National Park Service
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Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring in Zion National Park

2018 Field Season

Natural Resource Report NPS/NCPN/NRR—2019/1948



ON THE COVER

Zion Canyon from Emerald Pools in Zion National Park. NPS/Amy Washuta

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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 staff conducted surveys at Zion National Park (NP) from May 30 to June 4, 2018, representing the first component of the third monitoring rotation. Of 382 total IEP patches recorded, 288 patches of seven priority IEP species were detected along 110.4 kilometers (68.6 mi) of monitoring routes at Zion NP. The majority of patches (52.8%) were 40 m^2 or smaller, with cover low enough to make management feasible. Little bur-clover (*Medicago minima*) was the most prevalent IEP priority species, with bulbous bluegrass (*Poa bulbosa*), Bermudagrass (*Cynodon dactylon*), and Siberian elm (*Ulmus pumila*) also common. These four species represented 94.8% of all patches recorded in 2018. On average, roads had more IEP priority patches per kilometer than trails. The roads with highest density of patches were Watchman Campground and Visitor Center (7.09 patches/km) and Oak Creek and Administrative Area (6.78 patches/km). Patches of priority IEPs were detected along all monitored roads. The trails with the highest patch density were the Pa'rus Trail (9.55 patches/km) and Grotto Trail (5.84 patches/km). No priority species were detected along 10 of the trails monitored. IEPs were found on 144 (73.8%) of 195 transects monitored. Almost all of these detections were cheatgrass (*Bromus tectorum*). Cheatgrass was widespread—present in 71.3% of transects, with an estimated cover of 1.09% across all transects sampled. Across routes monitored in all three rotations (2012–2013, 2015–2016, and 2018), cheatgrass has increased in frequency (including along the East Rim Trail and Zion Scenic Drive, where it was not detected in transects in 2012–2013), though percent cover remained low. Scotch thistle and Johnsongrass have declined. Both bulbous bluegrass and Siberian elm have increased in prevalence since 2015–2016 but remained lower than in 2012–2013. Little bur-clover increased dramatically across the same monitoring routes from 2015–2016 (21 patches) to 2018 (174 patches). NCPN will return to Zion NP in 2020 to complete the third rotation of invasive plant monitoring.

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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 2018 field season and the first component of the third 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 the start of monitoring, 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 2015, little bur-clover (*Medicago minima*) was added to the list. The list did not change from 2015–2016 to 2018.

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 little bur-clover, are very difficult to detect in most field

Table 2-1. Priority invasive exotic plant list, Zion NP, 2018.

Scientific name	Common name
Alhagi maurorum	camelthorn
Bassia scoparia[1]	summer cypress
Brassica tournefortii	Sahara mustard
Cardaria sp.	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 priority list in 2015.

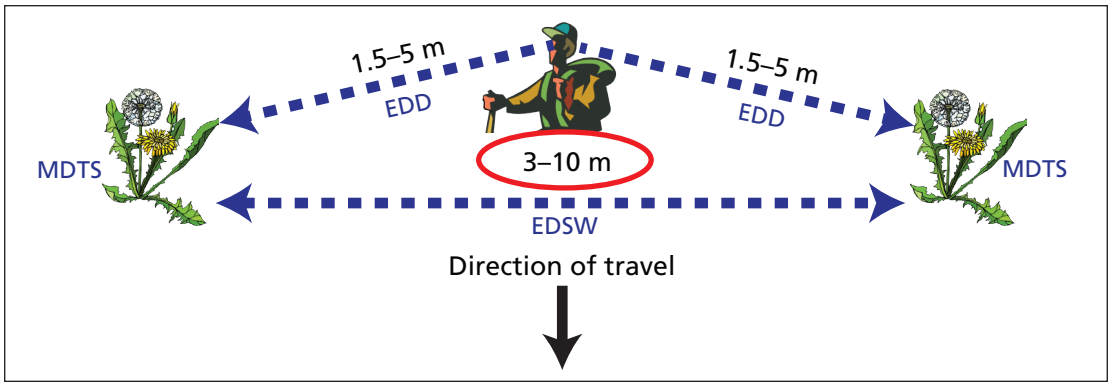


Figure 2-1. The maximum effective detection distance (EDD) at Zion National Park was 1.5–5 meters, making the effective detection swath width (EDSW) 3–10 meters.

conditions unless the observer is very close to the patch.

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 2018 was 1.5–5 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 the search route. The EDSW was 3–10 meters at Zion NP in 2018.

2.2.4 Patch separation resolution

We define patch separation resolution (PSR) 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. 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 10 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. 1–3 plants (used for isolated single plants or very small patches (≤2 × 2 m),
2. 4 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 of 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.

We developed a patch management index (PMI) to quantify both the extent and the density of a patch into a single value that helps identify the scale of the problem. Park managers can use this tool to help prioritize IEP treatment. PMI was determined using the following formula:

Patch size class (1–5) × Patch percent cover (1–5) = Patch management index (1–25)

We then grouped PMI into five classes:

1. Very low (1–5)
2. Low (6–10)
3. Moderate (11–-15)
4. High (16–20)
5. Very high (21–25)

Patches identified as very low or low PMI will generally be easier to control or remove than patches with high or very high PMI. In many cases, directing resources toward controlling patches with very low or low PMI can be a highly effective management strategy; the goal of early detection is to allow managers to eliminate patches before they can grow into bigger problems. Other times, a species with many patches that are mostly very low or low in PMI may or may not be easier to treat (and possibly eradicate) than a different species with just a few patches that are high or very high in PMI. Therefore, park managers should consider PMI within the context of information on species and patch numbers.

3 Results

3.1 Target invasive exotic plant list

There were 30 IEP species on the Zion NP priority list for 2018 (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, cheatgrass and Russian thistle were recorded consistently in transects.

We recorded a total of seven priority IEP species in 288 total patches on monitoring routes and three priority IEP species in transects in 2018 (Table 3-1). Ten non-priority IEPs were recorded in 94 patches on monitoring routes, and cheatgrass and Russian thistle were detected on transects. We covered 110.4 kilometers (68.6 miles) of monitoring routes and completed 195 transects in 2018.

3.2 Monitoring routes

Of 382 total IEP patches recorded, 288 patches of seven priority IEP species were detected along Zion NP monitoring routes in 2018, during the first component of the third monitoring rotation (see Table 3-1; Figures 3-1 to 3-6; Appendix A). The majority of patches (52.8%) were 40 m^2 or smaller, and 75.3% ranked very low on the patch management index.

The most common priority invasive species, by far, was little bur-clover, with a total of 174 patches (60.4% of all patches) recorded (Table 3-2). All little bur-clover patches were very low or low in PMI. The next-most common priority species were bulbous bluegrass (*Poa bulbosa*), Bermudagrass (*Cynodon dactylon*), and Siberian elm (*Ulmus pumila*). Together, these four species represented 94.8% of all patches recorded in 2018. Siberian elm was the only tree species detected. Of the 39 patches recorded, 18 (46.2%) were seedlings,

Table 3-1. Invasive exotic plants recorded at Zion NP, May 30–June 4, 2018.[1]

Scientific name	Common name	Method detected		Priority?
		Route	Transect	
Bassia scoparia	summer cypress	✓	✓	Yes
Cynodon dactylon	Bermudagrass	✓	–	Yes
Medicago minima	little bur-clover	✓	✓	Yes
Onopordum acanthium	Scotch thistle	✓	–	Yes
Poa bulbosa	bulbous bluegrass	✓	✓	Yes
Sorghum halepense	Johnsongrass	✓	–	Yes
Ulmus pumila	Siberian elm	✓	–	Yes
Bromus tectorum	cheatgrass	–	✓	Transect only[2]
Salsola sp.	Russian thistle	–	✓	Transect only[2]
Avena fatua	wild oat	✓	–	No
Cirsium vulgare	bull thistle	✓	–	No
Convolvulus arvensis	field bindweed	✓	–	No
Eleaegnus angustifolia	Russian olive	✓	–	No
Lathyrus latifolius	perennial sweetpea	✓	–	No
Marrubium vulgare	common horehound	✓	–	No
Rubia tinctorum	madder	✓	–	No
Tamarix sp.	tamarisk	✓	–	No
Tribulus terrestris	puncture vine	✓	–	No
Verbascum thapsus	woolly mullein	✓	–	No

[1]Additional non-priority species were observed but not recorded (see Table 4-1).

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

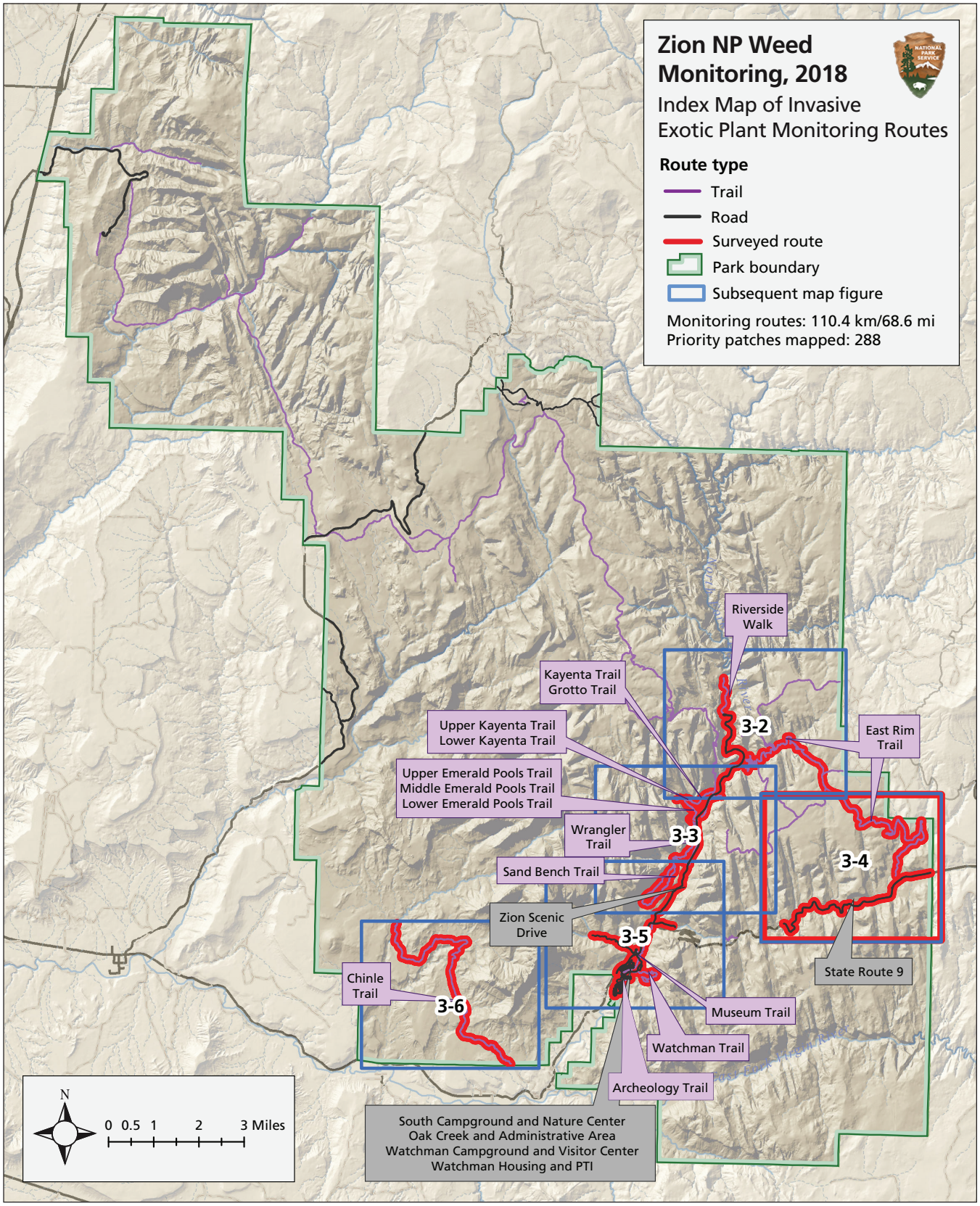


Figure 3-1. Index map of invasive plant monitoring routes by figure number, Zion National Park, May 30–June 4, 2018.

