive species.

VI. 2003-2005 Invasive Plant Survey Objectives.

In 2003, the Natural Resource Program for the Flagstaff Area National Monuments initiated field surveys to document the presence and extent of invasive plant species in Wupatki National Monument. Field surveys were planned and conducted to efficiently locate and record:

- Tamarisk and camelthorn population locations and total cover area within the monument.
- Invasive species presence, distribution, and representative invaded area statistics along the main road corridors.
- Invasive species presence, distribution, and representative invaded area statistics around visitor use, NPS operations, and abandoned administrative use areas.

V. Methods.

Field Surveys. Surveys for noxious and invasive plant species at Wupatki were completed by Biological Technician Mark Brehl working for Natural Resource Specialist Paul Whitefield at the Flagstaff Area National Monuments. The distribution of the species and field logistics allowed surveys to be completed in two phases: (1) a survey for tamarisk/camelthorn; and (2) a survey for selected (target) invasive species along the primary road corridors, around visitor use areas, and around other NPS administrative areas. For the latter phase, a target list was compiled of species which: (1) were frequently observed over preceding years by resource managers and field botanists along roadsides and developed areas within and nearby Wupatki; and (2) were known to San Francisco Peaks Weed Management Area members to establish high-density, persistent populations ("infestations") within

northern Arizona. Table 1 lists the common name, scientific name and Natural Resources Conservation Service (NRCS) standard identification code for target species. The survey was not restricted to these species. Brehl familiarized himself with other problem plants from available literature and websites. Incidentally-encountered species were added to the survey as field work progressed, and if necessary certain areas were re-surveyed. The surveys were initiated during August 2003 and continued on an intermittent schedule until September 2004. Brehl also continued to record incidental invasive plant observations while working on other field assignments during the 2005 season.

Table 1. Common name, scientific name, and Natural Resource Conservation Service identification code for target invasive plants at Wupatki National Monument.

Common Name	Family	Species (Auth.)	NRCS Code
Diffuse knapweed, white knapweed	*Asteraceae*	*Centarea diffusa* Lam.	CEDI13
Bull thistle, spear thistle	*Asteraceae*	*Cirsium vulgare* (Savi.) Ten.	CIVU
Halogeton, saltlover	*Chenopodiaceae*	*Halogeton glomeratus* (Bieb.)	HAGL
Russian thistle, prickly Russian thistle, tumbleweed	*Chenopodiaceae*	*Salsola tragus* L.	SATR12
Camelthorn	*Fabaceae*	*Alhagi maurorum* Medik	ALMA12
Yellow sweetclover	*Fabaceae*	*Melilotus officinalis* L. Lam.	MEOF
Horehound, hoarhound, white horehound,	*Lamiaceae*	*Marrubium vulgare* L.	MAVU
Cheatgrass, cheat, downy chess, downy brome	*Poaceae*	*Bromus tectorum* L.	BRTE
Wooly mullein, mullein, flannel leaf, velvet plant	*Scrophulariaceae*	*Verbascum thapsus* L.	VETH
Tamarisk, salt cedar	*Tamaricaceae*	*Tamarix chinensis* Lour.	TACH2

Conventional plot-based sampling to quantify species relative cover, density, frequency, or importance would be time-prohibitive given the large survey area, and the objective to efficiently provide distribution information for practical resource management application. The surveys were designed so field observations of target species could be rapidly recorded using a hand-held global positioning system (GPS) unit and incorporated into the geographic information system (GIS) for the Flagstaff Area National Monuments. Invasive plants were documented using different GPS mapping techniques, depending primarily upon whether the species growth habit, density, and cover were:

- Stands of trees, dense patches of shrubs, or dense patches of persistent herbaceous plants with relatively contiguous canopy or ground cover.
- Herbaceous or ephemeral annuals that did not occur in patches with contiguous ground cover, but were observed in high numbers of close but disjunct individuals within a given area of native vegetation.
- Randomly-encountered, very isolated individuals of perennial herbaceous; short-lived/rapidly-dehiscent herbaceous; and/or ephemeral annual plants.

Species of the first type of distribution/cover pattern listed above can be readily mapped and resolved on a GIS as a distinct cover area (polygon). Species of the second type, high-density/individual-plant distribution pattern, are very difficult and time consuming to map, and GPS methods were refined to allow practical reconnaissance over rather large survey zones (line and point data), while providing results that effectively support NPS planning, risk assessment, and invasive species management activities. For the third type of distribution/cover pattern, GPS point locations of widespread but notable locations for individual plants of target species were collected.

The project budget did not cover extensive mapping of non-target invasive species, but GPS point data was developed for a number of species that were encountered during field work. Although incidental records are of lesser importance for developing management strategies, the resulting presence/absence records are important for documenting newly detected invasive species or other notable distribution records.

GPS Data Correction and GIS Data Management. Location data for all invasive species was collected in the survey areas using a Trimble GeoExplorer 3 GPS unit, with the exception of one large tamarisk-dominated area at the confluence of Deadman Wash with the Little Colorado River (discussed below). Point (site), line (line), and area (polygon) files were recorded with the GPS unit to represent different distribution/density/cover patterns within the survey areas. PDOP (positional dilution of precision) was kept as low as possible to collect precise spatial data but was adjusted as necessary to ensure expeditious data collection. Post field-work processing of GPS files was done in the office using Trimble Pathfinder Office 2.80 computer software. GPS base files used for differential corrections were downloaded from Flagstaff 1 (FST1) CORS base station, operated by the U.S. Coast Guard with data provided through the National Geodetic Survey of the National Oceanic and Atmospheric Administration. GPS data files were then differentially corrected and exported into ESRI Shapefiles by Cindy Parker, Cartographic Technician, Flagstaff Area National Monuments. Shapefiles were displayed and manipulated in ESRI ArcGIS 8.3 to generate maps and images. Metadata was developed concurrently and incorporated into the GIS for the Flagstaff Area National Monuments. Processing the daily GPS files into a full GIS dataset for each invasive plant species, developing metadata, and composing the maps included in this report required about 160 hours of staff time.

Tamarisk and Camelthorn. Field surveys and GPS mapping of tamarisk and camelthorn was conducted between August 2003 and February 2004. Both species require shallow groundwater or reliable seasonal standing water, which reasonably excluded the western half of the monument above the Doney Monocline. All ephemeral drainages and their small-order tributaries within the Wupatki Basin were thoroughly surveyed (see Index Map in Appendix D), except for the mouths of Antelope Canyon and Citadel Canyon, which were avoided to minimize disturbance in sensitive wildlife habitat (Paul Whitefield noted no camelthorn or tamarisk present in either of these areas during prior field work). All known seeps, springs, man-made catchments, abandoned materials quarries, other disturbed areas, and other potential habitat within the Wupatki Basin was inspected. Approximately 120 hours were necessary to complete the field work.

Ephemeral drainage systems were surveyed by roaming on foot and using binoculars and spotting scopes. In addition, 1980's vintage maps and written directions to camelthorn and tamarisk populations by Cinnamon (1983, 1987) were used to resurvey known populations. Because the horizontal accuracy of the Trimble GPS unit is about 10 feet (about 3 meters), individual UTM points (site files) were collected to indicate the presence of individual plants or closely clustered stems/trunks within an area smaller than 50 square feet (about 5 square meters). Large camelthorn patches were recorded as polygons by following the outer edge of the shrub canopy. A very large tamarisk stand at the confluence of Dead Man Wash and the Little Colorado River was not field mapped with GPS. Instead, a polygon for this stand was derived from the GIS vegetation cover data for Wupatki produced by Hansen et al. (2004). The ArcInfo cover files include a "Riparian Invasive Shrubland" cover class which combines both tamarisk and camelthorn dominated vegetation. A large polygon of this cover class at the confluence area was modified by first subtracting the area dominated by camelthorn, which was field-mapped using the GPS. The polygon was next clipped to the monument boundary fence. The resulting polygon was thus of the large patch of tamarisk within the monument.

Road Corridors. Field work to search for and record the distribution of target invasive species along the primary access roads was completed between December 2003 and July 2004. This survey was conducted along 21 miles (33.79 kilometers) of the paved Wupatki-Sunset Crater Volcano Scenic Loop (NPS010/FR545), from the Wupatki National Monument entrance off of U.S. Highway 89, east and south to mile marker 21, at the Coconino National Forest boundary (see Index Map in Appendix E). This entire segment of road was scheduled by the NPS for re-paving, re-alignment, and other construction activities beginning in 2006. In addition to the scenic loop road, the paved spur roads to the Lomaki-Box Canyon and the Wukoki visitor use areas were also surveyed. Approximately 110 hours were necessary to complete the field work.

Roadside plant populations were located by driving very slowly in both directions, combined with walking surveys on both road shoulders, along the entire 21 miles of road. The search area was limited to a parallel belt extending approximately 15 feet (4.57 meters) on either side of the pavement edge. Species presence was determined by the occurrence of living plants and/or recognizable dead plant material obviously rooted within the roadside belt and not wind-blown or otherwise transported into the survey area.

Isolated individuals of the most widespread and abundant target species were often encountered within the belt, but were not recorded in order to make data collection feasible over long distances, assuming that mapping higher density occurrences of these same species would provide ample information for management purposes. Within the 15 feet-wide roadside survey belt, invasive species were recorded where densities reached at least 5 individual plants within a visually-estimated radius of 5.85 feet (1.78 meters, or a circle encompassing 10 square meters) around the observer. A GPS point (site file) was recorded if only 5 to 10 individual plants occurred within the 5.85 feet radius, which were disjunct from all other individuals outside of the perimeter by at least another 5.85 feet. Where invasive plants were more abundant within the roadside belt, GPS linear data were recorded parallel to the road. Each line feature represents a continuous population of a given species, where as the observer walked parallel to the road, a minimum of 11 individual plants continuously occurred within a 5.85 feet radius around the observer, no matter where the observer stood between the pavement and the outer edge of the survey belt. When this condition was true, the GPS was switched to record as the observer moved parallel to the road. When this condition was not true, the GPS recorder was paused. Where multiple species occurred within the same reach of roadside belt, it was traversed more than once, and a separate GPS line feature was collected for each species.

Of all the target species for the road corridor survey, only camelthorn grew in large enough patches to be mapped as polygons. Entire polygons of camelthorn were mapped even if a patch extended beyond the 15 feet roadside belt.

Visitor and Administrative Use Areas. All primary visitor-use and NPS operations areas at Wupatki were surveyed for invasive plants during 2005 (see Index Map in Appendix F). Visitor areas include the Visitor Center and the Wupatki, Citadel, Lomaki-Box Canyon, and Wukoki pueblos. NPS operations areas include the employee housing, maintenance shop, and wastewater discharge lagoons near the Visitor Center, and the New Heiser Administrative Area. Invasive plants are also a concern around abandoned NPS operations areas, including the former “Old Heiser” housing/maintenance area and two former construction materials quarries (see Index Map in Appendix G).

All of these areas were searched on foot, including a perimeter ranging from 20 to 100 feet (approximately 6 to 30 meters) around access drives, parking, sidewalks, trails, patios, archeological sites, employee residences, maintenance shops, equipment/materials yards, utility buildings, and other ancillary facilities. Some perimeter areas were excluded where the terrain was obviously too rugged, unvegetated slickrock, or densely covered with native shrubs. Invasive plant species were recorded

where densities reached a minimum of 5 individual plants within a radius of 5.85 feet (1.78 meters, or total area of 10 square meters) around the observer. For isolated occurrences of a given species, GPS points (site files) were recorded if 5 to 10 individual plants occurred within a 5.85 feet radius. Populations exceeding 10 individuals per 107.64 square feet (10 square meters) were recorded as polygons. Approximately 40 hours was required to complete the field work.

Species Area Calculations. Statistics that are representative of the area invaded by each species (not actual plant cover) were calculated in the office after all field data had been consolidated on the GIS. For site files of tamarisk and camelthorn, each GPS point represents a cover area of 50 square feet. The number of GPS points (site files) for each species was summed, then converted to acres. For the other predominantly herbaceous species, each site represents an infested area of 107.64 square feet (0.002 acres). The number of sites for each species was summed, then converted to acres. For line features recorded within the roadside survey belts, each 1 foot of line segment parallel to the road for a given species represents an infested area of 15 square feet (0.00034 acres) perpendicular to the pavement edge. The lengths of all the line feature segments for each species were calculated in feet using ESRI ArcGIS, summed, multiplied by 15, then converted to acres. The acreage of GPS polygons (shape files) collected during this survey, including the tamarisk polygon extracted from Hansen et al. (2004), was calculated using ESRI ArcGIS extension Xtools (free software developed by Mike Delaune and downloaded from the ESRI website). Lastly, the calculated acreages for site, line, and polygon data were summed by species to give total areas.

VI. Results.

This survey continues the camelthorn and tamarisk mapping efforts begun in 1983 at Wupatki National Monument, and is the first fully-documented survey of all suitable habitat for these two species within the monument. It is also the first systematic effort to develop information on selected invasive plants along paved road corridors and around other developed areas. A number of species are well-established and have remained at Wupatki since at least 1976 (identified in Table 2 and Table 3). Of the remainder, some were probably present but undocumented in 1976, so it is difficult to conclude which ones arrived since the late 1970's.

The calculated infested area for each of the ten target species is given in Table 2. Numerous isolated individuals and low-density occurrences of the most abundant species did not meet defined mapping criteria and were not recorded during the survey. However, the species distribution maps in the appendices provide useful baseline information for identifying areas in need of control efforts and developing treatment strategies. Within the entire survey area, a total of 84.46 acres (34.18 hectares) were mapped that harbor target invasive plants. The largest concentration of invasive species occurs in the riparian/ephemeral drainage system, with a combined 71.25 acres (28.83 hectares) covered by camelthorn and tamarisk. The roadside belt harbors nine target species, infesting a combined total of 8.43 acres (3.41 hectares). Five species occurred within the visitor use and facility areas, with a combined total of 2.09 acres (0.85 hectares). Another 2.69 acres (1.09 hectares) of camelthorn and tamarisk occur at two abandoned materials quarries. These and several other known quarries were not surveyed for the remaining eight target species in the monument.

Tamarisk and Camelthorn. Distribution maps for tamarisk and camelthorn in the Wupatki Basin are in Appendix D. In terms of total mapped land cover, tamarisk is the most prevalent invasive species within the monument. The current distribution largely agrees with Cinnamon's 1983 maps, and the results of this survey, along with Hansen et al.'s work (2004), confirm that tamarisk remains restricted to the Wupatki Basin. Tamarisk was found in thirty places, covering a total of 50.38 acres (20.39 hectares). The majority occurs in one rather large, homogenous stand located near the confluence of Deadman Wash and the Little Colorado River. This stand encompasses 49.25 acres (19.93 hectares)

Table 2. Calculated total area, in acres, of target invasive plant species mapped during 2003-2005 field surveys at Wupatki National Monument.

Common Name	NRCS Code	Roadside Corridors	Wupatki Basin	Visitor & Administrative Areas	Abandoned Materials Quarries	Total (acres)
tamarisk	TACH2 **	0.002	50.198	0.007	0.167	50.375
camelthorn	ALMA12 **	2.287	21.048	0.014	2.530	25.879
cheatgrass	BRTE **	3.482				3.482
Russian thistle	SATR12 **	1.885				1.885
halogeton	HAGL			1.800		1.800
horehound	MAVU **	0.085		0.267		0.352
bull thistle	CIVU **	0.322				0.322
yellow sweetclover	MEOF **	0.248				0.248
mullein	VETH **	0.113				0.113
diffuse knapweed	CEDI13	0.002		0.002		0.005
	Total	8.427	71.246	2.091	2.697	84.461

** Included on vascular plant checklist for WUPA, Appendix A, Bateman 1976.

within the monument, but it actually extends outside the boundary fence up and down the Little Colorado River floodplain. Twenty-two tamarisk sites, totaling 1.13 acres (0.46 hectares), were mapped within the remainder of the ephemeral drainages within the monument. Seventeen of these sites were individual plants or small patches of a few trees, totaling about 0.04 acres (0.02 hectares). One tamarisk tree was mapped at Peshlaki Spring. The two abandoned materials quarries included in the survey occur within or adjacent to these ephemeral drainages. One quarry contains three tamarisk patches totaling 0.17 acres (0.07 hectares) (see maps in Appendix G), while the second is partially covered by the large Deadman Wash stand mentioned above. Two tamarisk plants occur within the New Heiser administrative area (see maps in Appendix F).

Camelthorn is also relatively widespread within the Wupatki Basin, with a total cover of 25.88 acres (10.47 hectares). It occurs in several locations, mainly along the ephemeral drainages and tributaries of Deadman Wash, Antelope Wash, and the Little Colorado River. Camelthorn was mapped in the riparian/ephemeral drainage channels in 64 places, ranging from individual plants up to a single patch covering 3.39 acres (1.37 hectares), or an average of approximately 0.5 acres (0.20 hectares) per location. The largest patches occur in the northeast portion of the Wupatki Basin, where 20.9 acres (8.46 hectares) were mapped. Another moderately-sized patch in Heiser Wash covers 0.83 acres (0.33 hectares). Camelthorn covers 2.53 acres (1.02 hectares) at the two abandoned materials quarries included in the survey.

A total of 2.29 acres (0.97 hectares) of camelthorn occur along the road corridor (maps 23, 24, 30, 31, and 32 in Appendix D). The roadside populations were recorded in 31 locations with an average size of 0.07 acres (0.03 hectares). The largest roadside population, with an area of 0.99 acres (0.4 hectares), is found near the junction of NPS010/FR545 Road and the north access road to the abandoned Old Heiser operations area. Most other roadside populations occur along NPS010/FR545 near the south monument entrance, the New Heiser road junction, and the Heiser Wash area. Over half of the total area is in Heiser Wash, where two polygons have a combined area of 1.50 acres (0.61 hectares). Only three small populations were mapped along the road north and west of the Visitor Center. In addition to the total given in Table 2, a 0.17 acre (0.05 hectare) two patches were recorded along the

NPS010/FR545 right-of-way through the Gannon Ranch south of the park (maps 34 and 37in Appendix D). Another 0.07 acre (0.006 hectare) patch was recorded near Sunset Crater Volcano National Monument at the junction of NPS010/FR545 and FR 224 (not shown on maps). The only occurrence of camelthorn around NPS facilities is at the Wupatki Visitor Center, with a small patch in the center island and another on the southeast edge of the parking lot.

Road Corridor. Nine of the ten target species were detected and mapped along the NPS010/FR545 Road and paved spur road corridors (see maps in Appendix E). The road-side belt survey area encompassed a total of 76.36 acres (30.90 hectares), with 8.47 acres (3.43 hectares) covered by invasives species. Camelthorn covered the greatest area (discussed above), with cheatgrass the next most prevalent. Cheatgrass was mapped in 90 locations, covering 3.48 acres (1.41 hectares). The cheatgrass locations averaged 0.06 acres (0.02 hectares) in area, with a maximum of 0.23 acres (0.09 hectares).

