N-Appendix A: Wildlife Resources

Habitat Suitability Indices

All of the habitat suitability indices (HSI) were built using existing, system-wide GIS data. Datasets used include vegetation mapping, stream data, digital elevation models and existing trails infrastructure. Each model was run in two phases. The first identified all highly suitable habitat for a species based solely on environmental characteristics. This potential habitat value represents the greatest amount of habitat that could be expected on the system given only environmental variables such as vegetation characteristics, slope, aspect and size of habitat patch.

The second phase of modeling attempted to account for impacts to wildlife and habitat related to visitor access and activity by providing a current habitat value based on existing infrastructure and regulations. Existing literature and research was reviewed to identify human impacts related to each of the indicator species. In some cases, specific management recommendations were outlined in the literature and in others, staff used best professional judgment based on the ecology and behavior of similar species.

The products of the habitat suitability models are intended to be just one tool for making management decisions. Highly suitable habitat will help inform where impacts may be focused and where the most effective management for natural resource protection could occur. This will help guide in finding a balance between visitor access and natural resource protection.

Grassland-dependent Butterflies

Three species of grassland-dependent butterflies were chosen as the indicator species group for the Xeric Tallgrass Prairie Conservation Target because of their specific, but similar, habitat needs.

All three species depend on big bluestem, little bluestem or side-oats grama to complete their lifecycle. Female skippers will lay eggs on these grasses and the grasses serve as larval host plants. Therefore, vegetation containing big bluestem, little bluestem or sideoats grama scored higher in the habitat suitability index than other vegetation classes in the North TSA. Further, scoring within bluestem-containing vegetation associations was scaled based on whether bluestem was a major or minor component.

In terms of topography and habitats, skippers use hillsides and ridgetops to display and riparian areas to feed on plant nectar and obtain water (i.e., puddling). Further, research in the North TSA indicates that butterflies use riparian areas disproportionately to their availability. As such, these areas were scored higher in the HSI than other habitat types.

Little information exists on optimal habitat patch size for these species. However, research suggests that larger patches allow for better resiliency against large-scale fires and weed infestations as well as provide adults sufficient enough habitat to breed successfully (Selby 2005, Swengel and Swengel 2007). Staff combined adjacent primary and secondary bluestem

vegetation associations and assessed the distribution of patch sizes to score this variable. Because 90 percent of the skipper detections were in grassland habitat patches larger than two acres, staff used this as a minimum patch size to create Highly Suitable Habitat before and after trail impacts were included. These inputs created Highly Suitable Habitat without Trail Effect (**Map N17**).

Research suggests that recreational trails are avenues for weed infestations, and that, if left unmanaged, colonization by weeds can completely change the composition and structure of vegetation within a habitat (Cole 1978, Benninger-Truax 1992, Pineda and Ellingson 1998, Jordan 2000, Sovell 2014). Because of the dependent relationship between this group of skippers and their larval host plants, a 25 meter buffer was removed from highly suitable habitat adjacent to all designated and undesignated trails in the North TSA to create Highly Suitable Habitat with Trail Effect (**Map N18**).

Finally, although this did not occur in this model, trails and their associated impact zones (i.e., buffers) would split highly suitable habitat into separate patches.

Table NA1. Habitat suitability index inputs for grassland (bluestem)-dependent butterflies.

Variable	Attributes	Ranks	Weight
Vegetation	Vegetation associations with primary bluestem component	9	4
	Vegetation associations with secondary bluestem component	4	4
	Vegetation associations with tertiary bluestem component	2	4
	Other grassland vegetations associations/alliances	3	1
Habitat Modifier	2014 Prairie Dog Colonies	0	0
Topography of Habitat	Elevational Gradient	Valley = 2 Ridgetop = 5 Lower Slope = 7 Riparian = 7 Upper Slope = 9	1 (except Riparian:2x)
Patch Size	Habitat block size of rare skipper observations (acres)	>11 = 9 7-11 = 7 <7 = 5	1
Minimum Patch Size (applied before and after trail effects modeling)			
Only patches ≥2 acres remain highly suitable			
Trail Impacts			
Remove 25 meters of each side of roads, designated trails and undesignated trails Trails that completely bisect a habitat block will split patches			

Prairie Rattlesnake

OSMP staff has consistently observed prairie rattlesnakes, sometimes in groups of six or more, on the grasslands adjacent to Hwy 36 north of Boulder. Because the TSA process involves improving visitor experience, OSMP staff chose prairie rattlesnakes as an indicator species for the Mixed-grass Prairie Mosaic Conservation Target, and one which required further study to effectively manage important rattlesnake habitat and increase visitor safety. Staff incorporated information from a two year study on snake distribution and abundance in the North TSA (Vernalis 2015) to rank vegetation communities and ultimately identify a variety of important habitats (foraging, sunning and over-wintering). This study included the use of radio telemetry on prairie rattlesnakes, which allowed staff to assess rattlesnake habitat use and locate hibernacula of over-wintering rattlesnakes (See snake summary in Wildlife Monitoring Summaries section).

Although prairie rattlesnakes use almost all grassland habitats for foraging, prairie dog colonies are of particular importance as a food source and protection from extreme weather. Exposed rocks and cliffs provide opportunities for cold-blooded organisms to obtain warmth and increase their metabolic rate. Slope aspect also contributes to an increase in available sunlight and heat. Telemetry provided unique insight into habitat preferences of rattlesnakes in the study area. For instance, shrublands accounted for 23 percent of the observations of marked snakes, but the habitat only comprises 11 percent of the study area. Similarly, although prairie dog colonies covered 26 percent of the study area, they averaged 38 percent of the spatial home ranges of marked rattlesnakes (See snake summary in Wildlife Monitoring Summaries section). Habitat scoring in the habitat suitability index reflects these habitat preferences.

The minimum patch size was calculated by integrating the mean home range of radio-marked snakes in the North TSA snake study and identification of important habitat patches by staff. These inputs were used to create the Prairie Rattlesnake Highly Suitable Habitat Without Trail Effect (**Map N14**).

In recognition of the role roads and development play in blocking snake movement across the landscape and the potential for human and dog visitors to modify snake movement and behavior, 25 meters of habitat was removed adjacent to all trails and roads in the with trail effect models. The results of this are shown in the Prairie Rattlesnake Highly Suitable Habitat With Trail Effects (**Map N15**). Below are the complete inputs for the model.

Table NA2. Habitat suitability index inputs for prairie rattlesnake.

Variable	Attribute	Ranks	Weight
Vegetation	Exposed rock or sparse vegetation alliances 25 meter buffer around these alliances	9 5	2 2
	Choke Cherry Shrubland Alliance (A.919) , Skunkbush shrub savannah herbaceous alliance (A.1537), Wax current shrubland alliance (A.923) Slope within this group slope (%),	9 30-80 = 5 0-29 or 80-100 = 1	2 1
	Western Wheatgrass Herbaceous Alliance	9	2
	Shrubland and grassland vegetation alliances with high-	7	2

	use rattlesnake habitat		
	Shrubland and grassland vegetation alliances with moderate-use rattlesnake habitat	5	2
	Shrubland and grassland vegetation alliances with low-use rattlesnake habitat	3	2
	Other vegetation alliances in grassland conservation targets	3	1
Habitat modifier	2014 Prairie dog colonies	9	3
Habitat use	Hibernacula locations	9	3
Topography	Aspect (degrees)	135-225 = 9 45-134.9 = 7 225.1-315 = 5 0-44.9 & 315- 360) = 1	1
Minimum Patch Size (applied before and after trail effects modeling)			
Only patches > 3 acres remain highly suitable			
Trail Impacts			
Remove 25 meters of each side of roads, designated trails and undesignated trails Trails that completely bisect a habitat block will split patches			

Lark Sparrow

The grassland portions of the North TSA provide habitat for a diverse mix of wildlife species. Although lark sparrows are just one of the many bird and animal species that use this area, they were selected as a focal species for the North TSA because of their abundance in these grassland habitats and association with shale communities (Hair et al. 2000).

Highly suitable lark sparrow habitat in the North TSA represents areas dominated by mixed grass vegetation types, often with shale communities or a shrub/yucca component. Two main components that are required for lark sparrows to nest are a variety of vegetation heights and open views (Kingery 1998). Within these habitats, both low to moderate density herbs and grasses and scattered woody vegetation are required. Lark sparrows nest on the ground, often at the base of bunchgrass, cactus, or shrubs, or up to 3 meters high in a tree (Kingery 1998). This makes their nests susceptible to disturbance by off-trail human and dog use.

Grassland vegetation alliances with a mostly native grass component including those associated with shrub communities and with other woody vegetation present were included in the model. Non-native, or semi-native vegetative alliances within the grassland were included, but scored lower than native vegetation types because previous studies have found lark sparrows to be much more abundant on native grass than non-native grass sites (Knopf 1994, Flanders et al. 2006). Areas of current (2014 mapping) prairie dog occupation was included as a negative habitat modifier because successful lark sparrow nests have been found to be located in areas with less bare ground and more litter cover, both of which are not typical of occupied prairie dog areas (Lusk 2003).

Larger patches of habitat were given a higher rank because of their increased ability to support breeding grassland birds. In addition, a minimum patch size of 10 hectares (~25 acres) was applied to this model to account for territory requirements and the areas sensitive nature of many ground nesting grassland bird species. Results are shown in the lark sparrow Highly Suitable Habitat Without Trail Effects (**Map N12**).

Studies of grassland bird responses to recreational use have found that near trails, grassland nesting birds are less likely to nest, less abundant and experience lower nesting success (Miller et al. 1998). Further, Bock et al. (1999) found this species to be more abundant in interior grasslands than those near development.

Because of this, recreational trails were buffered up to 300 feet, and habitat quality was scored higher with increasing distance from the trail. Human development was buffered up to 600 feet and scored using similar methods. These results can be seen in **Map N13**.

Table NA3. Habitat suitability index inputs for lark sparrow.

Variable	Attribute	Ranks	Weight
Vegetation	Native grassland habitats, including those with yucca or other shrub components and shale communities	9	3
	Semi-native or non-native grassland habitats	4	3
Habitat Modifier	2014 Prairie dog colonies	0.5 multiplier	1
Patch Size	Acres of contiguous preferred vegetation	0-2 = 1 2-8 = 3 8-30 = 5 30-100 = 7 100-1283 = 9	1
Minimum Patch Size (applied before and after trail effects modeling)			
Only patches > 24.7 acres (10 hectares) remain highly suitable			
Trail and Road Impacts			
Habitat Edges	Distance (feet) from urban edges and roads	0-100 = -8 100-200 = -6 200-300 =-3 300-600 = -1	1
Trail Effects	Distance (feet) from designated and undesignated trails	0-150 = -6 150-300 = -3	1

Lazuli Bunting

This model accounts for a suite of bird species that depend on the shrub cover provided by the vegetation communities within the upland shrublands and wetland and riparian targets. Species like lazuli bunting, gray catbirds, blue-gray gnatcatchers, yellow-breasted chats, black-headed grosbeaks and blue grosbeaks are all species that depend on riparian and upland shrublands for

nesting habitat. Shrub-nesters require areas of dense vegetation and tend to nest one to three meters above the ground (Harrison 1979).