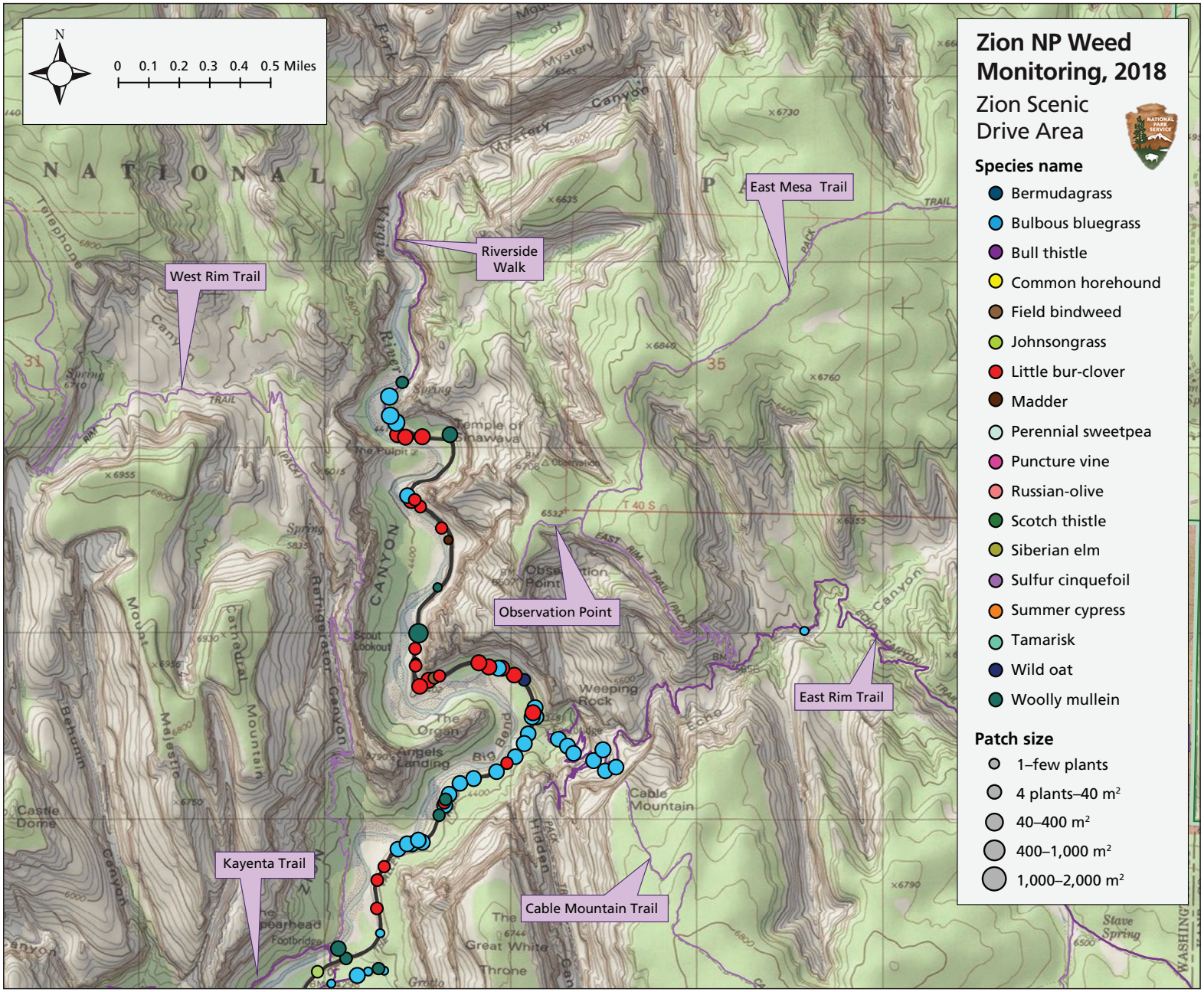


Figure 3-2. Invasive plants detected along the northern portion of the main canyon, Zion National Park, May 30–June 4, 2018.

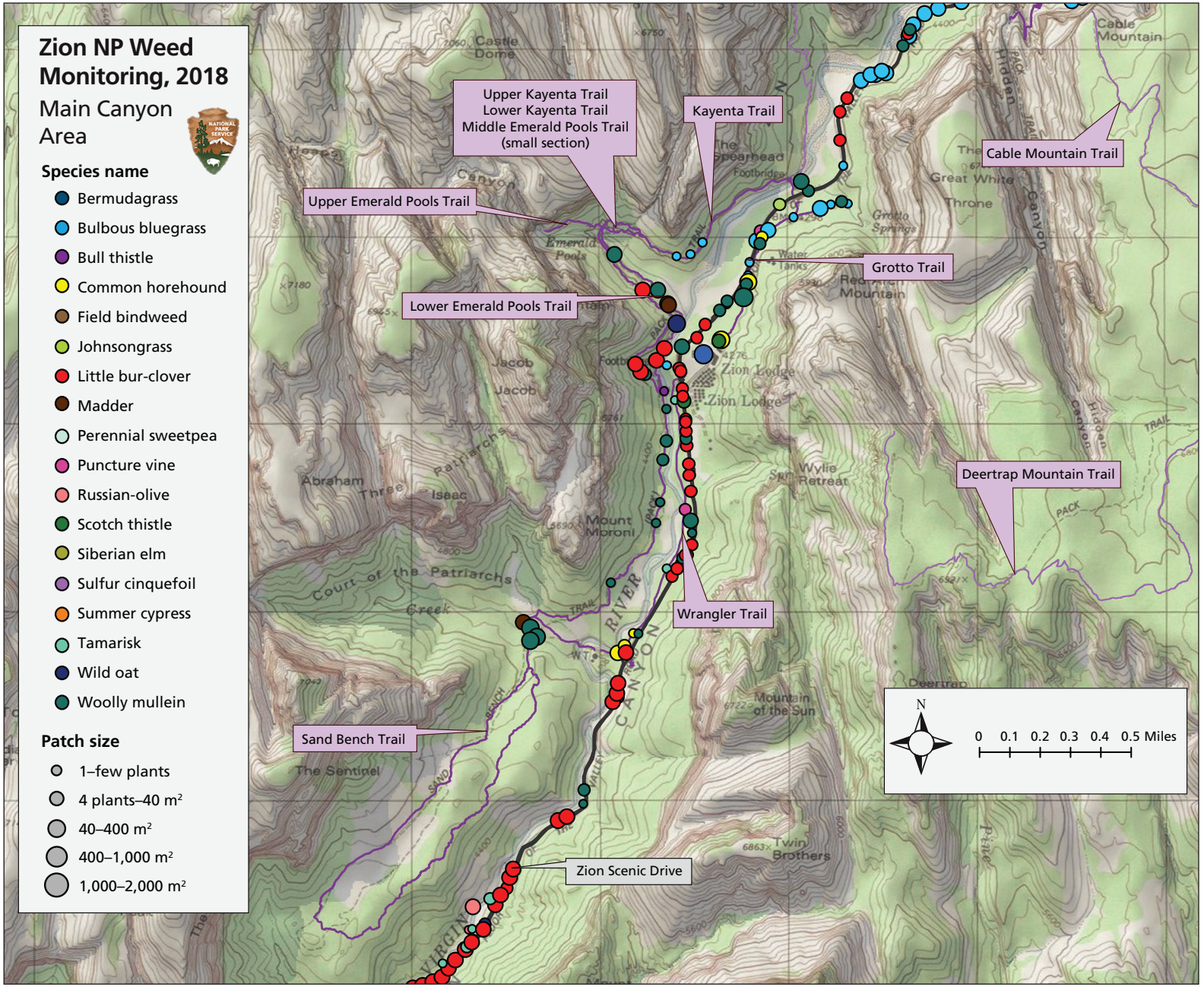


Figure 3-3. Invasive plants detected in the central portion of the main canyon, Zion National Park, May 30–June 4, 2018.

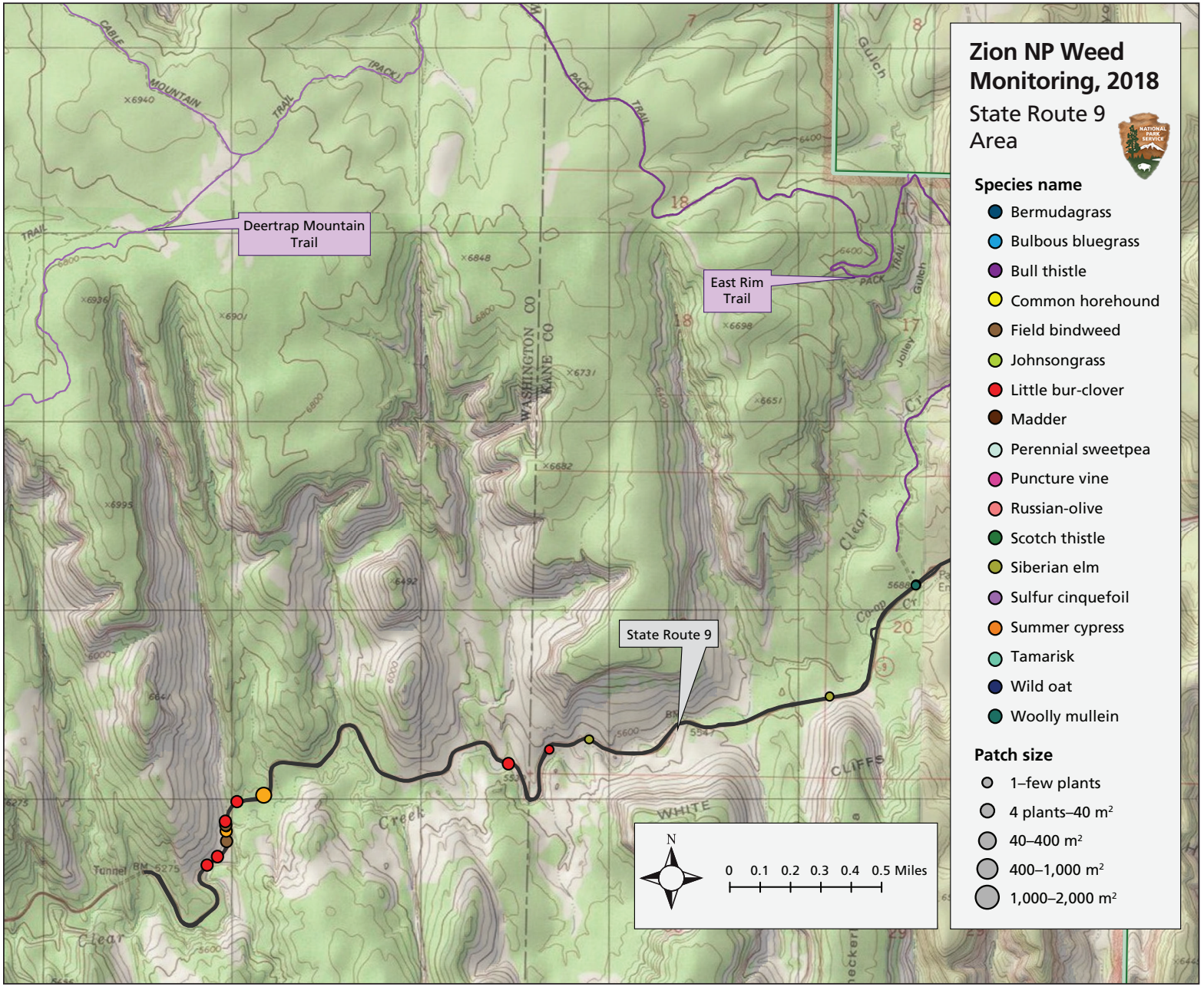


Figure 3-4. Invasive plants detected along the eastern portion of State Route 9, Zion National Park, May 30–June 4, 2018.

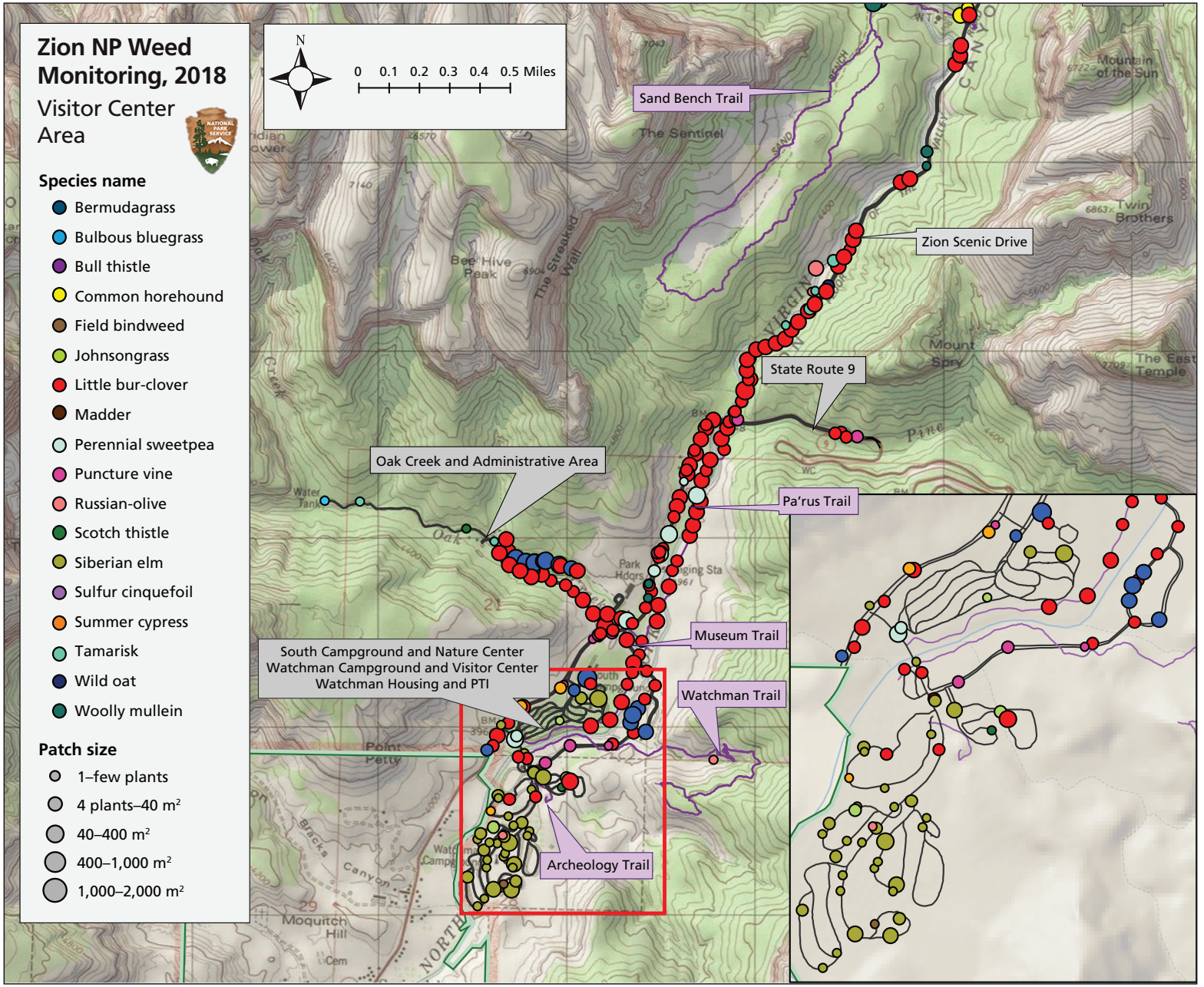


Figure 3-5. Invasive plants detected in the southern portion of the main canyon, Zion National Park, May 30–June 4, 2018.