Russian thistle is the third most prevalent invasive species found along the roadsides, and based upon observations on other field projects is generally noted to be extremely widespread across the greater Wupatki landscape. A total of 1.89 acres (.076 hectares) were mapped in fifty locations. Forty populations were large, averaging about 0.06 acres (0.02 hectares) each, with a maximum of 0.19 acres (0.08 hectares). Another 10 locations were small populations, covering a total of about 0.03 acres (0.01 hectares). In addition, an estimated 20+ acres (8.09 hectares) of Russian thistle extend immediately adjacent to the defined NPS010/FR545 road-side survey belt, but were not mapped or included in the results table.

Less than 0.50 acre each of five other target species was found along the roadsides. These populations were typically small, with an average of less than 0.05 acres (0.02 hectares). Bull thistle was mapped along the roadside near miles 2.5 and 5, occurring in 8 locations with a total of 0.32 acres (0.13 hectares). Yellow sweet clover occurs in ten sites, totaling 0.25 acres (0.10 hectares). The largest roadside population is near mile marker 4, between the junction of Lomaki-Box Canyon Road and the Citadel Pueblo parking lot. Wooly mullein occurs at seven sites near miles 1.5 and 5, covering a total of 0.11 acres (0.05 hectares). Several populations of horehound were recorded near mile markers 6, 8, and 21, with a total of 0.09 acres (0.04 hectares). One diffuse knapweed plant was found in the Wupatki Basin near mile 15.5, and is a probable newly invading species.

NPS Visitor and Administrative Use Areas. The NPS operations areas at Wupatki contain surprisingly few invasive plants, considering the intensity of human activity and potential for introduction. Four of the ten target species were detected and mapped around visitor and administrative use areas - halogeton, camelthorn, tamarisk, and horehound (see maps in Appendix F). All four are present at the New Heiser administrative area, where 1.80 acres (0.73 hectares) of halogeton was mapped around the materials piles and maintenance yard (note: subsequent control efforts have likely reduced halogeton cover within this area). Two tamarisk trees are present at New Heiser, along with camelthorn patches (camelthorn cover is included in the roadside survey totals). Horehound is prevalent around the parking lot and trail head at the Lomaki-Box Canyon Pueblos, with a total cover of 0.27 acres (0.11 hectares). A diffuse knapweed plant was also detected and recorded east of the Wukoki parking lot (this location was inadvertently left off of maps).

Abandoned Materials Quarries. Of the target species, only camelthorn and tamarisk occurred at the two abandoned material quarries included in the survey (see maps in Appendix G). Combined cover was 2.69 acres (1.09 hectares). The mapped occurrences are essentially within the Wupatki Basin ephemeral drainage system, and more information is provided in the tamarisk and camelthorn results section above.

Incidental Observations. A list of non-target invasive plant species encountered during the surveys was compiled as field work progressed and knowledge of the local flora improved (see Table 3). Site records were also collected for nine species (see maps in Appendix H). These observations represent species presence only – there are no defined search areas and the information is not representative of distribution patterns. The incidental observations include the first occurrence records for red brome, diffuse knapweed, Russian knapweed, and Dalmatian toadflax – species which should receive resource management attention as soon as possible. Until March and April 2005, red brome had not been not been noted or documented within the monument, but following a wet winter it suddenly appeared to be widespread in microhabitats along the limestone Doney bluffs and Moenkopi terrain near the River Road. Dalmatian toadflax was also observed during 2005 at two additional locations along the entrance road in the western half of the monument (not shown on maps). Even though the incidental occurrence information is scant, it is likely indicative of active immigration of regionally known problem species into the monument, and highlights the need for sustained reconnaissance and mapping efforts.

Table 3. Common name, scientific name, and Natural Resource Conservation Service identification code for incidental invasive plants encountered during 2003-2006 at Wupatki National Monument.

Incidental Invasive Species – Limited Site Records Collected			
Common Name	**Family**	**Species**	**NRCS Code**
Russian knapweed	*Asteraceae*	*Acroptilon repens* L.	ACRE3
Common cocklebur **	*Asteraceae*	*Xanthium strumarium* L.	XAST
Tall tumblemustard **	*Brassicaceae*	*Sisymbrium altissimum* L.	SIAL2
Russian olive	*Elaeagnaceae*	*Elaeagnus angustifolia* L.	ELAN
Red-stem stork's bill, fillaree **	*Geraniaceae*	*Erodium* cicutarium (L.) L'Hér. ex Aiton	ERCI6
Cheatgrass	*Poaceae*	*Bromus tectorum* L.	BRTE
Red brome	*Poaceae*	*Bromus rubens* L.	BRRU2
Broadleaf dock	*Polygonaceae*	*Rumex obtusifolius* L.	RUOB
Dalmatian toadflax	*Scrophulariaceae*	*Linaria dalmatica* L.(Mill.)	LIDA
Other Invasive Species - No Location Records Collected			
Sowthistle	*Asteraceae*	*Sonchus arvensis* L.	SOAR2
Bursage	*Asteraceae*	*Ambrosia acanthicarpa* Hook.	AMAC2
Ragweed **	*Asteraceae*	*Ambrosia artemisiifolia* L.	AMAR2
Salsify **	*Asteraceae*	*Tragopogon dubius* Scop.	TRDU
Horseweed	*Asteraceae*	*Conyza canadensis* L. Cronquist	COCA5
Pigweed **	*Amaranthaceae*	*Amaranthus cf. retroflexus* L.	AMRE
Lambsquarters **	*Chenopodiaceae*	*Chenopodium cf. album* L.	CHAL7
Kochia	*Chenopodiaceae*	*Kochia scoparium* (L.) A.J. Scott	KOSC
Rabbits foot polypogon	*Poaceae*	*Polypogon monspeliensis* (L.)Desf.	POMO5
Lombardy poplar	*Salicaceae*	*Populus nigra* L.	PONI
Siberian elm	*Ulmaceae*	*Ulmus pumila* L.	ULPU

** Included on vascular plant checklist for WUPA, Appendix A, Bateman 1976.

VII. Species Risk Assessment.

A total of 23 invasive plant species were detected within Wupatki National Monument during this survey. Prior to initiating management actions, an analytical and objective approach is useful to rank invasive species for treatment. Some invasive species do not greatly impact the biotic integrity of protected areas or undermine NPS management objectives, and therefore may not need intensive

management. Other species severely disrupt ecosystem function and unacceptably impact native flora and fauna, fire regimes, soils, hydrologic processes, nutrient cycling, or successional patterns. These often possess high reproductive capability, persistent seed banks and repeat germination events, or constant recruitment from populations outside of management area boundaries. For newly invading species, swift and vigorous action may be needed to forestall long-term (and often indefinite) efforts to combat them.

An objective assessment protocol is outlined in the Handbook for Ranking Exotic Plants for Management and Control (Heibert and Stubbendieck 1993). The protocol can be used to score and rank species according to three basic factors: (1) the current level of impact; (2) the innate ability of a species to become a pest; and (3) the feasibility of control. Appendix A summarizes these three factors and their associated elements. This assessment process also establishes a record of the various factors deliberated while species are prioritized. The Alien Plants Ranking System Version 5.1 (APRS) program (available for download at: http://www.npwrc.usgs.gov/resource/literatr/aprs/index.htm) is largely based upon Heibert and Stubbendieck's criteria. It is designed to identify those species which pose the greatest threat to native communities but can also be most successfully managed. The APRS is also weighted towards species which may not be currently abundant or causing major impacts, but possess life history traits of ruderal, weedy species or are known to cause substantial impacts within similar habitats. Low priority will be given to those species which are determined to be innocuous and/or impossible to control.

The APRS program was used to rank the invasive species in the Wupatki surveys. Consideration of the relationships between ranking factors, field observations, and literature reviews were used to categorize species as minor, moderate, or serious concern to management. Table 4 gives the scores for each species, and Appendix B and Appendix C document the numeric responses used to assess target and incidental species, respectively. Figure 1 graphically shows the relationship between current impact, innate ability to become a pest, and control feasibility for the ten target species. Figure 2 shows the same for incidental species. Scores resulting from species rankings were not used alone to categorize the level of concern.

Only the rankings for camelthorn and tamarisk are based upon actual knowledge of their entire distribution within the monument and a greater understanding of their ecological impacts. Although scientific information is lacking to accurately estimate the current level of impact for most other species, they were ranked using reasoned assumptions after three years of observing them in the Wupatki environment. It is important to note that some of the Wupatki species, particularly the incidental ones, may be ranked low due to the lack of information on their current distribution and impacts. Additional inventory, monitoring, and research may reveal some of them pose more serious threats or are already more difficult to control than their current rank indicates.

Invasive Plants of Minor Concern. Invasive species that ranked below an APRS total score of 111 are presumed to be of minor concern. Most of these species are generally restricted to frequently disturbed sites, and poorly compete with well-established native vegetation. They have limited ability to reproduce and spread, and relatively little effort is necessary to control them. These species are therefore relatively innocuous. They may be manually controlled as labor is available, although herbicide treatment may be more effective and economical.

At Wupatki, target species in this category include wooly mullein, bull thistle, and yellow sweet clover. Incidental species include amaranth, broadleaf dock, bursage, cocklebur, horseweed, Kochia, lambsquarters, Lombardy poplar, ragweed, red stem stork's bill, rabbitsfoot polypogon, Siberian elm, sowthistle, and yellow salsify. Hand pulling prior to flowering and removal of new or old seed heads will limit spread and may eventually help eradicate some species. Continued treatments, regardless of

methods, may be necessary to combat species with long lived seeds. The introduced landscape trees, Siberian elm and Lombardy poplar, should be mechanically removed using chainsaws. Periodic pruning of stump sprouts after felling can eventually deplete the tree's stored energy reserves and kill them. This method requires repetition over time and may not be effective. Cut stump application of herbicide is recommended to kill the trees immediately and prevent re-sprouting.

Table 4. Scores derived from the Alien Plant Ranking System Ver. 5.1 for invasive plant species at Wupatki National Monument. Species are listed in descending order by total score.

Target Species					
Species	**Symbol**	**(1) Impact**	**(2) Pest**	**(3) Control**	**Total**
Tamarisk	TACH2	82	87	79	248
Camelthorn	ALMA12	78	81	76	235
Cheatgrass	BRTE	67	63	63	193
Russian thistle	SATR12	51	56	75	182
Diffuse knapweed	CEDI13	47	68	24	139
Halogeton	HAGL	36	44	53	133
Horehound	MAVU	36	49	47	132
Bull thistle	CIVU	15	46	39	100
Yellow sweetclover	MEOF	25	41	33	99
Wooly mullein	VETH	20	38	39	97
Incidental Species					
Species	**Symbol**	**(1) Impact**	**(2) Pest**	**(3) Control**	**Total**
Russian knapweed	ACRE3	51	78	37	166
Red brome	BRRU2	53	60	43	156
Dalmatian toadflax	LIDA	33	62	53	148
Tall tumblemustard	SIAL2	33	52	52	137
Russian olive	ELAN	29	63	41	133
Fillaree	ERCI6	29	35	47	111
Rabbits foot polypogon	POMO5	22	49	35	106
Lambsquarters	CHAL7	16	35	49	100
Kochia	KOSC	22	41	31	94
Siberian elm	ULPU	7	38	44	89
Sowthistle	SOAR2	9	44	27	80
Bursage	AMAC2	20	37	20	77
Salsify	TRDU	9	29	35	73
Broadleaf dock	RUOB	7	33	31	71
Ragweed	AMAR2	11	22	16	49
Pigweed	AMRE	18	19	11	48
Horseweed	COCA5	15	24	7	46
Common cocklebur	XAST	7	29	8	44
Lombardy poplar	PONI	13	14	16	43

Invasive Plants of Moderate Concern. Species of moderate concern have APRS scores ranging from 132 to 166. These currently do not threaten to overwhelm biotic communities at Wupatki or to otherwise undermine NPS management goals. However, they have life history traits of weedy, ruderal species or are otherwise capable of prolific reproduction and spread. Existing populations should be closely monitored. Target species in this category include diffuse knapweed, halogeton, and horehound. Incidental species in this category include Russian knapweed, red brome, Dalmatian toadflax, tumble mustard, and Russian olive. These all currently occur in very isolated sites, and timely treatment is warranted. They can be controlled or eradicated with repeated manual removals, though herbicide is likely to be more effective and economical. If treatments are delayed, some species are likely to become species of serious concern.

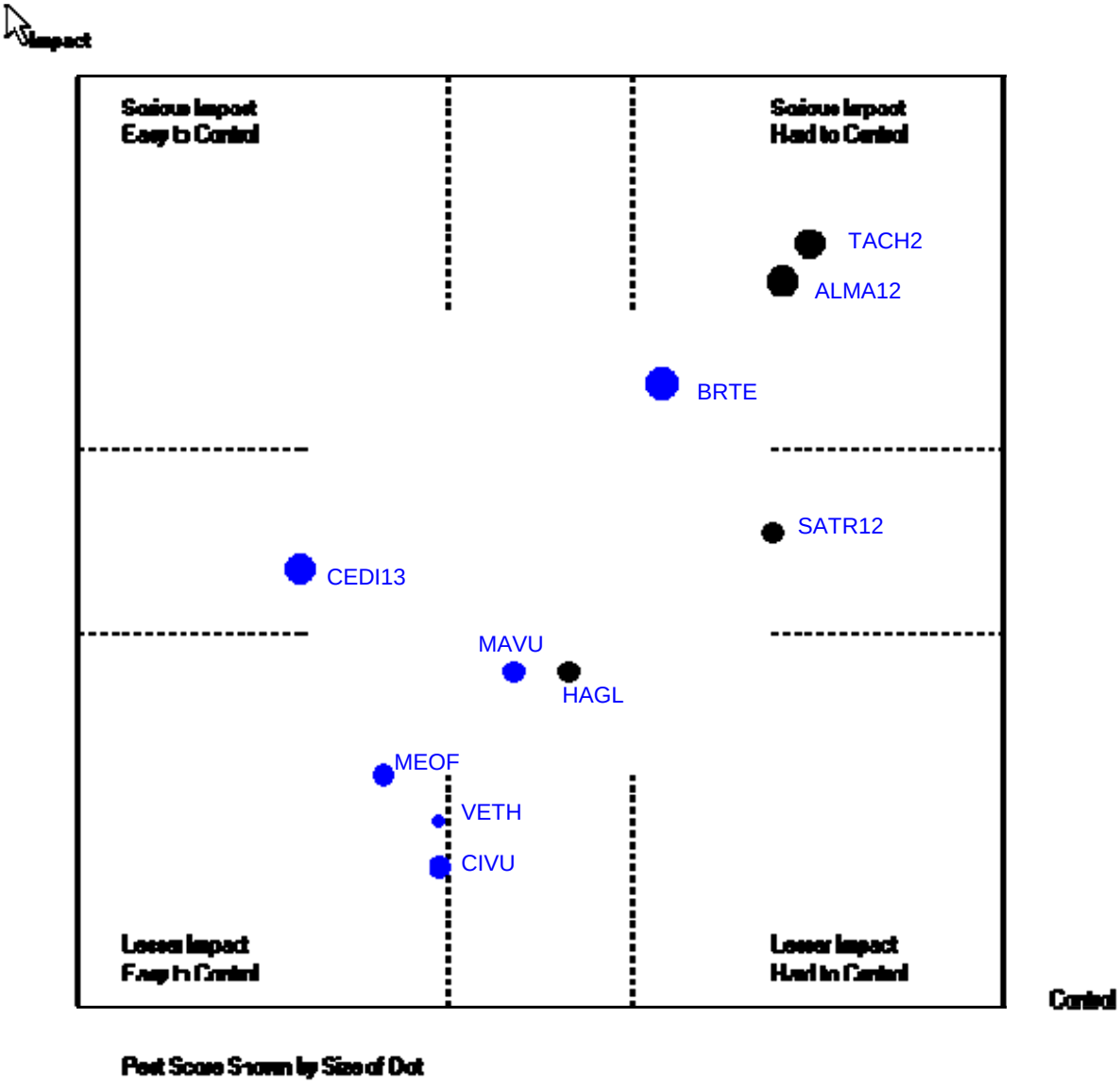


Figure 1. Relationships between current impact, innate ability to become a pest and control feasibility for the ten target species (see Table 3 for species names for plant identification acronyms).

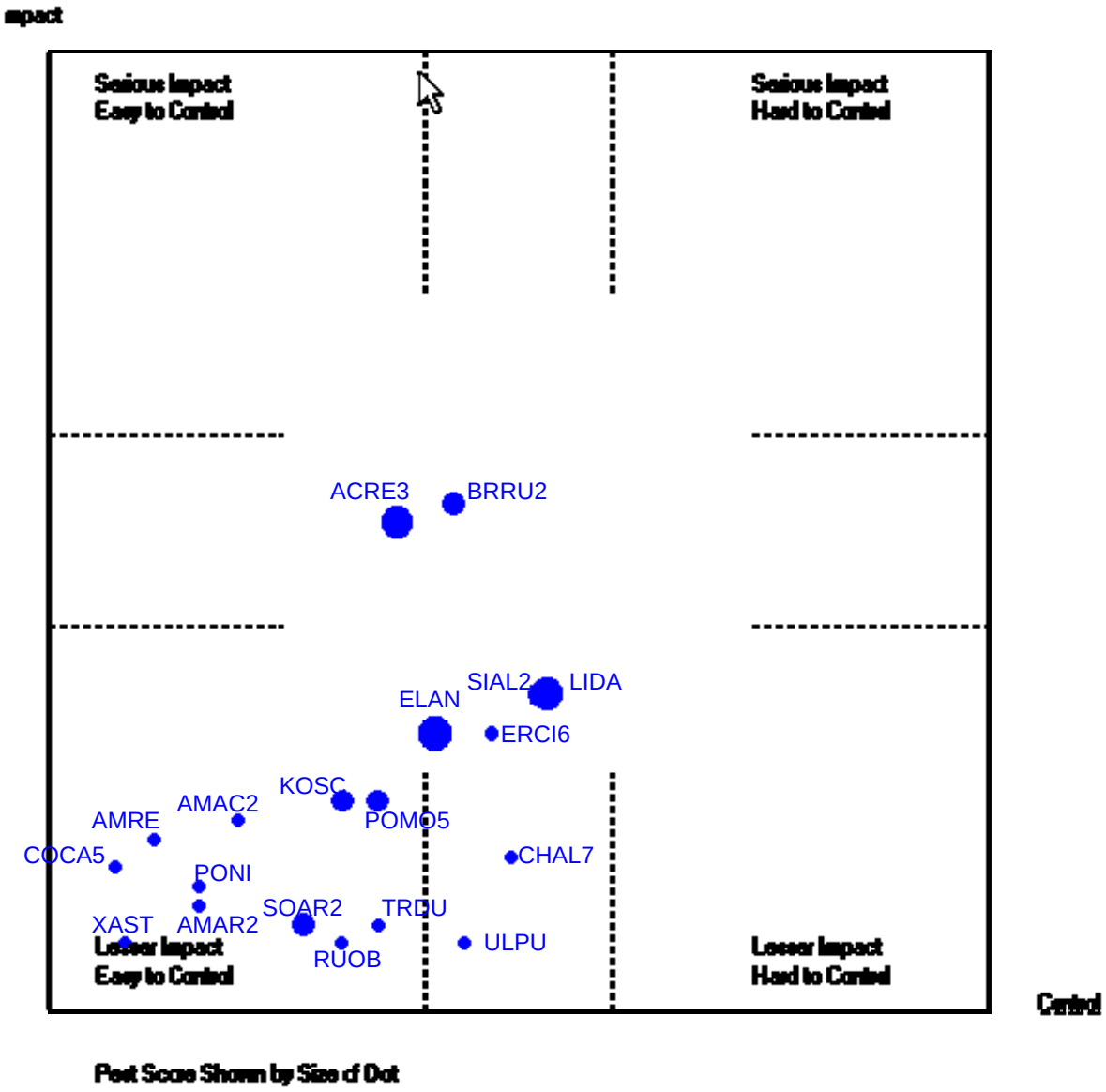


Figure 2. Relationship between current impact, innate ability to become a pest and control feasibility for incidental species (see Table 3 for species names for plant identification acronyms).

