National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

# Invasive Exotic Plant Monitoring in Zion National Park

## *2016 Field Season*

Natural Resource Report NPS/NCPN/NRR—2017/1514

ON THE COVER

Bulbous bluegrass (*Poa bulbosa*)/Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

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## *2016 Field Season*

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September 2017

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Perkins, D. W. 2017. Invasive exotic plant monitoring in Zion National Park: 2016 field season. Natural Resource Report NPS/NCPN/NRR—2017/XXX. National Park Service, Fort Collins, Colorado.

NPS 116/140099, September 2017

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# Executive Summary

Invasive exotic plant (IEP) species are a significant threat to natural ecosystem integrity and biodiversity, and controlling them is a high priority for the National Park Service. The Northern Colorado Plateau Network (NCPN) selected the early detection of IEPs as one of 10 monitoring protocols to be implemented as part of its long-term monitoring program. NCPN conducted surveys on June 17–24, 2015, and June 1–6, 2016, which represented the completion of the second monitoring rotation at Zion National Park. Over the course of the rotation, NCPN staff detected 271 patches of eight priority IEP species along 161 miles (259 km) of monitoring routes and transects at Zion National Park. Bulbous bluegrass (*Poa bulbosa*), Scotch thistle (*Onopordum acanthium*), little bur-clover (*Medicago minima*), Bermudagrass (*Cynodon dactylon*), and Johnsongrass (*Sorghum halepense*) were the most commonly detected priority invasive plants. The highest numbers of priority infestations were found at the Upper Kolob Terrace Road (5.78/km), Watchman Campground and Visitor Center area (4.55 infestations/km), Northgate/Wildcat Trails (2.82/km), Watchman Housing and Parks Transportation, Inc. (2.18/km), South Campground and Nature Center (1.94/km), Oak Creek and Administrative area (1.79/km), and Visitor Center Trails (Archaeology, Museum, Pa'rus, and Watchman) (1.18/km). Patch densities were generally higher on roads than on trails. Ten trails or groups of trails were free of priority IEP patches. IEPs were found on 265 transects (52% of all transects monitored). However, almost all of these detections were cheatgrass (*Bromus tectorum*). Cheatgrass was widespread—present in 50% of transects and with an estimated cover of 0.97% across all transects sampled. Cheatgrass cover was as high as 2.07% along the Zion Scenic Drive and 2.05% along the Sand Bench Trail. In areas that were sampled in 2012–2013 and 2015–2016, parkwide declines in Johnsongrass and Siberian elm were observed, while increases occurred for Scotch thistle. The largest declines were observed along the Central Trails (-83%), Zion Scenic Drive (-80%), and the Lower Kolob Terrace Road (-75%). The largest percent increases in number of invasive patches occurred at the Visitor Center Trails (+247%), Oak Creek and Administrative Area (+179%), Northgate Peaks/Wildcat Trails (+84%), and Upper Kolob Terrace Road (+76%). NCPN will return to Zion in 2018 to begin the third rotation of invasive plant monitoring.

# Acknowledgements

A. Wight was extremely helpful in generating routes, transects, and other GIS information. D. Firmage assisted with reviewing the park's target invasive plant list, and A. Fitzgerald assisted with arranging site logistics. Field work was conducted by L. Gommermann, K. Myers, S. Rose, and A. Washuta. R. Weissinger, L. Schrage, and D. Firmage all improved this report with their thoughtful review. Data management was provided by H. Thomas and B. Campbell. M. Schrade assisted with administrative and logistical details.

# 1 Introduction

Invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are second only to habitat loss as threats to global biodiversity (Scott and Wilcove 1998) and represent one of the most serious threats to natural ecosystem integrity (NRC 2002). Biological invasions are occurring at accelerated rates in nearly every major ecosystem (Mooney and Hobbs 2000). Exotic plants negatively affect park resources and visitor enjoyment by altering landscapes and fire regimes, reducing native plant communities and animal habitat, and increasing trail maintenance needs (Loope 1992). Recognizing these challenges, Northern Colorado Plateau Network (NCPN) parks identified invasive exotic plants (IEPs) as a high-priority vital sign for long-term monitoring (O'Dell et al. 2005).

IEPs are a subset of exotic plants "whose introduction does or is likely to cause economic or environmental harm or harm to human health" (Executive Order 13112). With the aim of facilitating strategic control approaches, this monitoring program detects early invasions, identifies existing invasions, and, to the extent possible, tracks changes in the abundance and distribution of priority IEPs in parks along key invasive pathways.

Invasive exotic plants can spread into national parks via a number of different pathway types. Predictable IEP pathways include roads, trails, and riparian corridors. Long-distance dispersal through cargo containers and air freight are examples of sudden pathways. Anthropogenic pathways include horticultural escapes and seeds transported on shoes and in restoration seed mixes. For the National Park Service (NPS), the consequences of these plant invasions present a significant challenge to the agency's ability to maintain natural resources "unimpaired for the enjoyment of future generations."

Because regular, comprehensive monitoring of the distribution and abundance of all exotic plant species within NCPN units is beyond the fiscal capabilities of the network and parks, the NCPN is focusing on the most likely areas where a broad range of invasive exotic plants may occur: riparian corridors, roads, trails, areas of high visitor impact (e.g., campgrounds), and park boundaries. This approach is cost-effective for finding many new invasions in areas where they are most likely to occur, but it may miss exotic plants dispersed to the interior areas of large parks by wind and/or animals.

Specific objectives of NCPN invasive exotic plant monitoring are:

1. To detect incipient populations and new introductions of invasive plant species before they become established in areas of management significance and invasion pathways; and
2. To determine status and trends of selected invasive plant populations of management significance.

This report summarizes the 2016 field season, completing the second rotation of monitoring routes at Zion National Park (NP).

# 2 Methods

We followed the invasive exotic plant monitoring protocol developed by the NCPN (Perkins et al. 2016), adapted from Andersen and Dewey (2007). The protocol emphasizes the quick collection of IEP location and abundance data in order to maximize the amount of area searched, thus increasing our chances of finding a higher percentage of both new invasions and established IEPs. By focusing on roads, trails, and waterways, which are major vectors for invasive plants, we will capture the greatest amount of information (i.e., benefit) with the least amount of time and effort (i.e., cost).

## 2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2012, NCPN and Zion NP staff reviewed the park's list of priority IEPs (Table 2-1). The list was developed by reviewing past park literature and state and county weed lists, and consulting with park staff and county weed managers. The high-priority target IEP list includes existing IEPs and potential IEPs of high management concern. This list is reviewed before each field season. In 2016, little bur-clover (*Medicago minima*) was added to the list.

Because these methods are designed to be rapid, field crews are trained to develop a focused search image on the target plants, instead of looking for every possible invasive plant species. The likelihood of eradicating these target species, or containing them within a park, is generally high.

## 2.2 Monitoring routes

### *2.2.1 Minimum detection target size*

The minimum detection target size (MDTS) represents the patch size that is large enough to be detected with a high level of confidence (typically at least 90% of the total number of patches of that size and larger in the monitoring area) under actual field conditions, but small enough so that any missed patches smaller than the MDTS could still feasibly be eradicated if not found until the next scheduled monitoring visit. We established an MDTS of 40 $m^2$ (0.01 acres or approximately 20 × 20 ft) for all IEPs. Use of the MDTS was necessary because field technicians are not expected to find every single plant of every targeted IEP species during route surveys. Searching for single mature plants of some species, such as Siberian elm (*Ulmus pumila*), is possible due to their large size. Single plants of other species, such as Medusahead (*Taeniatherum caput-medusae*), are nearly impossible to detect in most field conditions.

**Table 2-1. Priority invasive plant list, Zion NP, 2012–2016.**

| Scientific name | Common name |
|---|---|
| *Alhagi maurorum* | camelthorn |
| *Bassia scoparia*[1] | summer cypress |
| *Brassica tournefortii* | Sahara mustard |
| *Cardaria draba* | hoary cress |
| *Carduus nutans* | musk thistle |
| *Centaurea diffusa* | diffuse knapweed |
| *Centaurea melitensis* | Maltese starthistle |
| *Centaurea repens* | Russian knapweed |
| *Centaurea solstitialis* | yellow starthistle |
| *Centaurea virgata*[2] | squarrose knapweed |
| *Chrysanthemum leucanthemum*[3] | ox-eye daisy |
| *Cirsium arvense* | Canada thistle |
| *Conium maculatum* | poison hemlock |
| *Cynodon dactylon* | Bermudagrass |
| *Eragrostis cilianensis* | stinkgrass |
| *Euphorbia esula* | leafy spurge |
| *Hyoscyamus niger* | black henbane |
| *Hypericum perforatum* | St. Johnswort |
| *Isatis tinctoria* | Dyer's woad |
| *Lepidium latifolium* | broad-leaf pepperwort |
| *Linaria dalmatica* | Dalmatian toadflax |
| *Linaria vulgaris* | butter-and-eggs |
| *Lythrum salicaria* | purple loosestrife |
| *Medicago minima*[4] | little bur-clover |
| *Onopordum acanthium* | Scotch thistle |
| *Poa bulbosa* | bulbous bluegrass |
| *Potentilla recta* | sulfur cinquefoil |
| *Sorghum halepense* | Johnsongrass |
| *Taeniatherum caput-medusae* | Medusahead |
| *Ulmus pumila* | Siberian elm |

[1]Listed as *Kochia scoparia* (kochia) in the 2012 report.
[2]Listed as *Centaurea squarrosa* in the 2012 and 2013 reports.
[3]Listed as *Leucanthemum vulgare* in the 2012 and 2013 reports.
[4]Added to target list in 2015.

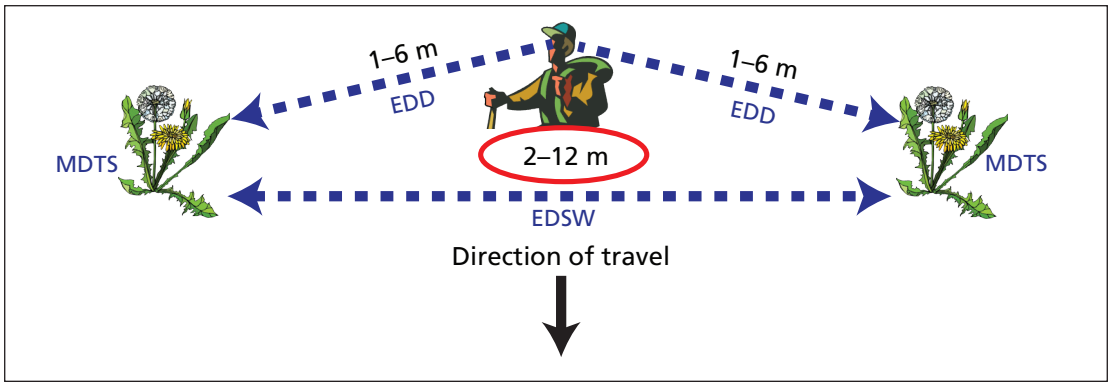


Figure 2-1. The maximum effective detection distance (EDD) at Zion National Park was 1–6 meters, making the effective detection swath width (EDSW) 2–12 meters.

### 2.2.2 Effective detection distance

The effective detection distance (EDD) is the maximum distance from which a searcher could consistently detect (i.e., see and recognize) the MDTS of the least-visible targeted species with at least 90% detection efficiency (Figure 2-1). Using fake plants of a targeted size, crew members are trained by walking away and determining the maximum distance from which they can consistently see and recognize the patch with complete confidence. The size of the EDD is then estimated in the field by crew members. The distance is measured either by pacing or using a laser rangefinder. The EDD for Zion NP in 2016 was 1–6 meters.

### 2.2.3 Effective detection swath width

Effective detection swath width (EDSW) is defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all target species of the MDTS (Figure 2-1). The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor is able to effectively detect IEPs for one EDD on either side of his/her search route. The EDSW was 2–12 meters at Zion NP in 2016.

### 2.2.4 Patch separation resolution

We define patch separation resolution as the minimum distance between plants that must be considered members of separate patches. Individuals or clusters of a target species separated by the PSR distance or more are recorded as separate patches. We consider plants separated by less than the PSR to be a single patch. The PSR is set at 50 meters, based on the assumption that most plants or groups of plants separated by less than 50 meters are typically considered to be one patch during planning and implementation of IEP-control operations. If a patch is continuous for more than 50 meters, then cover estimates are made every 50 meters to aid in developing an effective management strategy for the entire patch.

### 2.2.5 Between feature position

Between feature positions allow electronic tracking of a user's route. A GPS (global positioning system) unit is set to automatically generate these positions at a distance equal to the EDSW. Each time a surveyor walks the equivalent of one EDSW, the GPS unit creates a point.

### 2.2.6 Data collection methods

We established monitoring routes with advice from Zion NP staff (Figure 2-2). While walking, we searched for IEPs by visually scanning (side-to-side) all of the land within the borders of the swath. However, if the terrain was uneven or steep, and the observer had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 12 meters (the length of one EDSW) and visually scanned the area in all directions. As monitoring routes were traversed, locations of all target species were documented using GPS units with at least five-meter accuracy. Only priority species were consistently recorded during monitoring routes. Survey crew members

were permitted to record additional species if they were noteworthy.

When a priority IEP was discovered, we recorded the following information: (1) the monitoring route, (2) the sequential number of the invasion per monitoring route, (3) patch size class (see below), (4) whether the plant was pulled, and (5) canopy cover class (see below). If several species were present with similar distributions at a single point, then we recorded a point for each individual species and assigned it its own sequential identification number. Invasions more than 50 meters (55 yards) apart were considered separate invasions and recorded with separate points. Patch size class was estimated as follows:

1. 1–a few plants (used for isolated single plants or very small patches (≤2 × 2 m),
2. few plants–40 $m^2$ (48 $yd^2$),
3. 40–400 $m^2$ (48–478 $yd^2$),
4. 400–1,000 $m^2$ (0.1–0.25 acre), and
5. 1,000–2,000 $m^2$ (0.25–0.5 acre).

We recorded canopy cover class by estimating the amount, or "percentage," of ground covered by the vertical projection of plant matter as visualized from a bird's-eye view of the vegetation (Elzinga et al. 1998). This estimate included both the living and dead standing material of the vegetation of a single plant species. Canopy cover of a patch was recorded using the following classes:

1. Trace (<1%)
2. Low (1–5%)
3. Moderate (6–25%)
4. High (26–50%)
5. Majority (51–100%).

We recorded the following ancillary information with every patch: descriptive notes (e.g., hillside, distance to road, wetland, stream), the growth stage of exotic trees (e.g., sapling, pole, mature), evidence of prior treatment, and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

## 2.3 Monitoring transects

We established transects with three vegetation quadrats every 500 meters along monitoring routes.

### *2.3.1 Quadrat establishment*

We centered vegetation quadrats at 0.5, 5, and 10 meters away from the edge of a road on the same side as the route being walked and on alternating sides for riparian areas, small roads, or trails. A 1-$m^2$ sampling frame, used to sample vegetation cover and soil surface features, was placed on the right side of the transect line as the technician walked the monitoring route. In some cases, we leveled the sampling frame by propping up quadrat corners.