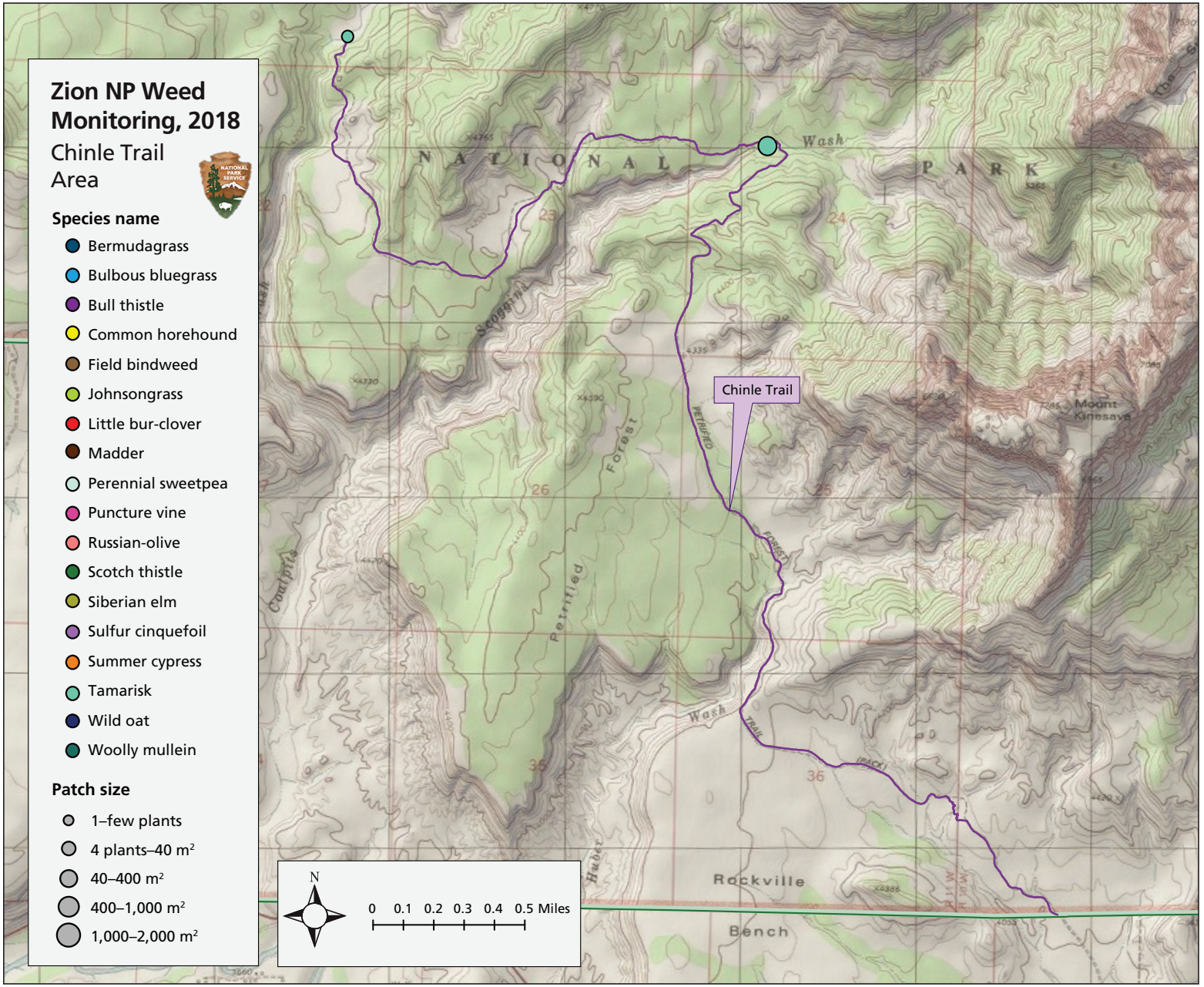


Figure 3-6. Invasive plants detected along the Chinle Trail, Zion National Park, May 30–June 4, 2018.

Table 3-2. Number of patches recorded along monitoring routes by species, patch size class, and patch management index, Zion NP, May 30–June 4, 2018.

Scientific name	Common name	Total patches (priority)	Patch size class[1]					Patch management index[2]				
			1	2	3	4	5	Very low	Low	Medium	High	Very high
Bassia scoparia	summer cypress	6 (6)	1	4	1	0	0	5	1	0	0	0
Cynodon dactylon	Bermudagrass	14 (14)	0	2	4	6	2	1	8	5	0	0
Medicago minima	little bur-clover	174 (174)	3	86	82	2	1	141	33	0	0	0
Onopordum acanthium	Scotch thistle	5 (5)	3	2	0	0	0	3	2	0	0	0
Poa bulbosa	bulbous bluegrass	46 (46)	0	14	29	3	0	33	13	0	0	0
Sorghum halepense	Johnsongrass	4 (4)	1	3	0	0	0	1	3	0	0	0
Ulmus pumila	Siberian elm	39 (39)	24	9	4	2	0	33	5	0	1	0
Avena fatua	wild oat	4 (0)	0	3	0	1	0	3	0	1	0	0
Cirsium vulgare	bull thistle	2 (0)	2	0	0	0	0	2	0	0	0	0
Convolvulus arvensis	field bindweed	4 (0)	1	3	0	0	0	4	0	0	0	0
Elaeagnus angustifolia	Russian olive	4 (0)	3	0	1	0	0	3	0	1	0	0
Lathyrus latifolius	perennial sweetpea	9 (0)	1	3	5	0	0	3	6	0	0	0
Marrubium vulgare	common horehound	6 (0)	1	2	1	2	0	4	1	1	0	0
Rubia tinctoria	madder	5 (0)	2	1	2	0	0	2	1	2	0	0
Tamarix sp.	tamarisk	10 (0)	6	3	0	0	1	7	3	0	0	0
Tribulus terrestris	puncture vine	13 (0)	4	9	0	0	0	12	1	0	0	0
Verbascum thapsus	woolly mullein	37 (0)	11	15	6	3	2	23	14	0	0	0
Total IEP patches (priority)		382 (288)	32	120	120	13	3	217	65	5	1	0

[1]Patch size classes: 1 = 1–a few plants (≤2 × 2 m), 2 = 4 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).

[2]Patch management index: Patch size class × Patch density (1–5) = Very low (1–5), Low (6–10), Moderate (11–15), High (16–20), Very High (21–25).

10 (25.6%) were saplings, and 11 (28.2%) were mature trees (see Appendix A).

On average, roads had more priority IEP patches per kilometer than trails (Table 3-3). priority IEP patches were detected along all monitored roads. The roads with the highest patch density of patches were Watchman Campground and Visitor Center (7.09 patches/km) and Oak Creek and Administrative Area (6.78 patches/km). The trails with the highest patch density were the Pa'rus Trail (9.55 patches/km) and the Grotto Trail (5.84 patches/km). There were no priority IEP species detected along 10 of the trails monitored.

3.3 Monitoring transects

A total of 195 transects were sampled in 2018 (Table 3-4; see Figures 3-7 to 3-10; Appendix B). IEPs were found on 144 transects (73.8%). Five IEP species were detected: cheatgrass, Russian thistle, little bur-clover, bulbous bluegrass, and summer cypress (*Bassia scoparia*, found on only one transect).

Cheatgrass was by far the most widespread IEP species, present in 71.3% of transects sampled in 2018 (Table 3-4). Cheatgrass also had the highest percent cover of any IEP species, averaging 1.09% across all transects in

Table 3-3. Number of IEP patches by route and route type, Zion NP, May 30–June 4, 2018.

Route	Route type	Length (m)	Total patches (priority)	Priority IEP patches/km
Oak Creek and Administrative Area	Road	4,423	32 (30)	6.78
South Campground and Nature Center	Road	3,606	7 (6)	1.66
State Route 9	Road	21,199	63 (46)	2.17
Watchman Campground and Visitor Center	Road	5,081	39 (36)	7.09
Watchman Housing and PTI	Road	4,133	19 (16)	3.87
Zion Scenic Drive	Road	20,513	131 (99)	4.83
All Roads		*58,956*	*291* (*233*)	*3.95*
Archeology Trail	Trail	221	0 (0)	0.00
Chinle Trail	Trail	11,204	2 (0)	0.00
Court of the Patriarchs Overview Trail	Trail	91	0 (0)	0.00
East Rim Trail	Trail	16,874	8 (8)	0.47
Grotto Trail	Trail	1,370	15 (8)	5.84
Hidden Canyon Trail	Trail	707	0 (0)	0.00
Kayenta Trail	Trail	1,084	3 (3)	2.77
Lower Emerald Pools Trail	Trail	1,109	8 (4)	3.61
Lower Kayenta Trail	Trail	206	0 (0)	0.00
Middle Emerald Pools Trail	Trail	1,622	5 (3)	1.85
Museum Trail	Trail	259	2 (1)	3.87
Pa'rus Trail	Trail	2,513	25 (24)	9.55
Riverside Walk	Trail	1,559	4 (3)	1.92
Sand Bench Trail	Trail	7,020	11 (0)	0.00
Upper Emerald Pools Trail	Trail	355	0 (0)	0.00
Upper Kayenta Trail	Trail	178	0 (0)	0.00
Watchman Trail	Trail	2,940	2 (1)	0.34
Weeping Rock	Trail	298	0 (0)	0.00
Wrangler Trail	Trail	1,865	6 (0)	0.00
All Trails		*51,473*	*91* (55)	*1.07*
Total		110,429	382 (288)	avg 2.61

Table 3-4. Number of transects in which the four most common priority IEP species were detected/total transects monitored, mean percent cover, and standard error along common monitoring routes at Zion NP, 2012–2013, 2015–2016 and 2018.

Route	Year	Cheatgrass		Little bur-clover[1]		Bulbous bluegrass		Russian thistle	
		Detected/ Total	Percent cover (SE)	Detected/ Total	Percent cover (SE)	Detected/ Total	Percent cover (SE)	Detected/ Total	Percent cover (SE)
Main Canyon routes	2012–2013	28/50	2.54 (0.89)	–	–	1/50	0.003 (0.003)	1/50	0.003 (0.003)
	2015–2016	34/60	0.99 (0.31)	0/60	0	1/60	0.01 (0.01)	3/60	0.59 (0.56)
	2018	43/58	1.61 (0.41)	5/58	0.08 (0.05)	1/58	0.01 (0.01)	4/58	0.01 (0.01)
State Route 9	2012–2013	33/39	1.96 (0.40)	–	–	0/39	0	0/39	0
	2015–2016	38/44	1.09 (0.23)	0/44	0	0/44	0	7/44	0.10 (0.07)
	2018	36/42	1.92 (0.63)	0/0	0	1/42	0.004 (0.004)	4/42	1.96 (0.62)
Zion Scenic Drive	2012–2013	0/32	0	–	–	7/32	0.10 (0.04)	0/32	0
	2015–2016	30/42	2.07 (0.90)	3/42	0.04 (0.02)	0/42	0	1/42	0.01 (0.01)
	2018	32/40	0.63 (0.13)	7/40	0.09 (0.03)	4/40	0.03 (0.02)	1/40	0.01 (0.01)
Chinle Trail[3]	2012–2013	6/11	0.12 (0.04)	–	–	0/11	0	0/11	0
	2015–2016	11/19	0.15 (0.04)	0/19	0	0/19	0	0/19	0
	2018	12/22	0.41 (0.17)	0/22	0	0/22	0	0/22	0
East Rim Trail	2012–2013	0/21	0	–	–	0/21	0	0/21	0
	2015–2016	12/34	0.26 (0.10)	0/34	0	0/34	0	0/34	0
	2018	16/33	0.13 (0.03)	0/33	0	1/33	0.01 (0.01)	0/33	0
All Routes	2012–2013	67/153	1.34 (0.32)	–	–	8/153	0.02 (0.01)	1/153	0.001 (0.001)
	2015–2016	126/199	1.04 (0.22)	4/199	0.01 (0.005)	2/199	0.002 (0.002)	12/199	1.25 (0.28)
	2018	139/195	1.09 (0.19)	12/195	0.04 (0.02)	7/195	0.01 (0.004)	9/195	0.01 (0.003)

[1]Added to the priority IEP list in 2015.

[2]Archeology, Grotto, Hidden Canyon, Kayenta, Court of the Patriarchs Overview, Lower Emerald Pools, Lower Kayenta, Middle Emerald Pools, Museum, Oak Creek and Administrative, Pa'rus, Riverside Walk, Sand Bench, South Campground and Nature Center, Upper Emerald Pools, Upper Kayenta, Watchman Campground and VC, Watchman Housing and PTI, Watchman, Weeping Rock and Wrangler routes.

[3]In each monitoring rotation, crews were able to monitor further down the Chinle Trail than in the previous rotation. The entire Chinle Trail was monitored in 2018.