Invasive Plants of Serious Concern. Species of serious concern have APRS total scores above 182. For species that are impossible to eradicate or control over entire landscapes, management alternatives include localized control, incremental control, or no action. Selected species may be managed in unique resource areas, rare plant communities, or sensitive plant and wildlife habitats. Another approach is to "quarantine" selected species to certain portions of the monument and prevent their spread. A confinement strategy entails control of small outlying portions surrounding the main population and incrementally working toward the center. This approach limits seed dispersal, and prevents expansion into adjacent areas. Large populations will likely require treatment exclusively with herbicides. Disjunct populations may be strategically controlled through repeated mechanical or manual treatments, but a combination of these with herbicide treatments will yield the best long term results. Eventually the population may be reduced so that eradication may be possible. The "no

action" alternative may be necessary for species or areas where treatments will likely be ineffectual. This allows management to focus limited funding and staff time on other species or populations where progress can be made. Ecological and operational impacts should be openly acknowledged as unavoidable, but mitigating measures may be identified to reduce effects on unique and sensitive species.

At Wupatki, tamarisk, camelthorn, cheatgrass, and Russian thistle currently cause the most serious impacts and are the hardest to control. Tamarisk occurs in every major watershed in the southwest (USDA Forest Service 2005) and is the dominant species along the Little Colorado River riparian corridor adjacent to Wupatki (Hansen et al. 2004.) Camelthorn is widespread and pernicious within the Little Colorado River Basin. However, reliable control methods are well-documented, and skilled crews with the NPS Exotic Plant Management Teams are available to complete initial treatments. Cheatgrass and Russian thistle are ubiquitous across the landscape of the southern Colorado Plateau, and cannot be feasibly controlled across the entire monument. Although complete eradication may not be possible, there are options to lessen impacts from these species. Management along road corridors and around developed areas is important to preserving natural viewsheds and maintaining the desired visitor experience. The NPS might consider designating Special Ecological Areas (SEA's) where justified, such as the relatively scarce riparian vegetation around the park's springs, seeps, near the Little Colorado River, and other unique resource areas. For a number of invasive species discussed earlier in this report, particularly some of the incidental species, continued inventory and assessment is needed to determine which species are best managed with quarantine/confinement or area exclusion strategies.

VIII. Management Recommendations.

Integrated Pest Management. An Integrated Pest Management (IPM) approach is probably the best pro-active, landscape-scale, invasive species management strategy. IPM planning combines manual, cultural, chemical and biological agents to control invasive species. Integrating two or more of these approaches often produces a synergistic effect. This approach not only limits herbicide dependence and reduces environmental effects from its use, but can also provide a more cost effective and successful long-term solution to the invasive problem. Control treatments must be followed by actively restoring native vegetation.

Project Mitigation. Another effective means for preventing the introduction or deterring the spread of invasive plants is to inventory project sites and incorporate control treatments in advance of ground-disturbing activities. Mitigating measures identified during project planning and other best management practices to minimize the risk of introducing invasive species via construction equipment and materials should be standard procedure, and incorporated into contracting documents and cooperative agreements. Follow-up treatment, active site restoration, and/or otherwise enhancing natural succession rates following project implementation will foster competition by native vegetation and suppress invasives at project sites.

Repeat Inventory and Routine Reconnaissance. A systematic approach to inventorying invasive plant populations and conducting reconnaissance for new arrivals is vital to a successful invasive plant management program. Inventories provide information on the presence, distribution and affected habitats, and are crucial for planning, budgeting, and setting work priorities. Routine reconnaissance is crucial for early detection of newly invading species and initiating prompt control actions while a species is still manageable. Monitoring determines whether species treatments methods or project mitigation measures are effective. All information on the occurrence and distribution of invasive plants should be incorporated into the Flagstaff Area National Monuments' GIS. In addition, issues of plant identification often arise, and voucher specimens should be collected and preserved as a matter of long-term record.

Natural resource personnel should conduct routine reconnaissance of roadsides, visitor-use and NPS administrative areas, and project sites. Secondary and primitive roads, including the Black Falls Crossing Road and the Crack-in-Rock Road, were omitted from this survey but probably should be included in any routine reconnaissance. Because the southern Colorado Plateau experiences a fairly strong bi-modal precipitation regime, conducting both spring and fall surveys is important for detecting ephemeral annual and other herbaceous species which may not be readily identifiable either at the beginning or the end of the growing season. A practical example of the effectiveness of post-project reconnaissance occurred within the monument as this survey project was initiated. In 2002, the NPS completed a waterline installation project to the New Heiser operations area. The following year, Paul Whitefield noticed the first occurrence of halogeton patches on the backfilled waterline trench. Over the course of 3 subsequent years of pulling, bagging, and disposal off-site by natural resource technicians, work groups, and other on-site NPS staff, the species appears to have been controlled and no individuals were observed in 2006 or 2007.

An inventory of all invasive species in the remaining “backcountry” area of Wupatki National Monument has not been conducted, but is highly recommended to gain baseline data. While a 100% survey is not feasible, systematic and strategic methods may be developed to associate various species with available habitats, and possibly improve the ability for early detection of problem species. A network of randomly-selected, fixed area plots stratified across the range of habitats and plant communities could provide information on the temporal dynamics and effects of invasive species on the Wupatki ecosystem. Invasives are more likely to be found in habitats with frequent natural disturbance regimes, although there may be focal habitats where they may have disproportionate impacts on overall species diversity. Backcountry areas which may be targeted for more frequent reconnaissance or systematic monitoring efforts include: wildfire burn areas, seeps, springs, ephemeral drainages, active aeolian deposits, or areas where trespass livestock or native ungulates frequently travel or congregate. The remaining areas presumably provide fewer ecological opportunities for invasion and dispersal, and may be checked less frequently than transportation corridors, frontcountry areas, and rare/vulnerable habitats.

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Appendix A:
Alien Plant Ranking System
Assessment Questions

(1) Current level of impact. The elements contributing to this factor are based on the existing impacts of invasives in the park as determined by recent site surveys.

A. *Distribution relative to disturbance regime*. What is the frequency of disturbance in the area where the species is present? Species occurring in recently or frequently disturbed areas may not be considered a serious threat. These species may have limited ability to thrive in undisturbed areas and generally occur in areas which can be easily accessed for treatment. Species which are present or actively invading native vegetation in relatively undisturbed habitats are perceived to be more pernicious and therefore a more serious threat.

B. *Abundance and Areal extent of populations*. How much of the site is invaded and how many populations exist? Species found in large or numerous populations are generally well established and can be difficult to control. They are given a high priority ranking for treatment. Smaller and more scattered populations should be given precedence in the treatment schedule over larger and more closely clustered populations. As population sizes and densities increase, so do the costs and efforts required for control.

C. *Numerical dominance of species within a community.* How dominant is the species in an area compared to native vegetation? The numerical dominance of a species represents its present intensity within a community. Species occurring in number greater than most native species are considered extremely pernicious and are given high priority over less abundant invasive species.

D. *Effects on natural processes and character*. What level of impact does the species have on ecological processes and fitness? Innocuous species which do not significantly harm park resources may not require extensive active management while pernicious species may require necessitate swift and vigorous action. Species which adversely natural processes such as fire and hydrological regimes, nutrient cycling, successional patterns or otherwise alter native communities are considered the greatest threat and are given high priority.

E. *Association with native community*. What seral stage is the community where the species is generally found? Early successional species are generally only found in disturbed areas. Species which exist in mature mid-late successional areas are generally capable of invading a wider range of habitats and are given high priority.

F. *Hybridization with native species*. Can the species hybridize with native species? Species with the ability to hybridize with native species are more capable of adapting to localized conditions and therefore receive a high priority ranking.

G. *Degree and threat of impact*. How urgent is the threat to the resources at risk? Certain park values at risk from existing populations can raise the priority ranking of a species. Species are ranked high which have an immanent threat to park resources.

H. *Effects on management goals*. What level of impact does the species have on management goals? Management goals for Wupatki include the perpetuation of ecological processes, protection of native species, preservation of cultural resources as well as providing for visitor experiences. Species with adverse direct or indirect effects on management goals are ranked higher for treatment than those with little or no impact on goals.

(2) Innate ability to become a pest. This section addresses the potential for an invasive to become a pest. Species are ranked according to their life history traits associated with ruderal weedy species and their known impacts in other natural areas.

A. *Mode of reproduction.* Does the species reproduce in the area? If not, it is not considered a threat. If so, is it sexual reproduction, vegetative or both? Vegetative reproduction maintains current populations and contributes to localized spread. Species producing sexually can create propagules with the potential for long distance dispersal and highly adapted genetic combinations helping them thrive in a wider range of conditions. Species utilizing both methods have an extreme competitive advantage and are given the highest priority.

B. *Vegetative Reproduction*. How much does vegetative growth contribute to the increase of population size? High priority is given to species which rapidly increase population size from vegetative growth.

C. *Frequency of sexual reproduction for a mature plant*. How often does a mature plant produce seeds? Species reproducing intermittently when climatic conditions allow are generally not considered a great threat. Other species reproduce biennially, annually or several times a season are given higher priority. Most frequently reproducing species are given the highest priority.

D. *Number of seeds per plant*. How many seeds can potentially be produced per plant? Species producing few seeds are not given the high priority reserved for more prolific seed producing species.

E. *Dispersal ability*. Does the species have special adaptations for long distance seed dispersal? Species with adaptations for long distance seed dispersal through wind, water and animals have the potential to invade new communities and are given high priority.

F. *Germination requirements*. Does the species have specific or general germination requirements? Does it need disturbed soil or can it germinate in fit and undisturbed community? Species requiring disturbed soil to germinate or other limiting factors are given low priority. Generalist species with the ability to germinate in variety of conditions are given high priority.

G. *Seed banks*. How long do the seeds persist in the soil. Species with long soil seed viability require long term monitoring and treatment of newly germinating plants and are given high priority.

H. *Competitive ability*. How successfully can the species compete with native species? Species with traits allowing them to out compete native species for light, water or other necessary resources are given high priority.

I. *Ecological effects*. What ecological effects is the species known to cause? Does it produce allelochemicals, affect soil nutrient availability, alter fire and hydrological regimes or other ecological functions? Species with the most potentially severe effects are given highest priority.

J. *Known level of impact in natural areas*. What level of impact has the species had on other natural areas? Species heavily impacting other natural areas are given high priority if the habitats and climate are similar. Species occurring impacting dissimilar habitats may not be expected to have the same types or level of impacts though can still serve to indicate the species characteristics.

(3) Feasibility of control. This factor incorporates the feasibility and costs of control into the overall species ranking allowing land managers to weigh the cost of control against both positive and negative effects. Species which are easier to control are given high priority. Species for which no effective control is available or those for which treatments result in unacceptable disturbances are given low priority.

A. *Abundance within Park*. How abundant is the species within the park? This element addresses the current presence in the Monument, as determined through site surveys, and how it will affect the level of effort necessary for control. Species with numerous large populations are more difficult to control than those with few or small populations.

B. *Likelihood of successful control*. What is the probability the species will be successfully controlled? This element considers how the life history traits of species affect the level of effort necessary for control. Species with generalist requirements and weedy ruderal traits such as the propensity for

C. *Saturation in surrounding region*. Is the species present around the park and to what extent? Species with numerous or large populations surrounding the park provide seed sources for distribution into the parks and are given high priority.

D. *Effectiveness of community management*. Are cultural techniques effective at controlling the species? Is burning flooding, inter-planting with competitive species or other cultural techniques effective?

E. *Vegetative regeneration*. Does the species have the ability to re-sprout from stumps or roots? Species with no vegetative regeneration are easier to control and therefore given high priority for treatment.

F. *Biological control*. Are bio-control options available and feasible? Bio-controls may provide an advantage to control when combined with other methods. Species which have now bio-control available will be more difficult to control and are given high priority.

G. *Side effects of control measures*. What are the side effects from control measures? Effective control of some species or populations may result in unacceptable site disturbance and can even create conditions ideal for re-colonization by the same species or establishment of species new to the site. Species with few negative side effects resulting form control measures or those which are easily mitigated are given high priority.

Appendix B:
Alien Plants Ranking System
Record of Responses for Target Species in Wupatki Surveys

APRS DataFile: WUPAWEED.DAT [9/22/2005]

1 Site: Wupatki National Monument Species: Camelthorn
#1:D #2:D #3:E #4:D #5:A #6:E #7:D #8:D #9:D #10:D #11:C #12:A #13:B #14:C #15:C #16:ACDE #17:E #18:C #19:B #20:D #21:B #22:C #23:C

2 Site: Wupatki National Monument Species: Halogeton
#1:A #2:E #3:E #4:A #5:A #6:D #7:C #8:C #9:A #10:D #11:C #12:B #13:A #14:C #15:A #16:C #17:D #18:B #19:A #20:B #21:A #22:C #23:A

3 Site: Wupatki National Monument Species: Yellow sweetclover Incomplete
#1:B #2:C #3:D #4:B #5:U #6:C #7:B #8:C #9:A #10:D #11:D #12:A #13:A #14:C #15:C #16:U #17:D #18:U #19:C #20:B #21:B #22:U #23:B

4 Site: Wupatki National Monument Species: Horehound Incomplete
#1:B #2:B #3:D #4:D #5:U #6:C #7:B #8:C #9:A #10:D #11:D #12:B #13:B #14:C #15:B #16:U #17:D #18:U #19:B #20:D #21:B #22:B #23:B

5 Site: Wupatki National Monument Species: Russian thistle
#1:D #2:E #3:E #4:B #5:A #6:D #7:C #8:C #9:A #10:D #11:D #12:B #13:C #14:B #15:B #16:E #17:D #18:B #19:D #20:D #21:A #22:C #23:D

6 Site: Wupatki National Monument Species: Wooly mullein Incomplete
#1:B #2:B #3:B #4:B #5:A #6:C #7:B #8:C #9:A #10:C #11:D #12:A #13:B #14:C #15:B #16:U #17:D #18:B #19:B #20:D #21:B #22:A #23:B

7 Site: Wupatki National Monument Species: Cheatgrass Incomplete
#1:C #2:E #3:E #4:D #5:U #6:E #7:C #8:C #9:A #10:D #11:C #12:B #13:B #14:C #15:C #16:E #17:E #18:U #19:D #20:B #21:A #22:C #23:C

8 Site: Wupatki National Monument Species: Diffuse Knapweed Incomplete
#1:B #2:B #3:B #4:D #5:A #6:E #7:B #8:C #9:A #10:D #11:D #12:B #13:C #14:C #15:C #16:B #17:E #18:U #19:B #20:B #21:A #22:B #23:B

9 Site: Wupatki National Monument Species: Bull thistle Incomplete
#1:B #2:B #3:B #4:A #5:U #6:C #7:B #8:C #9:A #10:C #11:D #12:B #13:B #14:C #15:B #16:U #17:D #18:C #19:B #20:D #21:A #22:B #23:A

10 Site: Wupatki National Monument Species: Tamarisk
#1:D #2:E #3:E #4:D #5:A #6:E #7:D #8:D #9:D #10:D #11:D #12:B #13:C #14:A #15:C #16:ABDE #17:E #18:C #19:C #20:D #21:C #22:B #23:C

Appendix C:
Alien Plants Ranking System
Record of Responses for Incidental Species in Wupatki Surveys

APRS DataFile: WUPA2.DAT [9/22/2005]

1 Site: Wupatki Species: Siberian elm Incomplete
#1:C #2:B #3:B #4:A #5:U #6:A #7:A #8:C #9:A #10:E #11:D #12:B #13:B #14:C #15:B #16:U #17:U #18:U #19:B #20:D #21:B #22:C #23:A

2 Site: Wupatki Species: Lombardy poplar Incomplete
#1:D #2:B #3:B #4:A #5:U #6:A #7:A #8:B #9:C #10:U #11:B #12:A #13:A #14:B #15:B #16:U #17:U #18:U #19:A #20:B #21:B #22:U #23:A

3 Site: Wupatki Species: Rabbits Foot Polypogon Incomplete
#1:A #2:B #3:B #4:D #5:U #6:A #7:U #8:C #9:A #10:D #11:D #12:B #13:C #14:B #15:B #16:U #17:D #18:U #19:B #20:D #21:A #22:C #23:A

4 Site: Wupatki Species: Redstem stork's bill Incomplete
#1:B #2:B #3:D #4:C #5:U #6:C #7:B #8:C #9:A #10:D #11:C #12:A #13:A #14:C #15:B #16:U #17:D #18:U #19:B #20:D #21:A #22:C #23:B

5 Site: Wupatki Species: Russian olive Incomplete
#1:B #2:B #3:B #4:D #5:U #6:A #7:B #8:C #9:A #10:D #11:D #12:B #13:C #14:C #15:C #16:U #17:E #18:U #19:B #20:D #21:B #22:B #23:B

6 Site: Wupatki Species: Broadleaf Dock Incomplete
#1:A #2:B #3:B #4:A #5:U #6:C #7:U #8:B #9:B #10:D #11:D #12:A #13:B #14:C #15:B #16:U #17:U #18:U #19:B #20:U #21:B #22:C #23:A

7 Site: Wupatki Species: Sowthistle Incomplete
#1:B #2:B #3:B #4:A #5:U #6:C #7:U #8:D #9:C #10:D #11:D #12:B #13:B #14:B #15:B #16:U #17:U #18:U #19:D #20:U #21:B #22:B #23:U

8 Site: Wupatki Species: Cocklebur Incomplete
#1:A #2:B #3:B #4:A #5:U #6:C #7:U #8:C #9:A #10:D #11:C #12:B #13:A #14:B #15:A #16:F #17:U #18:U #19:B #20:U #21:U #22:U #23:A