### *2.3.2 Data collection methods*

In the monitoring quadrats, all priority IEP species observed were recorded, as well as cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola* sp.). For each quadrat, we recorded percent cover of each IEP using the following classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100%. We also recorded percent cover, to the nearest 10%, of dominant soil surface features (i.e., dead wood, dung, fungus, lichen, litter/duff, live root/bole, mineral soil/sediment, moss, biological soil crust, road, rock, standing water/flooded, stream, or trash/junk).

## 2.4 Analyses

We calculated the mean number of patches per kilometer for monitoring routes. Percent cover estimates were generated from the monitoring quadrat data. We calculated the mean and standard error of percent cover by species for monitoring quadrats. Due to differences in observers' knowledge, only priority species should be used when comparing results from year to year.

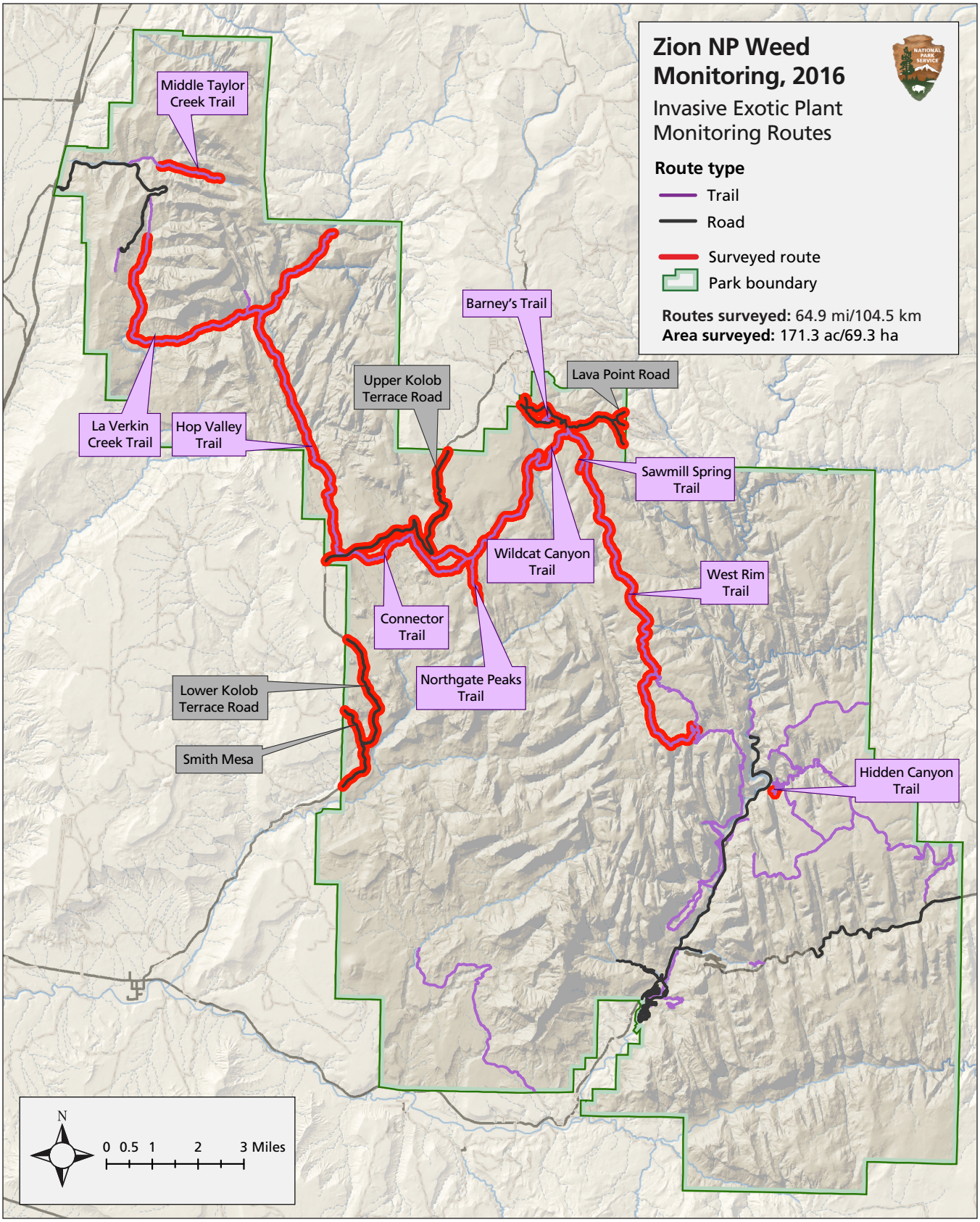


Figure 2-2. Routes monitored at Zion NP, June 1–6, 2016.

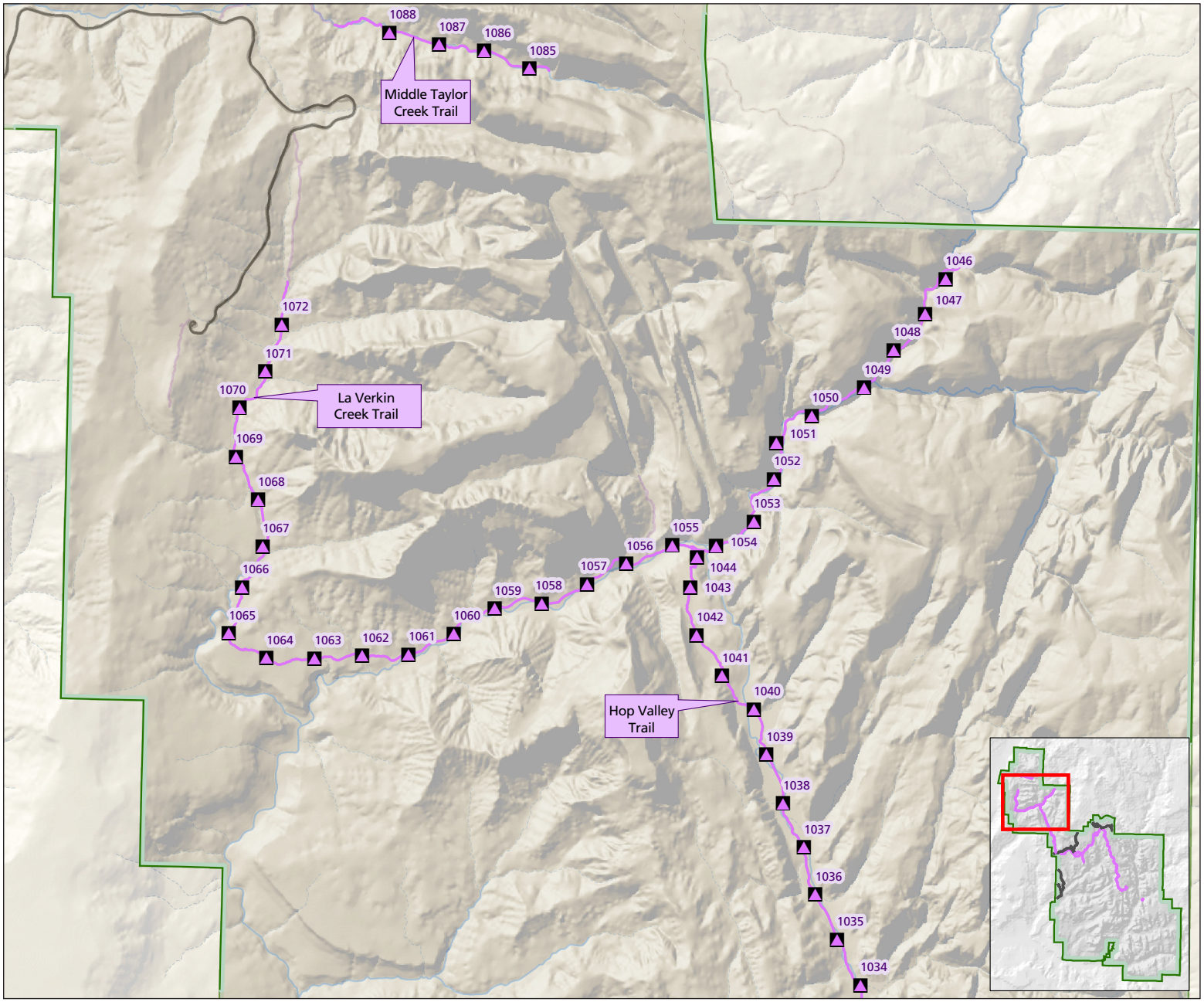


Figure 2-3. Transects completed in the La Verkin and Middle Taylor creeks area, Zion National Park, June 1–6, 2016.

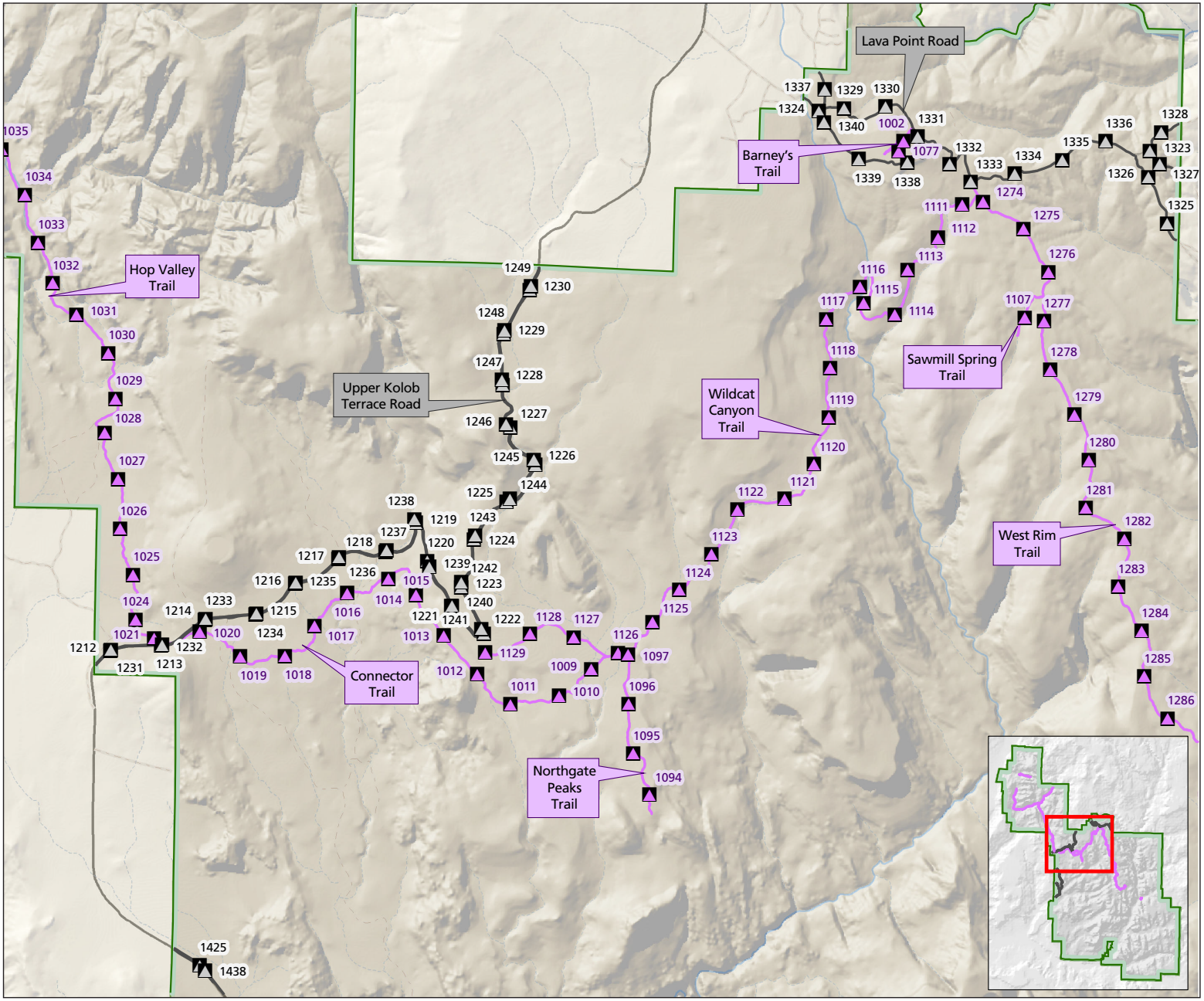


Figure 2-4. Transects completed in the Hop Valley Trail area, Zion National Park, June 1–6, 2016.

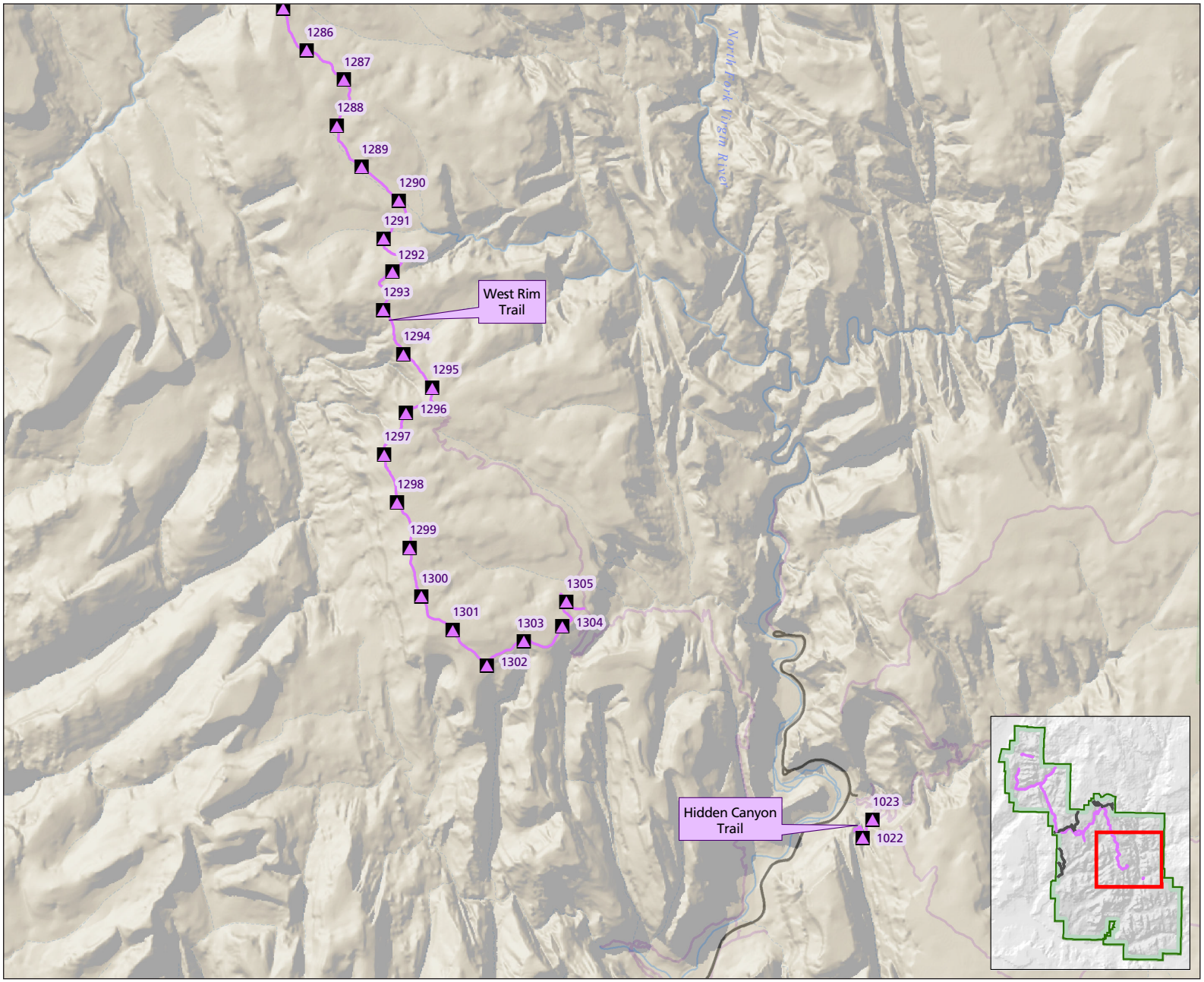


Figure 2-5. Transects completed in the West Rim Trail area, Zion National Park, June 1–6, 2016.