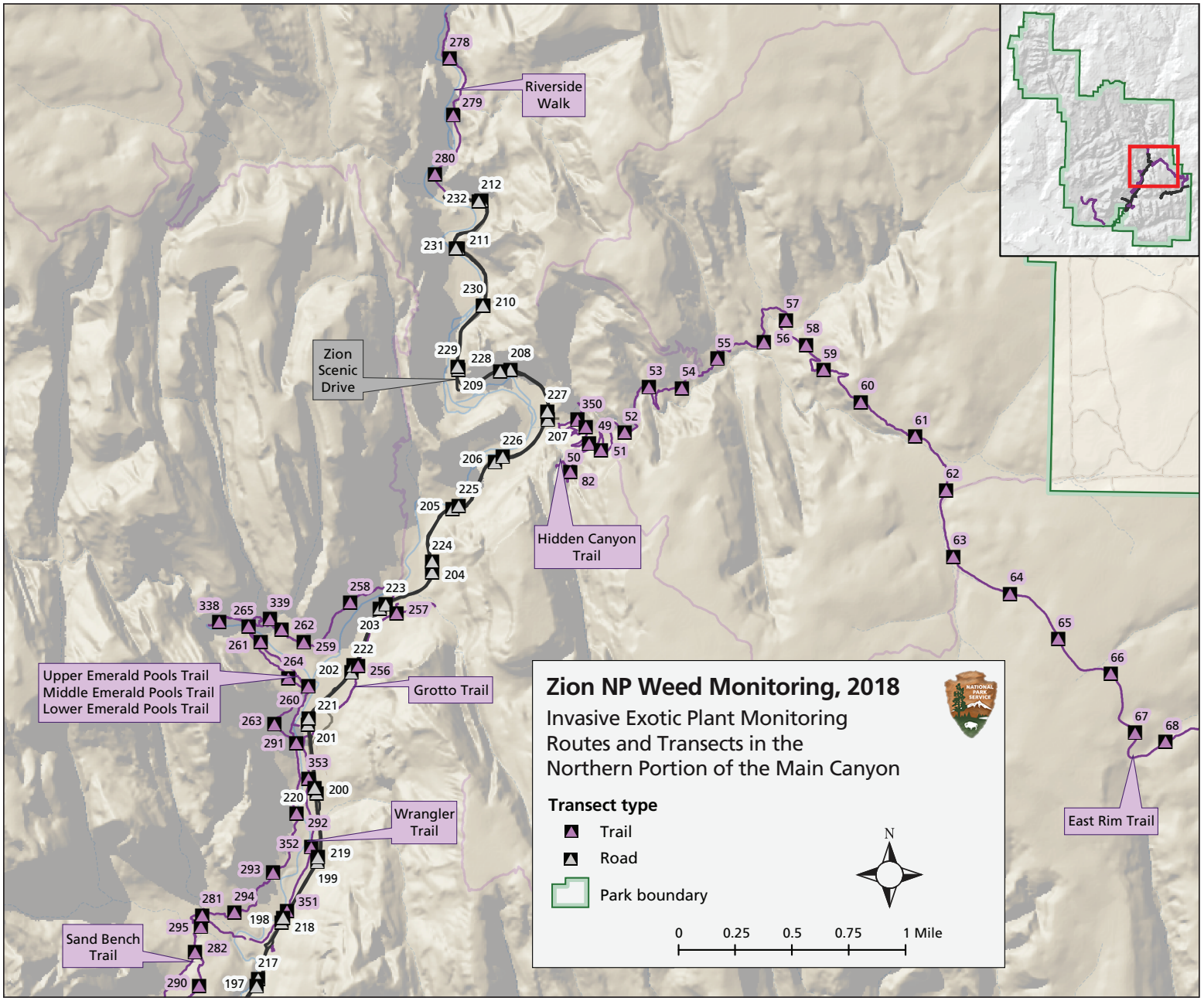


Figure 3-7. Transect locations in the northern portion of the main canyon, Zion National Park, May 30–June 4, 2018.

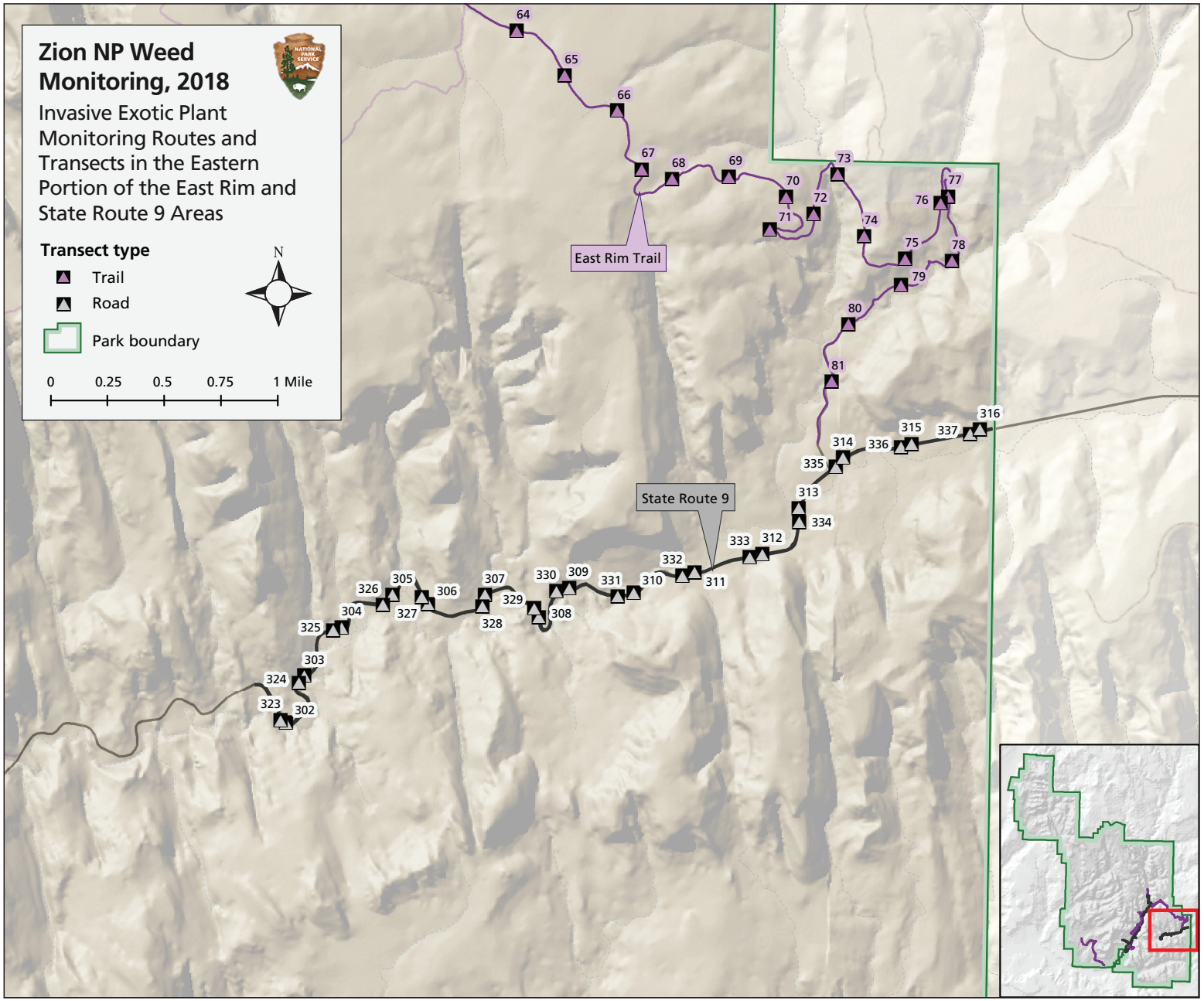


Figure 3-8. Transect locations along eastern portion of the East Rim and State Route 9, Zion National Park, May 30–June 4, 2018.

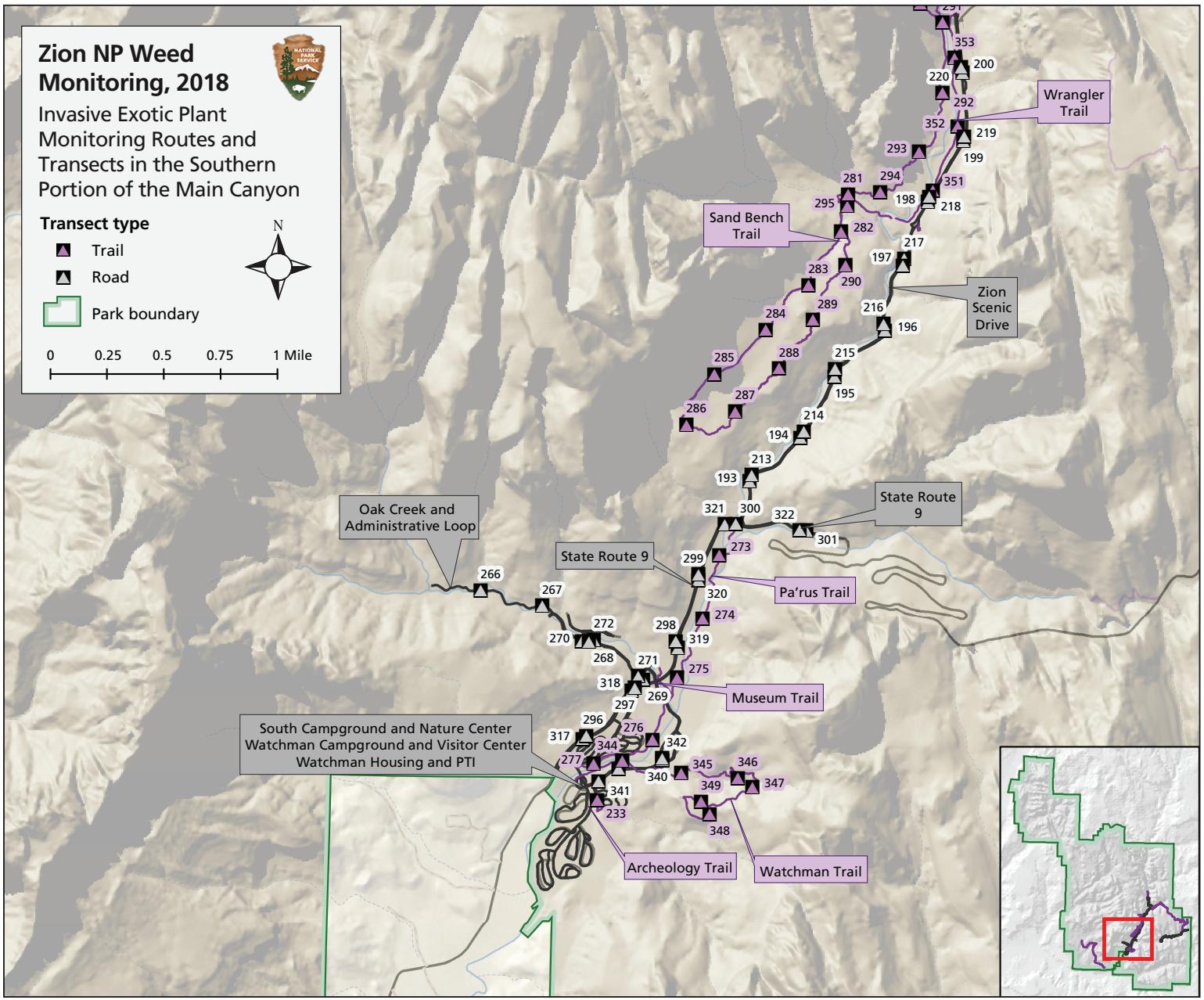


Figure 3-9. Transect locations along the southern portion of the main canyon, Zion National Park, May 30–June 4, 2018.

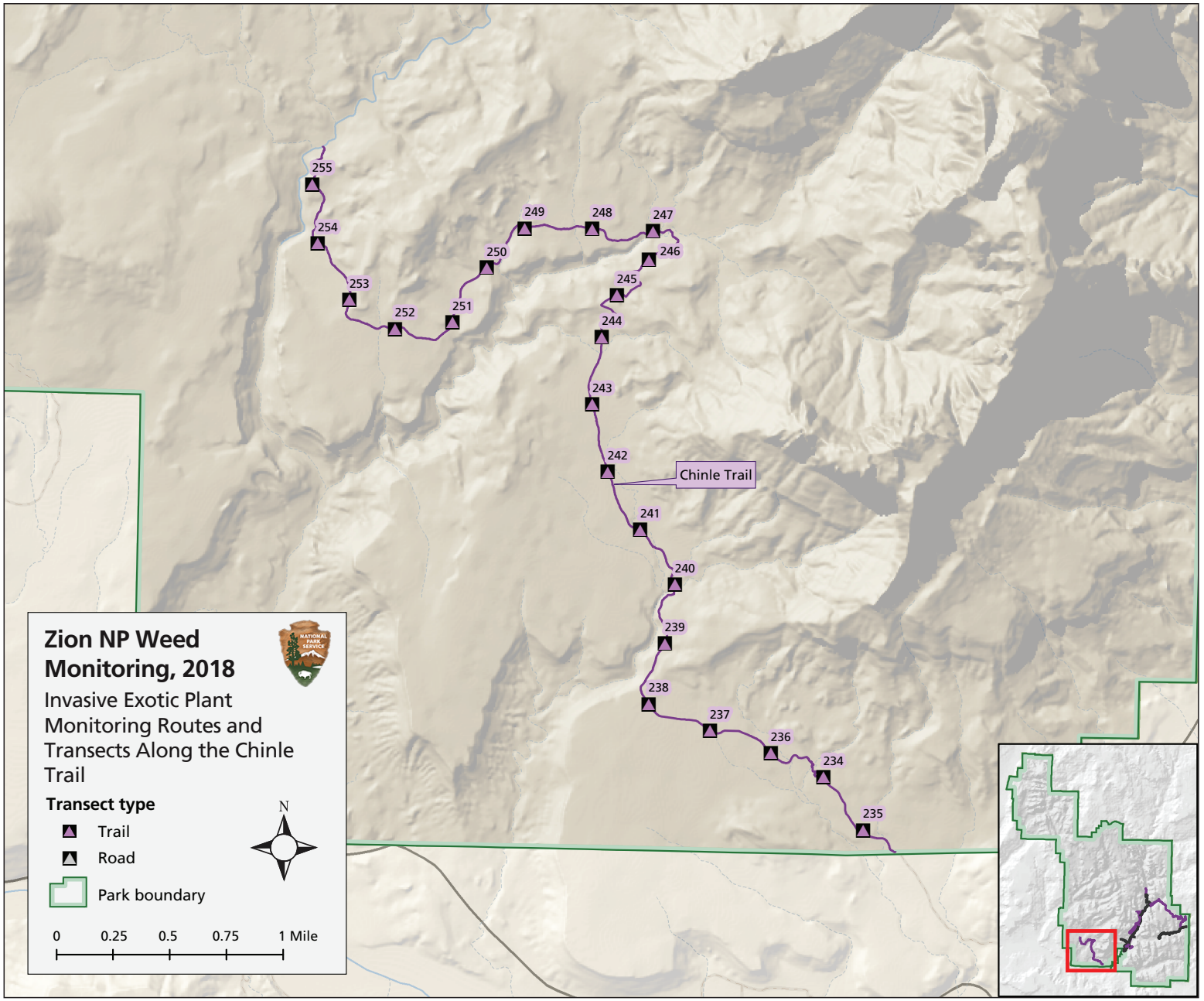


Figure 3-10. Transect locations along the Chinle Trail, Zion National Park, May 30–June 4, 2018.

2018. Little bur-clover, Russian thistle, bulbous bluegrass, and summer cypress all had <0.1 mean percent cover. Little bur-clover, Russian thistle, bulbous bluegrass, and summer cypress were present in 6.2%, 4.6%, 3.6%, and 0.5% of plots, respectively.