Shrub-nesting bird habitat in the TSA includes areas dominated by upland or riparian shrubland vegetation. Lazuli buntings are associated with shrublands between 5,500-7,000 feet and riparian areas that intersect the transitional area from the plains that provide a diversity of shrub and tree species and vegetative structure (Andrews and Righter 1992, Kingery 1998). Within these areas, lazuli buntings show no affinity to specific shrubland habitat and use a variety of different shrubland alliances within the transitional zone (Berry and Bock 1998, Kingery 1998). As a result, all vegetation alliances with high shrub components were included in the model as the base habitat layer. Larger shrub patches create more effective bird habitat and each patch was ranked based on overall patch size. In addition to patch size, shrublands within 25 meters of a stream were ranked higher than those beyond 25 meters. Interconnected patches within stream corridors provide nesting habitat but also provide movement corridors across the landscape and connect blocks of habitat together. In addition, larger complexes of connected shrub habitat provide high quality foraging areas and increase the chances of multiple nesting species. Because the model in intended to call out nesting habitat, a lower size threshold for highly suitable habitat was set at three acres based on the minimum territory size for a pair of lazuli buntings (Greene et al. 2014). The results from this analysis are displayed in the map Lazuli Bunting Highly Suitable Habitat without trail effect (**Map N23**)

A number of studies have been conducted on both OSMP lands and in other areas that look at the impacts of trails on birds. Miller et al. (1998, 2001) found that grassland and forest bird species were more abundant away from trails and the abundance increased as the distance from trails increased. A study of riparian areas in Boulder County (Miller et al. 2003) showed that trail use affected riparian bird densities. In addition, within riparian areas, species such as lazuli buntings may avoid riparian areas with high levels of recreational activity that favor human-adapted species such as corvids (Blakesly and Reese 1988, Miller et al. 2003). Trail impacts were accounted for in this model by removing areas directly adjacent to existing trails. An area of 50 meters was removed from highly suitable habitat on both sides of existing trails. This was based on the 75 – 100 meter area adjacent to trails where bird densities showed a decrease in the Miller (1998) study for grassland nesting birds. The number was reduced to account for differences in grassland and shrub habitats. An additional 20 feet was removed along trails with voice and sight regulations to account for dogs and people leaving the trail. **Map N24** displays the results of this analysis.

Table NA4. Habitat suitability index inputs for lazuli bunting.

Variable	Attribute	Ranks	Weight
Vegetation	Shrubland alliances, both upland and riparian	48-85 ac= 9 24-48 ac = 6 12-24 ac = 3 3-12 ac = 1	1
	Riparian corridor habitat blocks >=3 acres and <=25 meters from a perennial or intermittent stream	5	1
Minimum Patch Size (applied before and after trail effects modeling)			
Only patches > 3 acres remain highly suitable			

Trail and Road Impacts
Remove 20 feet + 50 meters on each side of Voice and Sight designated trails Remove 50 meters on each side of all other trails and roads

N-Appendix A: Wildlife Monitoring Summaries

This section summarizes all of the wildlife monitoring projects and surveys either conducted by OSMP staff or contractors in the North TSA. OSMP wildlife staff surveys songbirds nesting in native grasslands and in irrigated hayfields, amphibians, bats, raptors, prairie dogs and waterfowl. OSMP staff has also assisted Colorado Parks and Wildlife during fish surveys, and has recently partnered with CNHP to assess butterfly abundance and distribution and with Vernalis, Inc. to learn more about snake ecology in the North TSA.

Snake Distribution and Abundance and Prairie Rattlesnake Telemetry in the North Boulder Grasslands

Background and Methods

The OSMP-managed lands directly north of Boulder contain high-quality habitat for snakes as the grasslands and associated prairie dog colonies provide shelter and food while the hogbacks and exposed rocks, intermingled with shrub patches create ideal hibernacula locations (OSMP 1996). To learn more about snake distribution and abundance and identify important snake habitats in the North Boulder Grasslands (NBG), OSMP partnered with Vernalis, Inc., a non-profit organization specializing in studying herpetiles, to conduct snake surveys and attach radio transmitters to prairie rattlesnakes.

In years past, OSMP staff has consistently observed prairie rattlesnakes, sometimes in groups of six or more, on the grasslands adjacent to Hwy 36 north of Boulder. Because the TSA process involves improving visitor experience, OSMP staff chose prairie rattlesnakes as a focal conservation species and one which required further study to effectively manage important rattlesnake habitat and increase visitor safety. Although observations of snakes is useful for planning purposes, the use of radio telemetry allowed staff to learn more about rattlesnake habitat use and locate hibernacula of over-wintering rattlesnakes.

From 2012-2014, OSMP staff assisted Vernalis with snake surveys on the properties north of Boulder along both sides of Hwy 36, although greater time was spent surveying the properties west of the highway. Visual encounter surveys were employed to detect snakes. When snakes were encountered, they were captured and marked so as to avoid counting the same individual in subsequent surveys. In 2013 and 2014, Vernalis attached radio transmitters with a 10 week lifespan (model HB-2, Holohil, Inc.) to the dorsa of a subset of prairie rattlesnakes using carpet tape, then a layer of camouflaged duct tape. Although snakes will lose the transmitter when they shed, staff chose this method of attachment over surgical implantation to minimize disturbance to the individual. OSMP staff obtained visuals of each marked snake every two to five days.

Staff created minimum convex polygons (MCP) for each tracked rattlesnake to represent individual home ranges. OSMP's vegetation map was then used to characterize habitat within

each MCP. The “study area” was created using a 95 percent kernel estimator around all snake observations in the NBG.

Results and Discussion

Snake Detections: Six species were detected on the NBG—prairie rattlesnake, milk snake, plains black-headed snake, wandering garter snake, eastern racer and bullsnake. Prairie rattlesnakes were most numerous, whereas bullsnake and garter snake were rarely observed (Vernalis 2015, **Table NA5**, **Map N10**). Almost 90 percent of prairie rattlesnake (n=60) and plains black-headed snake (n=16) detections occurred in grassland habitat types (**Table NA5**), a value equal to the proportion of grassland habitats in the study area (89 percent).

Unlike other snake species, about half of the prairie rattlesnake detections in grassland habitat types occurred in prairie dog colonies, suggesting that prairie dog colonies provide important habitat for rattlesnakes. Further, although the western wheatgrass herbaceous alliance constituted 57 percent of the study area, more than ¾ of all prairie rattlesnakes and 70 percent of all eastern racers were detected here, suggesting that this grassland habitat type may also be important for snakes in the NBG.

Within the study area, prairie rattlesnakes exhibited a clumped spatial distribution significantly different from random (Vernalis 2015). Plains black-headed snakes; however, exhibited a highly clumped distribution, with most individuals located at mid-elevations in rocky areas on the southeast-facing sides of the hogbacks (**Figure NA1**, Vernalis 2015). It is unclear whether the observed close proximity between individual plains black-headed snakes is communalism or preference for a limited habitat type.

Records for plains black-headed snake in Colorado are relatively few, and the species distribution in Boulder County is thought to be limited (Vernalis 2015). Because of the species clustered distribution in two separate areas on the slopes of the hogbacks on the study site (**Figure NA1**), habitat protective measures should be taken to avoid disturbing natural surface objects (primarily rocks at these two areas). All detections of plains black-headed snakes were beneath rocks. Rocks serve as critical refugia during the warmer months when this species is surface active and the primary prey of plains black-headed snakes (centipedes and other crawling insects) are most plentiful beneath rocks (Vernalis 2015). Although plains black-headed snakes were not located near intermittent creeks on the NBG, the close proximity of individuals to these areas and the species reliance on moist microhabitats suggests protection of intermittent creeks and rock outcroppings is warranted (Vernalis 2015).

Prairie Rattlesnake Radio Telemetry (OSMP unpublished data): In 2013-2014, 15 prairie rattlesnakes were outfitted with radio transmitters. Transmitters remained on each snake for an average of 46.8 ± 6.4 days (range: 7-119 days) and each snake was observed 10.6 ± 1.4 times (range: 2-24). Average daily movement was 41.5 meters ± 9.4 (range: 4.5-147 meters). One snake moved at least 399 meters in two days, and one traveled at least 133 meters and gained 70 meters in elevation in two days across an intermittent stream en route to an over-wintering site (**Map N11**). These observations suggest that rattlesnakes can move relatively long distances in a short time frame. On average, marked rattlesnakes travelled 124 ± 38.8 meters from initial

capture location, and averaged 529.9 ±142.4 meters in total distance travelled (range: 9-2218 meters) further reinforcing that some rattlesnakes move substantial distances. Although eight rattlesnake home ranges were < 1 acre, four of which were < 0.2 acres, one was as large as 23.6 acres (mean: 4.3 [1.6] acres). Prairie rattlesnake home ranges in this study were substantially smaller than that documented for the same species in Arapahoe County, Colorado (mean: 38 acres; Shipley et al. 2013).

In terms of habitat use, 23 percent (n=44) of the observations of marked snakes were in shrublands (**Table NA6**). This suggests that opportunistic sightings of snakes in shrublands using visual encounter techniques was difficult (because only 10 percent of rattlesnake detections using this method occurred in shrublands) and that rattlesnakes are using this habitat type disproportionately to its availability in the study area (shrublands comprise 11 percent of the study area).

More than half of observations of marked rattlesnakes were in the western wheatgrass herbaceous alliance (**Table NA6**), and this grassland type constituted, on average, 62 percent of the snakes' home ranges. This was to be expected; however, as this alliance covered 58 percent of the study area (**Table NA5**). Although prairie dog colonies covered 26 percent of the study area, they represented 38 percent of the home ranges of marked rattlesnakes, suggesting that prairie dog colonies provide important habitat to rattlesnakes in the study area.

Seven rattlesnake hibernacula were identified during this study—two were located in the choke cherry shrubland alliance, four in the western wheatgrass herbaceous alliance, and one in the smooth brome/western wheatgrass herbaceous alliance (**Map N10**). Rattlesnakes were using prairie dog burrows as over-wintering sites in all five of the grassland locations, and two of these sites supported more than one prairie rattlesnake. This observation supports the findings of Shipley et al. (2013)—prairie rattlesnakes are strongly attracted to prairie dog burrows and favor the shorter sparser vegetation characteristics of prairie dog colonies.

Telemetry provided unique insight into habitat preferences of rattlesnakes in the study area. The information gleaned from this study highlights the importance of shrublands and prairie dog colonies in providing key habitat for rattlesnakes. Potential management actions involving protecting shrublands and prairie dog colonies should be considered to conserve this resource and maintain visitor safety in the North TSA.