9 Site: Wupatki Species: Red Brome Incomplete
#1:C #2:C #3:E #4:D #5:U #6:E #7:U #8:C #9:A #10:D #11:C #12:B #13:B #14:B #15:C #16:E #17:E #18:U #19:D #20:B #21:A #22:B #23:C

10 Site: Wupatki Species: Lambsquarters Incomplete
#1:A #2:B #3:D #4:B #5:U #6:C #7:U #8:C #9:A #10:D #11:D #12:A #13:A #14:C #15:B #16:U #17:C #18:D #19:C #20:A #21:A #22:C #23:B

11 Site: Wupatki Species: Yellow Salsify Incomplete
#1:B #2:B #3:B #4:A #5:U #6:C #7:U #8:C #9:A #10:C #11:C #12:B #13:B #14:B #15:A #16:U #17:A #18:U #19:B #20:D #21:A #22:C #23:A

12 Site: Wupatki Species: Russian Knapweed Incomplete
#1:B #2:B #3:D #4:D #5:U #6:E #7:B #8:D #9:D #10:D #11:D #12:B #13:C #14:C #15:C #16:B #17:E #18:C #19:B #20:B #21:B #22:A #23:B

13 Site: Wupatki Species: Dalmatian Toadflax Incomplete
#1:A #2:B #3:C #4:D #5:U #6:C #7:B #8:D #9:D #10:E #11:D #12:A #13:C #14:C #15:C #16:U #17:E #18:U #19:C #20:D #21:C #22:B #23:B

14 Site: Wupatki Species: Tumble Mustard Incomplete
#1:B #2:B #3:D #4:B #5:U #6:D #7:C #8:C #9:A #10:D #11:D #12:B #13:B #14:C #15:B #16:U #17:D #18:U #19:C #20:D #21:B #22:C #23:U

15 Site: Wupatki Species: Kochia Incomplete
#1:A #2:C #3:C #4:B #5:U #6:C #7:B #8:C #9:A #10:D #11:D #12:B #13:B #14:A #15:B #16:U #17:D #18:U #19:D #20:U #21:A #22:C #23:B

16 Site: Wupatki Species: Bursage Incomplete
#1:A #2:B #3:C #4:A #5:U #6:D #7:B #8:C #9:B #10:D #11:D #12:A #13:B #14:B #15:B #16:U #17:C #18:U #19:C #20:U #21:B #22:U #23:A

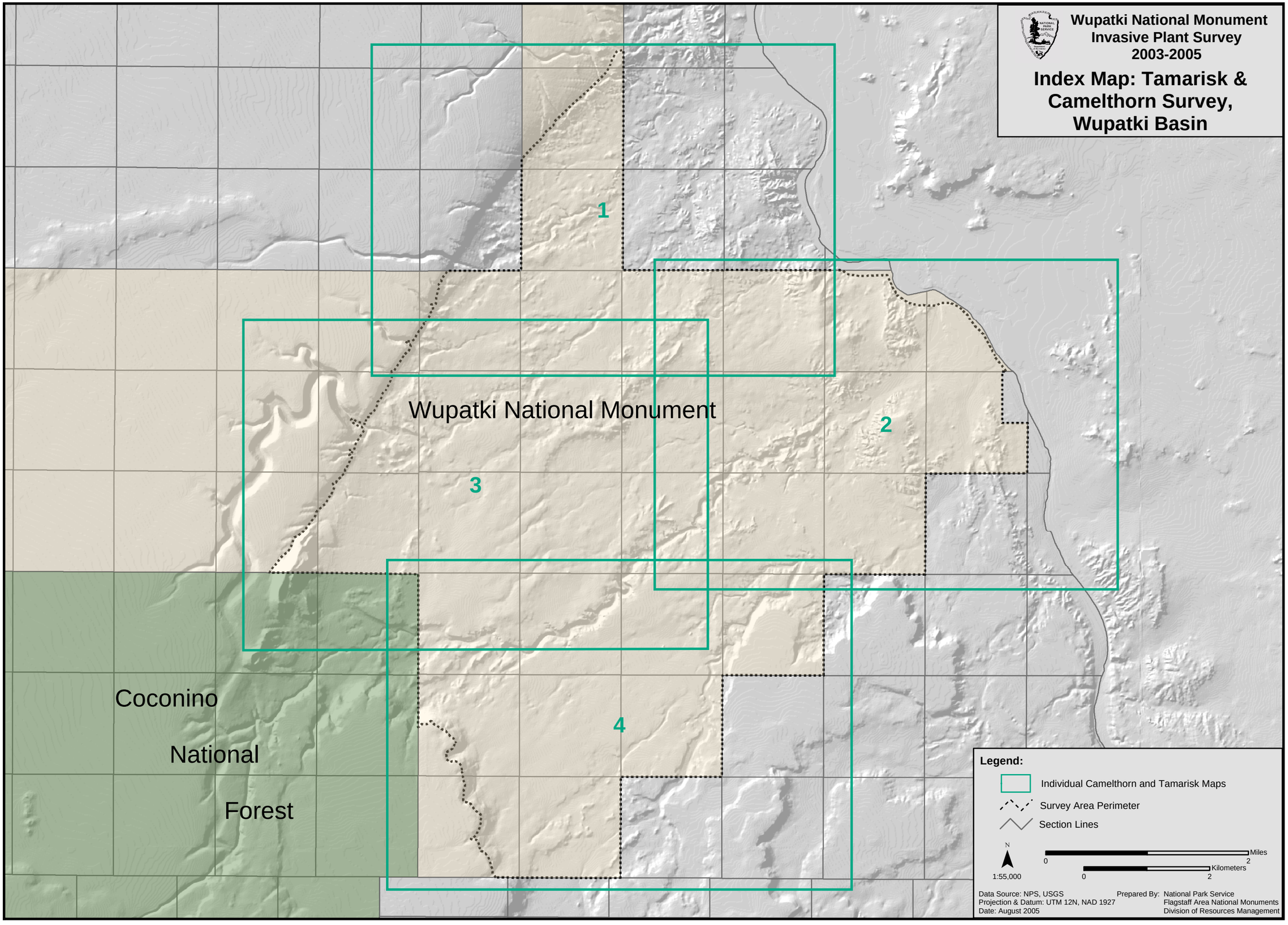
17 Site: Wupatki Species: Amaranth Incomplete
#1:A #2:B #3:B #4:U #5:B #6:A #7:B #8:C #9:A #10:D #11:D #12:U #13:U #14:U #15:U #16:U #17:U #18:U #19:B #20:U #21:B #22:U #23:A

18 Site: Wupatki Species: Ragweed Incomplete
#1:A #2:B #3:C #4:A #5:U #6:A #7:B #8:C #9:U #10:D #11:C #12:A #13:B #14:A #15:B #16:U #17:U #18:U #19:C #20:U #21:B #22:U #23:A

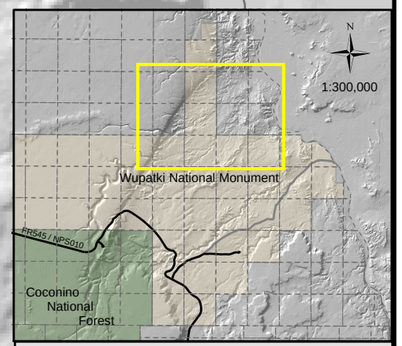
19 Site: Wupatki Species: Horseweed Incomplete
#1:A #2:B #3:C #4:A #5:U #6:C #7:B #8:U #9:U #10:D #11:C #12:B #13:B #14:U #15:U #16:U #17:U #18:U #19:B #20:U #21:U #22:U #23:A

Appendix D

Tamarisk and Camelthorn Distribution Maps
Wupatki National Monument


Wupatki National Monument
Invasive Plant Survey
2003-2005
Index Map: Tamarisk & Camelthorn Survey, Wupatki Basin
1
2
3
4
Wupatki National Monument
Coconino
National
Forest
Legend:
Individual Camelthorn and Tamarisk Maps
Survey Area Perimeter
Section Lines
N
1:55,000
Miles
0
2
Kilometers
0
2
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005
Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
Tamarisk & Camelthorn Distribution
Map 1



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Camelthorn *(Alhagi maurorum)*
- Tamarisk *(Tamarix chinensis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Boundaries

- Monument Boundary
- Survey Area Perimeter
- Section Lines

N

1:20,000

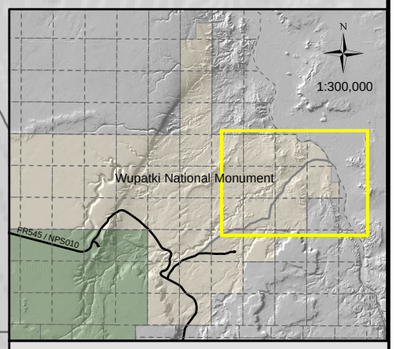
Miles
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Kilometers
0 0.5

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
Tamarisk & Camelthorn Distribution
Map 2



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Camelthorn *(Alhagi maurorum)*
- Tamarisk *(Tamarix chinensis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Boundaries

- Monument Boundary
- Survey Area Perimeter
- Section Lines

N

1:20,000

Miles
0 0.5

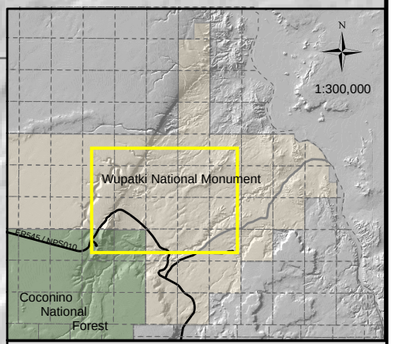
Kilometers
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Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Tamarisk & Camelthorn Distribution
Map 3



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Camelthorn *(Alhagi maurorum)*
- Tamarisk *(Tamarix chinensis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Boundaries

- Monument Boundary
- Survey Area Perimeter
- Section Lines

N

Miles
0 0.5

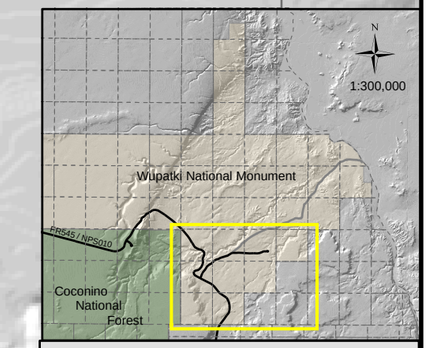
Kilometers
1:20,000 0 0.5

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

Tamarisk & Camelthorn Distribution
Map 4



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Camelthorn *(Alhagi maurorum)*
- Tamarisk *(Tamarix chinensis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Boundaries

- Monument Boundary
- Survey Area Perimeter
- Section Lines

N

1:20,000

Miles
0 0.5

Kilometers
0 0.5

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Appendix E

Distribution Maps for Target Invasive Species
Road Corridors
Wupatki National Monument

Wupatki National Monument
Invasive Plant Survey
2003-2005
Index Map: Road Corridors

Wupatki National Monument

Coconino

National

Forest

89

NPS010 / FR545

Legend:

- NPS010 / FR545 Road Segment Map
- Spur Road Segment Map
- Section Lines

N

1:68,000

0 1 2 Miles

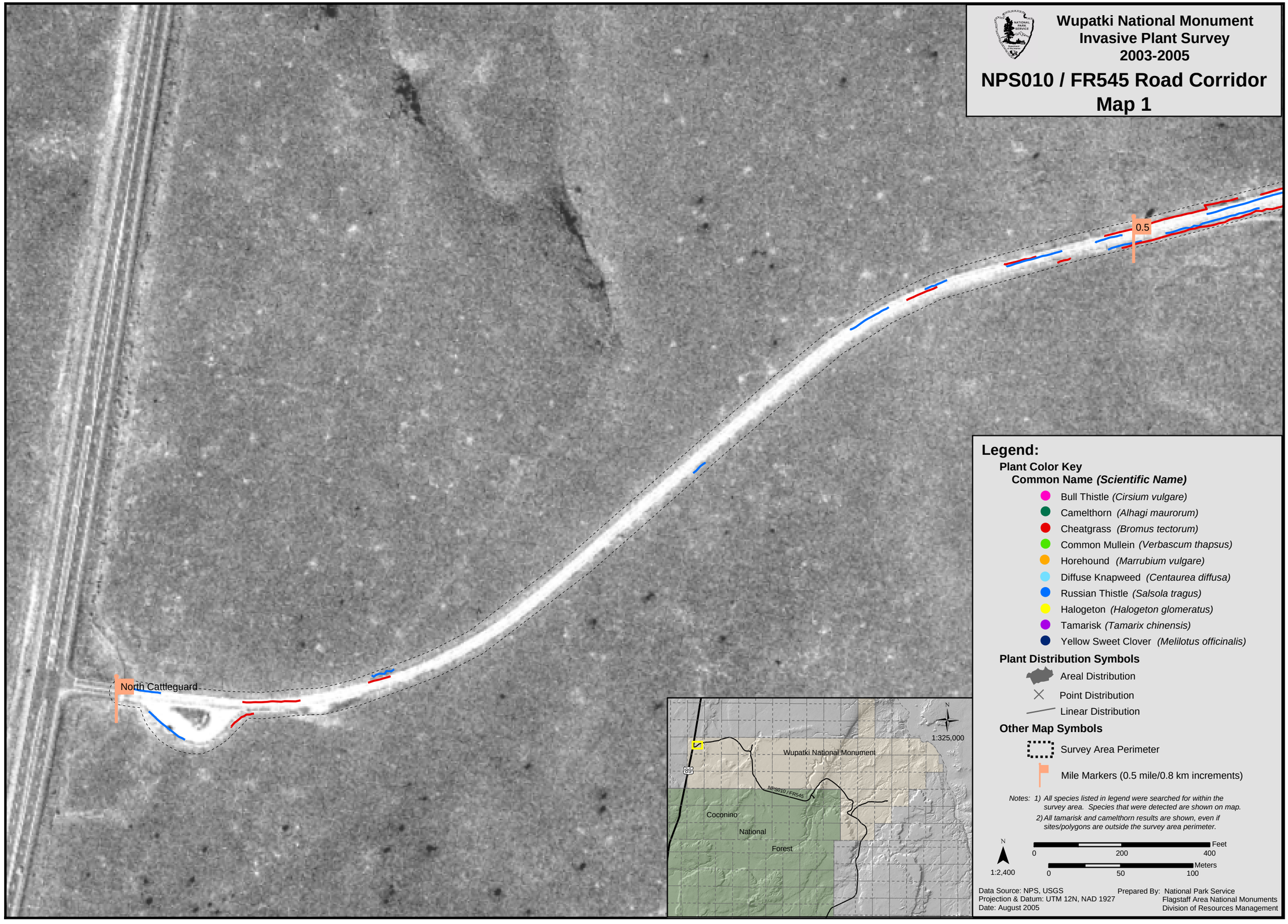
0 1 2 Kilometers

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 1



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

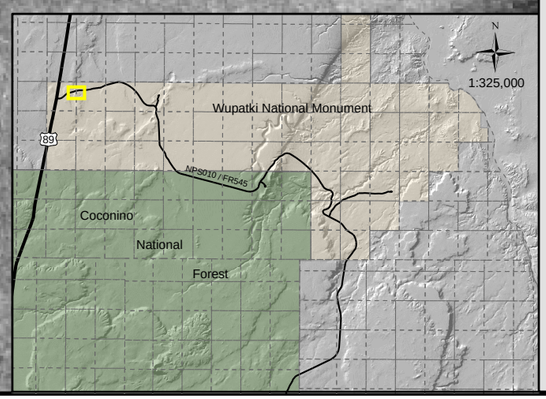
Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 2

0.5

1.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

Meters: 0 — 50 — 100

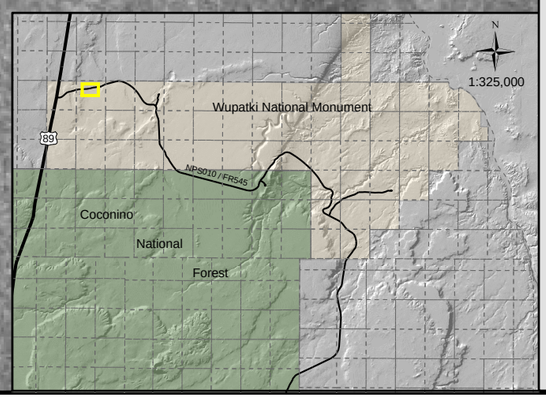
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 3

1.0

1.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 200 400

Meters: 0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

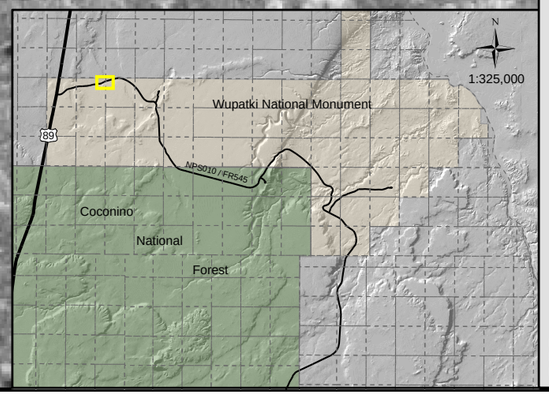
Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 4

2.0

1.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

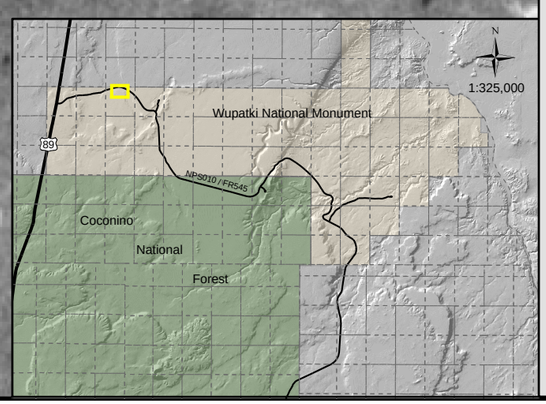
Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 5

2.0

2.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 6

2.5

3.0

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

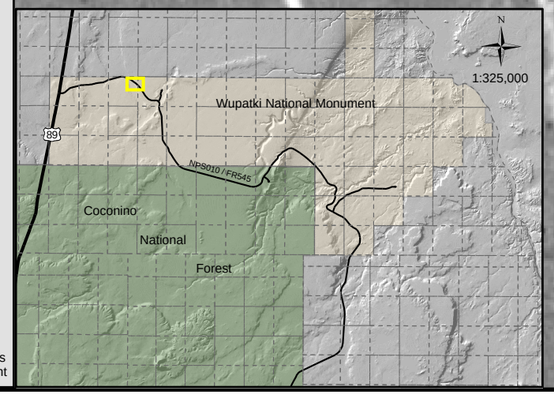
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 200 400

Meters: 0 50 100



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 7

3.0

3.5

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: *1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.*