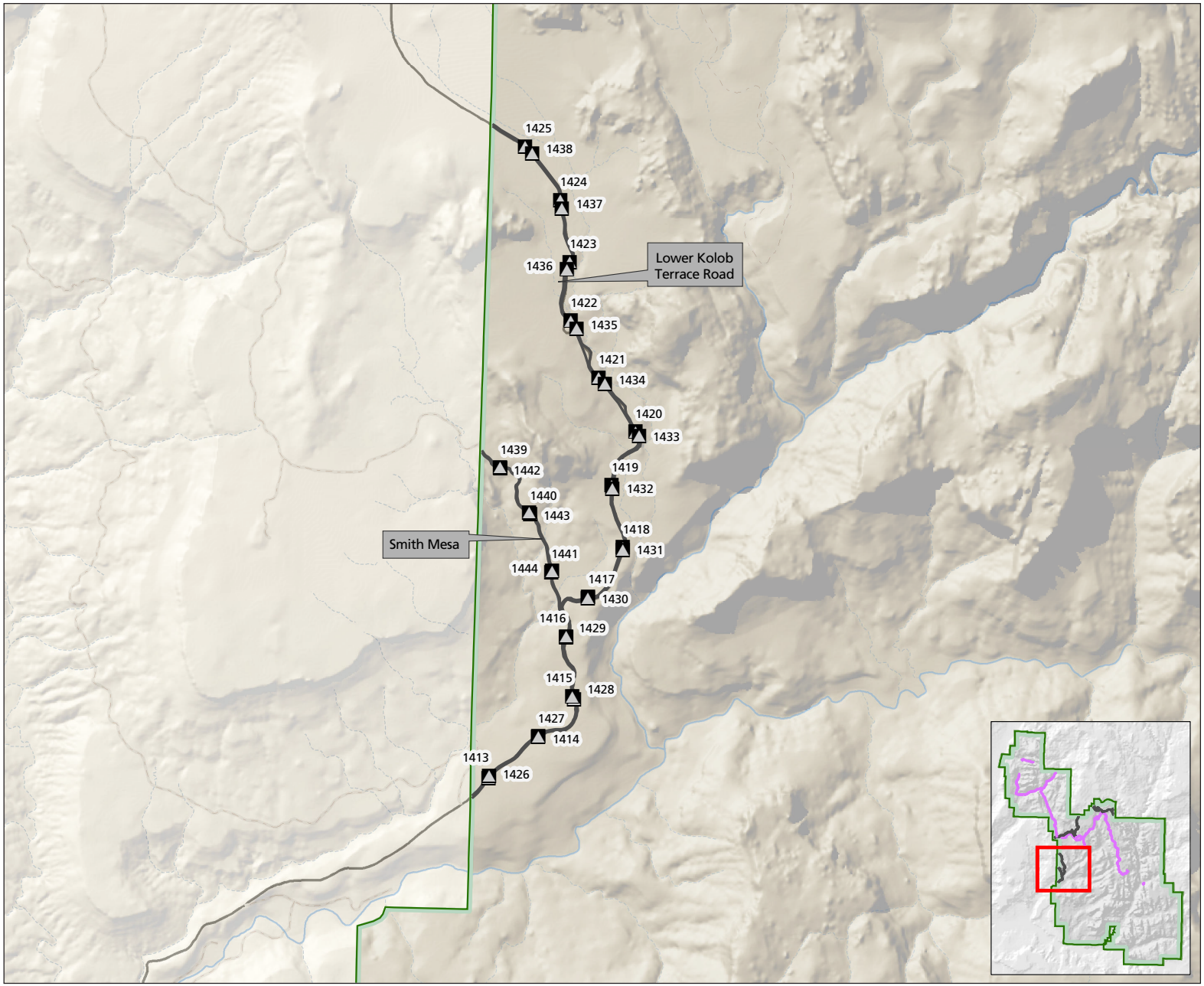


Figure 2-6. Transects completed in the Smith Mesa area, Zion National Park, June 1–6, 2016.

# 3 Results

## 3.1 Target invasive exotic plant list

Thirty priority IEP species were identified on the Zion NP target list for 2016 (see Table 2-1). Observers are trained to recognize priority species, but given the freedom to map additional species; therefore, presence and absence data for priority species are reliable for the areas searched, but absence data for non-priority species are suspect. In addition, two species, cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola* sp.), were recorded consistently in transects.

We recorded a total of eight priority IEP species on monitoring routes and three priority IEP species on transects in 2015–2016 (Table 3-1). Nine and two additional non-priority species were recorded on routes and transects, respectively.

## 3.2 Monitoring routes

We covered 259 kilometers (127 miles) of monitoring routes over the course of this second rotation (2015–2016), including 105 kilometers (65 miles) in 2016. We mapped 271 patches of eight different priority IEP species over the course of the rotation (Table 3-2), including 172 patches in 2016 (Figures 3-1 to 3-9; Appendix A).

Over the course of the rotation, the most common priority invasive species (Table 3-3) were bulbous bluegrass (*Poa bulbosa*), Scotch thistle (*Onopordum acanthium*), little bur-clover (*Medicago minima*), Bermudagrass (*Cynodon dactylon*), and Johnsongrass (*Sorghum halepense*). These five species represented 94% of the priority patches found.

The Upper Kolob Terrace Road had the highest number of priority patches (5.78/km) of any route (see Table 3-2). Areas with high

**Table 3-1. Invasive exotic plants detected at Zion NP, June 17–24, 2015 and June 1–6, 2016.**

| Scientific name | Common name | Method detected | | Priority? |
|---|---|---|---|---|
| | | Route | Transect | |
| ***Bassia scoparia*[1]** | **summer cypress** | **X** | | **Yes** |
| *Cynodon dactylon* | Bermudagrass | X | X | Yes |
| *Medicago minima* | little bur-clover | X | X | Yes |
| ***Onopordum acanthium*[1]** | **Scotch thistle** | **X** | | **Yes** |
| ***Poa bulbosa*[1]** | **bulbous bluegrass** | **X** | **X** | **Yes** |
| *Sorghum halepense* | Johnsongrass | X | | Yes |
| *Taeniatherum caput-medusae* | Medusahead | X | | Yes |
| *Ulmus pumila* | Siberian elm | X | | Yes |
| ***Aegilops cylindrica*[1]** | **jointed goatgrass** | **X** | | **No** |
| *Agropyron cristatum* | crested wheatgrass | X | | No |
| ***Bromus inermis*[1]** | **smooth brome** | **X** | | **No** |
| ***Cirsium vulgare*[1]** | **bull thistle** | **X** | | **No** |
| ***Conimum maculatum*[1]** | **poison hemlock** | **X** | | **No** |
| ***Dactylis glomerata*[1]** | **orchardgrass** | **X** | | **No** |
| ***Malcolmia africana*[1]** | **African mustard** | **X** | | **No** |
| *Marrubium vulgare* | common horehound | X | | No |
| ***Tamarix* sp.[1]** | **tamarisk** | **X** | | **No** |
| ***Bromus tectorum*[1]** | **cheatgrass** | | **X** | **Transect[2]** |
| ***Salsola* sp.[1]** | **Russian thistle** | | **X** | **Transect[2]** |

[1]Species detected in 2016.

[2]Transect species are recorded only in transects. They are not recorded along monitoring routes.

visitation, such as Watchman Campground and Visitor Center (4.78/km), Watchman Housing and PTI (shuttle staging area for Parks Transportation, Inc.) (2.18/km), South Campground and Nature Center (1.94/km), and the Oak Creek Administrative area (1.79/km), all had high levels of invasive plants. Trails had lower numbers of invasive plant patches. The Northgate/Wildcat Trails (2.82/km) and the Visitor Center Trails (Archaeology, Museum, Pa'rus, and Watchman trails) (1.18/km) were the only trails that approached the overall average of 1.66/km found on roads. No priority invasive plants were detected on 10 different trails or groups of trails. Invasive plants were present on all roads (Table 3-2).

Of the 271 IEP patches, 25% were larger than 40 $m^2$ (Table 3-3). Siberian elm and tamarisk were the only exotic tree species detected. Of the 21 tree patches, 4 were seedlings, 12 were in the sapling stage, and 5 were mature trees (see Appendix A).

## 3.3 Monitoring transects

A total of 508 transects were sampled in 2015–2016 (Table 3-4; see Figures 2-3 to 2-5; Appendix B). IEPs were found on 265 transects (52%). Five IEP species were detected: cheatgrass, Russian thistle, and the priority species little bur-clover, bulbous bluegrass, and Bermudagrass.

Cheatgrass had the highest percent cover, with 2.07%, 2.05%, 1.94%, and 1.90% along the Zion Scenic Drive, Sand Bench Trail, Lower Kolob Terrace Road, State Route 9, and Northgate/Wildcat Trails, respectively. Cheatgrass was widespread, present in 50% of transects sampled in 2015–2016. It was present in 71%, 80%, 92%, 84%, and 72% of transects along the Zion Scenic Drive, Sand Bench Trail, Lower Kolob Terrace Road, State Route 9, and Kolob Scenic Drive, respectively. Bermudagrass, little bur-clover, Russian thistle, and bulbous bluegrass all had <0.1 mean percent cover. Russian thistle and bulbous bluegrass were present in 4% and 1% of plots, respectively.

## 3.4 Results comparison: 2012–2013 to 2015–2016

From 2012 to 2015 (Perkins 2013; 2014; Karinen and Perkins 2016), NCPN staff surveyed the same areas of Zion NP with the same methods used in 2015–2016. Since then, patches per kilometer have declined in most areas in the Main Canyon, most notably on the Zion Scenic Drive (-80%), and Central Trails (-83%) (Table 3-5). Siberian elm, Johnsongrass, and bulbous bluegrass were primarily responsible for the declines in those areas. Patches also declined on the Lower Kolob Terrace Road (-75%). Scotch thistle saw the largest increase, while Siberian elm (*Ulmus pumila*) and Johnsongrass showed the largest decreases between the two sample periods (Table 3-6). No invasives were detected in 2015–2016 along the Riverside Walk, Sand Bench Trail, and Hidden Canyon/Weeping Rock Trail, where there were only a few patches in 2012–2013.

Large increases occurred at the Visitor Center Trails (+247%), Oak Creek and Administrative area (+179%), Northgate/Wildcat Trails (+84%), and Upper Kolob Terrace Road (+76%) (see Table 3-5). The numbers at the Visitor Center and Oak Creek were based on small routes and small numbers of patches (3 and 15 total patches in 2012–2013 and 2015, respectively), making the percent change appear large.

In transects, cheatgrass was, by far, the most frequently detected species in both sample periods, remaining at similar levels, or perhaps slightly lower, in areas where it was sampled in both time periods (Table 3-7).

**Table 3-2. Number of IEP patches and patches/ha by route and route type, Zion NP, June 17–24, 2015 and June 1–6, 2016.**

| Route | Route type | Length (m) | Area (ha) | Patches | | Patches/km | |
|---|---|---|---|---|---|---|---|
| | | | | Total | Priority only | Total | Priority only |
| Kolob Scenic Drive | Road | 17,410.9 | 15.73 | 11 | 9 | 0.63 | 0.52 |
| **Lava Point[1]** | **Road** | **7,737.7** | **6.48** | **4** | **4** | **0.52** | **0.52** |
| **Lower Kolob Terrace[1]** | **Road** | **13,087.7** | **7.86** | **3** | **2** | **0.22** | **0.15** |
| Oak Creek & Administrative | Road | 4,460.4 | 4.78 | 9 | 8 | 0.50 | 1.79 |
| **Smith Mesa[1]** | **Road** | **3,112.9** | **1.33** | **1** | **1** | **0.32** | **0.32** |
| S. Campground & Nature Ctr. | Road | 3,606.4 | 3.29 | 7 | 7 | 0.52 | 1.94 |
| State Route 9 | Road | 21,379.0 | 19.28 | 16 | 15 | 0.75 | 0.70 |
| **Upper Kolob Terrace[1]** | **Road** | **18,851.3** | **5.66** | **110** | **109** | **5.84** | **5.78** |
| Watchman CG and VC | Road | 4,837.1 | 4.73 | 22 | 22 | 4.55 | 4.55 |
| Watchman Housing & PTI[2] | Road | 4,137.3 | 3.05 | 9 | 9 | 2.18 | 2.18 |
| Zion Scenic Drive | Road | 20,505.8 | 20.78 | 13 | 12 | 0.63 | 0.59 |
| *Roads 2015–2016* | | *119,126.6* | *92.97* | *205* | *198* | *1.72* | *1.66* |
| **Barney's Trail[1]** | Trail | **418.4** | **0.25** | **0** | **0** | **0.00** | **0.00** |
| Cable Mountain | Trail | 2,888.8 | 4.32 | 0 | 0 | 0 | 0.00 |
| **Campground[1]** | **Trail** | **363.4** | **0.29** | **0** | **0** | **0.00** | **0.00** |
| Central Trails[3] | Trail | 3,231.2 | 5.70 | 3 | 1 | 0.93 | 0.31 |
| Chinle | Trail | 9,532.8 | 19.01 | 1 | 0 | 0.10 | 0.00 |
| **Connector[1]** | **Trail** | **6,373.5** | **6.37** | **6** | **6** | **0.94** | **0.94** |
| Deertrap Mountain | Trail | 6,975.1 | 13.84 | 1 | 0 | 0.14 | 0.00 |
| East Mesa/Observation Pt. | Trail | 7,637.0 | 5.31 | 0 | 0 | 0.00 | 0.00 |
| East Rim/Stave Spring | Trail | 17,771.6 | 21.77 | 5 | 5 | 0.28 | 0.28 |
| Emerald Pools Trails[4] | Trail | 3,085.4 | 3.11 | 4 | 4 | 1.29 | 1.29 |
| **Hidden Canyon/Weeping Rock[1]** | **Trail** | **1,004.8** | **0.63** | **0** | **0** | **0.00** | **0.00** |
| **Hop Valley[1]** | **Trail** | **10,428.3** | **8.34** | **0** | **0** | **0.00** | **0.00** |
| Kayenta Trails[5] | Trail | 1,467.2 | 1.42 | 0 | 0 | 0.00 | 0.00 |
| **Northern Trails[1,6]** | **Trail** | **20,142.5** | **16.11** | **10** | **1** | **0.49** | **0.05** |
| **Northgate/Wildcat[1]** | **Trail** | **11,000.7** | **8.34** | **31** | **31** | **2.82** | **2.82** |
| Riverside Walk | Trail | 1,557.9 | 3.11 | 0 | 0 | 0.00 | 0.00 |
| Sand Bench | Trail | 7,019.4 | 10.44 | 0 | 0 | 0.00 | 0.00 |
| **Sawmill Spring/West Rim[1]** | **Trail** | **23,522.5** | **19.63** | **2** | **1** | **0.09** | **0.04** |
| Visitor Center Trails[7] | Trail | 5,930.22 | 7.38 | 7 | 7 | 1.18 | 1.18 |
| *Trails 2015–2016* | | *140,350.8* | *155.37* | *21* | *17* | *0.27* | *0.22* |

[1]Route completed in 2015–2016

[2]Shuttle staging area for Parks Transportation, Inc.