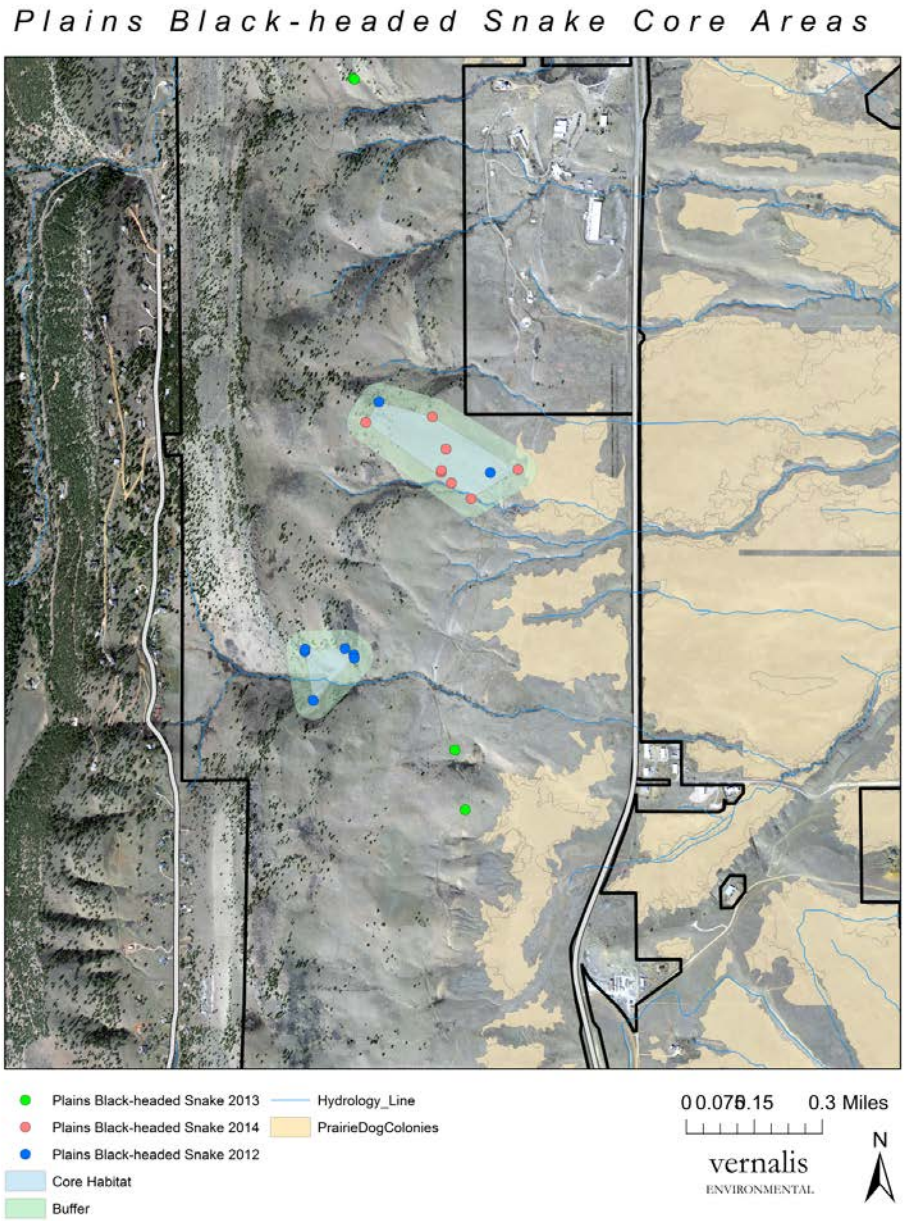

Figure NA1. Plains black-headed snake core areas as identified by clumped observations of the species in the North Boulder Grasslands.

Table NA5. Vegetation classes contained in the study area and snake observations (2012-2014) by OSMP staff and Vernalis, Inc.

	Western Wheat-grass	Intermediate Wheatgrass	Big Bluestem - (Yellow Indiangrass)	Needle and Thread-Blue Grama	New Mexico Needle-grass	Smooth Brome Semi-Natural	Ponderosa Pine Tallgrass Savannah	Baltic Rush Seasonally Flooded	Mountain-Mahogany	Choke Cherry	Netleaf Hackberry	Soapweed Yucca Evergreen	Skunkbrush Shrub Savannah	Shale Barrens	
Acres in Study Area	137	13	24	10.5	7.5	10.0	1.4	0.2	2.0	10.9	0.9	*	2.2	*	
% of Study Area	58	5.6	10.1	4.4	3.1	4.2	0.6	0.1	0.9	4.6	0.4	-	0.9	-	
															Total #
Prairie rattlesnake	47	-	4	2	1	1	1	1	2	4	1	2	-	2	68
Eastern racer	17	-	2	2	-	-	-	-	-	2	-	-	1	-	24
Plains black-headed snake	11	-	4	1	1	-	-	-	1	-	-	-	1	-	19
Bullsnake	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Milk snake	1	-	1	-	-	-	-	-	-	-	-	-	-	-	2

*Some habitat types where snakes were detected fell outside of the Study Area, but were still included in this table

Table NA6. Observations of marked prairie rattlesnakes by vegetation type in the North Boulder Grasslands in 2013-2014.

Level	**Count**	**%**
Big Bluestem - (Yellow Indiangrass) Herbaceous Alliance	7	3.7
Choke Cherry Shrubland Alliance	27	14.4
Crested Wheatgrass Semi-Natural Herbaceous Alliance	5	2.7
Indian Ricegrass Herbaceous Alliance	1	0.5
Intermediate Wheatgrass Semi-natural Herbaceous Alliance	6	3.2
Needle-and-Thread - Blue Grama Herbaceous Alliance	11	5.9
New Mexico Needlegrass Herbaceous Alliance	4	2.1
Peachleaf Willow Temporarily Flooded Woodland Alliance	4	2.1
Skunkbush Intermittently Flooded Shrubland Alliance	11	6.0
Skunkbush Shrub Savannah Herbaceous Alliance	2	1.1
Smooth Brome Semi-Natural Herbaceous Alliance	4	2.1
Western Wheatgrass Herbaceous Alliance	106	56.4
Total	188	

Raptor Monitoring

Background and Methods

The North TSA provides nesting habitat for four species of raptors—golden eagles, osprey, Northern harriers and burrowing owls (**Map N25**). All raptors are protected under the Migratory Bird Treaty Act. Golden eagles are also afforded additional protection under the Federal Bald and Golden Eagle Protection Act. Burrowing owls and golden eagles are considered threatened in Colorado. Burrowing owls and Northern harriers are considered sensitive by the US Forest Service and BLM. The Boulder County Comprehensive Plan also designates all of these species as species of special concern. To minimize human-caused disturbance to nesting pairs and manage for a protective buffer around occupied nest sites, OSMP institutes seasonal closures surrounding nest sites. Instituting these protective measures at nesting sites as well as managing for natural areas, which provide foraging opportunities for raptors, has helped OSMP provide high-quality nesting habitat for a wide variety of raptor species. Nest monitoring is conducted on a regular basis by staff and a dedicated team of volunteers. Closures are lifted early when monitoring indicates that raptors are no longer occupying the site.

Results and Discussion

Golden Eagle

The North TSA management area contains one golden eagle nesting territory—Lefthand Palisades. Occupancy of Lefthand Palisades by golden eagles was first described by Denis Gale in the 1880s and a handful of known nesting outcomes date as far back as 1904. The Lefthand territory was one of 10 Front Range golden eagle territories described by Jollie in his masters thesis, published in 1943. These sources suggest that the Lefthand Palisades has been consistently occupied by golden eagles for over 130 years.

Two metrics are commonly used to compare raptor population health among sites—nesting success (fledging at least one nestling) and productivity (number of fledglings produced). Nesting success by golden eagles at Lefthand Palisades was lower than that documented for golden eagles nesting elsewhere on OSMP (e.g. Skunk Canyon [91 percent] and Flagstaff [100 percent]), but higher than that reported by Kochert et al. (2002) for golden eagles nesting along the Snake River in Idaho (62 percent).

Golden eagle productivity at Lefthand Palisades was lower than at other sites on OSMP (Skunk: 1.4; Flagstaff: 1.2) and in Idaho (1.6), but still reached the biologically important threshold of 1.0 fledgling per nesting attempt similar to golden eagles studied in Alaska (McIntyre and Adams 1999).

Unfortunately, golden eagles nesting at the Lefthand Palisades have failed in their nesting attempts seven out of the last 10 years, although 2015 looks promising as the pair currently has one healthy fledging.

Osprey

Two artificial structures serve as osprey nesting substrates on OSMP property near Boulder Reservoir. Two additional poles are located on lands surrounding Boulder Reservoir managed by City of Boulder Parks and Recreation (PNR). Artificial nesting structures were established in the area to mitigate against osprey building nests on poles used by Xcel Energy to deliver electricity. According to Xcel, stick nests on poles which support "charged lines" are considered hazardous to the welfare of the birds, represent a potential fire hazard and could disrupt the delivery of electricity. Thus, alternate nesting substrates are provided nearby.

Osprey nesting success and productivity on OSMP has been low since the birds began nesting attempts. Osprey nesting attempts at Axelson North have not been successful since 2010 and only two of the last five nesting attempts (2010 thru 2014) at Axelson South have been successful. Comparatively, osprey nesting closer to the Reservoir on PNR property have been successful four of the last five years, and osprey nesting on other OSMP-managed properties and been successful at least three of the last four years. Causes of the comparatively low reproductive rate observed at Axelson are unknown.

Table NA7. Nest site information for osprey and golden eagles nesting in the North TSA.

Species	Site	1st year of seasonal closure	First year of monitoring (total # yrs)	# of nesting attempts	Nesting Success*	Mean Productivity**
Golden Eagle	Lefthand Palisades	1992	1974 (41)	39	72% (n = 28)	0.97 ± 0.119
Osprey	Axelson North (AX1)	2006	2006 (9)	9	55% (n = 5)	0.89 ± 0.31
Osprey	Axelson South (AX2)	2005	2005 (10)	7	57% (n = 4)	1.71 ± 0.644

* Success in fledging at least one nestling
** Number of fledglings/nesting attempt

Northern Harriers

The North TSA contains all of the known Northern harrier nesting attempts on OSMP and three of the four known 2015 nesting attempts in Boulder County. Northern harriers require large, undisturbed blocks of wetland habitat to nest and grasslands for foraging. Because of this, they may be habitat-limited in Boulder County. In 2014, a pair of Northern harriers nested successfully (three nestlings fledged) on OSMP property near Nelson Road and 51st Street. In 2015, a new pair of Northern harriers attempted to nest west of BVR pond 1 on Boulder Valley Ranch (outcome currently unknown).

These recent additions to the Boulder County breeding population of Northern harriers is an encouraging development because the historical nesting site on property managed by PNR has only supported nesting attempts in five of the last 10 years and only two of these have been successful in fledging young. Further, the other known Northern harrier nesting attempt in

Boulder County in 2015 is on land managed by Boulder County Parks and Open Space. This site has not been occupied by harriers since 2010, and that year the nesting attempt failed.

It is clear that this species is a rare breeder in Boulder County and struggles to successfully nest here. It is possible that fragmentation of potential nesting habitat by roads, agriculture and other human activities limits Northern harrier nesting opportunities and nesting success in Boulder County (Jones 2014). Nests situated in smaller, fragmented marshes may be more susceptible to predation by carnivores and raptors (Smith et. al. 2011). Jones (2014) reports that volunteers monitoring the nesting pair on PNR property have consistently observed coyotes accessing the harrier nesting site west of the reservoir and harriers defending territories from red-tailed hawks.

Amphibian Monitoring

Background and Methods

Since 2006, OSMP staff has employed Visual Encounter Survey (VES) methods to survey for amphibians. The focal species of interest is the northern leopard frog—a native species in marked population decline in the western US and considered a species of greatest conservation need in 21 states, including Colorado.