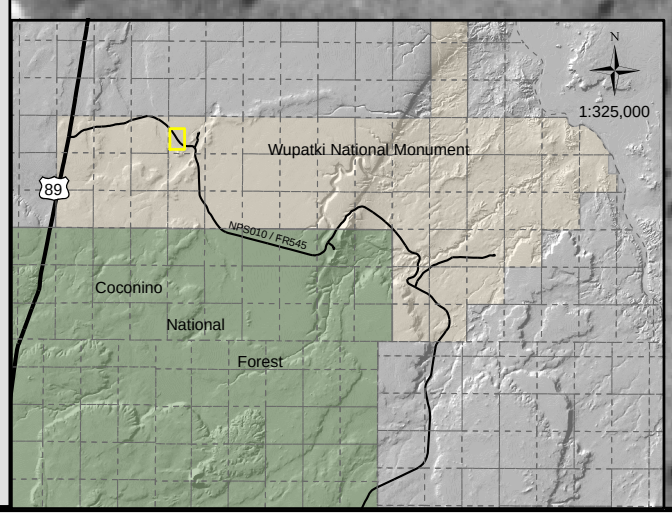
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 200 400

Meters: 0 50 100



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 8

3.5

4.0

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

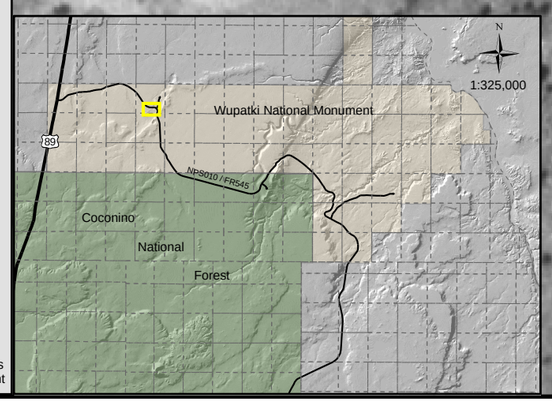
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0 200 400 Feet

0 50 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

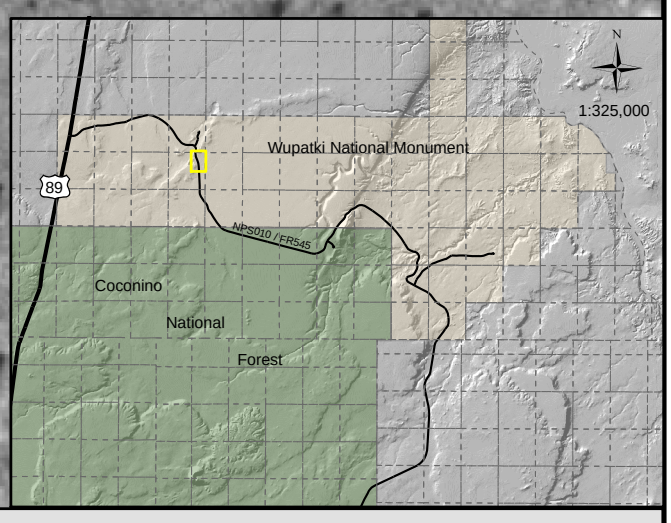
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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 9

4.0

4.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

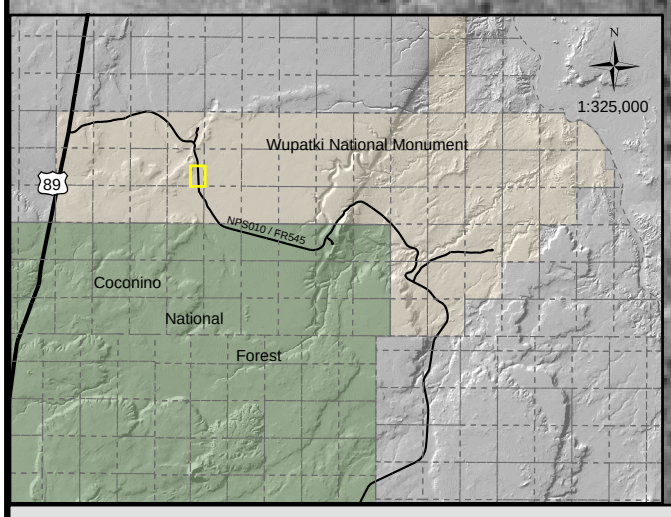
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 10

4.5



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: *1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.*

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

5.0

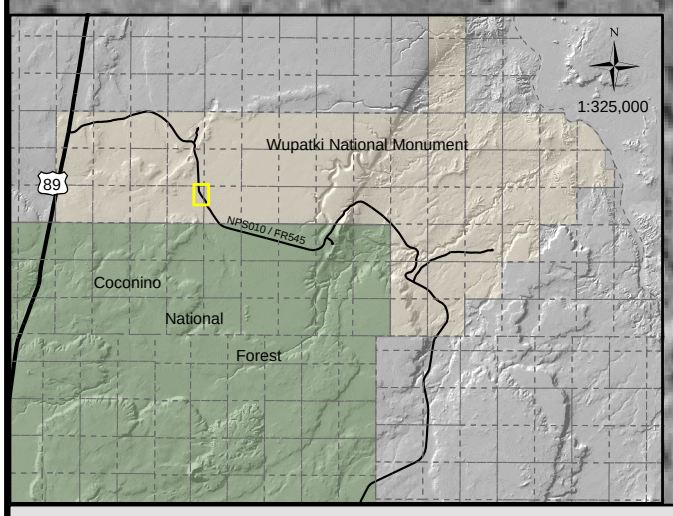
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 11

5.0



5.5

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: *1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.*

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

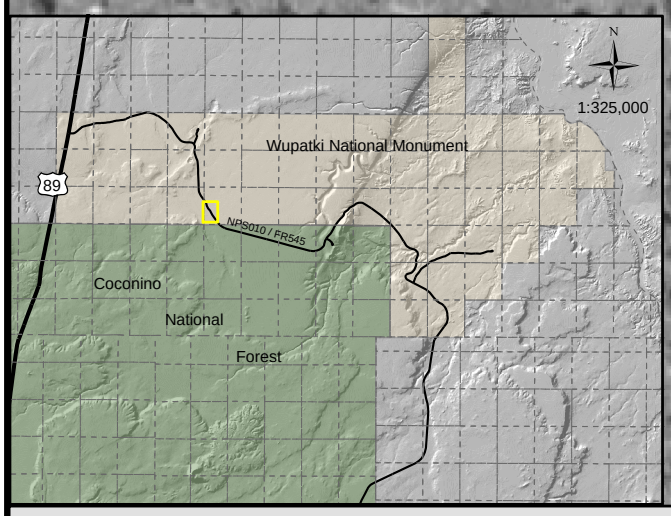
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 12

5.5

6.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 13

6.0

6.5

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

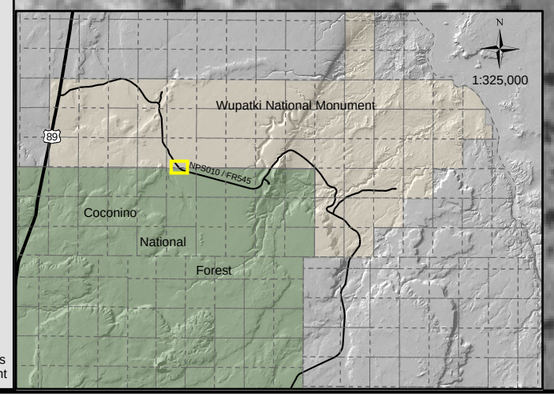
1:2,400

Feet: 0 200 400

Meters: 0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management



Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 14

6.5

7.0

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

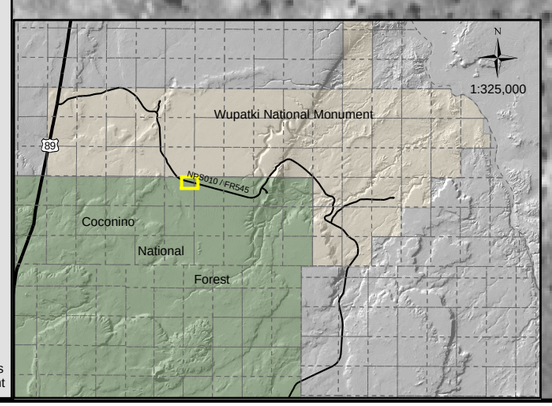
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

0 200 400 Feet

0 50 100 Meters



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 15

7.0

7.5

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

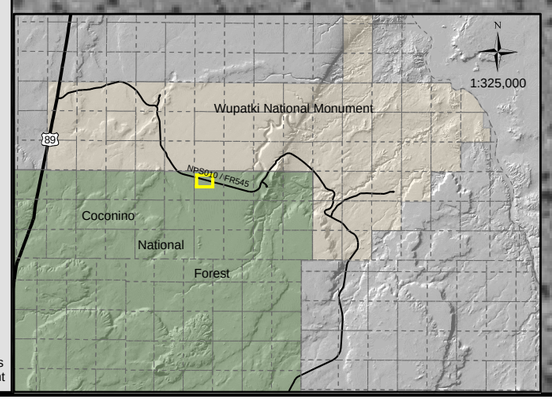
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

0 200 400 Feet

0 50 100 Meters



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 16

7.5

8.0

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

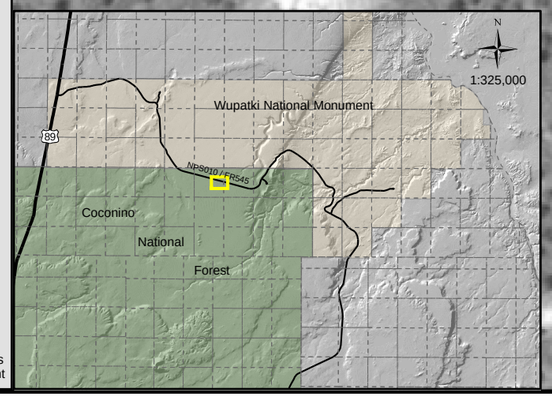
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 200 400

Meters: 0 50 100



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 17

8.0

8.5

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

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N

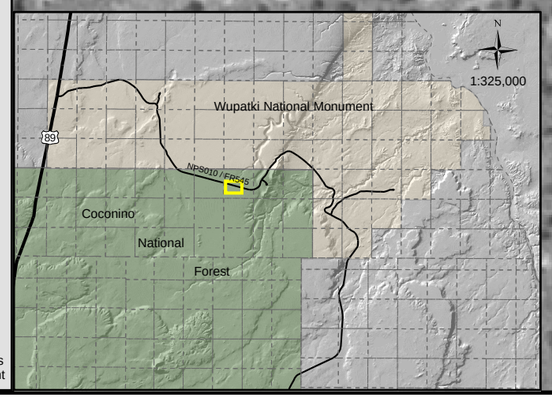
1:2,400

0 200 400 Feet

0 50 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management



Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 18

8.5

9.0

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

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N

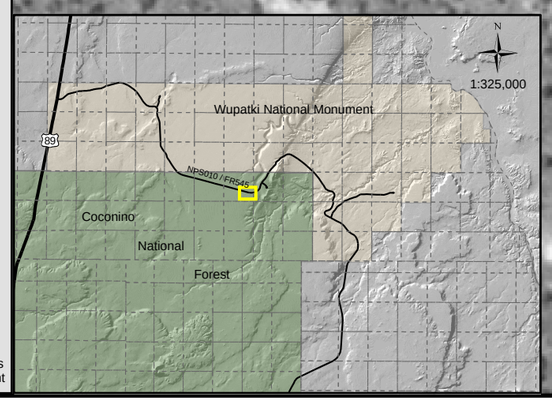
1:2,400

0 200 400 Feet

0 50 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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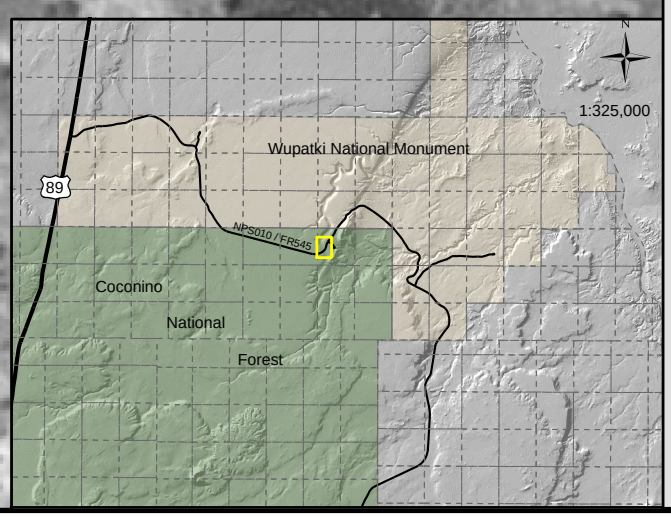


Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 19

9.5

9.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

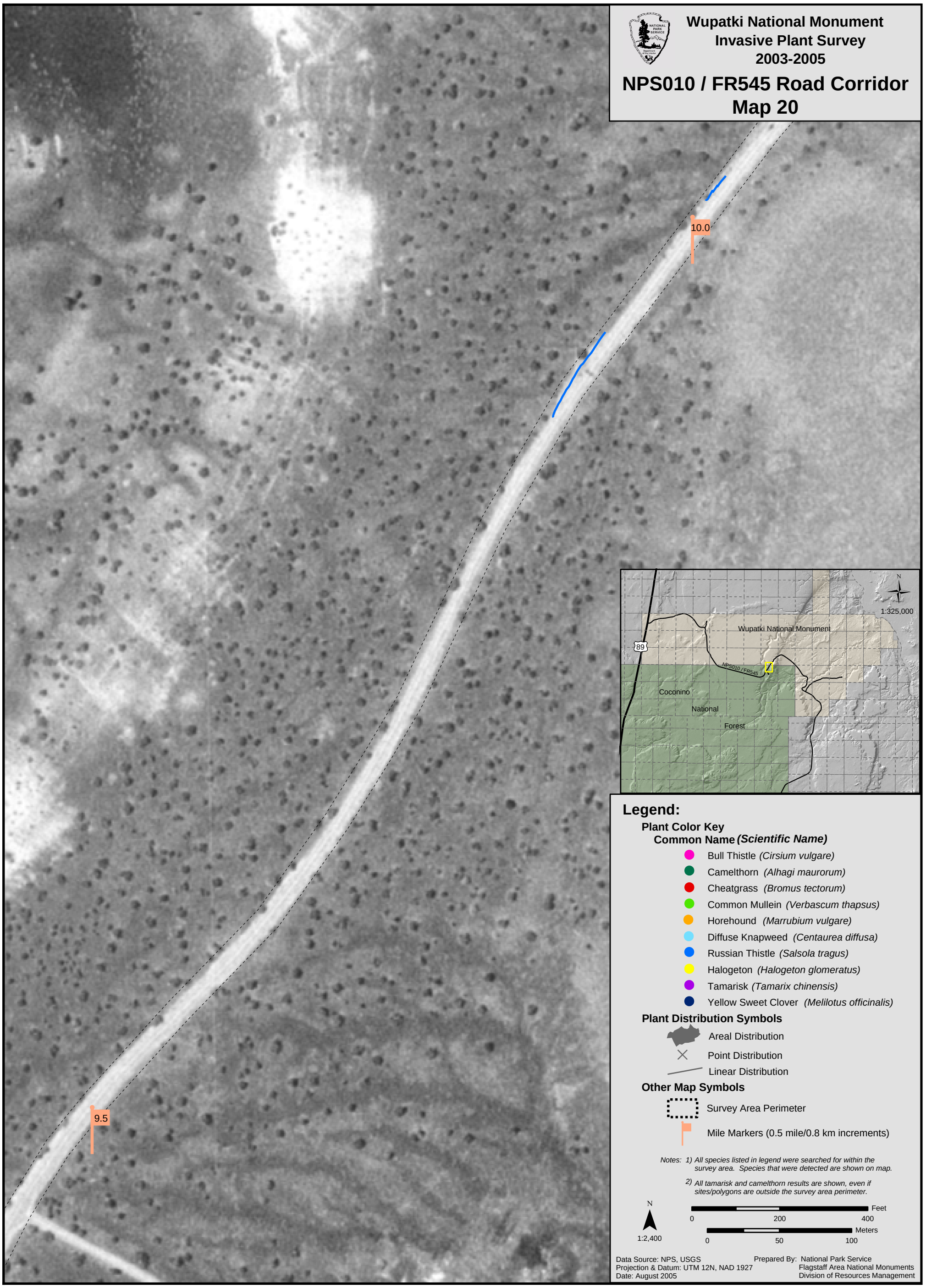
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 20



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

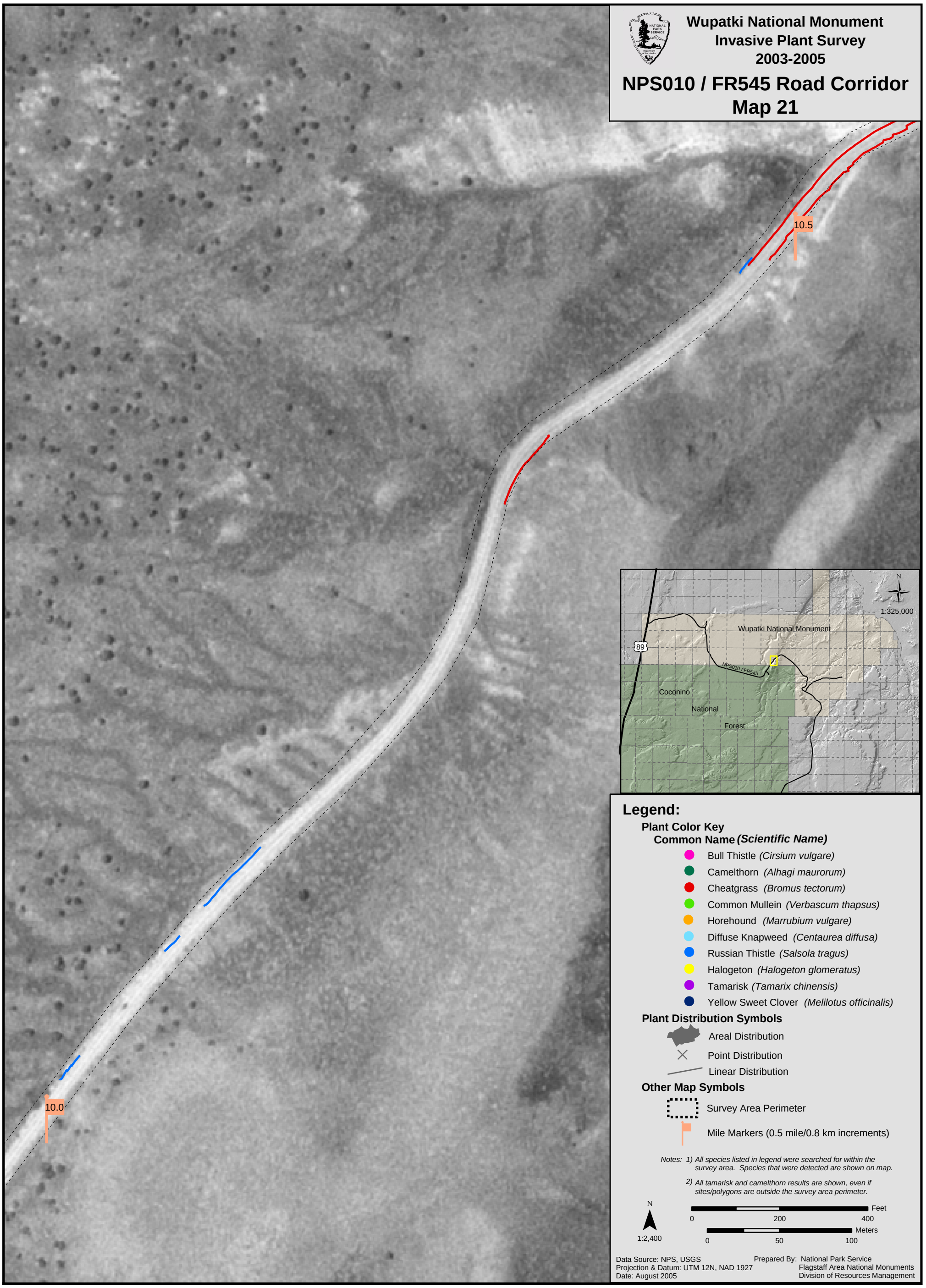
Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 21