[3]Grotto and Wrangler trails

[4]Upper, Middle, and Lower Emerald Pools trails

[5]Upper Kayenta, Lower Kayenta, Kayenta trails

[6]La Verkin, Middle Taylor Creek, and Timber Creek Overlook trails

[7]Archaeology, Museum, Pa'rus, and Watchman trails

**Table 3-3. Number of patches by species and patch size class detected along monitoring routes, Zion NP, June 17–24, 2015 and June 1–6, 2016.**

| Scientific name | Common name | Patches | | Patch size class* | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Total | Priority | 1 | 2 | 3 | 4 | 5 |
| *Aegilops cylindrica* | jointed goatgrass | 3 | 0 | 2 | 0 | 1 | 0 | 0 |
| *Agropyron cristatum* | crested wheatgrass | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Bassia scoparia* | summer cypress | 2 | 2 | 1 | 1 | 0 | 0 | 0 |
| *Bromus inermis* | smooth brome | 3 | 0 | 0 | 3 | 0 | 0 | 0 |
| *Cirsium vulgare* | bull thistle | 13 | 0 | 8 | 3 | 2 | 0 | 0 |
| *Conium maculatum* | poison hemlock | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Cynodon dactylon* | Bermudagrass | 19 | 19 | 4 | 7 | 2 | 1 | 5 |
| *Dactylis glomerata* | orchardgrass | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Malcolmia africana* | African mustard | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Marrubium vulgare* | common horehound | 2 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Medicago minima* | little bur-clover | 22 | 22 | 4 | 13 | 4 | 1 | 0 |
| *Onopordum acanthium* | Scotch thistle | 46 | 46 | 25 | 14 | 5 | 2 | 0 |
| *Poa bulbosa* | bulbous bluegrass | 153 | 153 | 23 | 64 | 51 | 15 | 0 |
| *Sorghum halepense* | Johnsongrass | 15 | 15 | 5 | 6 | 4 | 0 | 0 |
| *Taeniatherum caput-medusae* | Medusahead | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Tamarix* sp. | tamarisk | 9 | 0 | 4 | 3 | 1 | 1 | 0 |
| *Ulmus pumila* | Siberian elm | 12 | 12 | 4 | 3 | 1 | 3 | 1 |
| **Total** | | **304** | **271** | **83** | **120** | **72** | **23** | **6** |

*Patch size classes: 1 = 1–a few plants (≤2 × 2 m), 2 = few plants–40 $m^2$ (48 $yd^2$), 3 = 40–400 $m^2$ (48–478 $yd^2$), 4= 400–1,000 $m^2$ (0.1–0.25 acre), 5 = 1,000–2,000 $m^2$ (0.25–0.5 acre)

**Table 3-4. Number of transects where priority exotic plant species were detected/total transects monitored, mean percent cover, and standard error along monitoring routes at Zion NP, June 17–24, 2015 and June 1–6, 2016.**

| Route | Russian thistle* (*Salsola* sp.) | | Cheatgrass* (*Bromus tectorum*) | | All species | |
|---|---|---|---|---|---|---|
| | Detected/ Total | Percent cover (SE) | Detected/ Total | Percent cover (SE) | Detected/ Total | Percent cover (SE) |
| Chinle Trail | 0/19 | 0.00 (0.00) | 11/19 | 0.15 (0.04) | 11/19 | 0.15 (0.04) |
| Hop Valley/West Rim | 0/68 | 0.00 (0.00) | 16/68 | 1.54 (0.60) | 16/68 | 1.54 (0.60) |
| Connector Trail | 0/13 | 0.00 (0.00) | 9/13 | 0.95 (0.53) | 9/13 | 0.95 (0.53) |
| East Mesa/Observation Pt. | 0/15 | 0.00 (0.00) | 5/15 | 0.08 (0.03) | 5/15 | 0.08 (0.03) |
| Eastern Trails[1] | 0/55 | 0.00 (0.00) | 27/55 | 0.37 (0.09) | 27/55 | 0.37 (0.09) |
| Kolob Scenic Drive | 2/36 | 0.01 (0.01) | 26/36 | 0.45 (0.12) | 28/36 | 0.36 (0.12) |
| Main Canyon Trails[2] | 4/47 | 0.80 (0.72) | 23/47 | 0.61 (0.25) | 26/47 | 1.43 (0.75) |
| Lava Point Road | 0/18 | 0.00 (0.00) | 0/18 | 0.00 (0.00) | 0/18 | 0.00 (0.00) |
| Lower Kolob Terrace Road | 5/26 | 0.07 (0.03) | 24/26 | 1.94 (0.51) | 24/26 | 2.01 (0.50) |
| Northern Trails[3] | 0/42 | 0.00 (0.00) | 18/42 | 1.37 (0.66) | 18/42 | 1.37 (0.66) |
| Northgate/Wildcat | 0/23 | 0.00 (0.00) | 4/23 | 1.90 (1.95) | 5/23 | 1.91 (1.69) |
| Sand Bench | 0/15 | 0.00 (0.00) | 12/15 | 2.05 (0.96) | 12/15 | 2.05 (0.96) |
| Smith Mesa | 1/6 | 0.67 (0.67) | 3/6 | 0.44 (0.22) | 3/6 | 1.11 (0.67) |
| State Route 9 | 7/44 | 0.10 (0.07) | 37/44 | 1.06 (0.23) | 38/44 | 1.08 (0.23) |
| Upper Kolob Terrace Road | 1/38 | <0.00 (<0.00) | 11/38 | 0.30 (0.15) | 12/38 | 0.38 (0.17) |
| Zion Scenic Drive | 1/42 | 0.01 (0.01) | 30/42 | 2.07 (0.90) | 31/42 | 2.08 (0.90) |
| **All transects** | **21/508** | **0.09 (0.07)** | **256/508** | **0.97 (0.15)** | **265/508** | **1.08 (0.17)** |

*Not a priority species but was recorded in transects consistently by all observers in 2015

[1]Cable Mountain, Deertrap Mountain, East Rim, and Stave Spring trails

[2]Archeology, Grotto, Hidden Canyon, Kayenta, Lower Emerald Pools, Lower Kayenta, Middle Emerald Pools, Museum, Oak Creek and Administrative, Pa'rus, Riverside Walk, Upper Emerald Pools, Upper Kayenta, Watchman Housing and PTI, Watchman, Weeping Rock and Wrangler trails

[3]La Verkin, Middle Taylor Creek, Barney's, and Timber Creek Overlook trails

**Table 3.5. Patches/km on routes with the same priority species surveyed in 2012–2013 and 2015–2016, Zion NP.**

| Route | Route type | Patches/km | | Percent change | |
|---|---|---|---|---|---|
| | | 2012–2013 | 2015–2016 | Decrease | Increase |
| Kolob Scenic Drive | Road | 1.03 | 0.46 | -55% | - |
| Lava Point | Road | 0.00 | 0.52 | - | + |
| Lower Kolob Terrace | Road | 0.61 | 0.15 | -75% | - |
| Oak Creek & Administrative | Road | 0.48 | 1.34 | - | +179% |
| Smith Mesa | Road | 0.00 | 0.32 | - | + |
| S. Campground & Nature Ctr. | Road | 3.05 | 1.94 | -36% | - |
| State Route 9 | Road | 0.33 | 0.14 | -57% | - |
| Upper Kolob Terrace | Road | 3.29 | 5.78 | - | +76% |
| Watchman CG and VC | Road | 16.46 | 4.55 | -72% | - |
| Watchman Housing & PTI[1] | Road | 3.43 | 2.18 | -36% | - |
| Zion Scenic Drive | Road | 2.19 | 0.44 | -80% | - |
| Cable Mountain | Trail | 0.00 | 0.00 | NA | NA |
| Central Trails[2] | Trail | 1.88 | 0.31 | -83% | - |
| Chinle | Trail | 0.00 | 0.00 | NA | NA |
| Connector | Trail | 0.00 | 0.94 | - | + |
| Deertrap Mountain | Trail | 0.00 | 0.00 | NA | NA |
| East Mesa/Observation Pt. | Trail | 0.00 | 0.00 | NA | NA |
| East Rim/Stave Spring | Trail | 0.74 | 0.28 | -58% | - |
| Emerald Pools Trails | Trail | 0.00 | 0.65 | - | + |
| Hidden Canyon/Weeping Rock | Trail | 4.16 | 0.00 | -100% | - |
| Hop Valley | Trail | 0.00 | 0.00 | NA | NA |
| Kayenta Trails | Trail | 0.00 | 0.00 | None | None |
| Northern Trails[3] | Trail | 0.00 | 0.05 | None | None |
| Northgate/Wildcat | Trail | 1.53 | 2.82 | - | +84% |
| Riverside Walk | Trail | 1.28 | 0.00 | -100% | - |
| Sand Bench | Trail | 0.14 | 0.00 | -100% | |
| Sawmill Spring/West Rim | Trail | 0.00 | 0.04 | - | + |
| Visitor Center Trails[4] | Trail | 0.34 | 1.18 | - | +247% |

+ = Increase could not be quantified because previous value was 0.

[1]Shuttle staging area for Parks Transportation, Inc.

[2]Grotto and Wrangler trails

[3]La Verkin, Middle Taylor Creek, Barney's, and Timber Creek Overlook trails

[4]Archaeology, Museum, Pa'rus, and Watchman trails

**Table 3-6. Number of patches by species and patch size class detected along the same routes monitored in 2012–2013 and 2015–2016, Zion NP.**

| Scientific name | Common name | Year | Total patches | Patch size class* | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 |
| *Bassia scoparia* | summer cypress | 2012–2013 | 2 | 0 | 1 | 1 | 0 | 0 |
| | | 2015–2016 | 2 | 1 | 1 | 0 | 0 | 0 |
| *Cynodon dactylon* | Bermudagrass | 2012–2013 | 12 | 3 | 3 | 3 | 1 | 2 |
| | | 2015–2016 | 19 | 4 | 7 | 2 | 1 | 5 |
| *Conium maculatum* | poison hemlock | 2012–2013 | 1 | 0 | 1 | 0 | 0 | 0 |
| | | 2015–2016 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Onopordum acanthium* | Scotch thistle | 2012–2013 | 27 | 16 | 7 | 2 | 2 | 0 |
| | | 2015–2016 | 46 | 25 | 14 | 5 | 2 | 0 |
| *Poa bulbosa* | bulbous bluegrass | 2012–2013 | 153 | 19 | 63 | 60 | 11 | 0 |
| | | 2015–2016 | 153 | 23 | 64 | 51 | 15 | 0 |
| *Sorghum halepense* | Johnsongrass | 2012–2013 | 32 | 15 | 16 | 1 | 0 | 0 |
| | | 2015–2016 | 15 | 5 | 6 | 4 | 0 | 0 |
| *Taeniatherum caput-medusae* | Medusahead | 2012–2013 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2015–2016 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Ulmus pumila* | Siberian elm | 2012–2013 | 65 | 18 | 26 | 17 | 4 | 0 |
| | | 2015–2016 | 12 | 4 | 3 | 1 | 3 | 1 |
| **Total** | | 2012–2013 | **292** | **71** | **117** | **84** | **18** | **2** |
| | | 2015–2016 | **249** | **63** | **96** | **63** | **21** | **6** |

*Patch size classes: 1 = 1–a few plants (≤2 × 2 m), 2 = few plants–40 $m^2$ (48 $yd^2$), 3 = 40–400 $m^2$ (48–478 $yd^2$), 4= 400–1,000 $m^2$ (0.1–0.25 acre), 5 = 1,000–2,000 $m^2$ (0.25–0.5 acre)

**Table 3-7. Percent cover of cheatgrass and all species in transects surveyed in 2012–2013 and 2015–2016, Zion NP.**

| Route | Years | Cheatgrass (*Bromus tectorum*) | | All species | |
|---|---|---|---|---|---|
| | | Detected/ Total | Percent cover (SE) | Detected/ Total | Percent cover (SE) |
| Chinle Trail | 2012–2013 | 6/11 | 0.12 (0.04) | 6/11 | 0.12 (0.04) |
| | 2015–2016 | 11/19 | 0.15 (0.04) | 11/19 | 0.15 (0.04) |
| Hop Valley/West Rim | 2012–2013 | 9/20 | 1.38 (0.70) | 9/20 | 1.38 (0.70) |
| | 2015–2016 | 16/85 | 1.23 (0.49) | 16/85 | 1.23 (0.49) |
| Kolob Scenic Drive | 2012–2013 | 20/34 | 0.84 (0.32) | 20/34 | 0.84 (0.32) |
| | 2015–2016 | 26/36 | 0.45 (0.12) | 28/36 | 0.36 (0.12) |
| Main Canyon Trails[1] | 2012–2013 | 15/22 | 2.73 (1.33) | 15/22 | 2.73 (1.33) |
| | 2015–2016 | 23/47 | 0.61 (0.25) | 26/47 | 1.43 (0.75) |
| Northern Trails[2] | 2012–2013 | 3/11 | 0.24 (0.18) | 3/11 | 0.24 (0.18) |
| | 2015–2016 | 18/42 | 1.37 (0.66) | 18/42 | 1.37 (0.66) |
| Sand Bench | 2012–2013 | 13/14 | 4.76 (2.28) | 13/14 | 4.76 (2.28) |
| | 2015–2016 | 12/15 | 2.05 (0.96) | 12/15 | 2.05 (0.96) |
| State Route 9 | 2012–2013 | 33/39 | 1.96 (0.40) | 33/39 | 1.96 (0.40) |
| | 2015–2016 | 37/44 | 1.06 (0.23) | 38/44 | 1.08 (0.23) |
| Upper Kolob Terrace Rd | 2012–2013 | 13/26 | 0.89 (0.30) | 14/26 | 0.93 (0.30) |
| | 2015–2016 | 11/38 | 0.30 (0.15) | 12/38 | 0.38 (0.17) |

[1]Archeology, Kayenta, Lower Emerald Pools, Lower Kayenta, Middle Emerald Pools, Museum, Oak Creek and Administrative, Pa'rus, Riverside Walk, Upper Emerald Pools, Upper Kayenta, Watchman Housing and PTI, Watchman, and Weeping Rock trails