3.4 Results comparison: 2012–2013 to 2018

Two rotations of monitoring routes were completed in 2012–2013 and 2015–2016 (Perkins 2013; Perkins 2014; Karinen and Perkins 2016). In 2018, NCPN staff began the third monitoring rotation. Each monitoring rotation includes the same routes and uses the same methods. This report compares results from routes completed in all three rotations to date, only comparing priority IEP species common to all monitoring years. Little bur-clover is excluded because it was added to the priority IEP list in 2015.

Overall patches per kilometer along all routes compared was highest in 2012–2013 (1.77 patches/km) and lowest in 2015–2016 (0.63 patches/km), with 2018 (1.03 patches/km) falling in between (Table 3-5). The Oak Creek and Administrative Area has seen an increase in IEP patches/kilometer across all sampling years. Along the Zion Scenic Drive, patch density was still lower than in 2012–2013 but was higher than in 2015–2016 due to an increase in bulbous bluegrass. The Grotto Trail had higher patch density in 2018 than in previous years, also due to increases in bulbous bluegrass. The Watchman Campground and Visitor Center area had much lower patch density than in 2012–2013, but a slightly higher patch density than in 2015–2016, due to increases in Siberian elm. Patch densities for the Watchman Housing and PTI and South Campground and Nature Center routes have declined each monitoring year. The only priority IEP found along the Watchman Trail in 2018 was a single patch of little bur-clover.

We examined individual priority IEP species over time in the same routes.

- Bermudagrass was found in similar levels to the previous two monitoring periods of 2012–2013 and 2015–2016.
- Bulbous bluegrass was found in similar prevalence in 2018 to 2012–2013, but was much less prevalent in 2015–2016 (Table 3-6, Figure 3-11).
- Johnsongrass (*Sorghum halepense*) has declined in each monitored rotation, from 31 (2012–2013) to 15 (2015–2016) to 4 total patches in 2018.
- Little bur-clover increased from 21 total patches to 174 patches along the same monitoring routes from 2015–2016 to 2018. All patches of this plant were very low or low on the patch management index.
- Scotch thistle (*Onopordum acanthium*) declined to only 5 total patches (each Very low or Low on PMI) in 2018, from 15 in 2015–2016.
- Siberian elm was more prevalent in 2018 than in 2015–2016, but less prevalent than in 2012–2013.

In transects, cheatgrass was by far the most widespread species across all sampling periods (see Table 3-4). Across the same routes, the percent of transects in which cheatgrass was detected increased from 43.8% in 2012–2013 to 71.3% in 2018. Over the same time period, the percent cover of cheatgrass has not changed substantially (1.34% in 2012–2013, 1.09% in 2018). Notably, cheatgrass appears to have become widespread on the Zion Scenic Drive and East Rim Trail in recent sampling years, after not being detected on these routes in 2012–2013. Little bur-clover was not detected in transects along main canyon routes in 2015–2016, but was present in 8.6% of transects in 2018 (see Table 3-4). Little bur-clover also increased in presence along the Zion Scenic Drive, from in 7.1% of transects in 2015–2016 to 17.5% of transects in 2018. Bulbous bluegrass occurred in a similar amount in 2018 as in 2012–2013, though this species was less prevalent in 2015–2016. Russian thistle was present in 0.7% of transects in 2012–2013, 6.0% of transects in 2015–2016, and in 4.6% of transects in 2018.

Table 3-5. Patches per kilometer on routes surveyed for the same priority IEP species in Zion NP, 2012–2013, 2015–2016, and 2018.

Route	Route type	Patches/km		
		2012–2013	2015–2016	2018
Oak Creek and Administrative Area	Road	0.24	1.35	1.81
South Campground and Nature Center	Road	3.05	1.94	1.39
State Route 9	Road	0.28	0.14	0.52
Watchman Campground and Visitor Center	Road	16.46	4.55	6.30
Watchman Housing and PTI	Road	3.43	2.18	1.69
Zion Scenic Drive	Road	2.19	0.44	1.32
Archeology Trail	Trail	0.00	0.00	0.00
Chinle Trail	Trail	0.00	0.00	0.00
Court of the Patriarchs Overview Trail	Trail	0.00	0.00	0.00
East Rim Trail	Trail	0.77	0.30	0.47
Grotto Trail	Trail	4.86	0.73	5.84
Hidden Canyon Trail	Trail	1.11	0.00	0.00
Kayenta Trail	Trail	0.00	0.00	2.77
Lower Emerald Pools Trail	Trail	0.00	1.80	1.80
Lower Kayenta Trail	Trail	0.00	0.00	0.00
Middle Emerald Pools Trail	Trail	0.00	0.00	0.00
Museum Trail	Trail	0.00	0.00	0.00
Pa'rus Trail	Trail	0.00	1.59	0.00
Riverside Walk	Trail	1.28	0.00	1.92
Sand Bench Trail	Trail	0.14	0.00	0.00
Upper Emerald Pools Trail	Trail	0.00	0.00	0.00
Upper Kayenta Trail	Trail	0.00	0.00	0.00
Watchman Trail	Trail	0.67	0.34	0.00
Weeping Rock	Trail	13.43	0.00	0.00
Wrangler Trail	Trail	0.00	0.00	0.00
Averages		1.77	0.63	1.03

Table 3-6. Number of priority IEP patches by species, patch size class, and patch management index detected along the same monitoring routes monitored in Zion NP, 2012–2013, 2015–2016, and 2018.

Scientific name	Common name	Year	Total patches	Patch size class					Patch management index				
				1	2	3	4	5	Very low	Low	Medium	High	Very high
Bassia scoparia	summer cypress	2012–2013	2	0	1	1	0	0	1	1	0	0	0
		2015–2016	1	0	1	0	0	0	1	0	0	0	0
		2018	6	1	4	1	0	0	5	1	0	0	0
Cynodon dactylon	Bermudagrass	2012–2013	12	3	3	3	1	2	6	5	1	0	0
		2015–2016	19	4	7	2	1	5	8	10	1	0	0
		2018	14	0	2	4	6	2	1	8	5	0	0
Medicago minima	little bur-clover	2012–2013	-	-	-	-	-	-	-	-	-	-	-
		2015–2016	21	4	12	4	1	0	13	8	0	0	0
		2018	174	3	86	82	2	1	141	33	0	0	0
Onopordum acanthium	Scotch thistle	2012–2013	11	7	3	0	1	0	9	1	1	0	0
		2015–2016	15	6	6	2	1	0	13	2	0	0	0
		2018	5	3	2	0	0	0	3	2	0	0	0
Poa bulbosa	bulbous bluegrass	2012–2013	67	13	29	22	3	0	33	33	1	0	0
		2015–2016	8	3	1	4	0	0	6	2	0	0	0
		2018	46	0	14	29	3	0	33	13	0	0	0
Sorghum halepense	Johnsongrass	2012–2013	31	14	16	1	0	0	18	13	0	0	0
		2015–2016	15	5	6	4	0	0	8	7	0	0	0
		2018	4	1	3	0	0	0	1	3	0	0	0
Ulmus pumila	Siberian elm	2012–2013	64	18	25	17	4	0	25	35	4	0	0
		2015–2016	11	4	2	1	3	1	6	3	2	0	0
		2018	39	24	9	4	2	0	33	5	0	1	0
Total IEP patches		2012–2013	187	55	77	44	9	2	92	88	7	0	0
		2015–2016	69	22	23	13	5	6	42	24	3	0	0
		2018	114	29	34	38	11	2	76	32	5	1	0

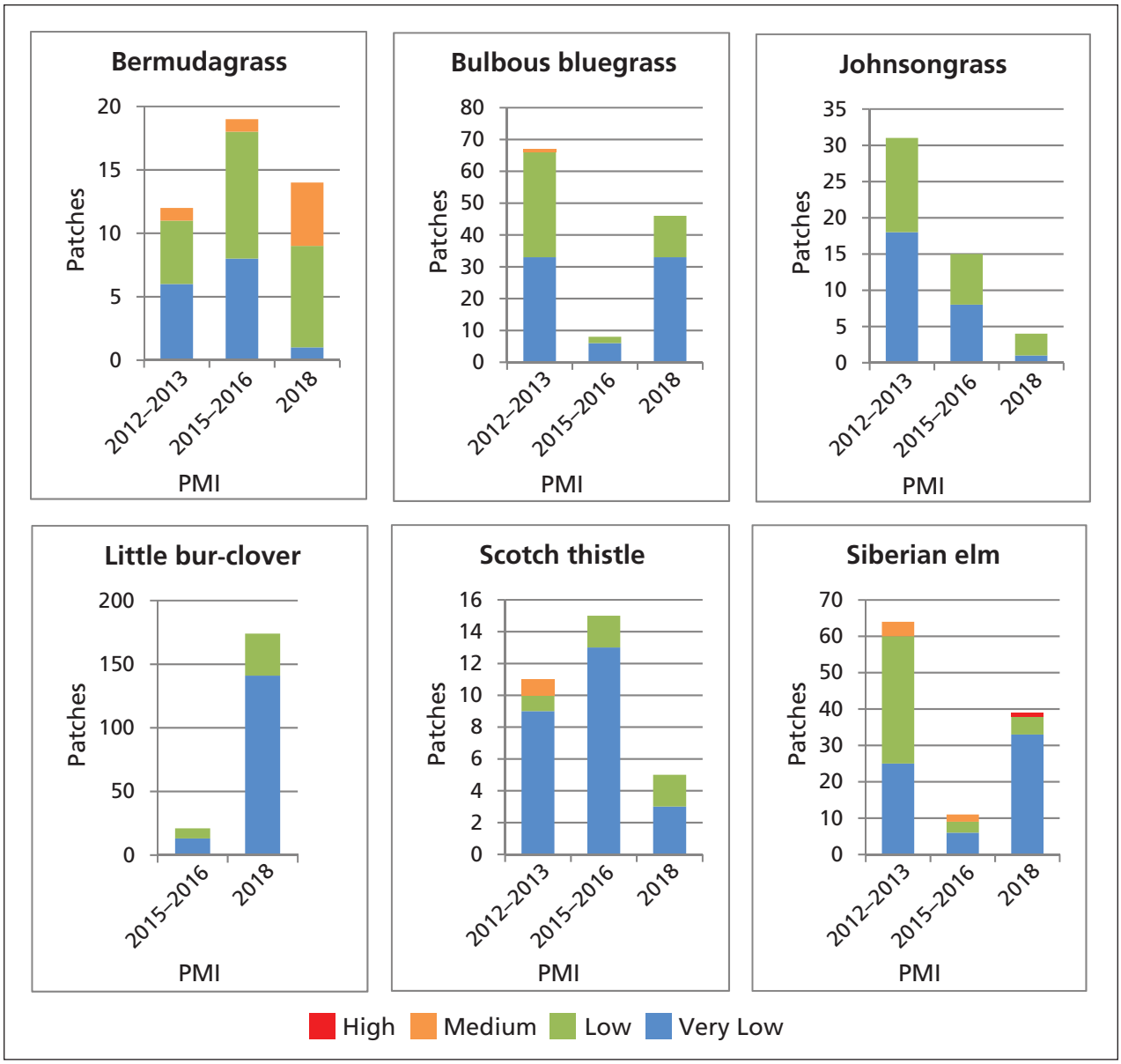


Figure 3-11. Number of patches and patch management index of six common priority IEP species along the same monitoring routes in Zion National Park, 2012–2013, 2015–2016, and 2018.

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. Presence and absence data for most priority species should be reliable for the area surveyed. However, data for non-priority species should not be assumed to be complete, as these species were not reliably mapped across observers, routes, or years.

4.2 Possibilities for management control

The patch management index (PMI) was originally intended to elucidate changes in IEP populations over time, but it can also be used to inform treatment decisions. In 2018, the vast majority of patches in Zion NP were classed very low or low, indicating that most patches are small in area, sparse in cover, or both (see Table 3-2). Patches with very low or low PMI should not be interpreted as insignificant. On the contrary, these patches may be some of the most important areas to treat, especially for isolated and/or uncommon species, such as Scotch thistle. Prioritizing treatment of small-scale patches can effectively prevent future spread and allow eradication. For widespread species, such as little bur-clover, the large number of patches with very low and low PMI indicates these species are sparsely scattered across a broad landscape, and controlling these populations will mean travel across broad areas. Managers should consider species traits (e.g., how likely and quickly plants may spread) and environmental conditions (precipitation and temperature), and combine this information with patch numbers and PMI values when determining treatment priorities.

The most common priority IEP species, by far, was little bur-clover, with a total of 174 patches recorded (see Table 3-2). All little bur-clover patches were very low or low in PMI. The next-most common priority species were bulbous bluegrass, Bermudagrass, and Siberian elm. Bulbous bluegrass and Bermudagrass patches were also very low or low in PMI, indicating that for these species, the infestations are small and/or sparse, though widespread. The temporary decline in bulbous bluegrass across much of the park in 2015–2016 might be explained by the dry conditions in those years and/or differences in detection between observers, as this species is not a target for control. Siberian elm appears to have rebounded and increased since 2015–2016, when numbers were much lower due to control efforts. Scotch thistle and Johnsongrass have both declined since monitoring began, likely due (at least in part) to control efforts. Each of these species was still found infrequently enough for control to be possible.

In transects, cheatgrass was, by far, the most widespread species. It appears to be becoming more widespread with each monitoring rotation, though the percent cover remains close to 1%. After 2018 monitoring, staff at Zion NP began a pre-emergent treatment series using the herbicide, Esplanade. Treatments began in late summer and early fall and continued throughout the winter. This has shown promising preliminary results for annuals, including cheatgrass and Russian thistle, in some areas of the main canyon near the campgrounds. The park is eager to see if the prevalence of these species will be affected in the next round of monitoring.

On average, roads had more priority IEP patches per kilometer than trails. Control efforts should continue in high-use, main-canyon areas that tend to have the most invasive plants: Watchman Campground and Visitor Center, Oak Creek and Administrative Area, and the Pa'rus and Grotto trails. It should also be noted that overall IEP percent cover was very low, and many monitoring routes had either few or no priority invasive plants. 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 some IEP species is lower in the interior of the park than along the monitoring routes.