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

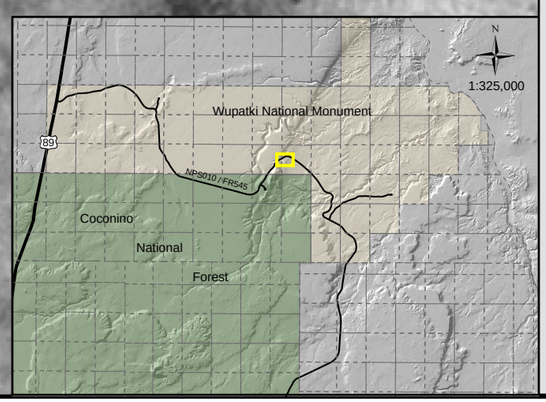
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 22

11.0

10.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

0 200 400 Feet

0 50 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 23

11.0

11.5

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

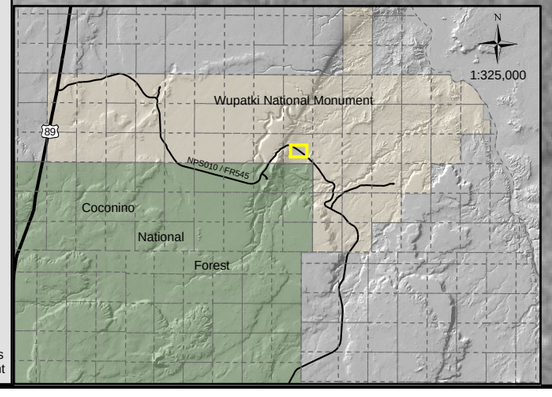
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

0 200 400 Feet

0 50 100 Meters



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

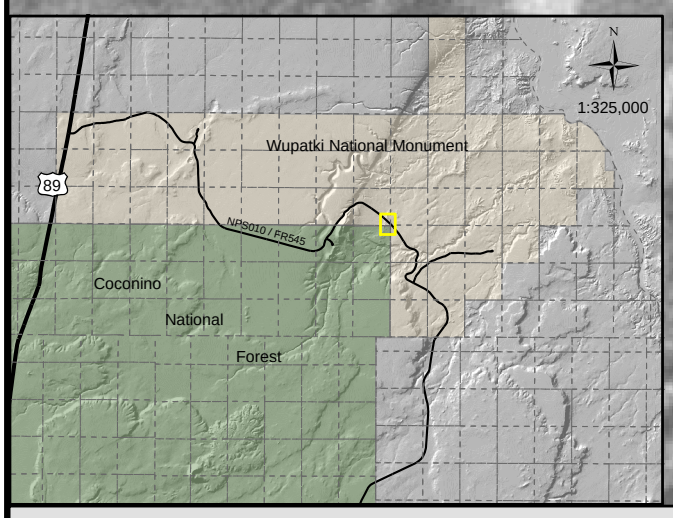
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 24

11.5

12.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: *1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.*

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

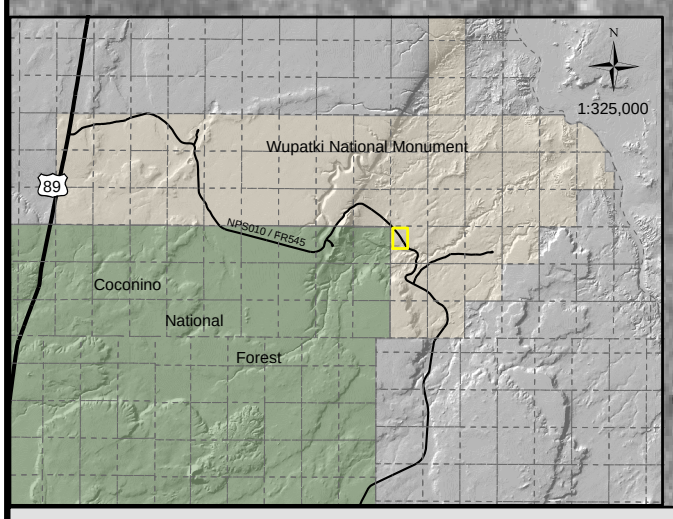
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 25

12.0

12.5



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 26

12.5

13.0

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

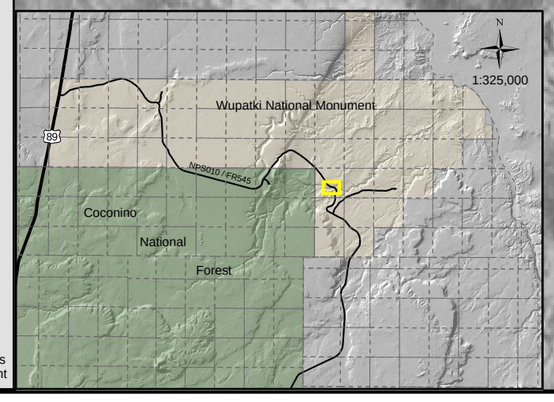
1:2,400

Feet: 0 200 400

Meters: 0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

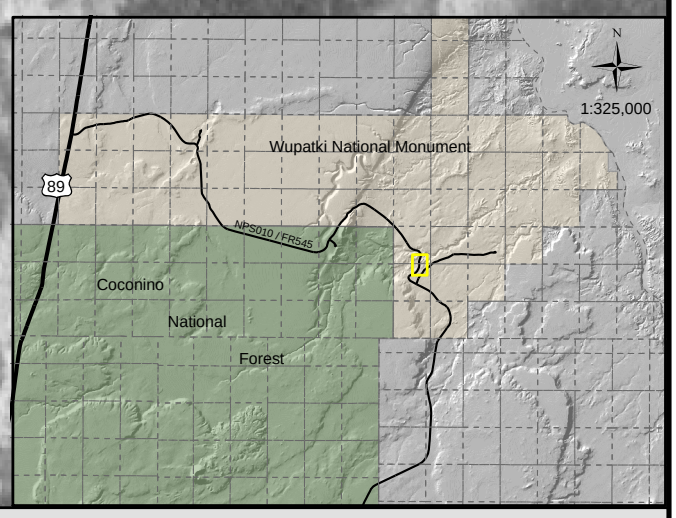
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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 27

13.0

13.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 28

13.5

14.0

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

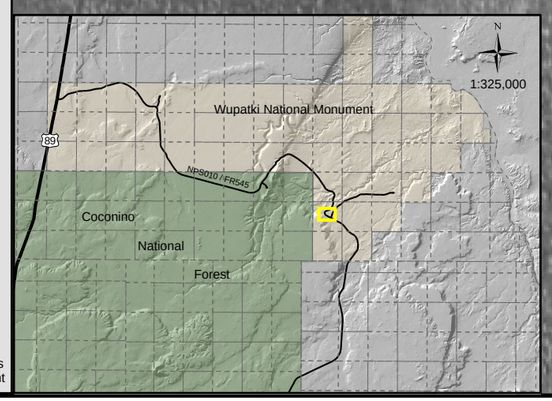
1:2,400

Feet: 0 200 400

Meters: 0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management



Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 29

14.0

14.5

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

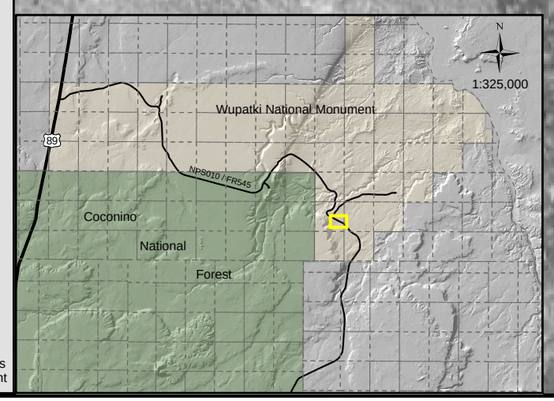
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

0 200 400 Feet

0 50 100 Meters



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 30

14.5

15.0

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

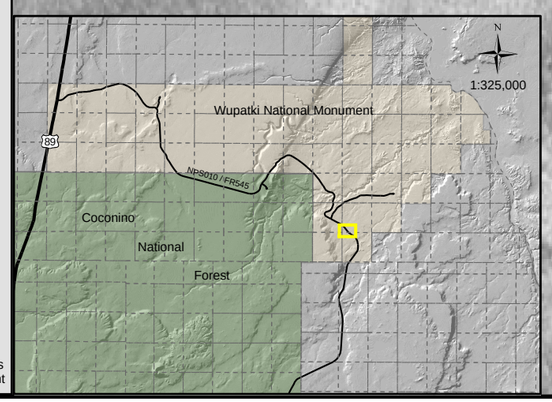
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 200 400

Meters: 0 50 100

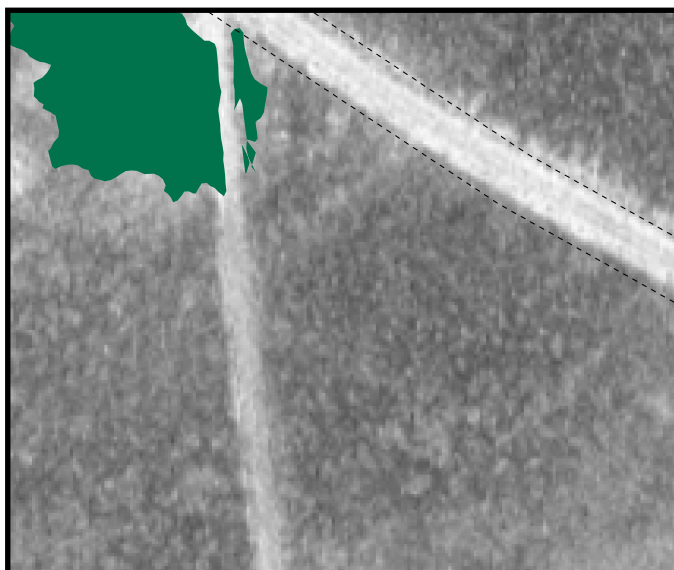


Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 31



15.0

15.5

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

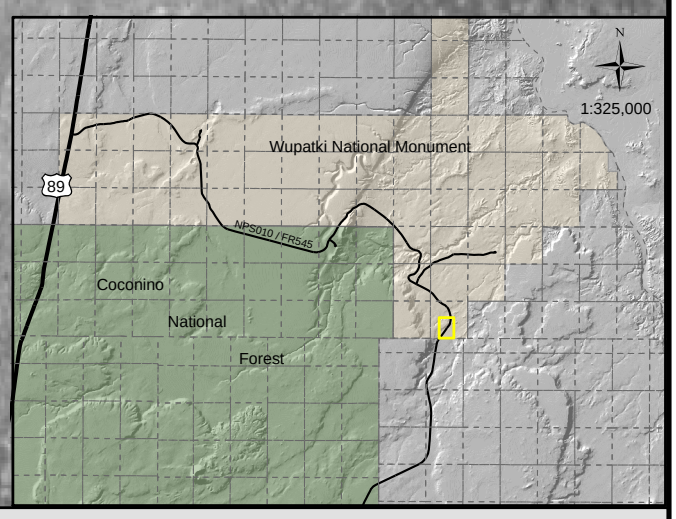
Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 32

15.5

16.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

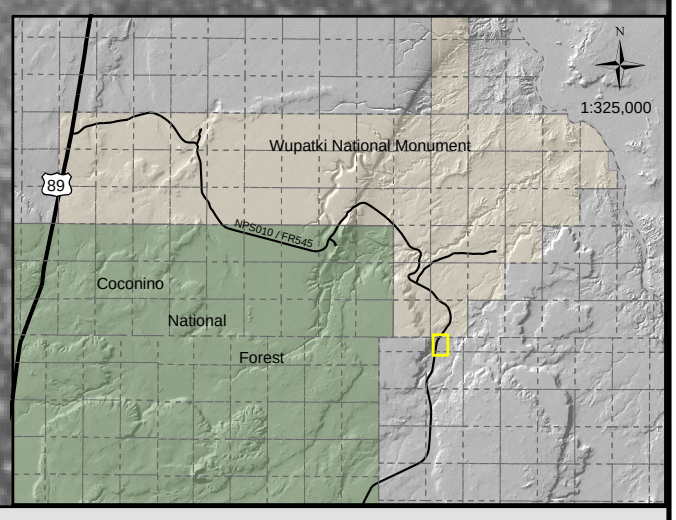
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 33

16.0

16.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

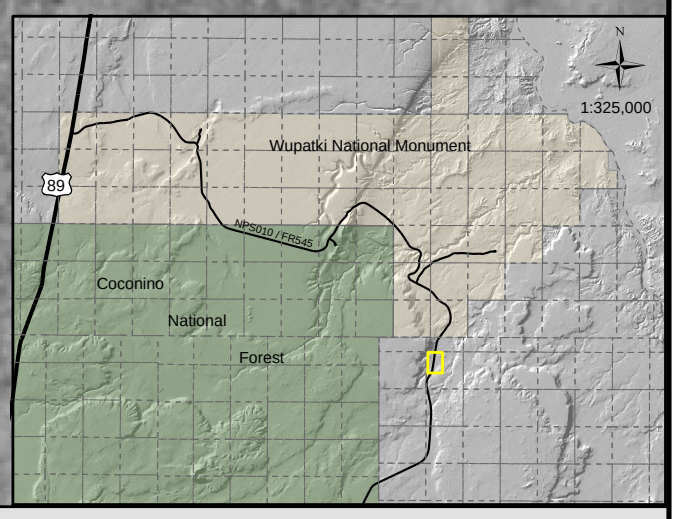
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 34

16.5

17.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

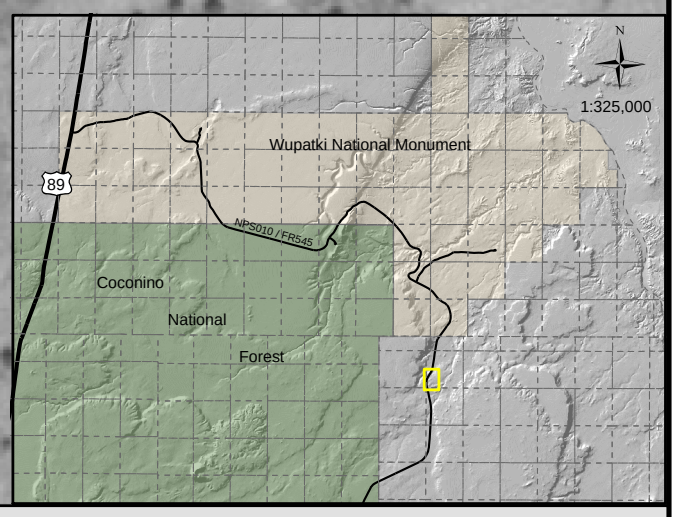
Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 35

17.0

17.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

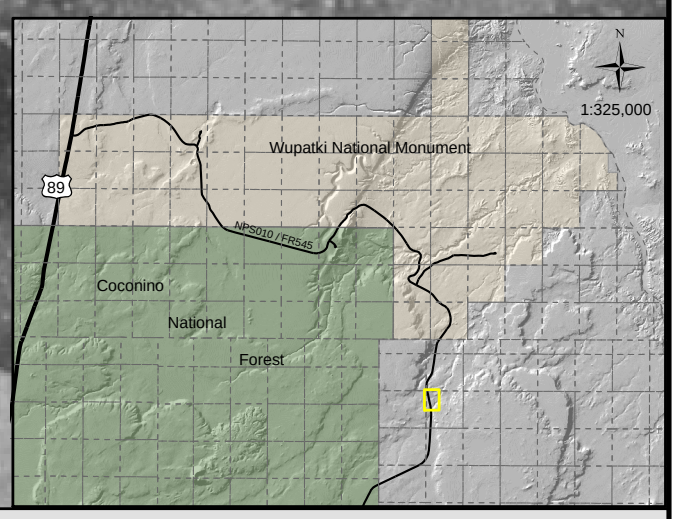
Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 36

17.5

18.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

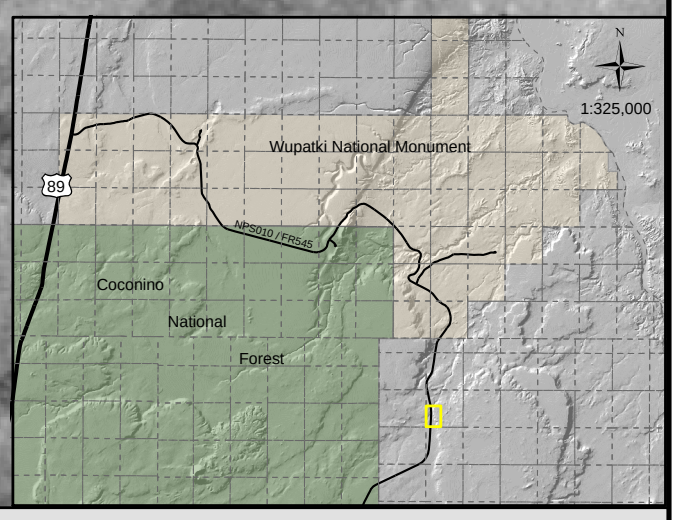
Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 37