[2]La Verkin, Middle Taylor Creek, Barney's, and Timber Creek Overlook trails

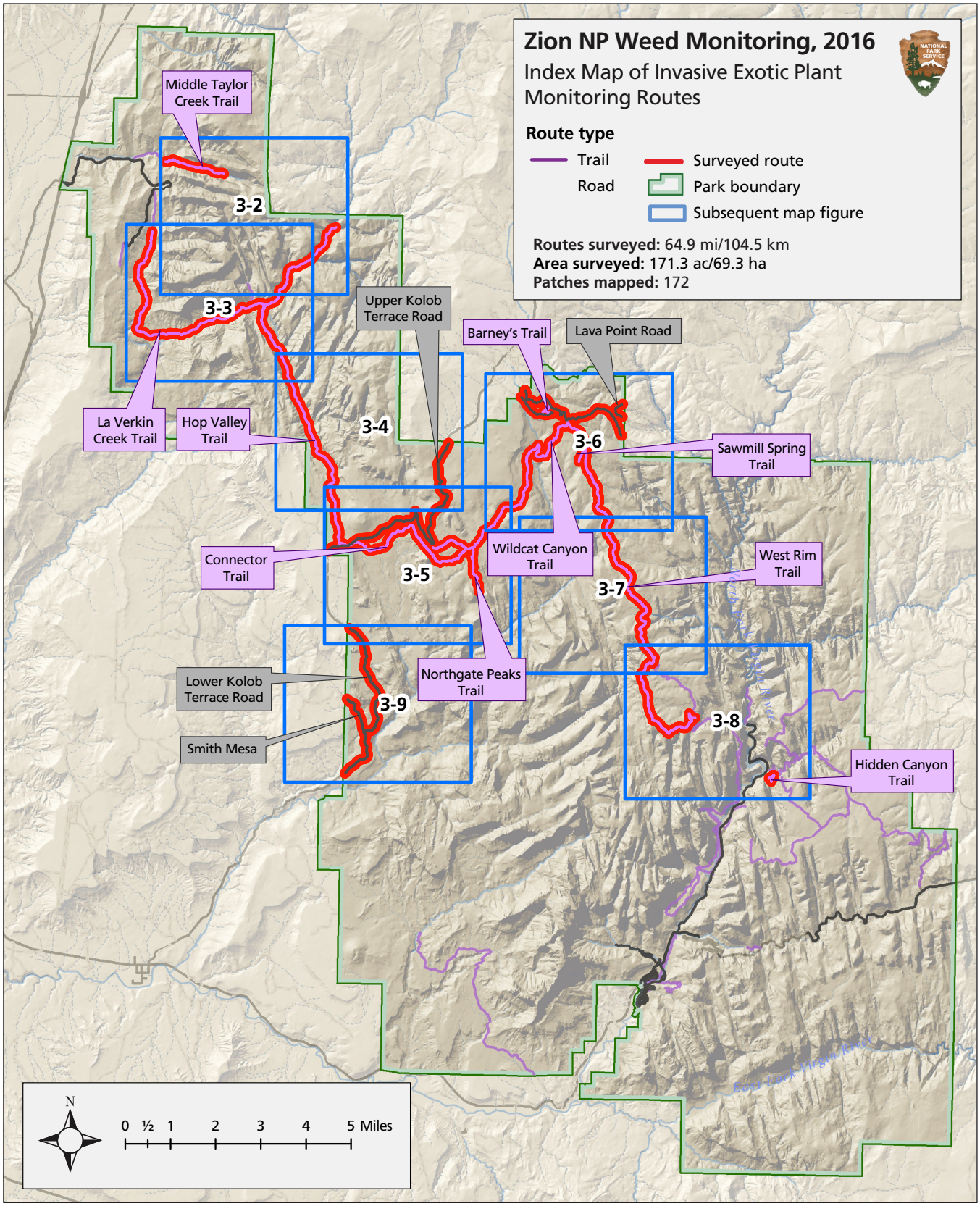


Figure 3-1. Index map of invasive plant monitoring routes by figure number, Zion National Park, June 1–6, 2016.

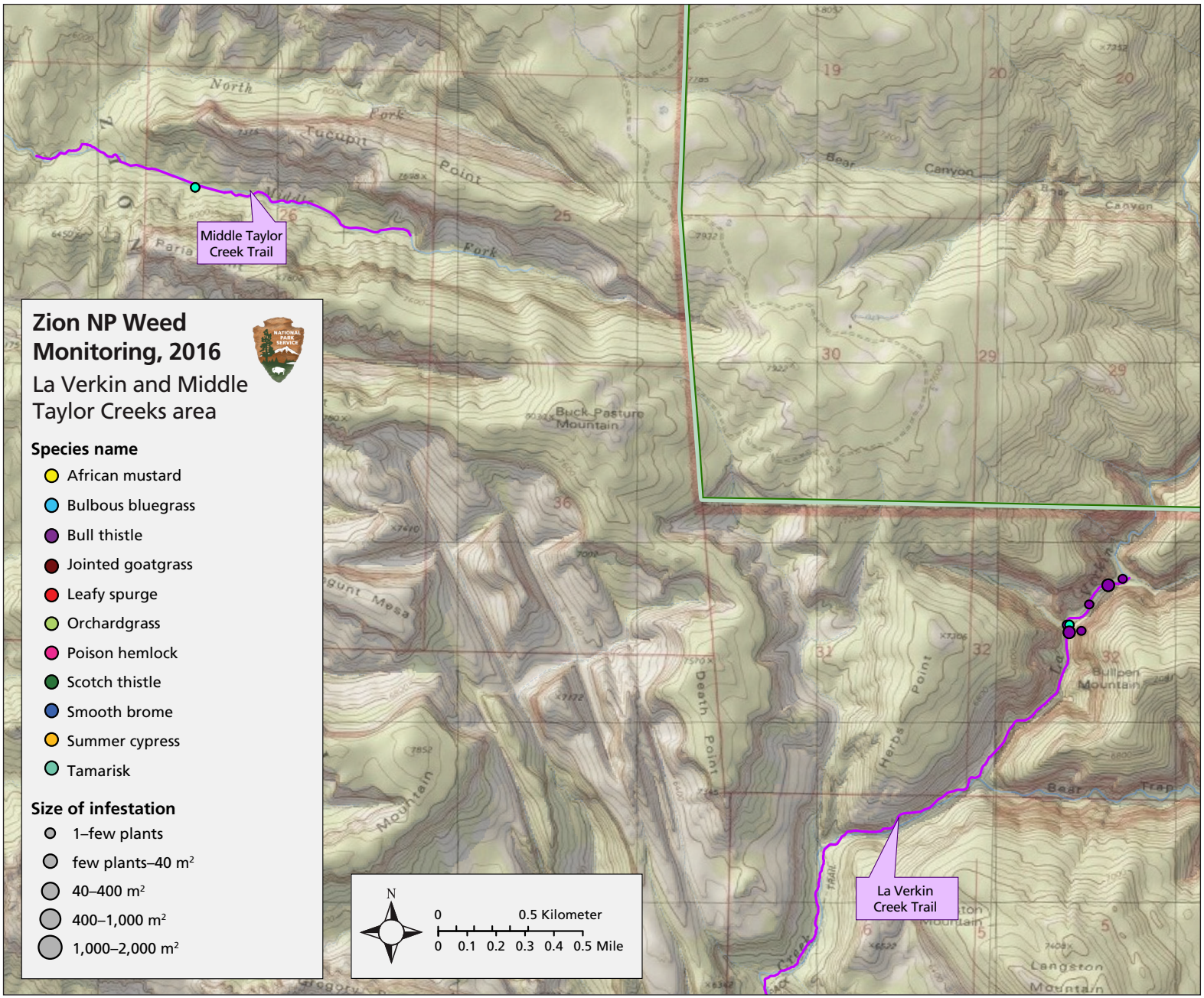


Figure 3-2. Invasive plants detected on monitoring routes in the La Verkin and Middle Taylor creeks area, Zion National Park, June 1–6, 2016.

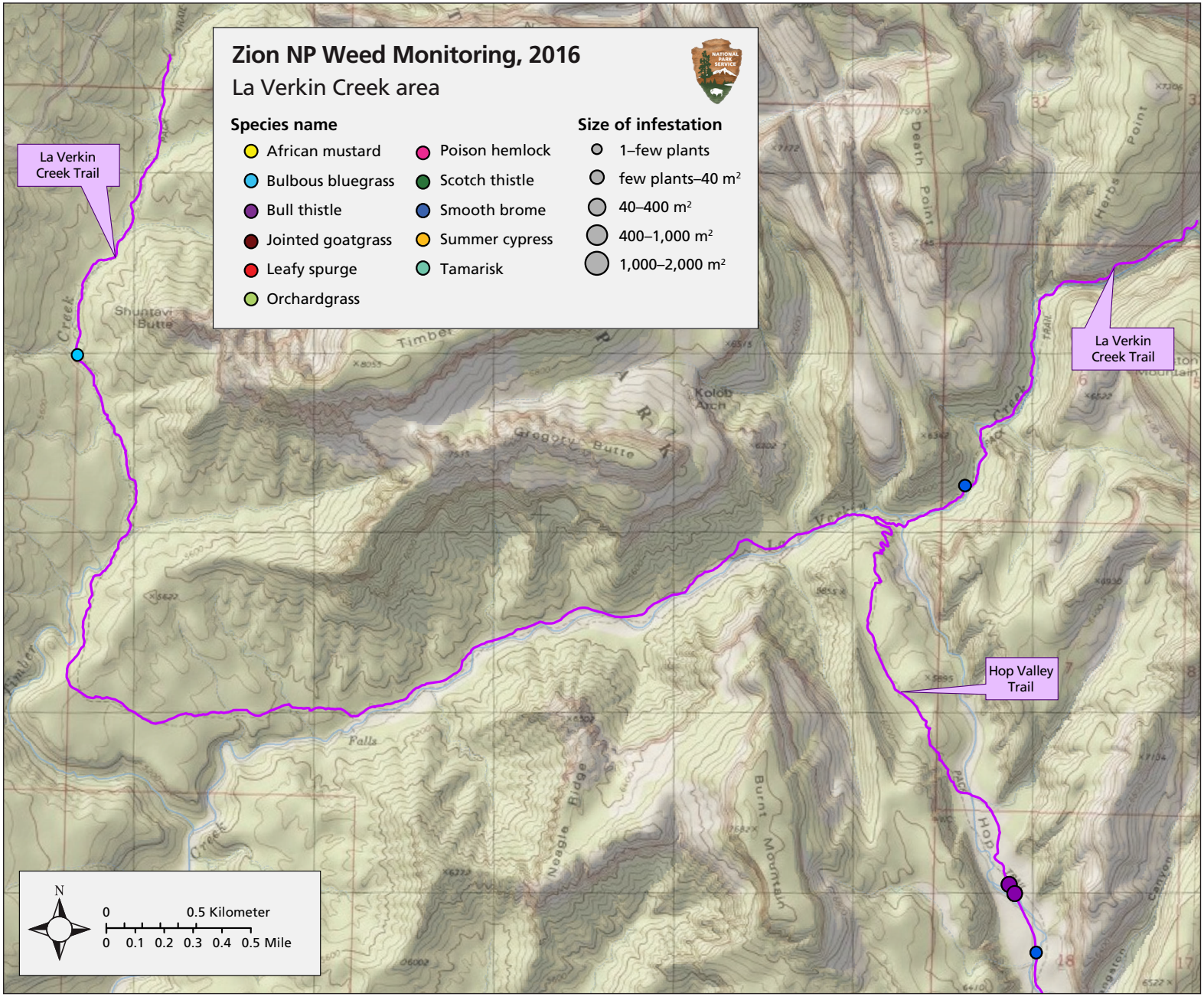


Figure 3-3. Invasive plants detected on monitoring routes in the La Verkin Creek area, Zion National Park, June 1–6, 2016.

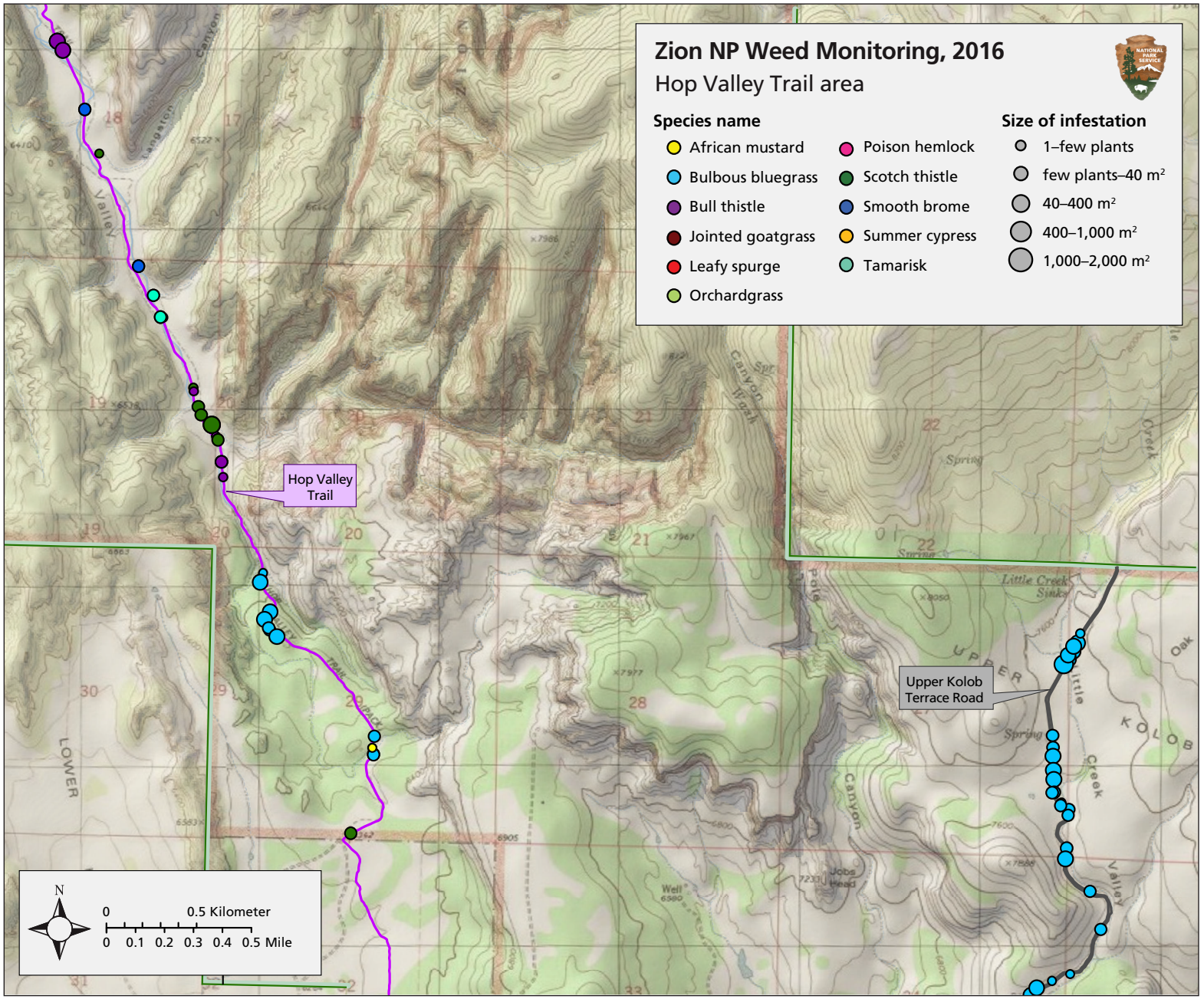


Figure 3-4. Invasive plants detected on monitoring routes in the Hop Valley Trail area, Zion National Park, June 1–6, 2016.