However, it is also possible that some remote disturbed areas (e.g., burned areas) may have significant infestations of common weeds, like cheatgrass.

During 2018 field monitoring, numerous non-priority exotic species were observed (Table 4-1). Some of these were occasionally recorded in the GPS (see Figures 3-2 to 3-6). Some of these species could be considered for addition to the priority IEP list for the next monitoring rotation. It will be important to consider the overall length of the priority IEP list, as well as potential for control when adding species. We could also consider adding some species to transects only.

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 2020, NCPN will return to Zion NP to finish the third rotation of invasive plant monitoring. We may also complete some extra-area surveys in locations yet to be determined. New monitoring transect locations are regenerated each year to maintain an unbiased sampling due to park exotic control efforts. 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.

Table 4-1. Non-priority IEPs observed along monitoring routes in Zion NP, May 30–June 4, 2018.

Scientific name	Common name	Recorded?	Comments
Avena fatua	wild oat	Yes	Observed infrequently along roadsides.
Cirsium vulgare	bull thistle	Yes	Observed in infrequent and small infestations along the Middle Emerald Pools and Sand Bench trails.
Convolvulus arvensis	field bindweed	Yes	Infrequently observed along roadsides and campgrounds.
Elaeagnus angustifolia	Russian olive	Yes	Occurred infrequently along routes, including Watchman Trail and Zion Scenic Drive.
Lathyrus latifolius	perennial sweetpea	Yes	Observed along irrigation ditches near visitor center, campgrounds, and nearby State Route 9.
Marrubium vulgare	common horehound	Yes	Observed in infrequent and dense infestations along Wrangler and Grotto trails and Zion Scenic Drive.
Rubia tinctorum	madder	Yes	Extensive and dense across Watchman and South campgrounds and Oak Creek/Administrative Area and vicinity. There were infrequent infestations along Zion Scenic Drive, State Route 9, and Sand Bench Trail.
Tamarix sp.	tamarisk	Yes	Occurred infrequently along routes, including Chinle Trail and Zion Scenic Drive.
Tribulus terrestris	puncture vine	Yes	Infrequently occurred in trace–low cover along routes, including Oak Creek/Administrative Area and State Route 9.
Verbascum thapsus	woolly mullein	Yes	Observed occasionally along most monitoring routes.
Bromus diandrus	ripgut brome	No	Widespread and dense across most monitoring routes, frequently composing more quadrat cover than cheatgrass (*Bromus tectorum*).
Bromus japonicus	Japanese brome	No	Observed at one location along route between Maintenance and Oak Creek Campground.
Sisymbrium altissimum	tumble mustard	No	Observed frequently along routes near the visitor center and Oak Creek and Administrative Area.
Tragopogon dubius	yellow salsify	No	Widespread but sparse along State Route 9 near the east entrance and Chinle Trail.
Erodium cicutarium	stork's bill	No	Frequently observed along roadsides.
Melilotus officinalis	yellow sweet-clover	No	Frequently observed along roadsides.
Amaranthus retroflexus	red-root pigweed	No	Observed infrequently along roadsides near Visitor Center/Oak Creek and Administrative Area.

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Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Chinle Trail	*Tamarix sp.*	tamarisk	0	Sapling(s)	4120210.736	318093.281	2	5
Chinle Trail	*Tamarix sp.*	tamarisk	0	Sapling(s)	4120837.442	315693.24	1	2
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4127206.05	329514.619	1	2
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126453.68	328440.334	1	3
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126567.643	328427.075	1	3
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126547.908	328269.892	1	3
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126622.744	328187.676	1	3
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126586.865	328237.111	1	3
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126509.338	328378.655	1	3
East Rim Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4126472.262	328499.129	1	3
Grotto Trail	*Cynodon dactylon*	Bermuda grass	0	–	4124576.82	326484.88	2	5
Grotto Trail	*Marrubium vulgare*	Common horehound	0	–	4125198.006	326797.445	2	2
Grotto Trail	*Marrubium vulgare*	Common horehound	0	–	4124654.053	326578.694	3	4
Grotto Trail	*Marrubium vulgare*	Common horehound	0	–	4124958.195	326724.728	1	4
Grotto Trail	*Onopordum acanthium*	Scotch thistle	0	–	4124646.821	326567.164	3	2
Grotto Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125374.850	327249.154	1	2
Grotto Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125370.288	327161.698	1	2
Grotto Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4124994.999	326722.546	1	2
Grotto Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125305.059	326964.753	1	2
Grotto Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125351.037	327103.633	1	3
Grotto Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125234.620	326829.788	1	3
Grotto Trail	*Verbascum thapsus*	Woolly mullein	0	–	4125387.486	327218.584	3	2
Grotto Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124948.429	326712.721	1	2
Grotto Trail	*Verbascum thapsus*	Woolly mullein	0	–	4125163.921	326784.482	2	2
Grotto Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124878.398	326697.084	1	5
Kayenta Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125171.222	326479.947	1	2
Kayenta Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125095.185	326343.126	1	2
Kayenta Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4125105.962	326415.87	1	2
Lower Emerald Pools Trail	*Avena fatua*	Wild oats	0	–	4124739.818	326341.742	3	4
Lower Emerald Pools Trail	*Medicago minima*	little bur-clover	0	–	4124606.755	326277.496	2	3
Lower Emerald Pools Trail	*Medicago minima*	little bur-clover	0	–	4124544.034	326234.535	1	3
Lower Emerald Pools Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4124516.151	326289.362	1	2

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Lower Emerald Pools Trail	*Poa bulbosa*	Bulbous bluegrass	0	–	4124845.867	326293.92	2	3
Lower Emerald Pools Trail	*Rubia tinctoria*	Madder	0	–	4124838.55	326300.02	4	3
Lower Emerald Pools Trail	*Verbascum thapsus*	Woolly mullein	0	–	4125106.94	326013.337	3	3
Lower Emerald Pools Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124916.648	326244.235	2	3
Middle Emerald Pools Trail	*Cirsium vulgare*	Bull thistle	0	–	4124477.48	326163.553	5	1
Middle Emerald Pools Trail	*Medicago minima*	little bur-clover	0	–	4124484.508	326151.751	2	3
Middle Emerald Pools Trail	*Medicago minima*	little bur-clover	0	–	4124918.212	326161.921	2	3
Middle Emerald Pools Trail	*Medicago minima*	little bur-clover	0	–	4124523.557	326124.26	2	3
Middle Emerald Pools Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124470.818	326175.783	2	2
Museum Trail	*Lathyrus latifolius*	Perennial sweetpea	0	–	4119766.362	324255.688	1	3
Museum Trail	*Medicago minima*	little bur-clover	0	–	4119656.665	324332.907	1	2
Oak Creek and Admin	*Cynodon dactylon*	Bermuda grass	0	–	4120085.617	323822.139	3	4
Oak Creek and Admin	*Cynodon dactylon*	Bermuda grass	0	–	4120098.494	323664.38	3	4
Oak Creek and Admin	*Cynodon dactylon*	Bermuda grass	0	–	4120080.286	323717.606	3	4
Oak Creek and Admin	*Cynodon dactylon*	Bermuda grass	0	–	4120074.603	323764.584	3	4
Oak Creek and Admin	*Cynodon dactylon*	Bermuda grass	0	–	4120044.929	323958.565	2	3
Oak Creek and Admin	*Cynodon dactylon*	Bermuda grass	0	–	4120064.837	323895.366	3	4
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119999.822	323746.409	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120125.474	323576.347	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120059.824	323903.449	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120064.612	323629.952	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120080.939	323763.351	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120030.491	323686.282	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119739.281	324141.277	1	4
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120031.955	323990.133	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120135.895	323622.912	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120074.157	323708.887	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120198.656	323614.377	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120095.355	323650.061	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120084.242	323809.192	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120010.948	323800.615	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119778.022	324226.905	1	3

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119877.649	324021.247	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119802.718	324151.357	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119921.707	323971.42	1	2
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119803.688	324076.916	1	3
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119956.784	323929.909	1	2
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4119980.716	323852.436	1	2
Oak Creek and Admin	*Medicago minima*	little bur-clover	0	–	4120035.268	323750.074	1	3
Oak Creek and Admin	*Onopordum acanthium*	Scotch thistle	1	–	4120256.891	323399.885	5	1
Oak Creek and Admin	*Poa bulbosa*	Bulbous bluegrass	0	–	4120406.695	322646.382	1	2
Oak Creek and Admin	*Tamarix sp.*	tamarisk	0	Sapling(s)	4120401.26	322834.959	5	1
Oak Creek and Admin	*Tamarix sp.*	tamarisk	0	–	4120187.012	323550.091	5	1
Parus Trail	*Lathyrus latifolius*	Perennial sweetpea	0	–	4120433.259	324625.887	2	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119427.338	324257.923	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119489.349	324283.103	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120874.323	324825.389	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120218.724	324589.378	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119947.156	324478.438	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119763.714	324415.427	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120084.696	324520.729	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120678.855	324771.409	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120513.939	324653.269	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119583.615	324321.871	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119237.958	324164.168	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119847.675	324422.016	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120272.906	324607.522	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120345.248	324624.401	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120400.59	324644.832	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119332.51	324226.684	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119542.675	324290.66	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120566.529	324677.325	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120878.974	324829.015	1	2
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120033.385	324496.495	1	2

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120790.497	324790.531	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120620.542	324698.41	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4120735.837	324755.773	1	3
Parus Trail	*Medicago minima*	little bur-clover	0	–	4119208.116	324062.822	1	3
Riverside Walk	*Poa bulbosa*	Bulbous bluegrass	0	–	4128366.501	327280.409	1	4
Riverside Walk	*Poa bulbosa*	Bulbous bluegrass	0	–	4128469.253	327276.532	1	4
Riverside Walk	*Poa bulbosa*	Bulbous bluegrass	0	–	4128331.822	327314.098	1	4
Riverside Walk	*Verbascum thapsus*	Woolly mullein	0	–	4128546.047	327346.392	2	2
Sand Bench Trail	*Cirsium vulgare*	Bull thistle	0	–	4124379.256	326277.339	5	1
Sand Bench Trail	*Rubia tinctoria*	Madder	0	–	4123150.584	325528.11	4	3
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4123073.496	325600.599	2	4
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124013.648	326270.982	3	2
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4123790.48	326254.412	2	1
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4123680.867	326231.646	5	1
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124115.505	326286.808	2	2
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4123123.928	325565.764	2	4
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4123363.234	325993.74	5	1
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4124286.413	326286.738	5	1
Sand Bench Trail	*Verbascum thapsus*	Woolly mullein	0	–	4123053.777	325564.7	2	4
South CG and Nature Center	*Cynodon dactylon*	Bermuda grass	0	–	4119398.056	323974.237	2	2
South CG and Nature Center	*Cynodon dactylon*	Bermuda grass	0	–	4119460.849	324043.164	2	5
South CG and Nature Center	*Lathyrus latifolius*	Perennial sweetpea	0	–	4119153.588	323668.935	2	2
South CG and Nature Center	*Medicago minima*	little bur-clover	0	–	4119430.532	324059.873	1	2
South CG and Nature Center	*Sorghum halepense*	Johnson-grass	0	–	4119234.16	323897.164	4	1
South CG and Nature Center	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4119350.273	324101.998	2	4
South CG and Nature Center	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4119354.411	324011.889	4	2
State Route 9	*Bassia scoparia*	Summer-cypress	0	–	4119311.137	323691.038	1	2
State Route 9	*Bassia scoparia*	Summer-cypress	0	–	4119408.07	323901.492	3	2
State Route 9	*Bassia scoparia*	Summer-cypress	0	–	4121031.325	329907.031	1	2
State Route 9	*Bassia scoparia*	Summer-cypress	0	–	4121223.78	330106.471	1	3
State Route 9	*Convolvulus arvensis*	Field bindweed	0	–	4121064.972	329904.956	1	2
State Route 9	*Convolvulus arvensis*	Field bindweed	0	–	4120979.929	329909.832	2	2

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
State Route 9	*Cynodon dactylon*	Bermuda grass	0	–	4119077.722	323511.508	3	2
State Route 9	*Lathyrus latifolius*	Perennial sweetpea	0	–	4119998.241	324377.796	3	2
State Route 9	*Lathyrus latifolius*	Perennial sweetpea	0	–	4120227.576	324479.146	3	3
State Route 9	*Lathyrus latifolius*	Perennial sweetpea	0	–	4120507.013	324559.675	5	1
State Route 9	*Lathyrus latifolius*	Perennial sweetpea	0	–	4120121.254	324430.363	2	3
State Route 9	*Lathyrus latifolius*	Perennial sweetpea	0	–	4120030.536	324400.447	3	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119697.767	324114.679	2	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4121189.389	329965.823	3	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119154.378	323565.49	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4120851.139	329805.779	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120791.095	324675.245	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4120808.079	324677.404	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119101.568	323544.301	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119305.872	323702.36	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4120567.938	324572.28	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120423.185	324536	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4119716.895	324180.084	2	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119750.689	324282.396	2	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119835.153	324354.469	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120657.087	324620.566	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4120320.318	324504.926	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120770.024	325393.983	2	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120547.662	324573.822	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4120743.656	325422.385	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119955.908	324372.811	2	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120825.587	324797.835	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120103.484	324424.472	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120375.557	324522.036	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4120673.567	324615.264	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120133.035	324430.555	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120835.081	324715.061	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4121085.545	329903.916	1	2