18.0

18.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

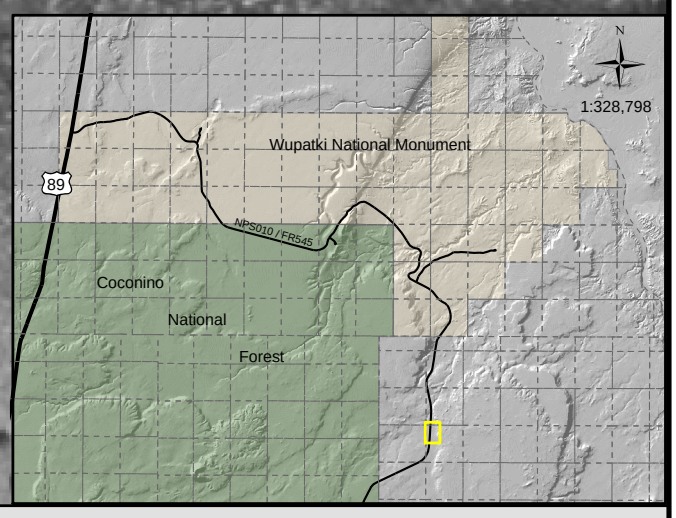
Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 38

18.5

19.0



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

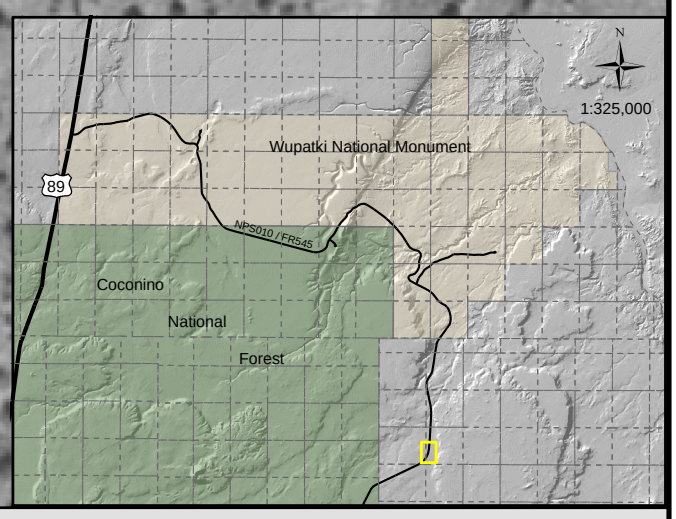
Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 39

19.0

19.5



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

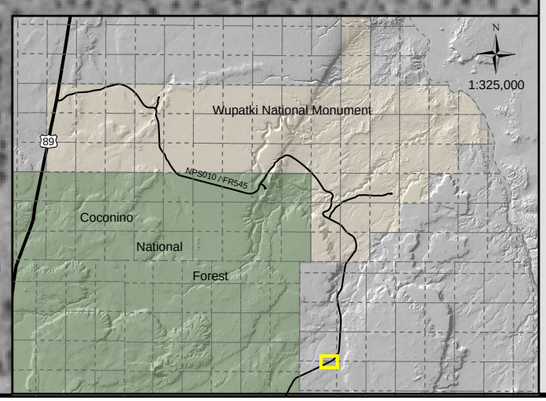
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 40

19.5

20.0



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

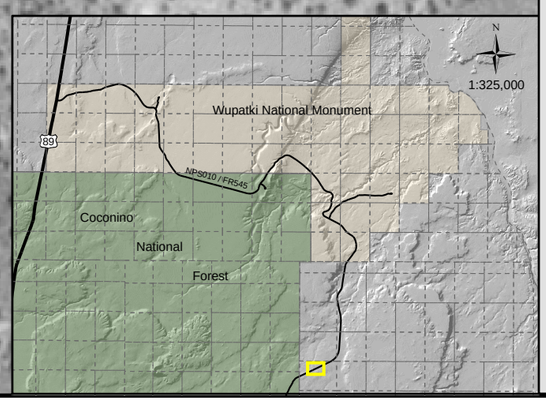
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005
NPS010 / FR545 Road Corridor
Map 41

20.0

20.5



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

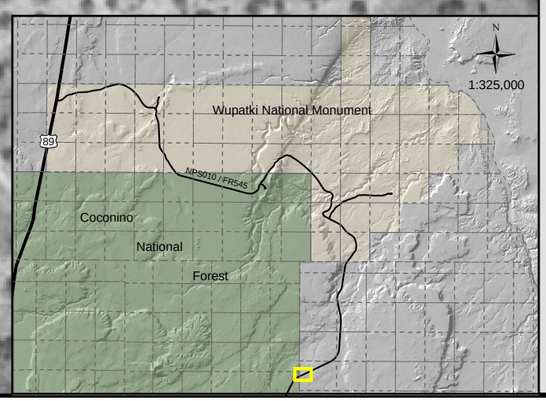
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Wupatki National Monument
Invasive Plant Survey
2003-2005

NPS010 / FR545 Road Corridor
Map 42

20.5

21.0



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

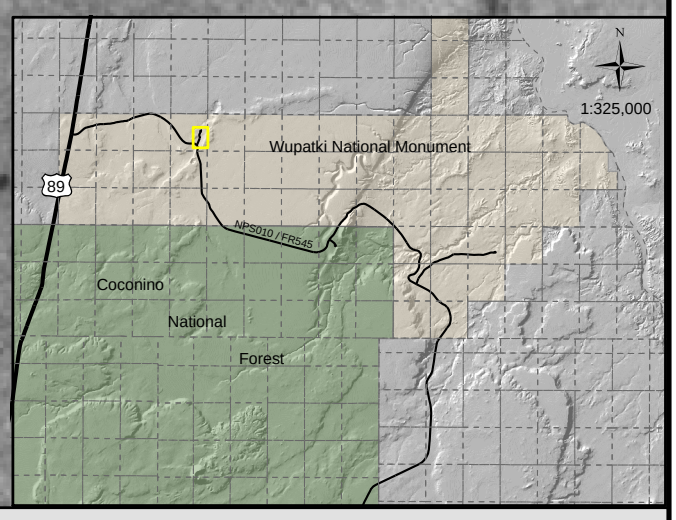
Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Lomaki-Box Canyon Spur Road Corridor
Map 1



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

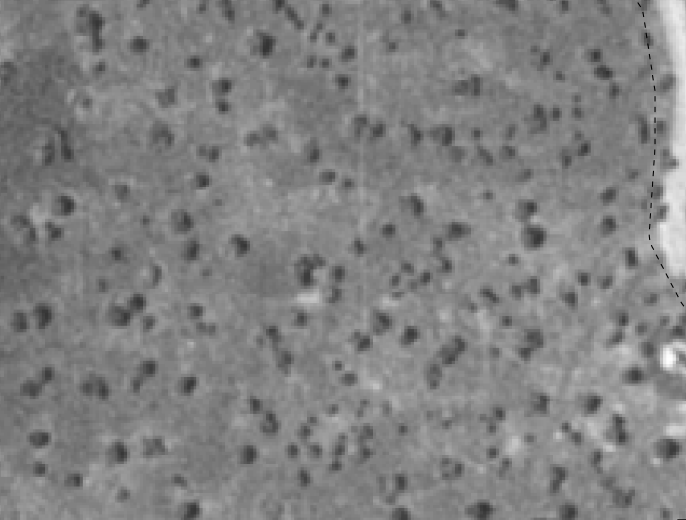
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

Doney Picnic Area
Spur Road Corridor
Map 2



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

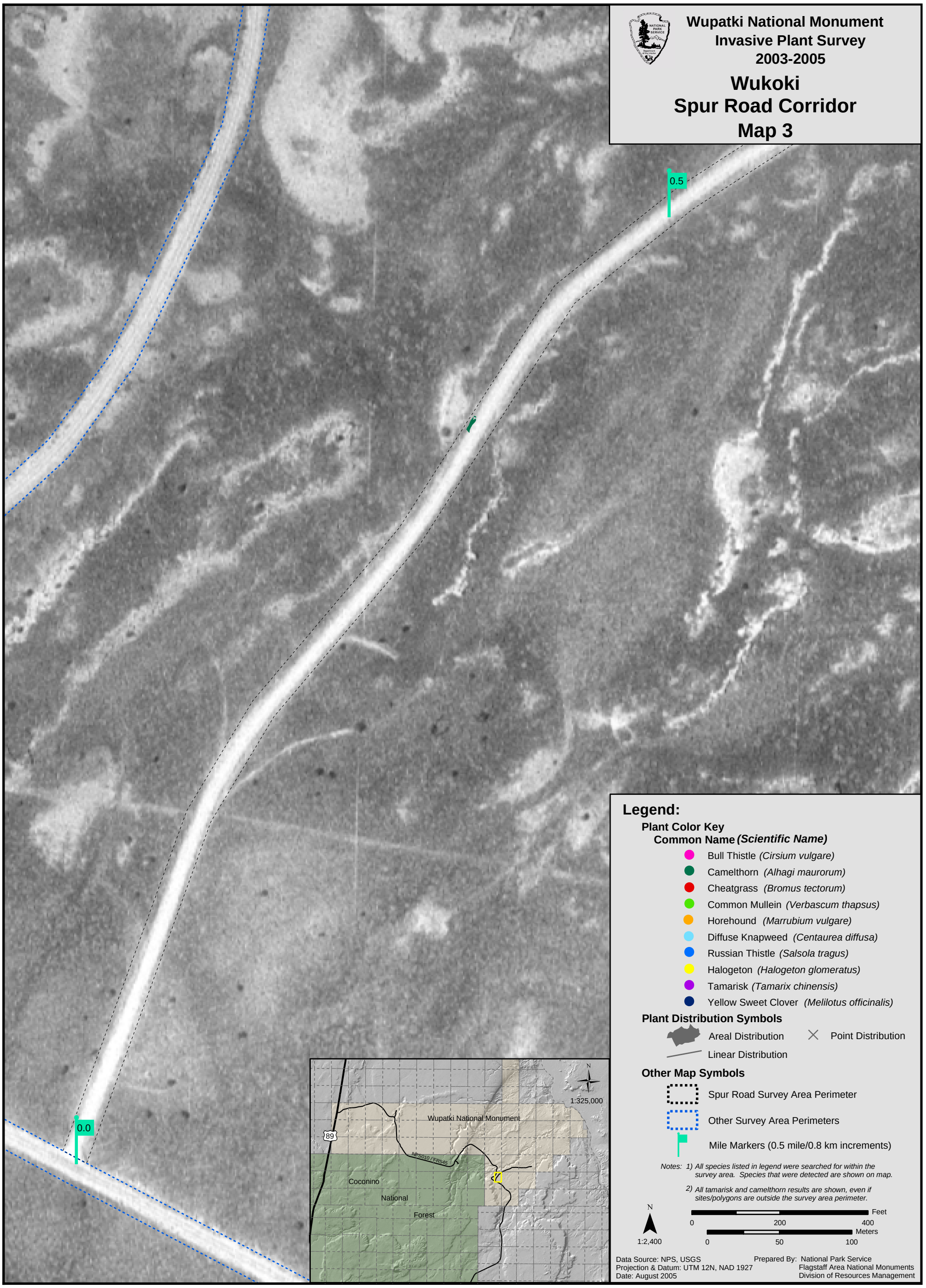
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

Wukoki
Spur Road Corridor
Map 3



Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.

2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N

1:2,400

Feet: 0 — 200 — 400

Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

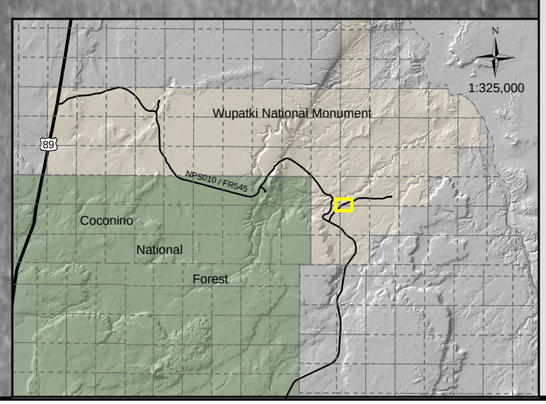
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Wukoki
Spur Road Corridor
Map 4

1.0

0.5



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

0 200 400 Feet
0 50 100 Meters

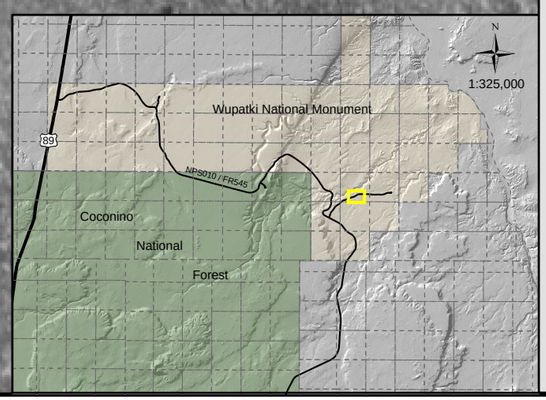
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
Wukoki
Spur Road Corridor
Map 5

1.5

1.0



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

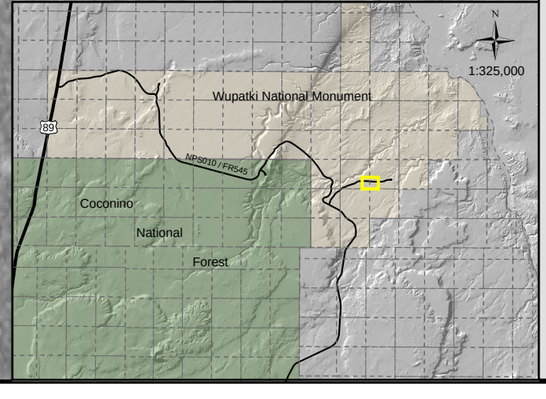
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Wukoki
Spur Road Corridor
Map 6

1.5

2.0



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400

Feet
0 200 400

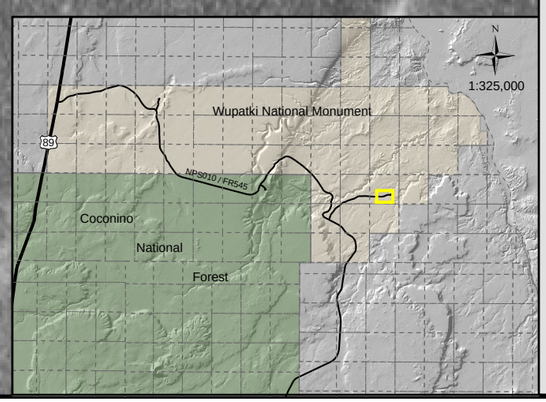
Meters
0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005
Wukoki
Spur Road Corridor
Map 7

2.0



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Spur Road Survey Area Perimeter
- Other Survey Area Perimeters
- Mile Markers (0.5 mile/0.8 km increments)

Notes: 1) All species listed in legend were searched for within the survey area. Species that were detected are shown on map.
2) All tamarisk and camelthorn results are shown, even if sites/polygons are outside the survey area perimeter.

N
1:2,400
Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Appendix F

Distribution Maps for Target Invasive Species
NPS Visitor and Administrative Use Areas
Wupatki National Monument

Wupatki National Monument Invasive Plant Survey 2003-2005

Index Map: Visitor & Administrative Use Areas

89

Lomaki/
Box Canyon

Citadel

Wupatki National Monument

Wukoki

Wupatki/
Visitor Center

Old Heiser

New Heiser

Coconino

National

Forest

Legend:

Individual Front Country Administrative Areas Map

Section Lines

N

1:70,000

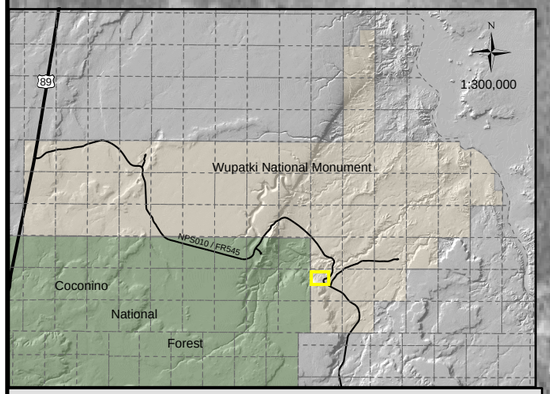
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0 2 Kilometers

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005
Wupatki Visitor Use & Administrative Area



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Other Map Symbols

- Survey Area Perimeter
- Other Survey Area Perimeters

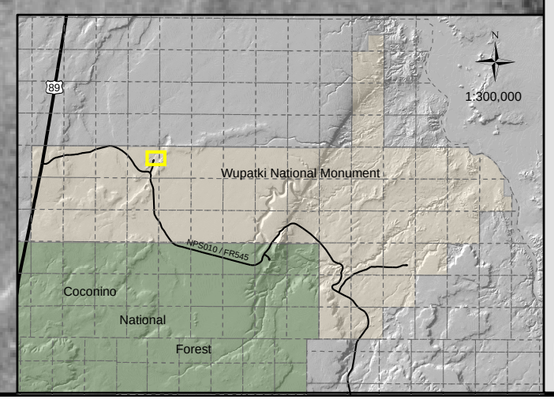
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Meters: 0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Lomaki - Box Canyon Visitor Use Area



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
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- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Other Survey Area Perimeters

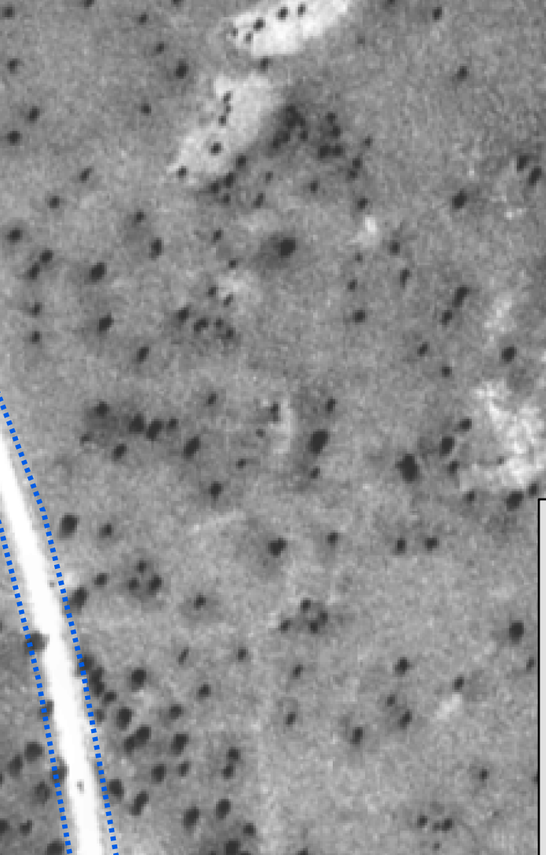
N
1:2,400

Feet: 0 200 400
Meters: 0 50 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005
Citadel
Visitor Use Area



Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
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- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
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- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution
- Linear Distribution

Other Map Symbols

- Survey Area Perimeter
- Other Survey Area Perimeters

N
1:2,400

Feet: 0 — 200 — 400
Meters: 0 — 50 — 100

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005
Wukoki
Visitor Use Area

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
- Camelthorn *(Alhagi maurorum)*
- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
- Horehound *(Marrubium vulgare)*
- Diffuse Knapweed *(Centaurea diffusa)*
- Russian Thistle *(Salsola tragus)*
- Halogeton *(Halogeton glomeratus)*
- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Other Map Symbols