Threats to leopard frog populations are numerous and likely interact. They include: habitat loss and degradation, pesticide use, fungal pathogens, the spread of non-native species like predaceous fish and bullfrogs into otherwise suitable breeding habitats, changes in the hydrological regime and increased variability in temperature and precipitation.

Because leopard frogs compete with American bullfrogs for resources and are sometimes predated by this invasive species, bullfrogs have been linked to population declines of western ranid frogs. Therefore, understanding the distribution and abundance of bullfrogs on OSMP is essential. From 2006-2008, volunteers and staff worked together to conduct VES to survey for amphibians on OSMP wetlands. From 2009 to the present, VES has been conducted by OSMP staff only.

Results and Discussion

Of the 163 VES sites throughout OSMP, 51 are located in the North TSA (**Map N20**). Of these sites, 53 percent (n=27) supported non-native bullfrogs, 33 percent (n=17) supported native Woodhouse's toads, 14 percent (n=7) supported native western chorus frogs and only one site supported native tiger salamanders (**Table NA8**).

In 2008, a single northern leopard frog was detected at Bennett pond. Unfortunately, this individual was never actually observed by the surveyor (i.e., detection was auditory) and subsequent surveys did not detect a leopard frog at Bennett. Thus, the accurate identification of this individual is questionable and it is probable that northern leopard frogs are entirely absent from waters in the North TSA.

Staff detected native amphibians only in 16 percent (n=6) of the 37 North TSA VES sites that supported amphibians. This is similar to what was found system-wide during 2012 surveys, when 22 percent of VES sites supported native amphibians only. However, bullfrog site occupancy was substantially higher in the North TSA than was found systemwide in 2013, when 31 percent of VES sites supported bullfrogs.

In the mid 1990s, northern leopard frogs were detected at three locations in the North TSA—Mesa Reservoir, Axelson pond #1 and a pond on the Hart-Jones property. The most northern OSMP property that currently supports northern leopard frogs is Ertl, along Boulder Creek. Northern leopard frogs prefer natural landscapes (e.g., less habitat fragmentation and human development) with less agricultural pressure. Most sites supporting leopard frogs on OSMP are ephemeral ponds surrounded by native grasslands located in the south half of the system. It is probable that the pressure introduced by the presence of bullfrogs, increased habitat

fragmentation near wetlands, as well as the availability of permanent water sources which favor bullfrogs has affected the ability of leopard frogs to populate OSMP properties north of Boulder. However, restoration opportunities exist at some sites in the North TSA that would improve northern leopard frog habitat conditions. Managing water levels is key to disrupting bullfrog breeding cycles; therefore, only sites where this is possible would qualify as candidates for restoration.

Table NA8. Numbers of years that amphibians were detected at ponds in the North TSA. *AMTI = Tiger Salamander; BUWO = Woodhouse's Toad; PSTR = Western Chorus Frog; RACA = American Bullfrog; RAPI = Northern Leopard Frog*

Site Number	Site Description	Years sampled	Number of years surveyed	AMTI	BUWO	PSTR	RACA	RAPI
005	Wonderland Lake	2006, 2013-14	3	-	-	-	2	-
018	Beech Intermittent Creek	2008	1	-	-	-	-	-
021	Waldorf Pond	2008-09, 2013-14	4	-	-	-	1	-
022	Suitts Pond West	2008, 2012-13	3	-	-	-	2	-
023	Suitts Pond East	2008, 2012-13	3	-	2	-	2	-
024	Bennett Reservoir	2008-14	7	-	4	-	7	1
025	Bennett SW Pond	2008-10, 2012-14	6	-	3	1	2	-
029	Waldorf Irrigation Ditch	2008-09, 2013-2014	4	-	-	-	-	-
032	Stratton North Pond	2008-09, 2011, 2013-14	5	-	2	-	4	-
034	Stratton South Pond	2008-09, 2011, 2013-14	5	-	2	-	1	-
036	Axelson Pond 2	2008, 2010, 2014	3	-	-	-	3	-
037	Axelson Pond 3	2008, 2010, 2014	3	-	-	-	1	-

038	Axelson Pond 4	2008, 2010, 2014	3	-	1	-	2	-
040*	Ellison Pond	2008, 2010, 2014	3	-	1	-	-	-
042	Schneider Intermittent Creek	2008	1	-	-	-	-	-
043	BVR Pond 1	2008, 2013-14	3	-	-	2	2	-
045	BVR Pond 2	2008-09, 2013-14	4	-	2	1	2	-
047	Papini Pond 5	2008, 2012-14	4	-	-	-	-	-
048	Papini Pond 4	2008, 2012-14	4	-	-	-	1	-
049	Papini Pond 3	2008, 2012-14	4	-	-	-	1	-
051	Papini Pond 2	2008, 2012-14	4	-	-	-	1	-
052	Papini Pond 1	2008, 2012-14	4	-	-	-	-	-
053	BLIP II Pond 1	2011-14	4	-	-	-	-	-
054	BLIP II Pond 2	2008-14	7	-	1	-	7	-
055	BLIP II Pond 4	2008-09, 2013-14	4	-	-	-	3	-
056*	Seigle Pond	2008-09, 2013-14	4	1	3	-	-	-
057	BLIP II Pond 3	2008-2009, 2011, 2013-14	5	-	-	-	4	-
058	Lousberg Pond 1	2008-09, 2012-14	5	-	-	-	5	-
059	Lousberg Pond 2	2008, 2012-14	4	-	-	2	2	-
060*	Papini Intermittent Stream 2	2008, 2013-14	3	-	-	1	-	-
061*	Papini Irrigation Ditch 1	2008, 2013	2	-	2	-	-	-
066	Mesa Reservoir	2006, 2008-09, 2011-14	7	-	4	1	5	-

072	Waldorf Creek	2008-09, 2013-14	4	-	-	-	-	-
075	Ryan Intermittent Creek	2008, 2013-14	3	-	-	-	-	-
076	Suitts Intermittent Creek	2008, 2012-13	3	-	-	-	-	-
077	Suitts Creek	2008, 2012-13	3	-	1	-	1	-
078	Steele Intermittent Creek 1	2008-09, 2012-13	4	-	-	-	-	-
079	Bennett Intermittent Creek 1	2008-09, 2014	3	-	1	-	1	-
081*	Steele Intermittent Creek 2	2008-09, 2014	3	-	1	-	-	-
082	Bennett Intermittent Creek 2	2008-09, 2014	3	-	-	1	1	-
083	Bennett Intermittent Creek 3	2008-09, 2013-14	4	-	-	-	-	-
084*	Steel Irrigation Ditch	2008-09, 2013-14	4	-	2	-	-	-
085	Johnson Irrigation Ditch	2008, 2013-14	3	-	-	-	-	-
086	Bruning Irrigation Ditch	2013-14	2	-	-	-	-	
087	IMEL South – Left Hand Creek	2008-09, 2012	3	-	2	-	2	-
088	Stratton Irrigation Ditch	2011	1	-	-	-	-	-
135	Stratton NW Pond	2009, 2011-14	5	-	-	-	3	

*only native species detected during surveys

Fish Surveys

Background and Methods

OSMP staff has historically assisted Colorado Parks and Wildlife (CPW) fish biologists in sampling ponds and creeks on OSMP to determine fish species distribution and abundance, identify important resources to sustain native fish populations, assess sport fish opportunities and direct aquatic habitat improvement projects.

Of particular interest to CPW is the conservation of Iowa darter, northern redbelly dace and plains topminnow—three native fish species considered by CPW to be of greatest conservation need (CPW 2014)—and continuing to provide high-quality sport fishing opportunities in Boulder County. Survey methods depended on the type of water, but included deploying seines and electrofishing using a boat or backpack.

To better inform CPW's fish management program on OSMP and to provide specific information to drive aquatic habitat restoration, OSMP staff collected bathymetric measurements at 20 ponds throughout the system in 2014 using a Hummingbird 386 fishfinder (Techsonic Industries, Inc. Eufaula, AL. USA) attached to a canoe. The area of each pond was covered in its entirety by paddling transects across the pond while the Hummingbird unit collected depth measurements and geographic coordinates.

Results and Discussion

In the North TSA, CPW sampled 31 sites from 1968-2013 (**Map N21**). Although northern redbelly dace and Iowa darter were not detected in the North TSA, CPW surveys identified five ponds on three properties in the North TSA that supported plains topminnow (Lappin, Axelson and BLIP). Because the North TSA contains five of the seven ponds on OSMP that support plains topminnow, habitat protection and improvement measures should be considered to conserve this species.

Plains topminnow were once common in transitional creeks and streams in the South Platte River Basin, but populations have substantially declined for a variety of reasons including changes in creek hydrology, water temperature, and in-stream habitat caused by dams and introduction of non-native fish. To mitigate the effects of habitat loss and interspecies competition on populations of native fishes, CPW routinely manages isolated ponds that meet specific habitat requirements as broodstock refugia with the ultimate goal of transplanting individuals from artificial ponds to creeks. In recent conversations with CPW, several ponds were identified as either already acting as important native fish refugia or provided compelling opportunities for habitat restoration to act as native fish refugia.

One of the goals of recording bathymetric measurements on OSMP ponds and reservoirs was to identify waters that were shallow and thus better suited to act as native fish (and amphibian) refugia and those that were deep, which would better support a recreational fishery. Introduced fish like largemouth bass and tiger muskie require colder water with higher oxygen levels, thus deeper ponds act as more effective fisheries for sport fish. One of the deepest reservoirs that OSMP manages is Wonderland Lake (deepest depth: 17 feet). Therefore, along with other

fishing opportunities on public lands north of Boulder like Coot Lake, Boulder County Fairgrounds Lake, Lagerman Reservoir, and Boulder Reservoir, Wonderland Lake may present an opportunity to provide a high-quality fishing experience in the North TSA.

Lepidoptera Surveys

Background and Methods

Butterflies and skippers (i.e., lepidopterans) are excellent indicators of ecosystem health and integrity. In particular, the presence of grassland-dependent species which rely on native grasses to feed their larvae provide an effective proxy in identifying high-quality habitat. In the Grassland Plan (OSMP 2011), a list of 20 grassland-specialist lepidopterans were identified as important species to track grassland health. Some of these species are considered vulnerable to extinction or imperiled statewide by CNHP, or are considered a species of conservation interest by the US Forest Service, and in the Boulder County Land Comprehensive Plan. Their unstable conservation status is largely due to the loss of about 99 percent of tallgrass prairie since European settlement in North America (Swengel and Swengel 2013).

The North Boulder Grasslands is identified as a potential conservation area by CNHP with a B2 ranking—very high biodiversity significance—because of the presence of intact native mixed-grass prairie and the associated rare grassland-dependent skippers that require the presence of native prairie grasses to complete their life cycle (**Map N2)**.

Various butterfly surveys have occurred in the North TSA throughout the years. These include surveys from 1997 (Pineda and Ellingson 1998),1999-2000 (Collinge et al. 2003), 2001-2002 (Armstead 2003), and 2007-2008 (Robinson et al. 2012). In 2013 and 2014, OSMP partnered with CNHP to conduct lepidoptera surveys in the North Boulder Grasslands to assess the distribution and abundance of rare skippers in the area. Unlike previous surveys in the area, which used either pre-established transects or plots to sample butterflies, CNHP employed Pollard-Yates walkabouts (Pollard 1977) to survey Lepidoptera in the North Boulder Grasslands in 2013 and 2014. The walkabout or "checklist" survey is an alternate methodology in which the survey route is not fixed (Royer et al. 1998). It involves an unrestricted comprehensive search and has the advantages of being fairly simple and focusing the effort in the habitats of targeted rare species.