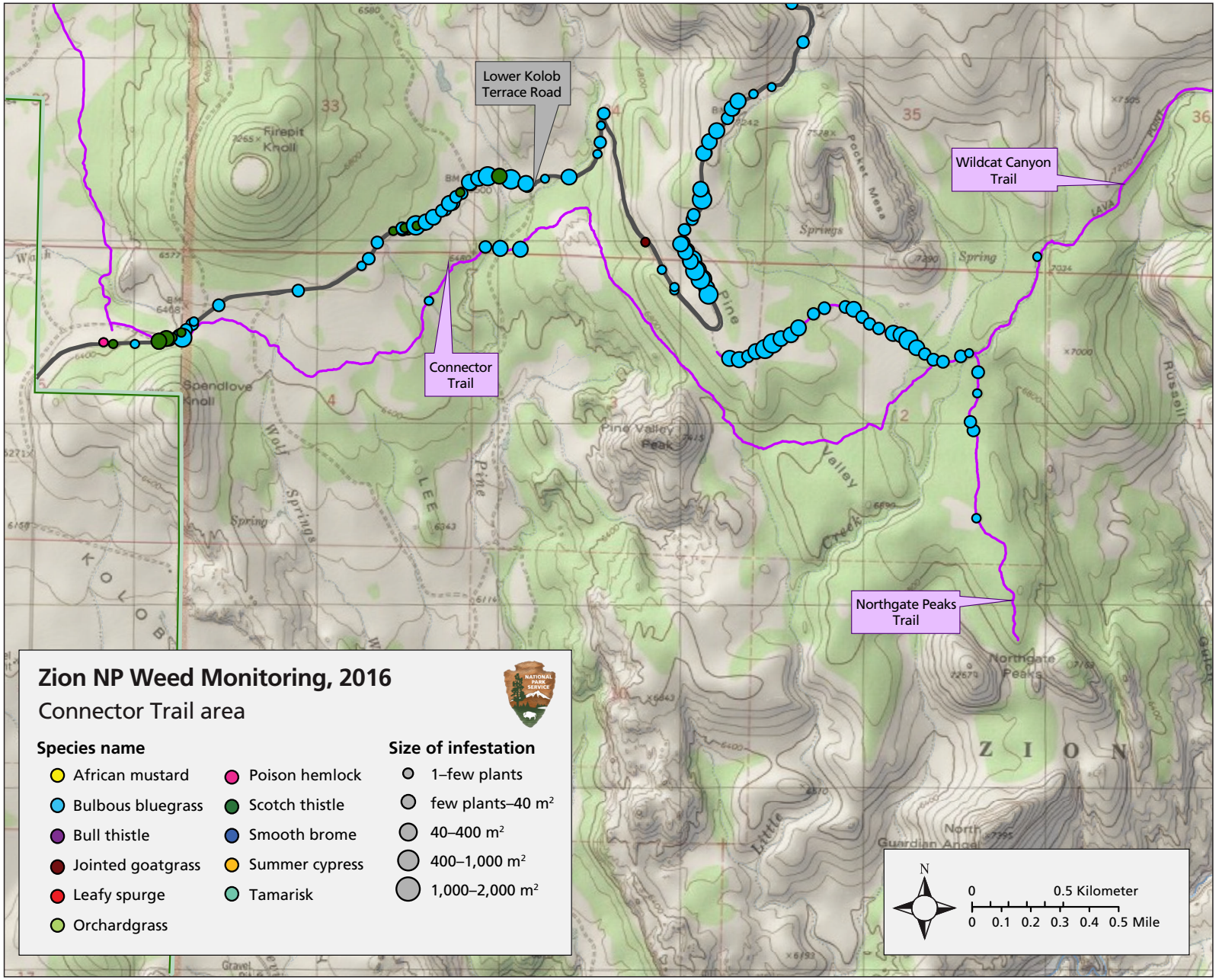


Figure 3-5. Invasive plants detected on monitoring routes in the Connector Trail area, Zion National Park, June 1–6, 2016.

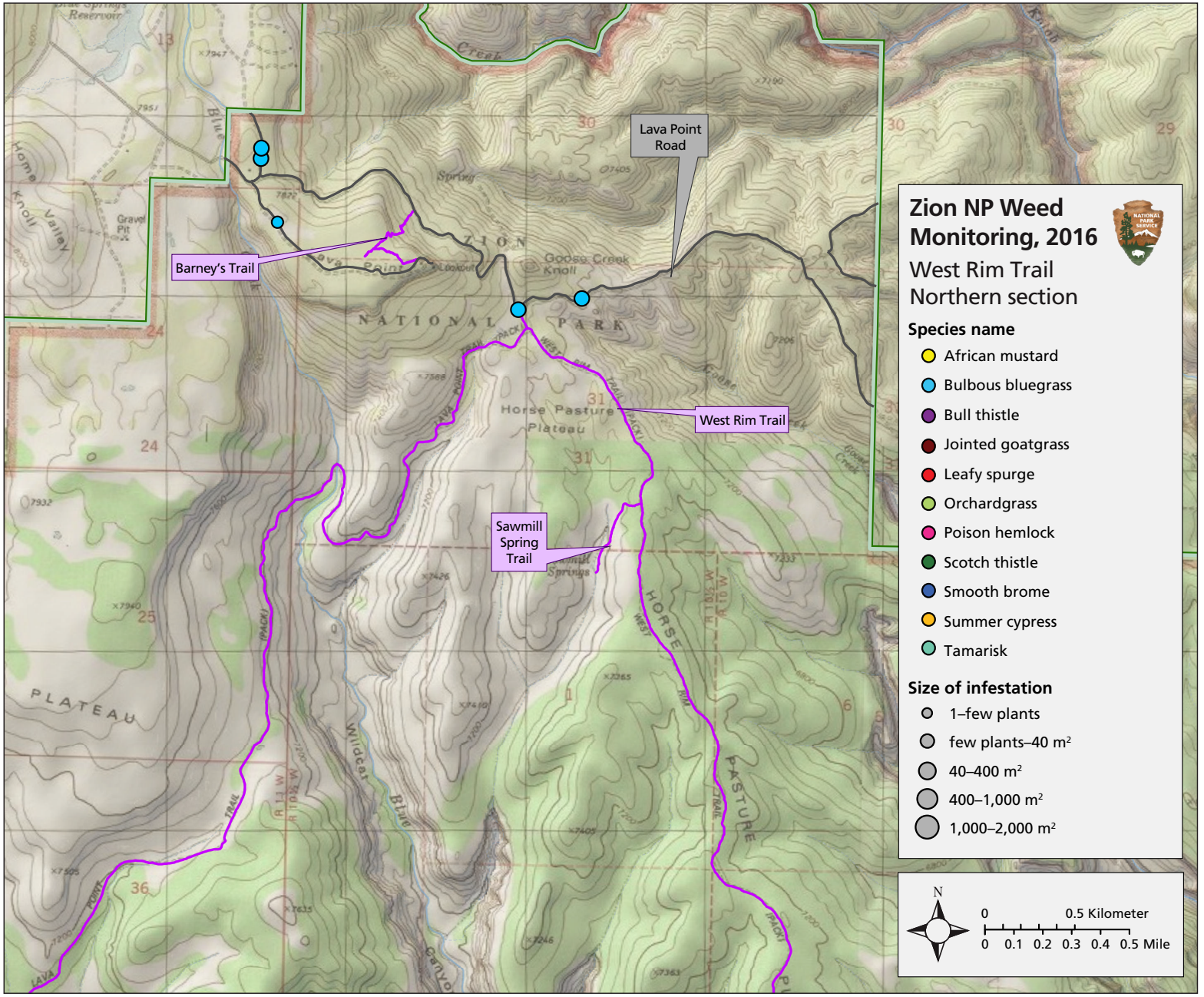


Figure 3-6. Invasive plants detected on monitoring routes in the northern section of the West Rim Trail area, Zion National Park, June 1–6, 2016.

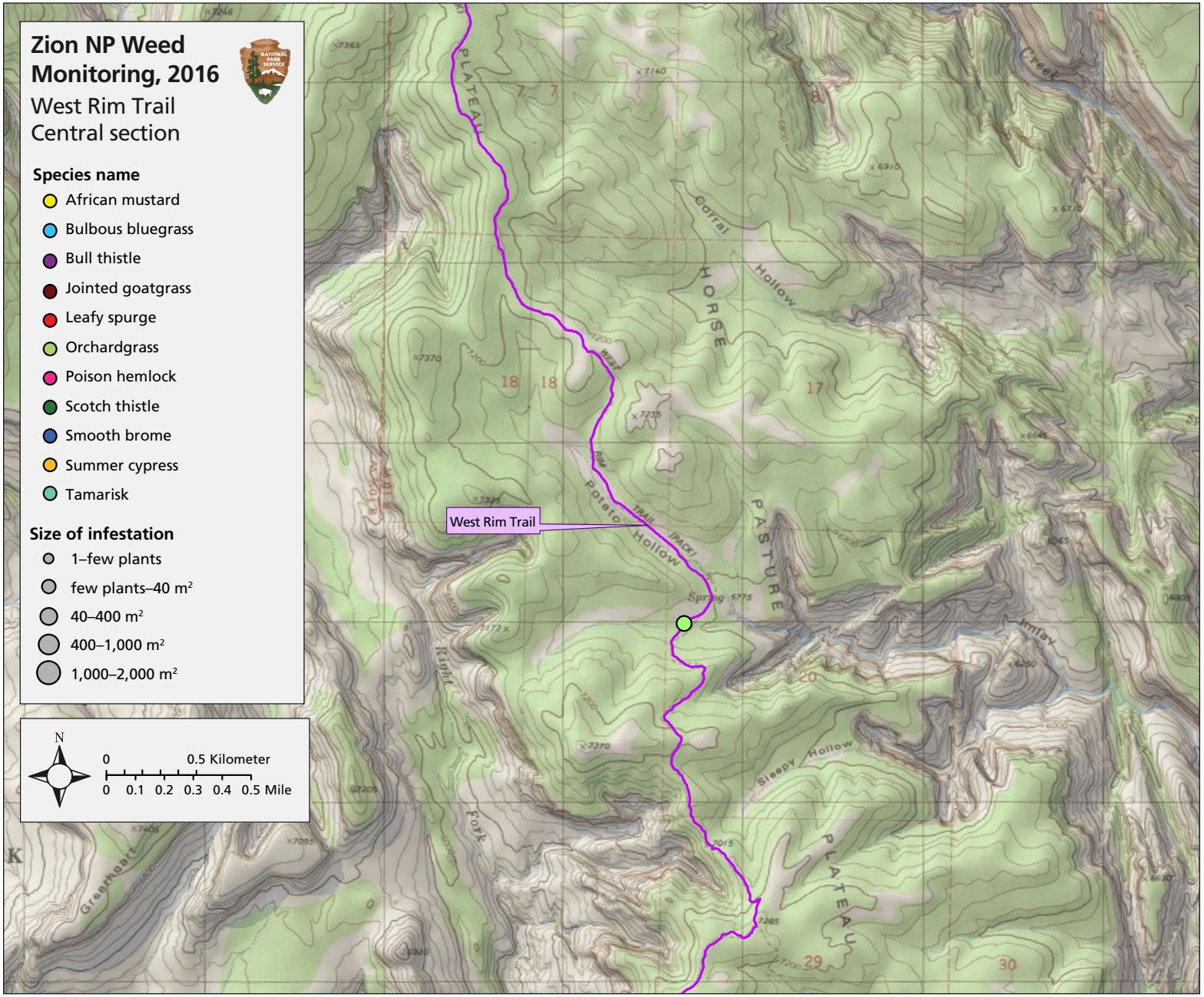


Figure 3-7. Invasive plants detected on monitoring routes in the central section of the West Rim Trail area, Zion National Park, June 1–6, 2016.

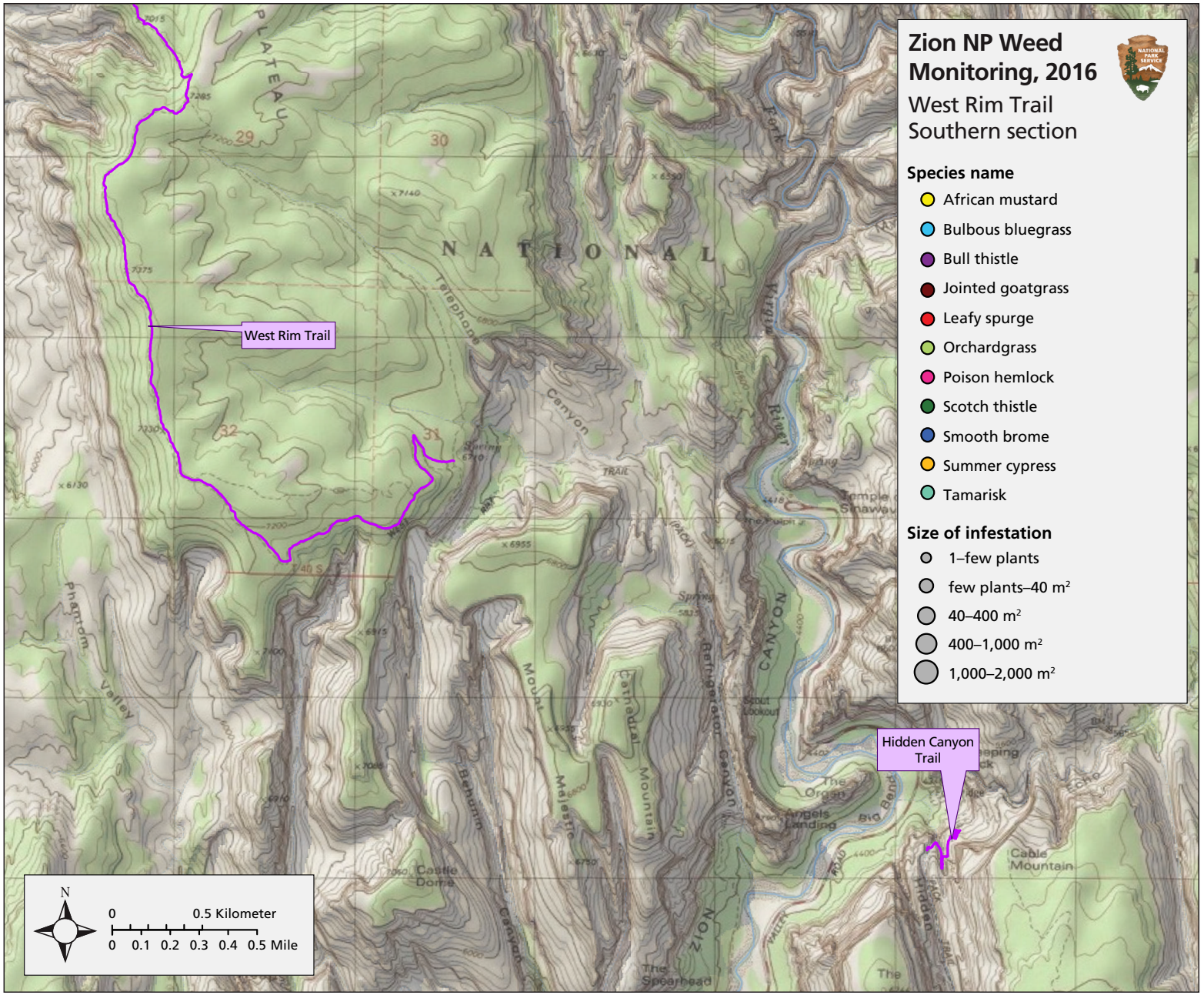


Figure 3-8. Invasive plants detected on monitoring routes in the southern section of the West Rim Trail area, Zion National Park, June 1–6, 2016.