- Survey Area Perimeter
- Other Survey Area Perimeters

N

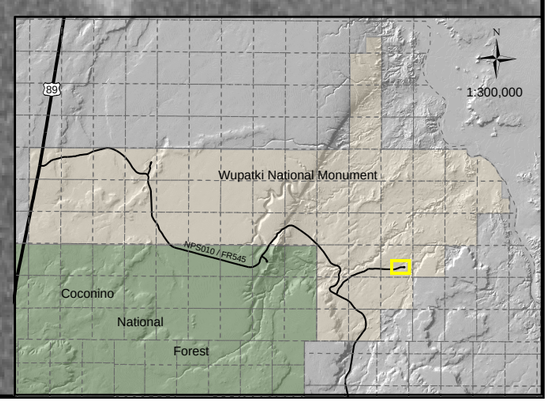
1:2,400

0 200 400 Feet

0 50 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management



Wupatki National Monument
Invasive Plant Survey
2003-2005
New Heiser
Administrative Use Area

Legend:

Plant Color Key
Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
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- Cheatgrass *(Bromus tectorum)*
- Common Mullein *(Verbascum thapsus)*
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- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Other Map Symbols

- Survey Area Perimeter
- Other Survey Area Perimeters

N

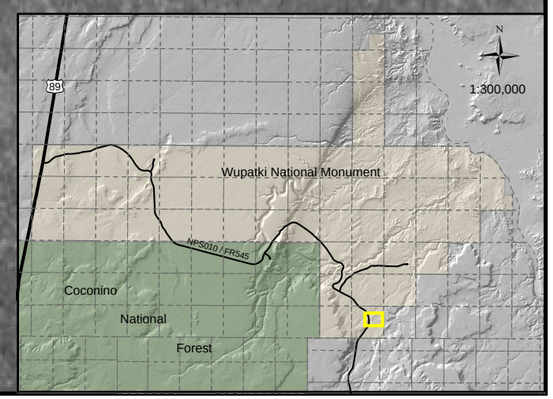
1:2,400

0 200 400 Feet

0 50 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management



Wupatki National Monument
Invasive Plant Survey
2003-2005
Old Heiser
Administrative Use Area

Legend:

Plant Color Key

Common Name *(Scientific Name)*

- Bull Thistle *(Cirsium vulgare)*
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- Tamarisk *(Tamarix chinensis)*
- Yellow Sweet Clover *(Melilotus officinalis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Other Map Symbols

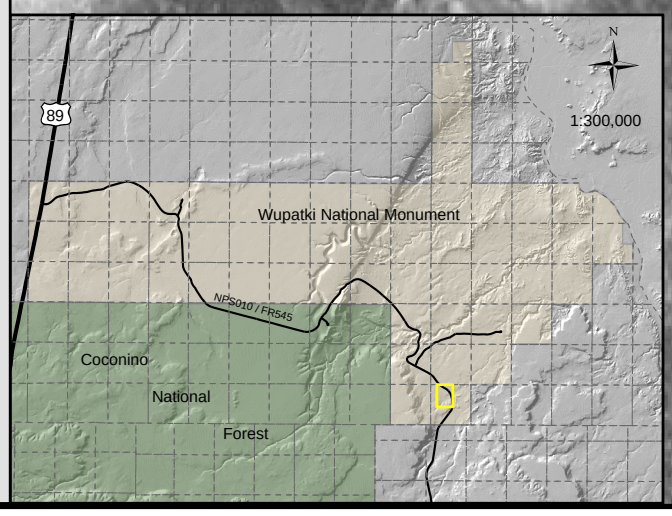
- Survey Area Perimeter
- Other Survey Area Perimeters

N

1:2,400

Feet: 0, 200, 400

Meters: 0, 50, 100



Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Appendix G

Distribution Maps for Tamarisk and Camelthorn
Abandoned Materials Quarries
Wupatki National Monument

Wupatki National Monument Invasive Plant Survey 2003-2005

Index Map: Abandoned Materials Quarries

89

Quarry #11

Quarry #12

Wupatki National Monument

Coconino National Forest

Legend:

Individual Materials Quarry Area Map

Section Lines

N

1:70,000

0 2 Miles

0 2 Kilometers

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Abandoned Materials
Quarry #11

Legend:

Plant Color Key -

Common Name *(Scientific Name)*

- Camelthorn *(Alhagi maurorum)*
- Tamarisk *(Tamarix chinensis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Boundaries

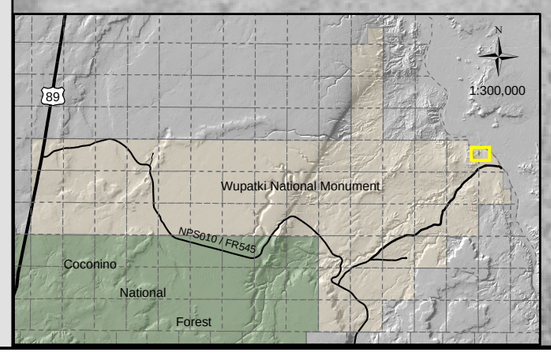
- Quarry Area
- Larger Tamarisk & Camelthorn Survey Area
- Monument Boundary

N

1:2,500

0 400 Feet

0 100 Meters

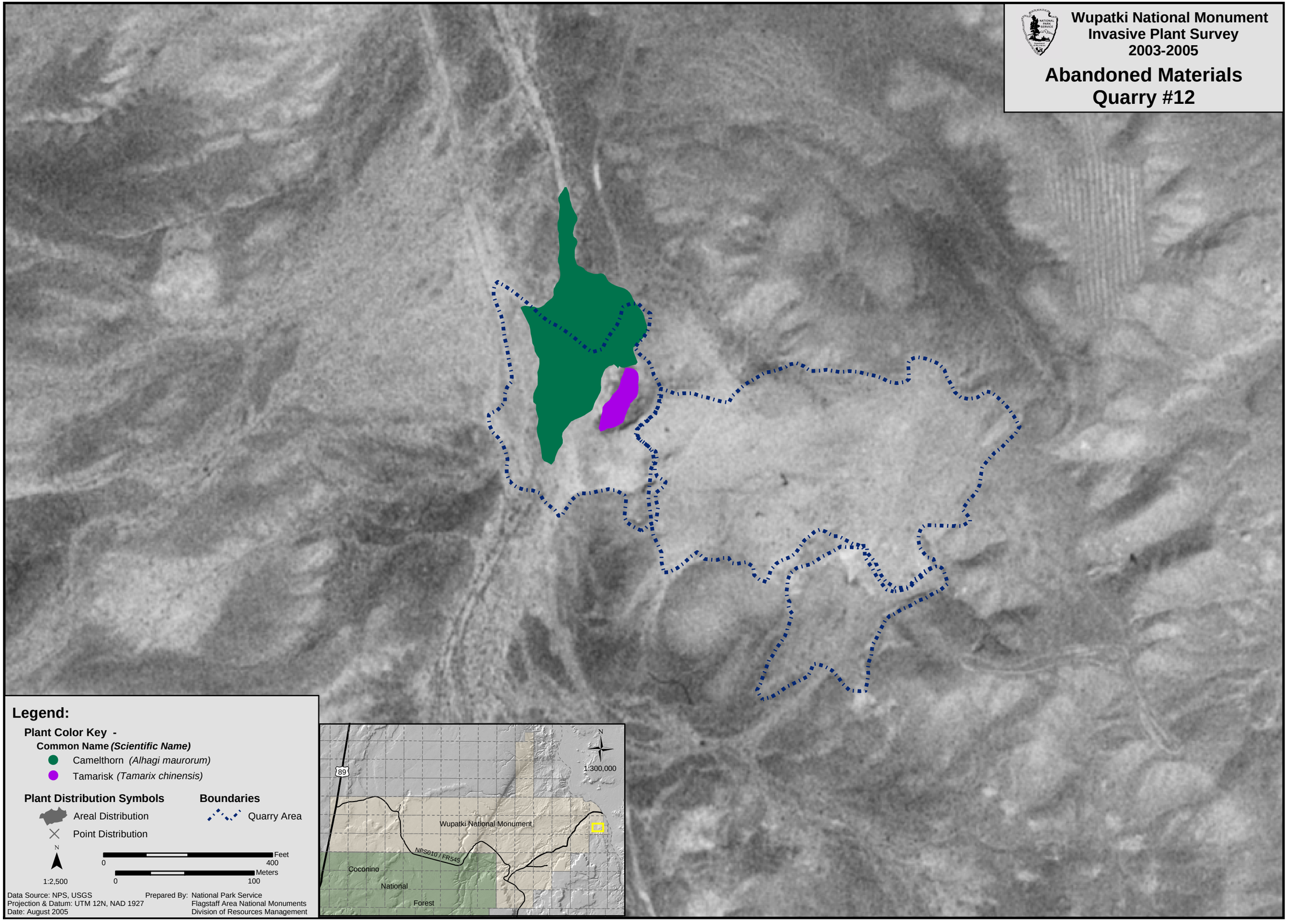


Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

Abandoned Materials
Quarry #12



Legend:

Plant Color Key -

Common Name *(Scientific Name)*

- Camelthorn *(Alhagi maurorum)*
- Tamarisk *(Tamarix chinensis)*

Plant Distribution Symbols

- Areal Distribution
- Point Distribution

Boundaries

- Quarry Area

N

1:2,500

0 400 Feet

0 100 Meters

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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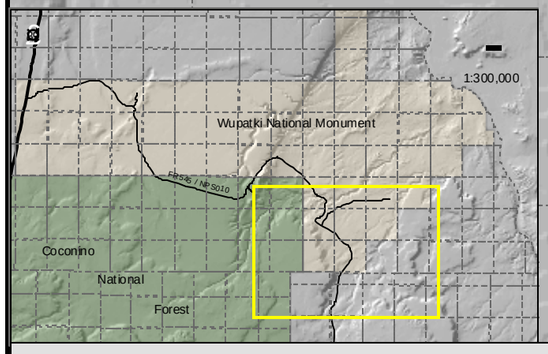
Appendix H

Location Maps for Incidental Invasive Species
Wupatki National Monument

Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 1

Dalmation Toadflax
(Linaria dalmatica)



Plant Color Key - Common Name *(Scientific Name):*

! Dalmation Toadflax *(Linaria dalmatica)*

Miles
0 0.5
Kilometers
1:25,000 0 1

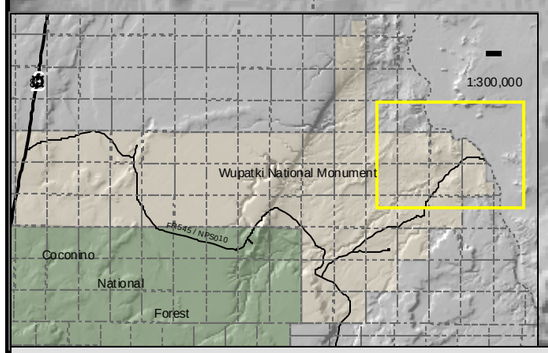
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Projection & Datum: UTM 12N, NAD 1927
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations Map 2

Russian Knapweed
(Acroptilon repens L.)



Plant Color Key - Common Name *(Scientific Name):*

! Russian Knapweed *(Acroptilon repens L.)*

1:20,033

Miles
0 0.5

Kilometers
0 1

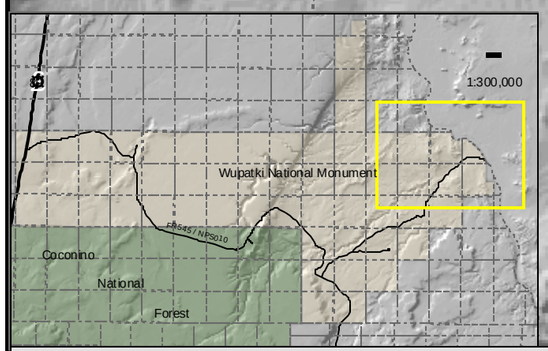
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 3

Russian Olive
(Elaeagnus angustifolia L.)



Plant Color Key - Common Name *(Scientific Name):*

! Russian Olive *(Elaeagnus angustifolia L.)*

Miles
0 0.5
Kilometers
1:20,033 0 1

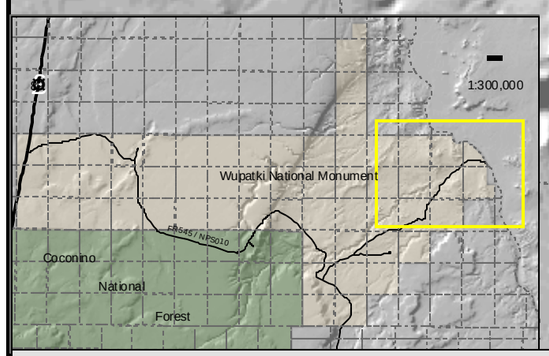
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 4

Broadleaf Dock
(Rumex obtusifolius)



Plant Color Key - Common Name *(Scientific Name):*

! Broadleaf Dock *(Rumex obtusifolius)*

1:20,070

0 0.5 Miles

0 1 Kilometers

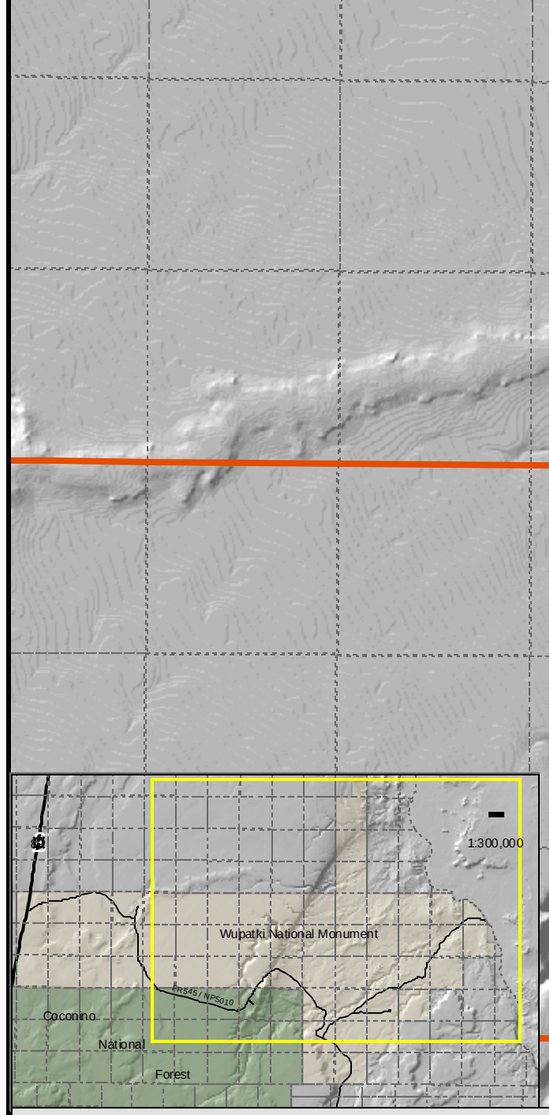
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Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 5

Cheatgrass
(Bromus tectorum)



Plant Color Key - Common Name *(Scientific Name):*

! Cheatgrass *(Bromus tectorum)*

Miles
0 2
Kilometers
0 2
1:50,083

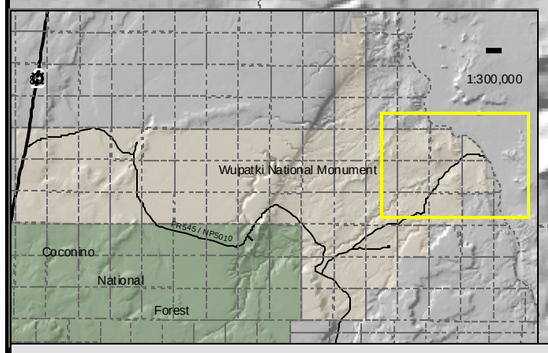
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Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 6

Cockleburr
(Xanthium strumarium L.)



Plant Color Key - Common Name *(Scientific Name):*

! Cockleburr *(Xanthium strumarium L.)*

Miles
0 0.5
Kilometers
0 1
1:20,033

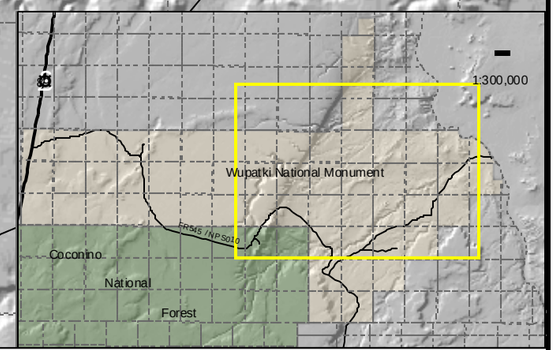
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Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 7

Red Brome
(Bromus rubens)



Plant Color Key - Common Name *(Scientific Name):*

! Red Brome*(Bromus rubens)*

1:33,000

Miles
0 1
Kilometers
0 2

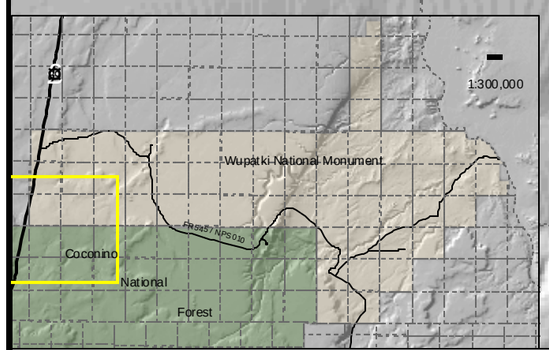
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Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

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Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 8

Redstem Stork's Bill
(Erodium cicutarium)



Plant Color Key - Common Name *(Scientific Name):*

! Redstem Stork's Bill *(Erodium cicutarium)*

Miles
0 0.5
Kilometers
0 1
1:20,033

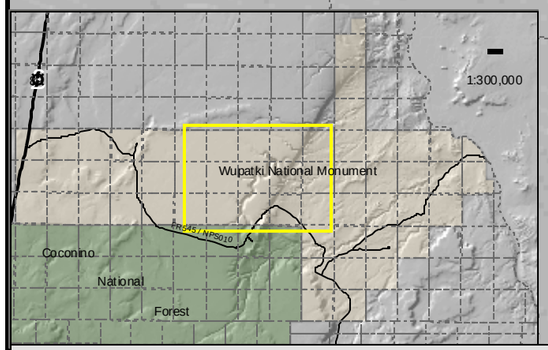
Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
Flagstaff Area National Monuments
Division of Resources Management

Wupatki National Monument
Invasive Plant Survey
2003-2005

Incidental Observations
Map 9

Tall Tumblemustard
(Sisymbrium altissimum)



Plant Color Key - Common Name *(Scientific Name):*

! Tall Tumblemustard *(Sisymbrium altissimum)*

Miles
0 0.5
Kilometers
0 1
1:20,033

Data Source: NPS, USGS
Projection & Datum: UTM 12N, NAD 1927
Date: August 2005

Prepared By: National Park Service
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