Results and Discussion

Species richness increased from 32 to 45 from 2013 to 2014 and there were 394 unique observation locations for butterflies within the study area in 2014, almost 400 percent more than the 79 unique observation sites recorded in 2013 (Sovell 2013, 2014). Taken together, these data suggest that conducting lepidopteran surveys for two consecutive years, as outlined in the Grassland Plan, addresses interannual changes in weather and detection probability and provides a more accurate account of butterfly populations.

During 2013-2014, there were 59 observations of rare butterflies that are tracked by CNHP including 20 records of the globally-vulnerable Arogos skipper (G3S2), two state-imperiled Crossline skipper (G4G5S2), 34 state-imperiled Dusted skipper (G4G5S2) and three records of the globally-vulnerable Ottoe skipper (G3G4S2) [**Table NA9**, **Map N16**]. All of these skippers were observed on the west portion of the study area, west of Hwy 36, even though surveys were conducted on the east side of the highway (Sovell 2013, 2014). One two-spotted skipper was detected in the wetland near Lefthand Valley Reservoir in 1997, but none were observed in 2013

or 2014. Habitat for other rare grass skippers was present throughout the study area including blue grama, the host plant for the simius roadside skipper (G4S3) and rhesus skipper (G4S2S3), but no individuals were observed.

Grassland was the most dominant habitat type where rare butterflies were observed during our surveys and in surveys conducted by Pineda and Ellingson (1998). The rare butterflies observed in the North Boulder Grasslands require large patches of native grasses like big bluestem, little bluestem and side-oats grama to complete their life cycle as these plants are the sole food sources for their larvae (i.e., host plant). The distribution of these insects suggests that high-quality native grassland habitat is fairly well distributed throughout the study area west of the highway. However, non-random clumping of individuals is associated with riparian areas as well as on the Buckingham property (**Map N16**).

In 2014, 20 percent (78 unique observation sites) of all butterfly sightings were located within riparian areas, similar to the 25 percent (20 unique observation sites) that were recorded in riparian areas in 2013. Riparian areas only occupy about 230 acres, or nine percent, of the 2,500 acre study area. This concentration of observations within drainages indicates not only that a moderate number of host plants are dependent upon riparian zones, but also that moist, mesic sites within an otherwise dry landscape, support higher proportions of nectar resources for adult butterflies (Sovell 2014).

The results of the surveys conducted by CNHP demonstrate the importance of the North Boulder Grasslands to the ecological integrity of the butterfly community along the Front Range. As noted earlier, some of the rare species observed in the study area are not only imperiled in Colorado, but also threatened globally. The Front Range offers highly desirable areas to live and recreate, and human-caused loss of native tall- and mixed-grass prairie habitats will continue to be a major threat to the stability of grassland-dependent species.

The North Boulder Grasslands represent one of OSMP's best opportunities to conserve threatened butterfly species and their native grassland habitats. Future management actions in the study area should consider this. Potential management considerations to conserve the habitat that supports rare skippers in the study area include (Sovell 2014):

1) Introduce prescribed fire— Prescribed fire is one of the principal tools used to manage native prairies. It benefits prairie-specialist butterflies such as the Arogos skipper, Crossline skipper, Dusted skipper, and Ottoe skipper and by helping to control habitat loss to cool season exotics and woody vegetation, increasing the vigor of native species (including larval food plants), and increasing flowering rates of important nectar sources (Selby 2005). In January 2009, the Olde Stage Fire burned the majority of the study area, yet many species that were detected before the fire were also detected after, suggesting that the intensity and coverage of the Olde Stage Fire did not severely impact the populations of CNHP-tracked, grassland-dependent butterflies in the study area.
2) Manage habitat loss via exurban development and intensive recreation— Intensive recreation including trail development should be avoided within tallgrass, mixedgrass and riparian habitats with habitats supporting tall grasses and the common hop being particularly important for rare butterfly populations. Problems associated with concentrated recreation and butterfly diversity include trampling by humans and pets;

run-off from trails, roads, and parking lots; increased fire risks; and introductions of weeds that can completely change the composition and structure of vegetation within a habitat. The current presence of nonnative plants is a concern within the study area and recreational trails are known to be avenues for weed infestations (Pineda and Ellingson 1998). If host plants and nectar resources are lost due to the effects of crowding by invasive plants, then butterfly diversity and abundance will decline. Mixed- and tallgrass prairie habitat important to rare grass skipper butterflies is spread throughout the study area. Important pockets of this important habitat exist in the northwest, central and south portions of the study area. Maintaining connectivity among these locations of important habitat and between these areas and areas with similar habitat outside of study area will be important.

Table NA9. Count of rare butterflies and skippers by habitat type detected during studies conducted by the CNHP in the North Boulder Grasslands in 1997, 2013 and 2014.

	CNHP Rank	Yucca Shrub-land Alliance	Baltic Rush	Big Bluestem - Little Bluestem	Big Bluestem - Prairie Dropseed	Choke Cherry - (American Plum) Shrubland	Mountain-mahogany /Needle-and-Thread Shrubland	Needle-and-Thread Herbaceous Vegetation	New Mexico Needlegrass Herbaceous Vegetation	Ponderosa Pine/Big Bluestem Xeric Tallgrass	Ponderosa Pine/ Needle-and-Thread Woodland	Skunkbush / Big Bluestem Xeric Tallgrass Shrub Savannah	Skunkbush /Needle-and-Thread Mixedgrass Shrub Savannah	Western Wheatgrass - Blue Grama Herbaceous Vegetation	Western Wheatgrass - Needle-and-Thread	Western Wheatgrass Herbaceous Vegetation	Mountain-mahogany Shrubland Alliance	Ponderosa Pine Woodland Alliance
Arogos skipper	G3 S2	-	-	5	6	-	1	-	1	1	-	-	-	2	-	7	1	-
Dusted skipper	G4G5 S2	-	-	12	10	-	-	-	-	2	-	2	-	3	2	2	-	-
Orangeheaded roadside skipper	OSMP-tracked	1	-	-	1	3	-	-	-	-	-	1	-	2	-	-	-	-
Ottoe skipper	G3G4 S2	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-
Uncas skipper	OSMP-tracked	-	-	-	-	-	-	2	1	-	-	-	-	1	-	-	-	-
Two-spotted skipper	G4 S2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crossline skipper	G4G5 S2	-	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-
Indra swallowtail	OSMP-tracked	-	-	-	4	1	-	-	-	-	2	-	-	-	-	-	-	1

<u>CNHP rankings</u> (CNHP 2014)

Each species is provided a Global (G) Ranking and a State (S) Ranking

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

Bat Monitoring

Background and Methods

In North America, nearly 40 percent of all bat species are included on state or federal threatened, endangered or sensitive species lists or are candidates for listing. Threats to conservation include habitat loss, human persecution and the recent impacts of white-nose syndrome on bat populations. White-nose syndrome (WNS), caused by a cold-tolerant fungus (*Pseudogymnoascus destructans*), affects bats during hibernation. Bats with WNS awaken more often and use up fat reserves needed for winter survival. They may also emerge from hibernation too early and ultimately starve or freeze to death.

WNS has killed more than 5.7 million bats since the discovery of the disease in a New York cave in 2006. In April 2015, Iowa became the 26th state with a confirmed case of WNS; western Missouri is currently the furthest west the disease has been confirmed. Among those bat species most susceptible are little brown bats (*Myoties lucifugus*) and big brown bats (*Eptesicus fuscus*)—once two of the most common species in North America. In 2014, Canada listed the little brown bat as endangered in response to the impacts of WNS, and populations of both of these species have suffered precipitous declines in the US.

Unlike species that OSMP manages for in the Flatirons like fringed myotis and Townsend's big-eared bat, little brown and big brown bats are generalist species that can readily adapt to human landscape alteration. Because of this, staff expects that the majority of bat activity in the North TSA is comprised of little brown and big brown bats. It is important to note that with the onset of WNS, Colorado may become essential habitat and a population source for these declining species. Thus, continued management to provide roosting habitat and water sources for these species may be vital to their conservation.

In partnership with CPW and the Colorado Bat Society, the OSMP bat monitoring program began in 1995. For two consecutive nights per month from June through September, trained volunteers perform emergence counts at known roost sites and assess bat activity levels using visual counts and auditory monitoring (with a Heterodyne D100 bat detector) at select ponds throughout OSMP-managed lands. Ponds are surveyed for two hours following sunset and roosts are surveyed until dark. Some sites are surveyed each year, whereas others are surveyed every four or five years, depending on volunteer commitment. These survey data may be important in tracking trends of bat activity in the wake of climate change, changes in hydrology caused by the September 2013 flood event and the emergence of WNS.

Results and Discussion

Volunteers surveyed bat activity at ponds (n=9) and roosts (n=1) in the North TSA (**Map N19**). The number of big brown bats using the BATR-JH roost has been steady throughout the years and peaks in the summer months of June and July (**Table NA10**). Bats seek out water before they begin nocturnal foraging, and all ponds surveyed in the North TSA provided this much-needed resource to bats. The most effective method for assessing bat activity at ponds depended on the location. At some locations, "listening" to the bat detector proved to be a more effective

method, whereas counting bat passes was more effective at others. This suggests that collecting data using both methods is valuable. At larger ponds, like BLIP and BVR, audio was a more effective indicator of bat activity, while at smaller ponds like SchP and AxP, counting bat passes provided a better proxy of bat activity (**Table NA11**). It is notable that bat activity was recorded for almost ¼ of the entire survey period at BLIP, BVR, LoP and WL, suggesting that these sites may not only serve as a watering hole for bats, but also act as a foraging location.

Table NA10. Average number ± SE of big brown bats counted by volunteers emerging from a roost in the North TSA. Number of monitoring visits during each month is in parenthesis.

Site Name	Years Surveyed	May	June	July	August	September	Overall
BATR-JH	2004, 2006-2014	147 ± 24.0 (4)	216 ± 12.1 (18)	210 ± 20.0 (20)	102 ± 9.2 (20)	35 ± 6.3 (11)	152 ± 10.5 (73)

Table NA11. Summary of data collected by volunteers at ponds in the North TSA.

Site Name	Years Surveyed	Number of Surveys	Avg Audio (min)	Avg Number of Bat Passes
BATW-AxP	1998, 1999	12	9.2 ± 2.2	20.4 ± 11.1
BATW-BLIP	2009, 2010	13	28.7 ± 4.2	2.1 ± 1.0
BATW-BVR	1995, 1998, 2000, 2001, 2010	26	26.3 ± 3.2	7.0 ± 2.0
BATW-HP	2002-2005	24	14.8 ± 2.7	29.8 ± 7.1
BATW-LoP	2004	4	26.0 ± 19.0	3.8 ± 0.9
BATW-MarkP	2004	4	4.8 ± 2.8	2.5 ± 0.9
BATW-MR	2003-2006, 2008, 2010-2013	53	8.3 ± 2.1	5.4 ± 2.1
BATW-SchP	1995-1998	12	6.3 ± 1.6	20.3 ± 6.3
BATW-WL	1996, 1999, 2000, 2004, 2006-2013	65	22.2 ± 2.1	23.9 ± 5.6

Grassland Bird Monitoring

Background and Methods

As part of the Grassland Plan, staff designed a system-wide project to monitor birds in grassland habitats across OSMP- managed lands. Grassland birds are sensitive to a number of factors, many that are influenced by management including those that are applicable to OSMP grasslands. They are sensitive to changes in grazing and fire regimes, the establishment of exotic plant species, increased predation by dogs, human travel on trails, incompatible nearby land uses and reduction of habitat block size by a variety of sources of fragmentation (Vickery et al. 1994, Johnson 1996, Brennan and Kuvlesky 2005, Knick and Rotenberry 1995). These sensitivities combined with the ease of detectability and precipitous declines across their range for many species make these species convenient and informative focal species.