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
State Route 9	*Medicago minima*	little bur-clover	0	–	4121465.434	331621.433	5	1
State Route 9	*Medicago minima*	little bur-clover	0	–	4120897.923	329861.69	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120731.092	324648.147	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4121392.151	331405.872	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120596.013	324588.476	1	3
State Route 9	*Medicago minima*	little bur-clover	0	–	4119224.038	323624.978	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120764.819	325361.62	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4119921.691	324387.732	1	2
State Route 9	*Medicago minima*	little bur-clover	0	–	4120150.984	324446.997	1	2
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4119668.364	324073.085	5	1
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4120127.74	324416.909	1	2
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4120746.105	325479.064	1	2
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4119702.601	324174.999	1	2
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4119426.507	323919.781	4	1
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4119675.735	324105.703	5	1
State Route 9	*Tribulus terrestris*	Puncture vine	0	–	4119688.995	324103.081	2	2
State Route 9	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4120137.27	324438.42	5	1
State Route 9	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4121519.664	331831.461	5	1
State Route 9	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4119211.124	323584.812	5	1
State Route 9	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4121054.131	329906.983	5	1
State Route 9	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4121748.923	333108.555	5	1
State Route 9	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4122341.626	333567.727	5	1
State Route 9	*Verbascum thapsus*	Woolly mullein	0	–	4119963.932	324370.449	2	1
State Route 9	*Verbascum thapsus*	Woolly mullein	0	–	4119888.665	324367.101	5	1
State Route 9	*Verbascum thapsus*	Woolly mullein	0	–	4122337.459	333565.21	2	1
Watchman CG and VC	*Bassia scoparia*	Summer-cypress	1	–	4118753.62	323531.126	5	1
Watchman CG and VC	*Convolvulus arvensis*	Field bindweed	0	–	4118364.736	323599.191	5	1
Watchman CG and VC	*Elaeagnus angustifolia*	Russian-olive	0	Sapling(s)	4118625.071	323593.634	5	1
Watchman CG and VC	*Lathyrus latifolius*	Perennial sweetpea	0	–	4119137.223	323660.632	3	3
Watchman CG and VC	*Medicago minima*	little bur-clover	0	–	4118816.6	323629.607	1	2
Watchman CG and VC	*Medicago minima*	little bur-clover	0	–	4118963.532	323756.522	1	2
Watchman CG and VC	*Medicago minima*	little bur-clover	0	–	4119033.749	323723.465	1	2

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Watchman CG and VC	*Medicago minima*	little bur-clover	0	–	4118828.563	323769.276	1	2
Watchman CG and VC	*Sorghum halepense*	Johnson-grass	0	–	4118668.251	323545.888	3	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118287.805	323497.358	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118622.527	323725.39	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118586.546	323524.186	1	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118632.137	323478.499	1	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4118822.516	323571.266	2	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4118512.246	323598.142	3	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118338.623	323546.406	1	3
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118646.837	323736.517	4	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118248.347	323460.088	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118691.908	323695.785	1	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4118957.912	323758.805	2	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4118604.017	323459.178	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118835.44	323569.75	4	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118494.69	323513.463	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118401.817	323407.032	1	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118530.511	323606.382	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118544.409	323495.359	1	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4119063.026	323708.926	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118677.849	323552.013	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118726.06	323625.187	1	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118451.564	323647.991	3	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4118677.163	323651.127	5	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118453.021	323507.887	2	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Mature Tree(s)	4118584.331	323626.768	5	4
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118619.645	323602.86	2	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118869.199	323748.709	1	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Sapling(s)	4118469.576	323655.951	2	3
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118378.965	323664.359	1	2
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118582.201	323565.537	1	1
Watchman CG and VC	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118334.255	323640.842	1	3

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Watchman Housing and PTI	*Cynodon dactylon*	Bermuda grass	0	–	4119174.006	324355.886	2	3
Watchman Housing and PTI	*Cynodon dactylon*	Bermuda grass	0	–	4119225.33	324275.383	2	3
Watchman Housing and PTI	*Cynodon dactylon*	Bermuda grass	0	–	4119265.606	324285.117	2	4
Watchman Housing and PTI	*Cynodon dactylon*	Bermuda grass	0	–	4119300.963	324313.598	2	3
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119499.179	324360.589	1	2
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119174.289	324355.978	1	2
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119349.404	324350.351	1	2
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119421.714	324405.209	1	2
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119662.536	324255.066	1	3
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4118909.701	323952.271	1	4
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119279.476	324298.93	1	2
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119167.244	324288.899	1	2
Watchman Housing and PTI	*Medicago minima*	little bur-clover	0	–	4119110.975	324178.276	1	2
Watchman Housing and PTI	*Onopordum acanthium*	Scotch thistle	0	–	4118879.734	323909.757	2	1
Watchman Housing and PTI	*Sorghum halepense*	Johnson-grass	0	–	4118929.438	323933.081	3	2
Watchman Housing and PTI	*Tribulus terrestris*	Puncture vine	0	–	4119101.297	323952.446	1	2
Watchman Housing and PTI	*Tribulus terrestris*	Puncture vine	0	–	4119102.252	324157.155	5	1
Watchman Housing and PTI	*Tribulus terrestris*	Puncture vine	0	–	4119008.602	323821.129	2	2
Watchman Housing and PTI	*Ulmus pumila*	Siberian elm	0	Seedling(s)	4118934.086	323810.392	3	3
Watchman Trail	*Elaeagnus angustifolia*	Russian-olive	0	Sapling(s)	4119027.629	324714.232	5	1
Watchman Trail	*Medicago minima*	little bur-clover	0	–	4119042.072	323678.899	1	2
Wrangler Trail	*Marrubium vulgare*	Common horehound	0	–	4123095.28	326111.541	5	1
Wrangler Trail	*Marrubium vulgare*	Common horehound	0	–	4122989.013	326029.077	2	3
Wrangler Trail	*Marrubium vulgare*	Common horehound	0	–	4123028.801	326066.25	2	2
Wrangler Trail	*Tamarix sp.*	tamarisk	0	Sapling(s)	4124332.429	326333.224	5	1
Wrangler Trail	*Tamarix sp.*	tamarisk	0	–	4123437.007	326290.41	5	1
Wrangler Trail	*Tribulus terrestris*	Puncture vine	0	–	4123750.35	326387.988	2	2
Zion Scenic Drive	*Avena fatua*	Wild oats	0	–	4121547.449	325326.154	2	2
Zion Scenic Drive	*Avena fatua*	Wild oats	0	–	4126943.387	328004.428	2	2
Zion Scenic Drive	*Avena fatua*	Wild oats	0	–	4121416.262	325226.569	2	2
Zion Scenic Drive	*Bassia scoparia*	Summer-cypress	0	–	4120840.123	324832.824	1	2
Zion Scenic Drive	*Convolvulus arvensis*	Field bindweed	0	–	4126954.224	327519.939	2	2

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Zion Scenic Drive	*Elaeagnus angustifolia*	Russian-olive	0	Mature Tree(s)	4121639.977	325261.221	4	3
Zion Scenic Drive	*Elaeagnus angustifolia*	Russian-olive	0	Sapling(s)	4121518.074	325238.582	5	1
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123562.723	326422.868	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124734.143	326494.884	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124167.643	326393.828	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124664.187	326451.258	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124229.546	326392.057	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4125936.543	327248.748	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127112.289	327415.766	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4125712.948	327209.417	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124394.351	326372.658	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127036.735	327758.439	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124486.832	326365.592	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124501.669	326355.157	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126963.707	327548.277	3	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123511.146	326398.314	3	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121520.007	325316.748	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122774.722	326026.191	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121162.166	324910.064	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121328.994	325150.573	5	1
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4120979.632	324897.552	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126767.908	328051.626	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121451.661	325255.366	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121049.308	324902.463	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127008.068	327883.041	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122991.187	326074.726	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121221.754	324992.408	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121414.675	325219.028	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121315.069	325130.912	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121832.472	325483.137	5	1
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121702.56	325407.548	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121154.568	324896.258	2	3

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121209.035	324943.118	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121652.641	325380.026	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122828.032	326031.63	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4128254.890	327454.566	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122099.302	325713.177	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121795.528	325455.95	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121840.566	325474.903	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121051.199	324911.9	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121740.319	325441.399	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122754.974	326033.194	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122117.835	325758.384	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4120934.591	324865.322	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126907.62	327439.461	1	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4120991.714	324885.207	1	5
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123846.295	326417.965	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126969.884	327949.473	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126280.664	327572.098	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126496.091	327911.405	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127914.483	327414.384	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121242.059	325047.418	3	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121357.821	325167.195	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121099.908	324893.291	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4122727.725	326002.885	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123438.805	326345.962	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4121267.322	325095.623	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124350.768	326376.279	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4128265.698	327320.555	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123464.273	326369.947	3	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124088.76	326395.598	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4128253.389	327364.365	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127014.854	327812.087	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127910.514	327395.201	2	3

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123507.184	326387.988	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123395.84	326318.964	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127761.254	327558.319	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4125864.126	327211.29	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123991.682	326405.849	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127878.275	327444.357	2	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4126941.852	327488.652	2	3
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4123932.172	326409.71	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4124217.179	326390.231	1	2
Zion Scenic Drive	*Medicago minima*	little bur-clover	0	–	4127019.964	327418.817	1	2
Zion Scenic Drive	*Onopordum acanthium*	Scotch thistle	0	–	4124839.495	326607.932	5	1
Zion Scenic Drive	*Onopordum acanthium*	Scotch thistle	0	–	4124327.934	326382.048	3	2
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126449.073	327856.145	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126528.77	327955.809	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126385.174	327658.886	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126744.546	328066.006	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126059.945	327373.494	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126079.168	327432.921	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126600.345	328002.766	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4125064.233	326730	3	2
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126030.655	327322.66	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4127039.22	327418.026	2	2
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126411.454	327731.623	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4127006.555	327864.589	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126792.987	328062.256	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4125065.744	326729.529	1	2
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4127936.204	327375.481	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126744.826	328047.108	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4125179.021	326768.289	3	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4125577.863	327227.625	2	2
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126267.437	327575.581	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126068.389	327453.131	3	3

Appendix A. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	N_Coord	E_Coord	Cover_Class	Size_Class
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126059.544	327397.763	1	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126327.513	327600.163	2	3
Zion Scenic Drive	*Poa bulbosa*	Bulbous bluegrass	0	–	4126652.107	328026.18	1	3
Zion Scenic Drive	*Rubia tinctoria*	Madder	0	–	4127698.652	327594.661	2	1
Zion Scenic Drive	*Rubia tinctoria*	Madder	0	–	4121463.289	325259.094	3	2
Zion Scenic Drive	*Rubia tinctoria*	Madder	0	–	4121238.566	325040.206	3	1
Zion Scenic Drive	*Sorghum halepense*	Johnson-grass	0	–	4125370.475	326889.836	3	2
Zion Scenic Drive	*Tamarix sp.*	tamarisk	0	Sapling(s)	4121338.221	325100.847	5	1
Zion Scenic Drive	*Tamarix sp.*	tamarisk	0	Sapling(s)	4121426.746	325228.035	3	2
Zion Scenic Drive	*Tamarix sp.*	tamarisk	0	Sapling(s)	4121682.51	325352.988	3	2
Zion Scenic Drive	*Tamarix sp.*	tamarisk	0	Seedling(s)	4121522.537	325256.721	5	1
Zion Scenic Drive	*Tribulus terrestris*	Puncture vine	0	–	4120836.237	324844.562	1	2
Zion Scenic Drive	*Tribulus terrestris*	Puncture vine	0	–	4125229.655	326787.554	3	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4123491.867	326375.496	2	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4126214.683	327545.954	2	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4125443.13	327043.197	3	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4122187.071	325847.983	5	1
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4127195.52	327433.462	2	5
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4122262.883	325851.363	3	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4125495.24	327002.321	2	3
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4126300.021	327580.408	2	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4124128.261	326393.757	2	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4123626.633	326423.965	5	1
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4124809.135	326570.875	2	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4128265.336	327603.935	2	3
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4124857.2	326612.28	2	2
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4127443.246	327535.836	5	1
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4123690.242	326418.263	2	3
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4124615.48	326371.498	2	3
Zion Scenic Drive	*Verbascum thapsus*	Woolly mullein	0	–	4123092.405	326140.492	5	1

Appendix B. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018.

Route	Transect	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	Average_Cover
Archeology Trail	233	323821.126	4118878.766	Bromus tectorum	Cheatgrass	Y	0.5
Archeology Trail	233	323821.126	4118878.766	Salsola sp.	Russian thistle	Y	0.167
Chinle Trail	237	318426.960	4116683.382	Bromus tectorum	Cheatgrass	Y	0.333
Chinle Trail	239	318106.820	4117302.016	Bromus tectorum	Cheatgrass	Y	0.167
Chinle Trail	241	317933.472	4118109.196	Bromus tectorum	Cheatgrass	Y	0.5
Chinle Trail	243	317590.764	4119000.477	Bromus tectorum	Cheatgrass	Y	3.333
Chinle Trail	244	317659.462	4119477.231	Bromus tectorum	Cheatgrass	Y	0.333
Chinle Trail	245	317765.822	4119775.599	Bromus tectorum	Cheatgrass	Y	0.333
Chinle Trail	246	317993.776	4120026.080	Bromus tectorum	Cheatgrass	Y	1.333
Chinle Trail	249	317112.330	4120250.734	Bromus tectorum	Cheatgrass	Y	0.167
Chinle Trail	250	316840.974	4119970.330	Bromus tectorum	Cheatgrass	Y	0.167
Chinle Trail	251	316598.335	4119582.410	Bromus tectorum	Cheatgrass	Y	0.167
Chinle Trail	254	315642.906	4120145.176	Bromus tectorum	Cheatgrass	Y	0.667
Chinle Trail	255	315603.960	4120564.856	Bromus tectorum	Cheatgrass	Y	1.5
East Rim Trail	50	328346.260	4126520.430	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	50	328346.260	4126520.430	Poa bulbosa	Bulbous bluegrass	Y	0.167
East Rim Trail	51	328429.455	4126472.089	Bromus tectorum	Cheatgrass	Y	0.167
East Rim Trail	52	328596.693	4126598.449	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	53	328769.314	4126919.316	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	56	329584.763	4127236.836	Bromus tectorum	Cheatgrass	Y	0.167
East Rim Trail	60	330272.623	4126814.771	Bromus tectorum	Cheatgrass	Y	0.167
East Rim Trail	61	330658.437	4126571.957	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	62	330877.942	4126189.379	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	63	330928.081	4125718.546	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	66	332043.302	4124887.631	Bromus tectorum	Cheatgrass	Y	0.333
East Rim Trail	71	333126.251	4124043.068	Bromus tectorum	Cheatgrass	Y	0.25
East Rim Trail	72	333436.849	4124153.708	Bromus tectorum	Cheatgrass	Y	0.167
East Rim Trail	77	334392.573	4124278.498	Bromus tectorum	Cheatgrass	Y	0.5
East Rim Trail	78	334419.236	4123821.647	Bromus tectorum	Cheatgrass	Y	0.167
East Rim Trail	79	334055.920	4123648.424	Bromus tectorum	Cheatgrass	Y	0.167
East Rim Trail	81	333563.548	4122966.692	Bromus tectorum	Cheatgrass	Y	0.167
Grotto Trail	256	326706.740	4124942.975	Bromus tectorum	Cheatgrass	Y	0.167
Grotto Trail	257	326979.077	4125313.681	Bromus tectorum	Cheatgrass	Y	0.333