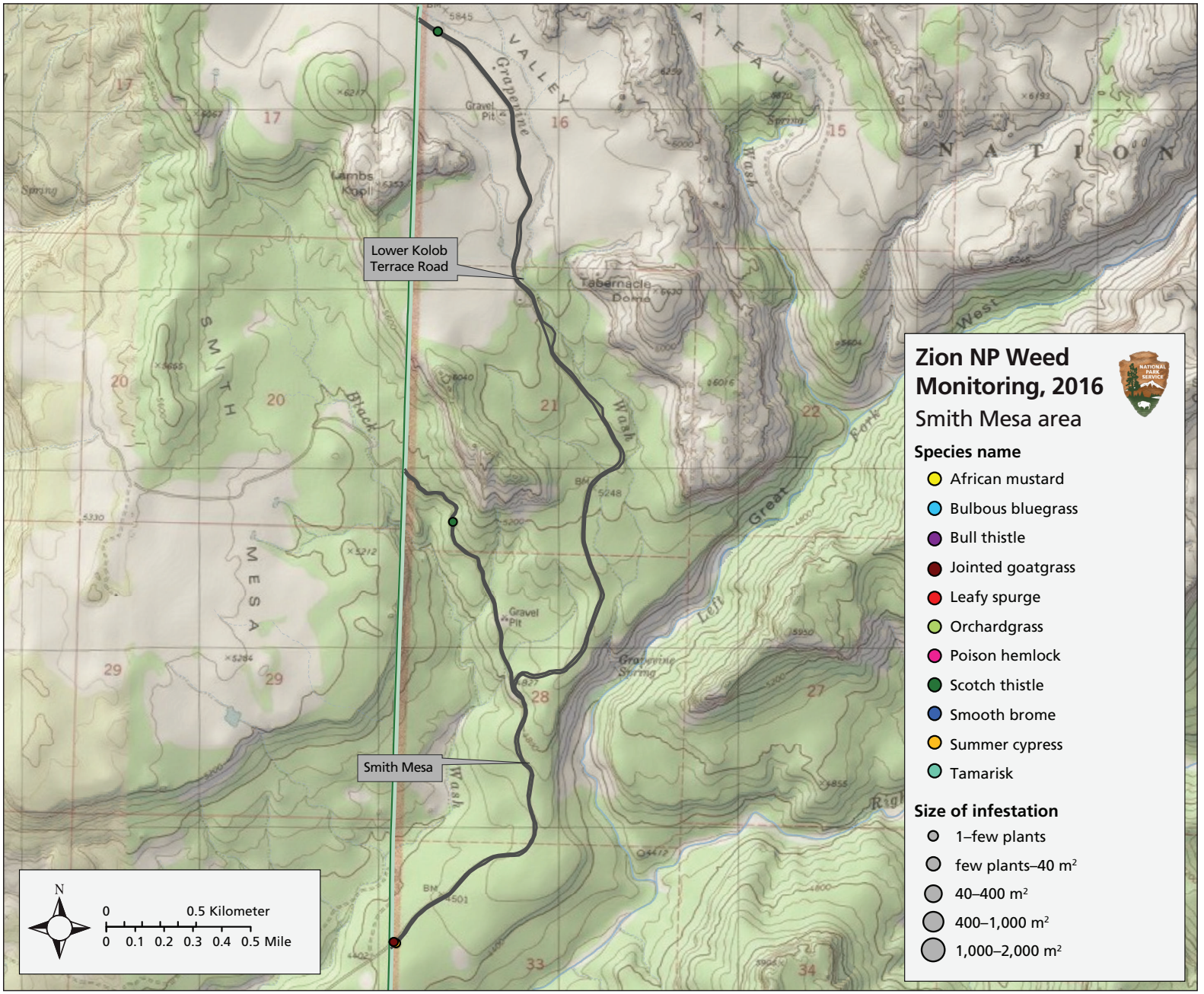


Figure 3-9. Invasive plants detected on monitoring routes in the Smith Mesa area, Zion National Park, June 1–6, 2016.

# 4 Discussion

## 4.1 Priority IEP list

The NCPN will continue to work with park staff and area IEP experts to review and update the list of priority species each year. Cheatgrass and Russian thistle were added to the priority list for transects only in 2013, but these species were not mapped due to their widespread presence. Presence and absence data for most priority species, and presence data for other species, should be reliable for the area surveyed. However, absence data for non-priority species are suspect, because not all observers recorded all of these species in all years.

## 4.2 Possibilities for management control

Bulbous bluegrass, Scotch thistle, and little bur-clover were the most widespread invasive plant species, representing 82% of all priority invasive plant patches detected over the course of this second rotation. Bulbous bluegrass and Scotch thistle are best controlled with manual methods, such as pulling, but careful use of herbicides can also be effective if done at the right time and growth stage. Little bur-clover is best controlled with careful use of herbicides.

Bermudagrass and Johnsongrass, the fourth and fifth-most prevalent priority IEP species, are best controlled with careful use of herbicides and manual methods, such as pulling. The decline in Johnsongrass and Siberian elm in the area of the South and Watchman campgrounds is likely the result of control efforts by Zion NP staff and contractors. While cheatgrass has declined along State Route 9 and the Main Canyon trails, these areas were not targeted for control and this decline may be due to environmental changes between the two sampling periods. There was also a large decline on the Lower Kolob Terrace Road which has been the subject of control efforts. In addition, the Kolob Terrace Road Rehabilitation project, in 2015, could have impacted local invasive patches and may also have created additional disturbances for invasive plants to invade. This work included road-widening, shoulder work, and repaving. The Kolob Terrace Road should be watched carefully for future invasions.

Only 25% of priority patches were larger than 40 $m^2$, indicating that control is still possible. The Upper Kolob Terrace Road had the highest number of priority patches (5.78/km) of any route. Efforts should be made to control invasive plants in high-use visitor areas that tended to have the most invasive plants: Watchman Campground and Visitor Center, Watchman Housing and PTI area, South Campground, Oak Creek Administrative Area, Grotto and Wrangler trails, and Visitor Center Trails. Patch numbers were generally higher in areas that receive more visitation. Patch densities were also generally higher along roads than along trails.

It should also be noted that overall percent cover was very low and many monitoring routes had either few or no priority invasive plants (see Table 3-2). Efforts should be made to keep these areas IEP-free. Estimates of percent cover in this report (see Table 3-4) are limited to the routes surveyed; actual percent cover of IEPs across the entire park cannot be inferred with these methods. Because we have chosen to monitor along areas most likely to be invaded by a broad suite of IEPs, it is plausible that the percent cover for most IEP species is lower in the interior of the park than along the monitoring routes.

## 4.3 Future monitoring efforts

IEPs at Zion NP will generally be monitored at the same time each year. Consistency in timing of monitoring should ensure consistency in detection probabilities and cover estimates of most species. For many species, sampling at any time from May through September is not expected to drastically alter the chances of detecting invasive species at a level larger than the minimum detection target size.

In 2018, NCPN will return to Zion NP to start the third rotation of invasive plant monitoring. We may also complete some extra-area surveys in locations yet to be determined. Because any previous detections could have been eradicated by park staff, the locations of monitoring quadrats are re-generated each year. Long-term trend reporting will focus on trends in species distributions, trends in percent cover of individual species, and changes in IEP percent cover of priority species by monitoring route.

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# Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| Lower Kolob Terrace Road | Aegilops cylindrica | Jointed goatgrass | No | | 5 | 1 | 4126559.651 | 313012.995 |
| Upper Kolob Terrace Road | Aegilops cylindrica | Jointed goatgrass | No | | 5 | 1 | 4135196.688 | 315741.116 |
| Lower Kolob Terrace Road | Bassia scoparia | Summer-cypress | Yes | | 5 | 1 | 4126553.824 | 313025.364 |
| Hop Valley Trail | Bromus inermis | smooth brome | No | | 1 | 2 | 4139980.389 | 311261.807 |
| Hop Valley Trail | Bromus inermis | smooth brome | No | | 3 | 2 | 4140850.691 | 310961.978 |
| La Verkin Creek Trail | Bromus inermis | smooth brome | No | | 2 | 2 | 4143448.612 | 310564.852 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4139035.318 | 311690.551 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4139693.843 | 311398.615 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4139283.006 | 311568.011 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4138808.858 | 311729.369 |
| La Verkin Creek Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4145988.601 | 312642.775 |
| La Verkin Creek Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4145845.869 | 312457.223 |
| La Verkin Creek Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4145733.102 | 312333.335 |
| La Verkin Creek Trail | Cirsium vulgare | Bull thistle | No | | 5 | 1 | 4145700.28 | 312411.67 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 2 | 2 | 4138892.512 | 311721.845 |
| La Verkin Creek Trail | Cirsium vulgare | Bull thistle | No | | 2 | 2 | 4145954.369 | 312563.176 |
| La Verkin Creek Trail | Cirsium vulgare | Bull thistle | No | | 2 | 2 | 4145692.45 | 312345.143 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 1 | 3 | 4141178.278 | 310841.268 |
| Hop Valley Trail | Cirsium vulgare | Bull thistle | No | | 1 | 3 | 4141229.716 | 310808.894 |
| Upper Kolob Terrace Road | Conium maculatum | Poison-hemlock | No | | 3 | 1 | 4134645.351 | 312762.08 |
| West Rim Trail | Dactylis glomerata | Orchard grass | No | | 3 | 3 | 4132193.251 | 323603.406 |
| Hop Valley Trail | Malcolmia africana | African mustard | No | | 5 | 1 | 4137303.987 | 312560.163 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4140605.324 | 311043.862 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4139305.233 | 311564.058 |
| Lower Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4131635.581 | 313257.362 |
| Smith Mesa | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4128901.927 | 313342.599 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 3 | 1 | 4135557.244 | 314926.87 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 1 | 1 | 4135256.422 | 314356.259 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 1 | 1 | 4134672.839 | 313141.985 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4134634.655 | 312814.902 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4135286.796 | 314484.117 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4134700.809 | 313190.189 |

*Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016, cont.*

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4135467.379 | 314722.513 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 2 | 1 | 4135273.519 | 314418.259 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4134640.639 | 313081.021 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 5 | 1 | 4135546.363 | 314881.547 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 2 | 2 | 4136831.154 | 312439.898 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 2 | 2 | 4139197.675 | 311591.68 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 2 | 2 | 4139014.074 | 311703.541 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 3 | 2 | 4139153.362 | 311609.094 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 3 | 2 | 4135269.515 | 314435.774 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 3 | 2 | 4135555.2 | 314868.333 |
| Connector Trail | Onopordum acanthium | Scotch thistle | No | | 2 | 3 | 4134664.729 | 313108.602 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 1 | 3 | 4135556.165 | 314939.31 |
| Upper Kolob Terrace Road | Onopordum acanthium | Scotch thistle | No | | 2 | 3 | 4134651.529 | 313069.702 |
| Hop Valley Trail | Onopordum acanthium | Scotch thistle | No | | 1 | 4 | 4139098.652 | 311667.273 |
| Connector Trail | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4134873.403 | 314550.587 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4138274.991 | 311952.946 |
| Northgate Peaks Trail | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4133679.628 | 317557.516 |
| Northgate Peaks Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 1 | 4134363.518 | 317562.699 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4137938.663 | 316491.013 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4134760.681 | 313258.278 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4134930.91 | 315900.131 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 1 | 4136009.344 | 316333.924 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4135544.131 | 315322.757 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 1 | 4137000.525 | 316386.278 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4134636.469 | 312935.917 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4136045.845 | 316434.329 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4135065.99 | 314180.586 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 1 | 4135679.76 | 315476.825 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4135834.855 | 315497.255 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4135044.622 | 315829.511 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4134948.963 | 315899.743 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4135542.725 | 315188.043 |

*Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016, cont.*

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 5 | 1 | 4134585.197 | 317519.647 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | Yes | | 5 | 1 | 4135115.335 | 317893.953 |
| Connector Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135169.192 | 314861.485 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4137269.9 | 312567.407 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4137957.657 | 311990.725 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4137368.463 | 312570.57 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4137267.692 | 312565.918 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4137970.398 | 311982.819 |
| La Verkin Creek Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4144176.502 | 305623.424 |
| Lava Point | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4139594.654 | 319556.805 |
| Northgate Peaks Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134159.613 | 317542.542 |
| Northgate Peaks Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134209.436 | 317526.217 |
| Northgate Peaks Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134480.971 | 317567.424 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4136929.518 | 316424.671 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135503.998 | 315090.987 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135262.087 | 315953.098 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134681.698 | 313177.049 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135264.084 | 314406.221 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135319.369 | 315997.516 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134743.828 | 313250.3 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135921.536 | 316225.162 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4136747.487 | 316415.216 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4136983.993 | 316381.936 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4137058.272 | 316346.245 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135540.484 | 314833.68 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4137372.607 | 316336.79 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134849.657 | 313397.574 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134929.072 | 313833.052 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135295.436 | 314525.321 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134657.72 | 313127.003 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135743.685 | 315491.59 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135271.749 | 314402.385 |

*Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016, cont.*

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135524.78 | 315015.462 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135194.322 | 314268.022 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4135369.497 | 314621.292 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135462.037 | 314729.997 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135194.637 | 315949.932 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4136506.267 | 316544.958 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135513.03 | 314781.213 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135686.795 | 316071.929 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4135443.835 | 314700.372 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135415.85 | 316058.854 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4137055.893 | 316334.176 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4136293.906 | 316606.18 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135323.062 | 314577.273 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135376 | 314643.178 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4135346.244 | 316004.179 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134713.111 | 313218.578 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4137305.09 | 316338.186 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 2 | 4135901.586 | 315510.139 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135472.087 | 316057.067 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4135105.16 | 314219.784 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4135876.794 | 316191.555 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 2 | 4136960.676 | 316428.737 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 2 | 4134800.66 | 316663.511 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134840.715 | 316838.292 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134785.245 | 316930.255 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134538.136 | 317374.196 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134568.101 | 316304.054 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134832.345 | 316723.871 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134551.481 | 317320.908 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134568.319 | 317473.07 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134720.251 | 317021.87 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134746.218 | 316971.305 |

*Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016, cont.*

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 2 | 4134579.691 | 317274.516 |
| Connector Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135157.746 | 315054.258 |
| Connector Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135161.676 | 314942.666 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4137922.497 | 312028.703 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4138224.79 | 311937.645 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4138016.862 | 311960.469 |
| Hop Valley Trail | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4138059.185 | 311993.18 |
| Lava Point | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4140007.66 | 319466.985 |
| Lava Point | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4139168.059 | 321252.311 |
| Lava Point | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4139949.388 | 319465.485 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4137817.123 | 316424.616 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135332.569 | 314576.588 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135682.627 | 316060.9 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135091.036 | 315987.931 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135748.601 | 316092.627 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135929.515 | 316217.005 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135808.237 | 316130.199 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135970.382 | 316248.533 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4137796.69 | 316426.082 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4135185.35 | 315933.722 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 3 | 4134944.691 | 316075.558 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 3 | 4137178.342 | 316341.852 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135486.422 | 316043.246 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135142.662 | 315961.057 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135516.904 | 315084.463 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 3 | 4135148.106 | 315968.159 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135523.964 | 314773.582 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4137256.787 | 316339.809 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135546.192 | 314823.422 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 3 | 4137128.068 | 316342.33 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4135407.395 | 314663.447 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4135306.089 | 314534.187 |

*Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016, cont.*

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4135553.541 | 315321.085 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4137886.308 | 316475.886 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 3 | 4137867.809 | 316453.058 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4135413.406 | 314678.927 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4136687.794 | 316407.687 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4137838.892 | 316448.407 |
| West Rim Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4139105.561 | 320898.971 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4134694.771 | 317100.066 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4134551.259 | 316255.988 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4134557.643 | 316203.31 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4134595.033 | 316346.196 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4134686.931 | 317144.977 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4134664.663 | 316485.705 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4134615.734 | 317228.985 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4134725.03 | 316581.784 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 3 | 4134687.236 | 316539.816 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 3 | 4134827.492 | 316884.339 |
| Connector Trail | Poa bulbosa | Bulbous bluegrass | No | | 2 | 4 | 4134670.607 | 313196.183 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 4 | 4135428.437 | 316050.492 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 4 | 4135098.306 | 315995.588 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 4 | 4134989.4 | 316044.129 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 4 | 4135040.482 | 316023.632 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 4 | 4134907.879 | 316086.27 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 4 | 4135541.317 | 315000.54 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 2 | 4 | 4135037.717 | 316014.648 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 4 | 4 | 4134990.915 | 316050.964 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 4 | 4137768.484 | 316398.644 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 3 | 4 | 4135556.613 | 314874.86 |
| Upper Kolob Terrace Road | Poa bulbosa | Bulbous bluegrass | No | | 1 | 4 | 4135287.254 | 314479.182 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 4 | 4134641.403 | 316438.841 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 4 | 4134607.986 | 316397.432 |
| Wildcat Canyon Trail | Poa bulbosa | Bulbous bluegrass | No | | 3 | 4 | 4134659.205 | 317186.477 |

*Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Zion NP, June 1–6, 2016, cont.*

| Plot_ID | Species | Master_Common_Name | Pulled | Growth_ Stage | Cover_ Class | Size_ Class | N_Coord | E_Coord |
|---|---|---|---|---|---|---|---|---|
| La Verkin Creek Trail | Tamarix sp. | tamarisk | No | Sapling(s) | 5 | 1 | 4145734.484 | 312347.178 |
| Middle Taylor Creek Trail | Tamarix sp. | tamarisk | No | Sapling(s) | 5 | 1 | 4148169.974 | 307479.85 |
| Hop Valley Trail | Tamarix sp. | tamarisk | No | Sapling(s) | 2 | 2 | 4139816.058 | 311344.56 |
| Hop Valley Trail | Tamarix sp. | tamarisk | No | Sapling(s) | 1 | 2 | 4139697.202 | 311384.178 |

# Appendix B. Exotic Plant Transect Data Detected at Zion NP, June 1–6, 2016

| Route | Transect | E_Coord | N_Coord | Species | Master_Common_Name | Alive? | AverageCover |
|---|---|---|---|---|---|---|---|
| Connector Trail | 1011 | 316413.297 | 4134072.297 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Connector Trail | 1012 | 316092.776 | 4134364.946 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Connector Trail | 1014 | 315500.226 | 4135129.959 | Bromus tectorum | Cheatgrass | Y | 0.833 |
| Connector Trail | 1015 | 315232.94 | 4135286.012 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Connector Trail | 1017 | 314517.636 | 4134830.799 | Bromus tectorum | Cheatgrass | Y | 1 |
| Connector Trail | 1018 | 314228.241 | 4134537.685 | Bromus tectorum | Cheatgrass | Y | 7 |
| Connector Trail | 1019 | 313791.572 | 4134533.271 | Bromus tectorum | Cheatgrass | Y | 2.167 |
| Connector Trail | 1020 | 313402.34 | 4134774.642 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Connector Trail | 1021 | 312960.563 | 4134708.52 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Hop Valley Trail | 1024 | 312781.978 | 4134893.29 | Bromus tectorum | Cheatgrass | Y | 3.167 |
| Hop Valley Trail | 1025 | 312755.89 | 4135326.126 | Bromus tectorum | Cheatgrass | Y | 1.667 |
| Hop Valley Trail | 1027 | 312612.598 | 4136253.833 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Hop Valley Trail | 1028 | 312479.863 | 4136705.784 | Bromus tectorum | Cheatgrass | Y | 0.833 |
| Hop Valley Trail | 1029 | 312586.575 | 4137034.248 | Bromus tectorum | Cheatgrass | Y | 25 |
| Hop Valley Trail | 1030 | 312515.74 | 4137472.68 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Hop Valley Trail | 1031 | 312207.104 | 4137844.35 | Bromus tectorum | Cheatgrass | Y | 1 |
| Hop Valley Trail | 1033 | 311833.047 | 4138546.404 | Bromus tectorum | Cheatgrass | Y | 1.333 |
| Hop Valley Trail | 1035 | 311481.965 | 4139452.487 | Bromus tectorum | Cheatgrass | Y | 13.333 |
| Hop Valley Trail | 1037 | 311157.785 | 4140351.903 | Bromus tectorum | Cheatgrass | Y | 26.667 |
| Hop Valley Trail | 1038 | 310954.532 | 4140777.696 | Bromus tectorum | Cheatgrass | Y | 6.667 |
| Hop Valley Trail | 1039 | 310792.84 | 4141250.288 | Bromus tectorum | Cheatgrass | Y | 4.667 |
| Hop Valley Trail | 1040 | 310671.01 | 4141690.834 | Bromus tectorum | Cheatgrass | Y | 5 |
| Hop Valley Trail | 1042 | 310116.176 | 4142409.01 | Bromus tectorum | Cheatgrass | Y | 13.333 |
| La Verkin Creek Trail | 1050 | 311236.834 | 4144545.231 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| La Verkin Creek Trail | 1051 | 310892.353 | 4144280.838 | Bromus tectorum | Cheatgrass | Y | 0.667 |
| La Verkin Creek Trail | 1053 | 310669.213 | 4143514.035 | Bromus tectorum | Cheatgrass | Y | 0.833 |
| La Verkin Creek Trail | 1055 | 309877.487 | 4143284.456 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| La Verkin Creek Trail | 1056 | 309429.845 | 4143106.893 | Bromus tectorum | Cheatgrass | Y | 2.667 |
| La Verkin Creek Trail | 1057 | 309048.801 | 4142906.159 | Bromus tectorum | Cheatgrass | Y | 0.667 |
| La Verkin Creek Trail | 1058 | 308610.91 | 4142718.876 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| La Verkin Creek Trail | 1061 | 307314.45 | 4142223.968 | Bromus tectorum | Cheatgrass | Y | 20.333 |

*Appendix B. Exotic Plant Transect Data Detected at Zion NP, 2016, cont.*

| Route | Transect | E_Coord | N_Coord | Species | Master_Common_Name | Alive? | AverageCover |
|---|---|---|---|---|---|---|---|
| La Verkin Creek Trail | 1067 | 305893.802 | 4143272.134 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| La Verkin Creek Trail | 1070 | 305670.153 | 4144620.725 | Bromus tectorum | Cheatgrass | Y | 1.5 |
| La Verkin Creek Trail | 1071 | 305921.717 | 4144976.379 | Bromus tectorum | Cheatgrass | Y | 14.667 |
| La Verkin Creek Trail | 1072 | 306082.104 | 4145430.102 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Middle Taylor Creek Trail | 1085 | 308489.279 | 4147919.423 | Bromus tectorum | Cheatgrass | N | 0.167 |
| Middle Taylor Creek Trail | 1085 | 308489.279 | 4147919.423 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Middle Taylor Creek Trail | 1087 | 307611.079 | 4148153.537 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Northgate Peaks Trail | 1094 | 317765.551 | 4133190.626 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Northgate Peaks Trail | 1096 | 317559.369 | 4134072.402 | Bromus tectorum | Cheatgrass | Y | 0.667 |
| Wildcat Canyon Trail | 1127 | 317028.988 | 4134716.837 | Bromus tectorum | Cheatgrass | Y | 3.833 |
| Wildcat Canyon Trail | 1129 | 316171.049 | 4134569.584 | Bromus tectorum | Cheatgrass | Y | 39 |
| Upper Kolob Terrace Road | 1212 | 312537.508 | 4134588.237 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1213 | 313030.148 | 4134641.087 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1216 | 314329.939 | 4135239.194 | Bromus tectorum | Cheatgrass | Y | 4.667 |
| Upper Kolob Terrace Road | 1217 | 314746.52 | 4135479.631 | Bromus tectorum | Cheatgrass | Y | 1.833 |
| Upper Kolob Terrace Road | 1220 | 315608.764 | 4135460.985 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1221 | 315841.304 | 4135026.747 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1224 | 316063.248 | 4135667.096 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Upper Kolob Terrace Road | 1231 | 312540.353 | 4134599.363 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1232 | 313036.001 | 4134648.06 | Bromus tectorum | Cheatgrass | Y | 3.333 |
| Upper Kolob Terrace Road | 1233 | 313458.395 | 4134899.07 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1236 | 314752.103 | 4135496.077 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| West Rim Trail | 1299 | 323787.45 | 4129100.499 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| West Rim Trail | 1305 | 325310.781 | 4128579.673 | Bromus tectorum | Cheatgrass | Y | 1.667 |
| Lower Kolob Terrace Road | 1413 | 313127.276 | 4126695.622 | Bromus tectorum | Cheatgrass | Y | 4.667 |
| Lower Kolob Terrace Road | 1414 | 313506.159 | 4127001.51 | Bromus tectorum | Cheatgrass | Y | 2 |
| Lower Kolob Terrace Road | 1415 | 313767.042 | 4127306.717 | Bromus tectorum | Cheatgrass | Y | 3.333 |
| Lower Kolob Terrace Road | 1416 | 313719.583 | 4127770.047 | Bromus tectorum | Cheatgrass | Y | 5.667 |
| Lower Kolob Terrace Road | 1419 | 314069.444 | 4128931.193 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Lower Kolob Terrace Road | 1420 | 314251.523 | 4129342.197 | Bromus tectorum | Cheatgrass | Y | 2 |
| Lower Kolob Terrace Road | 1422 | 313753.779 | 4130197.265 | Bromus tectorum | Cheatgrass | Y | 0.167 |
| Lower Kolob Terrace Road | 1423 | 313746.165 | 4130649.638 | Bromus tectorum | Cheatgrass | Y | 6.833 |

*Appendix B. Exotic Plant Transect Data Detected at Zion NP, 2016, cont.*

| Route | Transect | E_Coord | N_Coord | Species | Master_Common_Name | Alive? | AverageCover |
|---|---|---|---|---|---|---|---|
| Lower Kolob Terrace Road | 1424 | 313672.366 | 4131124.784 | Bromus tectorum | Cheatgrass | Y | 1.333 |
| Lower Kolob Terrace Road | 1426 | 313122.585 | 4126678.83 | Bromus tectorum | Cheatgrass | Y | 2.667 |
| Lower Kolob Terrace Road | 1427 | 313502.794 | 4126995.741 | Bromus tectorum | Cheatgrass | Y | 10.167 |
| Lower Kolob Terrace Road | 1428 | 313780.994 | 4127288 | Bromus tectorum | Cheatgrass | Y | 4.333 |
| Lower Kolob Terrace Road | 1429 | 313719.09 | 4127758.433 | Bromus tectorum | Cheatgrass | Y | 2.333 |
| Lower Kolob Terrace Road | 1430 | 313885.128 | 4128061.588 | Bromus tectorum | Cheatgrass | Y | 0.5 |
| Lower Kolob Terrace Road | 1432 | 314075.47 | 4128905.798 | Bromus tectorum | Cheatgrass | N | 0.167 |
| Lower Kolob Terrace Road | 1435 | 313799.503 | 4130132.769 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Lower Kolob Terrace Road | 1436 | 313724.798 | 4130592.532 | Bromus tectorum | Cheatgrass | Y | 1 |
| Lower Kolob Terrace Road | 1437 | 313686.47 | 4131061.834 | Bromus tectorum | Cheatgrass | Y | 2.333 |
| Lower Kolob Terrace Road | 1438 | 313456.576 | 4131486.238 | Bromus tectorum | Cheatgrass | Y | 0.333 |
| Smith Mesa | 1440 | 313442.347 | 4128712.474 | Bromus tectorum | Cheatgrass | Y | 1.167 |
| Smith Mesa | 1441 | 313604.713 | 4128265.408 | Bromus tectorum | Cheatgrass | Y | 0.5 |
| Smith Mesa | 1444 | 313612.205 | 4128270.923 | Bromus tectorum | Cheatgrass | Y | 1 |
| Wildcat Canyon Trail | 1128 | 316605.402 | 4134753.379 | Poa bulbosa | Bulbous bluegrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1217 | 314746.52 | 4135479.631 | Poa bulbosa | Bulbous bluegrass | Y | 0.167 |
| Upper Kolob Terrace Road | 1243 | 316072.76 | 4135709.678 | Poa bulbosa | Bulbous bluegrass | Y | 2.667 |
| Upper Kolob Terrace Road | 1236 | 314752.103 | 4135496.077 | Salsola sp. | Russian thistle | Y | 0.167 |
| Lower Kolob Terrace Road | 1415 | 313767.042 | 4127306.717 | Salsola sp. | Russian thistle | Y | 0.5 |
| Lower Kolob Terrace Road | 1425 | 313404.293 | 4131537.53 | Salsola sp. | Russian thistle | Y | 0.5 |
| Lower Kolob Terrace Road | 1429 | 313719.09 | 4127758.433 | Salsola sp. | Russian thistle | Y | 0.333 |
| Lower Kolob Terrace Road | 1437 | 313686.47 | 4131061.834 | Salsola sp. | Russian thistle | Y | 0.167 |
| Lower Kolob Terrace Road | 1438 | 313456.576 | 4131486.238 | Salsola sp. | Russian thistle | Y | 0.333 |
| Smith Mesa | 1441 | 313604.713 | 4128265.408 | Salsola sp. | Russian thistle | Y | 4 |

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NPS 116/140099, September 2017

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