All monitoring was done along 200 meter transects that were placed randomly within identified survey locations. Selection was stratified by habitat block, with crossing of roads and trails avoided. Transects were placed so as to ensure sufficient coverage of an area while still maintaining independence between transects. Staff surveyed birds along each transect twice during the breeding season (mid-May to mid-June). Staff used distance sampling (Buckland et al. 1993), which provides estimates of bird densities without assuming all birds have an equal probability of detection or that every bird present during the survey is detected. Staff recorded all bird species seen or heard along the transects and estimated their distance to the nearest meter, calibrated with a laser rangefinder (Bushnell Corporation, Overland Park, Kansas; Nikon USA, Melville, New York) and sighting angle. These detectability-based density estimates are more reliable than traditional index counts (Rosenstock et al. 2002). Sampling occurred between sunrise and three hours after sunrise and was not conducted in inclement weather.

System-wide, 119 transects are monitored annually. Of these, 36 transects are located in the North TSA. Three other transects were added in 2014 with the purchase of the Joder property. Twenty transects are located on West Beech and Joder, 12 are located on East Beech, two on IBM conservation easement, and two on Boulder Warehouse (**Map N9**). The North TSA transects include habitats that are interesting and distinct from other areas on OSMP-managed lands. The eastern portions of the area include mixedgrass prairie mosaic, including large blocks of this habitat on East Beech. These areas support the suite of grassland specialist bird species including grasshopper sparrows, which were a conservation focal species in previous TSAs and the Grassland Plan. Grassland bird protective seasonal closures have been included in all of the last three TSAs to help protect these grassland specialist species. While the North TSA supports these species, it is not at the highest concentrations seen on the system. As a result, focus in the North TSA is on species not found as frequently on grassland transects outside the TSA.

Results and Discussion

Results from surveys are presented in **Table NA12** below.

Species Richness-
Transects in the North TSA have been monitored since 2008 with expansions in the number of transects in 2009/2010 as part of the Grassland Plan implementation and in 2014 with the

purchase of the Joder property. Staff have found native species richness at two sets of transects to be extremely high. North Boulder (area west of US 36 Foothills Highway) has the highest species richness detected on the system with 63 native species. The next highest areas for species richness are Tallgrass West and Southern Grasslands with 50 and 48 species respectively. This result highlights the unique nature of this area, particularly the area west of Foothills Highway. This area supports a mixture of habitats with rock outcroppings, shrubby drainages, upland shrub patches and shale barrens intermixed with the grassland habitats. This close juxtaposition of habitats found along the hogback areas supports higher biodiversity of birds than found throughout grasslands elsewhere on the system.

To highlight this uniqueness, we analyzed data related to three species- lark sparrow, rock wren and lazuli bunting. Lark sparrows are detected frequently in the North TSA, but only infrequently anywhere else on the OSMP system. Likewise, rock wrens are detected frequently in the rock outcropping and hogback communities. While rock wrens occur elsewhere outside the grasslands on OMSP, the North TSA represents the areas they are most frequently seen and where their habitat is embedded in surrounding grassland and shrub communities. Finally, lazuli bunting, while not typically a species seen on grassland transects, is common in the heavily vegetated drainages embedded in the grassland habitats of the western portion of the North TSA. This species helps us to monitor the shrub nesting bird community.

Lark Sparrow

We detected lark sparrows at three of the five areas surveyed in the North TSA. These areas represented three of the top four areas for lark sparrow abundance. Joder and IBM did not have lark sparrows. Where lark sparrows were detected, they were found in high abundance. East Beech and Boulder Warehouse had the highest abundance of lark sparrows on the system, followed by Tallgrass West (included in West TSA with grassland bird protective seasonal closure) and North Boulder (areas west of the Foothills Highway) (**Table NA12**). Overall, the North TSA transects had an average abundance of .74 lark sparrows per transect as compared to a system wide average of 0.28. Breeding Bird Survey data shows lark sparrow populations declining slightly within Colorado and more substantially across the United States in the period between 1966-2013. Across the United States, this species has declined nearly 1 percent each year during that timeframe (Sauer et al. 2014). As a result, given the unique habitat in the North TSA that is able to support this species and the conservation concern surrounding lark sparrows, lark sparrows have been selected as a conservation focal species for the North TSA.

Rock Wren

Rock wrens were detected in only two areas of OSMP on grassland transects- both in the North TSA. Relatively high abundance was noted on the North Boulder transects and Joder transects (**Table NA12**). As discussed above, rock wrens do occur elsewhere on the system, but similar habitat patches interspersed with grassland and shrubs which provide ideal habitat are restricted to the North TSA. Rock wrens are also a focal species due to the unique North TSA habitat for them, and substantial declines both in Colorado and across the United States (-2.32 percent per year over timeframe of 1966-2013) (Sauer et al. 2014). Rock wrens are included as a focal species in the Target Description for Exposed Rock and outcroppings.

Lazuli Bunting

Lazuli buntings occur in areas with substantial shrub and riparian vegetation. Over most of our system, this species is tied to permanent or semi-permanent water sources with appropriate associated vegetation. Lazuli buntings within the North TSA occur in vegetated ephemeral drainages that occur along the face of the hogbacks. Although more widespread system-wide than rock wrens, lazuli buntings similarly are found in unique pockets of appropriate habitat surrounded by grasslands. Lazuli bunting is a focal species for the North TSA because it is a species in decline (-2.75 percent annually between 1966-2013) and is representative of a suite of shrub nesting birds that are important conservation indicators on OSMP. Lazuli buntings were detected most frequently in areas of the North TSA during grassland bird surveys. East Beech, North Boulder and Joder transects showed the highest abundance of lazuli buntings. Buntings were also detected in very low abundance at West Rudd and Tallgrass West (**Table NA12**).

The grassland bird transects within the TSA show extremely high species richness in comparison to transects system-wide. This is likely due to the close spatial association of diverse habitats in the area- particularly in areas such as West Beech and Schneider. Focal species for this TSA include lark sparrows, rock wrens and lazuli buntings. Each of these species is in decline and represents a different habitat type within the grassland ecosystems of the North TSA.

Grassland bird monitoring allows examination of the nature of the bird community within the North TSA as well as what is special or unique about these habitats on a system-wide scale.

Table NA12. Summary of Grassland Bird monitoring data.

Property/Area	Number of transects	Years surveyed	North TSA?	Native Species Richness (# spp. Detected)	Average Abundance of Lark Sparrows	Average Abundance of Lazuli Buntings	Average Abundance of Rock Wrens
East Beech	**12**	**2009*-2012**	**Yes**	**43**	**1.49**	**0.31**	**0**
North Boulder	**17**	**2008*-2014**	**Yes**	**63**	**0.34**	**0.37**	**0.25**
Boulder Warehouse	**2**	**2010-2014**	**Yes**	**27**	**0.80**	**0**	**0**
IBM	**2**	**2009-2014**	**Yes**	**17**	**0**	**0**	**0**
Joder	**2**	**2014**	**Yes**	**13**	**0**	**0.67**	**0.33**
West Rudd	11	2008*-2014	No	39	0.15	0.05	0
Southern Grasslands	20	2008*-2014	No	48	0.09	0	0
Damyonovitch	2	2010-2014	No	22	0	0	0
Jewell Mtn	15	2008*-2014	No	26	0.08	0	0
Aweida	2	2010-2014	No	18	0.05	0	0
Steinbach	2	2009-	No	26	0	0	0

		2014					
Gunbarrel Hill	12	2008-2014*	No	34	0	0	0
Wood Brothers	3	2009-2014	No	27	0	0	0
Tallgrass West	30	2008-2014**	No	50	0.36	0.03	0
Jafay	3	2009-2014	No	16	0.06	0	0
System-Wide	97			96	0.28	0.07	0.04
North TSA	**72**			**69**	**0.74**	**0.22**	**0.14**

Hayfield Bird Monitoring

Background and Methods

Bobolinks are ground-nesting songbirds which nest primarily in wet meadows in the Boulder Valley (Thompson and Strauch 1987). They are protected under the Migratory Bird Treaty Act and are considered "vulnerable to extirpation" ("S3B") by the CNHP and "rare breeding species" by the BCCP. Bobolink populations in the western United States are unique in that they are separated from the main breeding range of bobolinks further to the east (Hamilton 1962).

Bobolinks originally nested in tallgrass or mixedgrass prairie of the mid-western United States and southcentral Canada (Bent 1958), but because of land conversion, have now increased their use of irrigated hayfields throughout their range (Martin and Gavin 1995). The use of this habitat creates a potential management conflict as most irrigated hayfields are managed under maximum yield principles, which translates to several harvests (i.e., mowing) each season. The bobolink is of particular interest to land managers because of its extreme population decline during the past thirty years and its affinity to breed late in the summer when much of the mowing typically occurs (Martin and Gavin 1995). Bollinger et al. (1990) documented a 90-100 percent failure rate of bobolink nests because of hayfield mowing. On OSMP hayfields, Roeder (1998) documented no breeding bobolink mortality at four nests and attributed this to the fact that mowing did not occur until after the young had fledged and parental activity ceased.

Efforts by OSMP staff to manage irrigated hayfields to conserve bobolinks began in 1993 when the Burke II property was closed to visitor use. However, records date to 10 years before that which document successful breeding attempts by bobolinks on the Burke II property. Thompson and Strauch (1987) reported a mean fledgling date of July 8 for nests on the Burke I, Burke II and Gebhard OSMP properties, but the general consensus is that postponing mowing until July 15 will allow for the majority of fledglings to be able to sustain flight and hence avoid mowing impacts (Thompson and Strauch 1987, Vierling 1997, Roeder 1998). The incubation period for bobolinks is about two weeks and nestlings leave the nest between 10 and 14 days later (Martin and Gavin 1995). Male bobolinks usually arrive in Boulder County around the end of May and

females tend to arrive one week later (Thompson and Strauch 1987). However, exact time of nesting is not known for OSMP-managed lands.

OSMP managers seek to maintain traditional agricultural land use (haying, grazing) while preserving and maintaining natural systems and native species. In order to identify key bobolink breeding sites and thus inform management decisions, OSMP initiated a hayfield bird monitoring program in 2000. Using these data, staff identified key breeding sites in terms of abundance and density of singing male bobolinks, a common metric used to assess grassland bird abundance. These highest density breeding areas were designated as "Class A Bobolink Management Areas". OSMP staff also designated a set of second tier breeding areas as "Class B Bobolink Management Areas" (**Map N22**).