Appendix B. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Route	Transect	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	Average_Cover
Kayenta Trail	258	326649.301	4125391.188	Bromus tectorum	Cheatgrass	Y	0.167
Middle Emerald Pools Trail	265	325930.035	4125221.796	Bromus tectorum	Cheatgrass	Y	0.333
Oak Creek and Admin	266	322993.504	4120368.545	Bromus tectorum	Cheatgrass	Y	1.333
Oak Creek and Admin	267	323429.357	4120258.159	Bromus tectorum	Cheatgrass	Y	1.5
Oak Creek and Admin	268	323761.511	4120004.395	Bromus tectorum	Cheatgrass	Y	0.167
Oak Creek and Admin	268	323761.511	4120004.395	Medicago minima	little bur-clover	Y	0.167
Oak Creek and Admin	269	324146.626	4119733.689	Bromus tectorum	Cheatgrass	Y	6.667
Oak Creek and Admin	269	324146.626	4119733.689	Medicago minima	little bur-clover	Y	0.167
Oak Creek and Admin	270	323713.370	4120006.835	Bromus tectorum	Cheatgrass	Y	7.167
Oak Creek and Admin	271	324111.144	4119759.060	Bromus tectorum	Cheatgrass	Y	1.167
Oak Creek and Admin	271	324111.144	4119759.060	Salsola sp.	Russian thistle	Y	0.167
Oak Creek and Admin	272	323796.822	4120015.609	Bromus tectorum	Cheatgrass	Y	5.167
Oak Creek and Admin	272	323796.822	4120015.609	Medicago minima	little bur-clover	Y	1.333
Parus Trail	273	324687.954	4120617.229	Bromus tectorum	Cheatgrass	Y	0.667
Parus Trail	273	324687.954	4120617.229	Medicago minima	little bur-clover	Y	2.833
Parus Trail	274	324568.450	4120165.011	Bromus tectorum	Cheatgrass	Y	14.333
Parus Trail	275	324388.982	4119749.784	Bromus tectorum	Cheatgrass	Y	3.333
Parus Trail	276	324213.500	4119306.065	Bromus tectorum	Cheatgrass	Y	1.167
Parus Trail	277	323796.431	4119136.700	Bromus tectorum	Cheatgrass	Y	0.833
Riverside Walk	278	327355.846	4129251.752	Bromus tectorum	Cheatgrass	Y	0.167
Riverside Walk	279	327381.734	4128848.985	Bromus tectorum	Cheatgrass	Y	0.333
Riverside Walk	280	327252.505	4128431.285	Poa bulbosa	Bulbous bluegrass	Y	0.333
Sand Bench Trail	281	325600.650	4123173.158	Bromus tectorum	Cheatgrass	Y	0.5
Sand Bench Trail	283	325318.241	4122532.001	Bromus tectorum	Cheatgrass	Y	0.5
Sand Bench Trail	284	325017.369	4122215.178	Bromus tectorum	Cheatgrass	Y	0.167
Sand Bench Trail	285	324651.188	4121900.610	Bromus tectorum	Cheatgrass	Y	1.5
Sand Bench Trail	286	324453.571	4121542.018	Bromus tectorum	Cheatgrass	Y	0.167
Sand Bench Trail	288	325111.676	4121940.128	Bromus tectorum	Cheatgrass	Y	0.5
Sand Bench Trail	289	325351.436	4122288.052	Bromus tectorum	Cheatgrass	Y	0.667
Sand Bench Trail	291	326269.496	4124396.572	Bromus tectorum	Cheatgrass	Y	1
Sand Bench Trail	292	326270.314	4123895.411	Bromus tectorum	Cheatgrass	Y	0.333
Sand Bench Trail	293	326105.175	4123477.250	Bromus tectorum	Cheatgrass	Y	14.5
Sand Bench Trail	294	325828.493	4123193.442	Bromus tectorum	Cheatgrass	Y	1.333

Appendix B. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Route	Transect	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	Average_Cover
Sand Bench Trail	295	325593.958	4123093.123	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	296	323746.027	4119335.683	Bromus tectorum	Cheatgrass	Y	3.667
State Route 9	297	324087.160	4119676.345	Bromus tectorum	Cheatgrass	Y	18
State Route 9	298	324378.557	4120007.670	Bromus tectorum	Cheatgrass	Y	12
State Route 9	299	324539.735	4120479.373	Bromus tectorum	Cheatgrass	Y	10
State Route 9	300	324803.251	4120840.159	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	302	329694.760	4120543.208	Bromus tectorum	Cheatgrass	Y	1
State Route 9	303	329826.106	4120877.129	Bromus tectorum	Cheatgrass	Y	3
State Route 9	304	330087.569	4121220.020	Bassia scoparia	Summer-cypress	Y	1
State Route 9	305	330450.998	4121452.963	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	306	330702.619	4121384.245	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	307	331104.510	4121451.631	Bromus tectorum	Cheatgrass	Y	0.167
State Route 9	309	331703.140	4121499.048	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	310	332160.989	4121463.976	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	311	332591.879	4121609.279	Bromus tectorum	Cheatgrass	Y	0.167
State Route 9	311	332591.879	4121609.279	Salsola sp.	Russian thistle	Y	0.167
State Route 9	312	333073.018	4121742.239	Bromus tectorum	Cheatgrass	Y	0.167
State Route 9	313	333330.868	4122065.833	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	314	333644.850	4122425.285	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	314	333644.850	4122425.285	Salsola sp.	Russian thistle	Y	0.167
State Route 9	315	334129.809	4122524.102	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	316	334617.331	4122626.119	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	317	323717.383	4119311.983	Salsola sp.	Russian thistle	Y	0.167
State Route 9	318	324064.786	4119653.125	Bromus tectorum	Cheatgrass	Y	1.833
State Route 9	318	324064.786	4119653.125	Salsola sp.	Russian thistle	Y	0.167
State Route 9	319	324393.525	4119958.425	Bromus tectorum	Cheatgrass	Y	14.833
State Route 9	320	324538.895	4120440.101	Bromus tectorum	Cheatgrass	Y	1
State Route 9	322	325255.088	4120794.305	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	322	325255.088	4120794.305	Poa bulbosa	Bulbous bluegrass	Y	0.167
State Route 9	323	329656.674	4120562.814	Bromus tectorum	Cheatgrass	Y	0.667
State Route 9	324	329786.042	4120829.070	Bromus tectorum	Cheatgrass	Y	2
State Route 9	326	330383.137	4121383.062	Bromus tectorum	Cheatgrass	Y	2
State Route 9	327	330658.759	4121434.753	Bromus tectorum	Cheatgrass	Y	0.333

Appendix B. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Route	Transect	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	Average_Cover
State Route 9	328	331087.128	4121370.965	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	329	331455.128	4121355.040	Bromus tectorum	Cheatgrass	Y	0.833
State Route 9	330	331610.611	4121476.099	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	331	332046.937	4121440.181	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	332	332505.634	4121586.569	Bromus tectorum	Cheatgrass	Y	0.333
State Route 9	333	332983.067	4121717.237	Bromus tectorum	Cheatgrass	Y	0.167
State Route 9	334	333334.965	4121965.864	Bromus tectorum	Cheatgrass	Y	0.5
State Route 9	335	333594.593	4122361.210	Bromus tectorum	Cheatgrass	Y	1.667
State Route 9	336	334056.342	4122498.178	Bromus tectorum	Cheatgrass	Y	0.167
State Route 9	337	334546.100	4122595.558	Bromus tectorum	Cheatgrass	Y	0.333
Upper Emerald Pools Trail	338	325721.969	4125255.25	Bromus tectorum	Cheatgrass	Y	0.333
Watchman Housing and PTI	340	324283.276	4119165.895	Bromus tectorum	Cheatgrass	Y	2
Watchman Housing and PTI	340	324283.276	4119165.895	Medicago minima	little bur-clover	Y	0.167
Watchman Housing and PTI	341	323831.531	4119013.499	Bromus tectorum	Cheatgrass	Y	1.667
Watchman Housing and PTI	342	324281.588	4119177.679	Bromus tectorum	Cheatgrass	Y	0.667
Watchman Housing and PTI	342	324281.588	4119177.679	Salsola sp.	Russian thistle	Y	0.167
Watchman Housing and PTI	343	323972.868	4119102.532	Bromus tectorum	Cheatgrass	Y	3.167
Watchman Housing and PTI	343	323972.868	4119102.532	Salsola sp.	Russian thistle	Y	0.167
Watchman Trail	344	323998.660	4119161.181	Bromus tectorum	Cheatgrass	Y	4.333
Watchman Trail	345	324416.408	4119074.095	Bromus tectorum	Cheatgrass	Y	10.167
Watchman Trail	347	324920.622	4118971.284	Bromus tectorum	Cheatgrass	Y	0.167
Watchman Trail	348	324618.984	4118780.481	Bromus tectorum	Cheatgrass	Y	0.167
Watchman Trail	349	324557.630	4118867.259	Bromus tectorum	Cheatgrass	Y	0.5
Wrangler Trail	352	326376.089	4123658.760	Bromus tectorum	Cheatgrass	Y	3.167
Wrangler Trail	353	326354.973	4124143.172	Bromus tectorum	Cheatgrass	Y	0.333
Zion Scenic Drive	193	324899.457	4121142.290	Bromus tectorum	Cheatgrass	Y	1.333
Zion Scenic Drive	193	324899.457	4121142.290	Medicago minima	little bur-clover	Y	0.333
Zion Scenic Drive	194	325263.460	4121448.629	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	194	325263.460	4121448.629	Salsola sp.	Russian thistle	Y	0.5
Zion Scenic Drive	195	325506.315	4121881.889	Bromus tectorum	Cheatgrass	Y	0.333
Zion Scenic Drive	196	325861.226	4122208.814	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	197	325987.472	4122670.541	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	199	326418.640	4123552.893	Bromus tectorum	Cheatgrass	Y	3.667

Appendix B. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Route	Transect	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	Average_Cover
Zion Scenic Drive	200	326412.101	4124037.000	Bromus tectorum	Cheatgrass	Y	2.667
Zion Scenic Drive	201	326351.302	4124526.904	Bromus tectorum	Cheatgrass	Y	1
Zion Scenic Drive	202	326658.595	4124895.221	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	203	326860.391	4125351.183	Bromus tectorum	Cheatgrass	Y	0.667
Zion Scenic Drive	204	327231.769	4125608.485	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	205	327375.389	4126055.761	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	206	327677.824	4126388.480	Bromus tectorum	Cheatgrass	Y	0.333
Zion Scenic Drive	207	328051.837	4126689.688	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	208	327789.270	4127046.184	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	209	327418.214	4127045.544	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	209	327418.214	4127045.544	Poa bulbosa	Bulbous bluegrass	Y	0.167
Zion Scenic Drive	210	327594.651	4127496.451	Bromus tectorum	Cheatgrass	Y	0.333
Zion Scenic Drive	212	327580.479	4128245.124	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	213	324915.315	4121185.735	Medicago minima	little bur-clover	Y	1
Zion Scenic Drive	214	325286.433	4121494.383	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	214	325286.433	4121494.383	Medicago minima	little bur-clover	Y	0.667
Zion Scenic Drive	215	325507.371	4121939.395	Bromus tectorum	Cheatgrass	Y	1
Zion Scenic Drive	217	325997.700	4122720.319	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	217	325997.700	4122720.319	Medicago minima	little bur-clover	Y	0.5
Zion Scenic Drive	218	326176.107	4123155.775	Bromus tectorum	Cheatgrass	Y	1.167
Zion Scenic Drive	219	326423.621	4123587.126	Bromus tectorum	Cheatgrass	Y	0.333
Zion Scenic Drive	220	326398.879	4124075.581	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	221	326357.288	4124570.033	Bromus tectorum	Cheatgrass	Y	1.333
Zion Scenic Drive	222	326672.838	4124945.821	Bromus tectorum	Cheatgrass	Y	3
Zion Scenic Drive	223	326900.954	4125380.755	Bromus tectorum	Cheatgrass	Y	0.667
Zion Scenic Drive	224	327232.654	4125684.369	Bromus tectorum	Cheatgrass	Y	0.833
Zion Scenic Drive	225	327421.334	4126079.162	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	225	327421.334	4126079.162	Poa bulbosa	Bulbous bluegrass	Y	0.167
Zion Scenic Drive	226	327731.863	4126426.865	Bromus tectorum	Cheatgrass	Y	0.833
Zion Scenic Drive	227	328050.024	4126749.256	Bromus tectorum	Cheatgrass	Y	0.5
Zion Scenic Drive	227	328050.024	4126749.256	Medicago minima	little bur-clover	Y	0.333
Zion Scenic Drive	227	328050.024	4126749.256	Poa bulbosa	Bulbous bluegrass	Y	0.667
Zion Scenic Drive	228	327713.710	4127032.741	Medicago minima	little bur-clover	Y	0.5

Appendix B. Exotic plant patches detected on monitoring routes, Zion NP, May 30–June 4, 2018, cont.

Route	Transect	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	Average_Cover
Zion Scenic Drive	231	327400.336	4127903.644	Bromus tectorum	Cheatgrass	Y	0.167
Zion Scenic Drive	231	327400.336	4127903.644	Medicago minima	little bur-clover	Y	0.167
Zion Scenic Drive	231	327400.336	4127903.644	Poa bulbosa	Bulbous bluegrass	Y	0.167

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National Park Service
U.S. Department of the Interior

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