Results and Discussion

OSMP staff and volunteers survey 43 hayfields in the North TSA, encompassing 921 acres. This is 1/3 of the hayfield habitat managed by OSMP. Over the past five years (2010-2014), these fields have supported, on average, 35 percent of the total population of bobolinks on the OSMP system (**See Table NA13**). Field number 19 on the Deluca property supports the highest density of bobolinks (5.7 per 10 acres) of any hayfield managed by the department (**See Table NA14**). Other important hayfields that support large numbers and densities of bobolinks in the North TSA include Deluca (13, 14), Hester (18), Campbell (459) and Lore/Ellison (80). Over the course of this project, 81 percent of the fields in the North TSA have supported bobolinks in at least one year. A total of 60 bird species have been found during hayfield surveys in the study area from 2010-2014 (**See Table NA15**).

Table NA13. Bobolink population counts in the North TSA compared to the entire system.

Year	System-wide Bobolink Count	North TSA Bobolink Count	% of Total Population
2010	213	68	31.9
2011	304	89	29.3
2012	219	108	49.3
2013	270	96	35.6
2014	227	73	32.2

Table NA14. A comparison of North TSA bobolink abundance and density between the 2008 Grassland Plan data and more recent years (2010-2014).

Property	**Field #**	**Grassland Plan designation**	**Acres Surveyed (in 2010)**	**Number of visits from 2010-2014**	**BOBO avg abundance (2010-2014)**	**BOBO density in Grasslan d Plan (2008)**	**Avg BOBO per 10 acres (2010-2014)**
Deluca	13	B candidate	32	5	14	1.4	4.4
Lore Ellison	80		93	5	10.8		1.2
Deluca	19	B candidate	18	5	10.2	3.3	5.7
Deluca	14	B candidate	27	5	8.8	2	3.3

Campbell	459	B candidate	29	5	6.4	2.6	2.21
Axelson West	49		21	5	4.2		2
Hester	18	B candidate	25	5	4	2.6	1.8
Axelson West	42		41	5	3		0.7
Terre Bison	2		18	4	3		1.67
Johnson	36		39	5	2.4		0.62
Bruning	15		22	4	2		0.91
Johnson	46		26	4	2		0.77
Axelson West	38		13	5	1.6		1.2
Axelson West	48		14	5	1.4		1
Gallagher	133	B	39	5	1.4		0.4
Boulder Valley Ranch	93		37	3	1.33		0.4
Axelson East	56		20	5	1.2		0.6
Johnson/Dawson	37		32	5	1.2		0.38
Lousberg	145		28	5	1.2		0.43
Axelson East	61		19	5	1		0.5
Boulder Valley Ranch	102		28	4	1		0.36
Johnson	57		10	4	1		1
Axelson West	51		11	5	0.8		0.7
Johnson	35		12	5	0.8		0.67
Johnson	58		14	4	0.75		0.54
Johnson	33		4.8	3	0.67		1.4
Johnson	34		11	5	0.6		0.54
Axelson West	54		4	4	0.5		1.3
Siegle	441		18	2	0.5		0.3
Axelson West	55		23	5	0.4		0.2
Axelson West	41		17	3	0.33		0.2
Terre Bison	3		10	4	0.25		0.3
Ditzel	127		31	5	0.2		0.6
Johnson	44		13	5	0.2		0.15
Axelson West	40		10.79	2	0		0
Axelson West	52		8.5	2	0		0
Axelson West	59		8	4	0		0
Axelson West	65		2	4	0		0
Johnson	64		9	4	0		0
Johnson	66		13	4	0		0
Siegle	440		15	3	0		0
Steele	10		26	4	0		0
Terre Bison	4		12	4	0		0

Table NA15. List of bird species observed in North TSA hayfields from 2010-2014.

Species Name	**Species Name**
American Bittern	Great Horned Owl
American Crow	Grasshopper Sparrow
American Goldfinch	House Finch
American Kestrel	Horned Lark
American Robin	House Wren
American White Pelican	Indigo Bunting

Bank Swallow	Killdeer
Barn Swallow	Lark Bunting
Black-billed Magpie	Mallard
Black-capped Chickadee	Mountain Bluebird
Black-crowned Night-Heron	Mourning Dove
Brown-headed Cowbird	Northern Flicker
Blue Grosbeak	Northern Harrier
Blue Jay	Osprey
Bobolink	Rock Pigeon
Brewer's Blackbird	Red-tailed Hawk
Broad-tailed Hummingbird	Red-winged Blackbird
Bullock's Oriole	Say's Phoebe
Canada Goose	Savannah Sparrow
Cliff Swallow	Song Sparrow
Common Grackle	Spotted Towhee
Common Yellowthroat	Turkey Vulture
Double-crested Cormorant	Vesper Sparrow
Dickcissel	Violet-green Swallow
Downy Woodpecker	Western Kingbird
Eastern Kingbird	Western Meadowlark
Empidonax flycatcher species	Western Wood-Pewee
Eurasian Collared-Dove	Wilson's Phalarope
European Starling	Wilson's Snipe
Great Blue Heron	Yellow Warbler

Burrowing Owl Monitoring

Background and Methods

The Western burrowing owl (*Athene cunicularia hypugaea*) is a small ground-dwelling owl of open habitats throughout the western US. It is listed as a Threatened species in Colorado. The burrowing owl is on the CNHP's Watch List, meaning they are not a substantial conservation concern, but their populations should be monitored. On the whole, populations of burrowing owls have been on the decline throughout their range, but especially on the periphery (USFS 2003). The North American Breeding Bird Survey data suggest that in some areas, like the central Great Plains, they are doing well and populations are growing, while in other areas they are on the decline. All sources stress the need for more adequate monitoring of breeding populations so that proper assessments of their status can be made.

Burrowing owls rely upon fossorial mammals like prairie dogs and ground squirrels for the creation of appropriate shelter and breeding sites. In the breeding season, they occupy abandoned burrows that were created by these mammals. The wide-spread and dedicated efforts to eradicate species like the black-tailed prairie dog are often cited as a primary driver in the population decline of the owls. Vehicle strikes and predation by badgers and avian predators like Great horned owls are often cited as major sources of mortality. In the West, large-scale alterations of grasslands habitats have been recognized as one of the primary drivers of this species' population decline (Bent 1958).

Each spring, OSMP staff survey appropriate habitat for burrowing owls. This includes most active black-tailed prairie dog colonies on the system, as well as several inactive colonies where the owls have been known to occur in the past and where the burrow structures are still intact. Site visits are prioritized by management category (Prairie Dog Conservation Areas and Grassland Preserves are surveyed more often than Removal Areas) and previous owl occurrence. Staff systematically search for burrowing owls during daylight hours by scanning prairie dog colonies with binoculars from multiple vantage points. If a nesting pair is found, OSMP enacts seasonal closures that run from March 15 -October 31. Closures remain in effect for three years after a breeding attempt in order to provide a disturbance-free environment for the owls if they choose to return to a site.

Results and Discussion

In Boulder County, burrowing owls are a rare and isolated breeding species. Despite extensive habitat for the owls (3,052 acres of black-tailed prairie dog colonies in 2014), they remain a rare breeding species on OSMP. The number of breeding pairs on the system varies from two to five, with an average fledgling count of 13 per year over the past seven years (see **Figure NA2**).

The black-tailed prairie dog colonies in the North TSA have historically supported nesting burrowing owls. In 2009, a pair nested on the Walker property. They fledged two young. In 2008, a pair nested on the Axelson property northwest of Boulder Reservoir, rearing seven young. This site was occupied again in 2010 and 2011, but no successful nesting attempts were documented. Burrowing owls have been spotted in the North TSA several other times (**Map N8**). Most of these sightings have been of transitory individuals seen while mapping prairie dog

colonies or performing other activities in and around prairie dog colonies. In 2014, there were 2,073 acres of black-tailed prairie dog colonies in the planning area. Despite this abundance of habitat for burrowing owls, there have not been any successful breeding attempts in the planning area since 2009.

Table NA16. Survey Effort and Breeding Output of Burrowing Owls on OSMP Lands 2008-2014.

Year	# Colonies Surveyed	# Site Visits	# Active Nests	# Fledglings	# Site Visits with BUOW Detection
2008	26	83	4	19	26
2009	42	134	4	7	30
2010	35	107	4	10	50
2011	38	140	5	19	57
2012	40	191	3	13	63
2013	40	167	3	13	58
2014	43	190	2	13	36

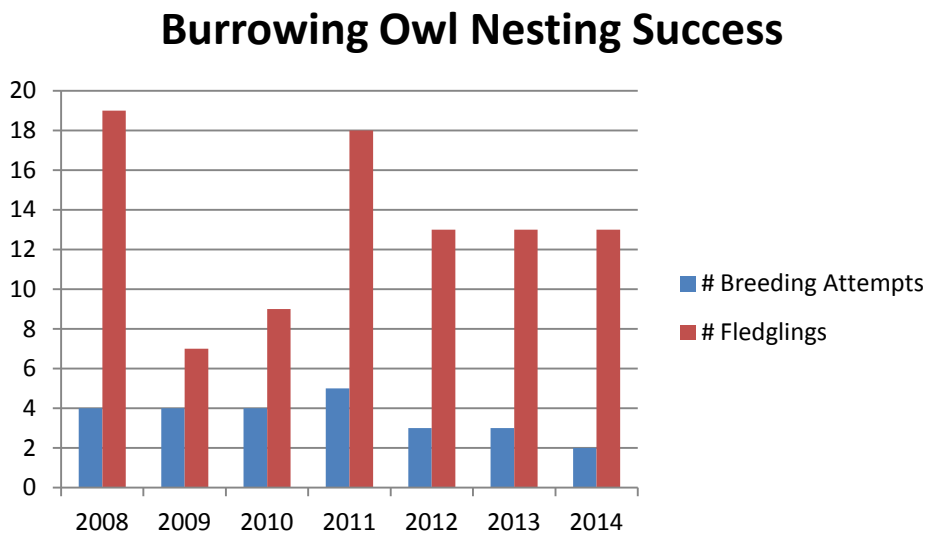

Figure NA2. Burrowing owl nesting success on OSMP 2008-2014.

Table NA17. Burrowing Owl Presence by North TSA property

Property	**Date**	**Count**
Axelson	4/27/2010	2
Axelson	4/21/2011	1
Axelson	10/1/2011	1
B.L.I.P.	10/13/2010	1

Boulder Valley Ranch	4/21/2011	1
East Beech	4/28/2010	1
Johnson/Monarch	5/2/2013	1
Steele South	9/18/2014	1

Remote Wildlife Cameras

Background and Methods

OSMP Wildlife staff deployed cameras at eight locations in the North TSA since 2012 (see **Table NA18 and Map N27**). Five camera deployments covered the West Beech and Schneider properties from March 2012 through November 2013. Three locations on the Joder property have been monitored continuously since August 2013.

Remote digital cameras are an important tool utilized by wildlife staff to monitor wildlife throughout the OSMP system. In the North TSA, remote cameras have been deployed in order to obtain baseline data on the presence of wildlife species in anticipation of this planning effort. Since they operate continuously for many months at a time, these cameras are optimal for long-term monitoring of all types of wildlife. OSMP staff installed the cameras at ideal locations, such as game trails or drainage bottoms, where various types of animals may be expected to pass.

Two models of camera were used in the study area. The Cuddeback Attack IR cameras use an infrared flash which reduces the visibility of the camera at night. They also have a dual photo/video mode in which a single photo is taken and then the camera immediately takes a 20-30 second video. There is a five second delay between each trigger, plus the video time. It is apparent from the videos that some animals would be missed by just a camera trigger. For instance, there is a pack of coyotes which roams the area near the Joder 1 camera. The first animal triggers the camera and a photo is taken, then the video mode turns on. The video often captures two other animals following closely behind the first. These would not be picked up by just the camera mode due to the delayed trigger inherently built in to the camera. The second model used, Moultrie D-555i, just takes photos or videos, but not both. This model has a much more sensitive motion-sensing trigger, resulting in many thousands of erroneous photos. The camera is triggered by the slightest movement of vegetation. The field of view on the Moultrie cameras is much wider than on the Cuddebacks, but the image quality is inferior. The Moultrie cameras do provide good information, but the added time involved with sorting through the misfires and the poor image quality makes them a less desirable choice. The Cuddebacks have proven to be accurate and sturdy, and at the price they seem to work well for projects such as these.

With their use, wildlife staff can easily monitor and collect data on wildlife that inhabits the North TSA with a limited commitment of staff time. The photos and the associated data (time stamp, some weather info on certain models) are stored in a user-friendly database that was developed by researchers at CSU. The database can be searched for particular species, locations, date ranges, etc.

Results and Discussion

Remote cameras in the North TSA have taken over 5,400 photographs of 34 different species of mammals and birds (See **Table NA19**). Notable are the abundance of mule deer, coyote and red fox. Shrubby drainages are utilized by black bears in the fall. Wild turkeys inhabit the upland Ponderosa pine forests on the Buckingham property. White-tailed deer, typically a species associated with riparian floodplains, wander into the uplands on the north end of the

Buckingham property. On one occasion, a secretive ringtail was captured traveling along a social trail on the Joder property. There is an abundance of red fox on the Joder property, and gray foxes have been found on several occasions. Elk detections are limited, but there is evidence that the remote grasslands on the Beech property support cows and calves in the summer months. Although only one mountain lion has been detected in the area, bobcats were detected at almost all of the camera locations.

Some species are ubiquitous at all location, such as coyote and mule deer (**See Table NA18**). Red fox wasn't detected at every location, although at the Joder location they have been photographed 426 times, demonstrating their propensity to use this particular social trail. Use of these areas by people is rather low and is concentrated near established undesignated trails. An undesignated trail on Joder had the largest number of people and dogs detected. In addition to hiking which was the most common activity recorded, there was also a low level of horseback riding, mountain biking and one instance of illegal dirt bike riding observed.

Table NA18: Remote camera species captures at eight locations in the North TSA 2012-2015.

Species	NOBO 1	NOBO 2	NOBO 3	NOBO 4	NOBO 5	Joder 1	Joder 2	Joder 3
American Robin	X							X
Bald Eagle								X
Black Bear	X				X	X	X	X
Black-billed Magpie	X			X	X	X		X
Bobcat	X	X		X	X	X	X	X
Brown Thrasher	X							
Cooper's Hawk				X				
Cottontail sp.	X	X		X	X	X		X
Coyote	X	X	X	X	X	X	X	X
Dark-eyed Junco								X
Dog	X				X	X	X	X
Elk	X			X			X	X
European Starling								X
Fox Squirrel	X					X		
Gray Fox						X		X
Horse	X					X		
Human	X			X	X	X	X	X
Lark Sparrow								X
Mountain Lion		X						
Mule Deer	X	X	X	X	X	X	X	X
Northern Flicker					X	X		X
Raccoon	X			X	X	X		X
Red Fox	X	X			X	X	X	
Ringtail						X		
Rock Pigeon								X
Rock Squirrel	X				X	X		X
Spotted Towhee					X			
Steller's Jay						X		
Striped Skunk	X	X	X	X	X	X		X
Western Scrub-Jay	X							X
White-tailed Deer	X					X	X	
Wild Turkey							X	
Wilson's Snipe					X			
Woodrat sp.	X				X			
# of Species	**20**	**7**	**3**	**10**	**16**	**19**	**10**	**21**

Table NA19: Number of camera captures at each deployment location 2012-2015.

Species	NOBO 1	NOBO 2	NOBO 3	NOBO 4	NOBO 5	Joder 1	Joder 2	Joder 3
American Robin	3							3
Bald Eagle								1
Black Bear	7				2	4	6	45
Black-billed Magpie	12			5	106	12		190
Bobcat	19	4		1	21	14	1	34
Brown Thrasher	1							
Cooper's Hawk				1				
Cottontail sp.	41	12		7	1	28		41
Coyote	228	25	6	46	113	124	2	180
Dark-eyed Junco								6
Dog	1				3	54	5	13
Elk	23			50			1	1
European Starling								6
Fox Squirrel	1					120		
Gray Fox						5		1
Horse	16					7		
Human	22**			4*	17***	126**	2***	21**
Lark Sparrow								1
Mountain Lion		1						
Mule Deer	194	21	39	291	234	69	104	1696
Northern Flicker					1	1		12
Raccoon	7			4	7	20		11
Red Fox	6	2			3	426	7	
Ringtail						1		
Rock Pigeon								2
Rock Squirrel	5				20	2		27
Spotted Towhee					1			
Steller's Jay						3		
Striped Skunk	117	8	1	21	78	28		5
Western Scrub-Jay	3							6
White-tailed Deer	3					1	39	
Wild Turkey							14	
Wilson's Snipe					1			
Woodrat sp.	1				1			
# of Species	**20**	**7**	**3**	**10**	**16**	**19**	**10**	**21**

*OSMP staff or contractors only
** OSMP staff as well as visitors
*** Visitors only

Waterfowl Monitoring

Background and Methods

Waterfowl (ducks and geese) have traditionally been of interest to wildlife managers because of their value as game species. Continent-wide conservation efforts have successfully bolstered the populations of most North American waterfowl species in the past decades, reversing historical trends. Only one species, the Barrow's goldeneye, is tracked by the CNHP. It is considered to be threatened in Colorado because of its limited breeding distribution in alpine lakes. It has been extirpated as a breeding bird from Boulder County but occurs in small numbers in larger water bodies on the plains during the winter. The ring-necked and wood ducks are considered to be Species of Special Concern in the BCCP. Ring-necked ducks are a rare breeder in high-elevation ponds, but are common in almost any open water habitat in the county during the winter. Wood ducks breed in tree cavities along riparian corridors, limiting their breeding distribution in the county. Eight species of waterfowl breed in Boulder County (Kingery 1998).

OSMP staff has performed waterfowl surveys at several small ponds in the North TSA. This includes data collected for the Mid-Winter Waterfowl Survey, a nation-wide population survey organized by the U.S. Fish and Wildlife Service each winter. Since 2013, wildlife staff has made occasional visits to North TSA water bodies to conduct waterfowl surveys in an effort to collect baseline data for a pilot project that may grow into an organized volunteer survey. Additionally, some sightings from Wonderland Lake were mined from a publically accessible online database (ebird.org). Waterfowl are identified and counted by scanning water bodies from advantageous vantage points. Efforts are made not to disturb the birds. The Mid-Winter Waterfowl Count is typically conducted in early January. Most surveys by staff have been conducted from fall through spring as time allows. These surveys have been opportunistic and the program has not yet been developed in a way that water bodies are surveyed systematically on a regular schedule.

Results and Discussion

Six ponds in the North TSA have been surveyed by staff and volunteers (See **Table NA20**). Fifteen species of waterfowl have been observed during these visits. Canada geese have been observed on nests at Mesa Reservoir, but otherwise there have been no direct observations of nesting ducks in the study area during these surveys. Presumably, common species like mallard and Canada goose can be expected to breed at any of these locations. There have been no observations of Barrow's goldeneye or wood duck at ponds in the North TSA, although they have been observed at other water bodies within the study area but not on OSMP-managed lands (e.g. Boulder Reservoir). Of interest is one sighting of a long-tailed duck at the Lappin Pond on May 3, 2012, a rare sighting anywhere in Colorado.

Wonderland Lake and Mesa Reservoir (Conservation Easement) provide some of the best habitat for wintering waterfowl in the study area. Depending on the water levels, Mesa Reservoir is also a likely breeding site for several species of dabbling duck. Both of these sites are in close proximity to trails, so negative effects from recreation should be considered when developing management strategies. Water management at some of the smaller water bodies is also important. Mesa Reservoir occasionally dries up, which may have an adverse effect on the

ecosystem; however, lack of fee ownership at Mesa Reservoir limits management options for OSMP in this location.

Table NA20. North TSA waterfowl sightings.

Site	# of Visits	Species Count	Total Number of Birds Detected
Mesa Reservoir	9	12	202
Wonderland Lake	18	7	486
Lappin Pond	2	4	15
Anderson Pond	1	4	19
Bennett Pond	2	6	133
BVR Pond 1	1	1	1

Table NA21. Species observed in the North TSA.

Waterfowl observed in TSA
American Wigeon
Blue-winged Teal
Bufflehead
Canada Goose
Cinnamon Teal
Gadwall
Green-winged Teal
Lesser Scaup
Long-tailed Duck
Mallard
Northern Pintail
Northern Shoveler
Redhead
Ring-necked Duck
Ruddy Duck

Prairie Dog Mapping

Background and Methods

Black-tailed prairie dogs have far-reaching impacts on the grassland that they inhabit and their presence provides prey and landscape structure necessary for the presence of associated species. Because of these far-reaching effects, prairie dogs are often considered "keystone" species (Kotliar et al. 1999, Hoogland 2006). They are a species that defines the basis of a unique animal community on OSMP-managed lands: The "Black-tailed Prairie Dog and Associates" which is one of the conservation targets included in the Grassland Ecosystem Management Plan (2011).

The black-tailed prairie dog is a medium-sized, diurnal, colonial ground squirrel inhabiting subterranean burrows in suitable grassland habitat. The black-tailed prairie dog historically inhabited much of the central plains, but through loss of habitat and direct extermination, populations have been significantly reduced (Miller et al. 1990). Black-tailed prairie dogs exist on OSMP throughout grassland areas with large complexes of colonies clustered on the northern half of OSMP-managed lands.

In 2005, approximately 3,500 acres of OSMP grassland habitat was inhabited by black-tailed prairie dogs. Since then, an active epizootic of sylvatic plague reduced the number of acres occupied by approximately 2,000 acres based upon colony mapping conducted in 2008. By 2013, the population had rebounded to an occupied acreage of 3,090 acres. The conditions present on OSMP prairie dog towns varies widely. Some colonies support a healthy native plant community and several animal species associated with prairie dogs. Others are characterized by a high density of burrows, diminished native vegetation, localized soil loss and no evidence of the vertebrate species considered dependent upon prairie dogs. In many cases, surrounding land use, underlying vegetation communities and other factors are important contributing factors to the ecological status of the colony.

The existence of several other closely associated species that rely on black-tailed prairie dogs contributes to their function as a keystone species. These species benefit from the prairie dogs directly as prey, indirectly through use of their burrows, or both. These associated species are considered nested targets and include species that are common on OSMP as well as some less common, and several extirpated species.

Burrowing owls, American badgers, ferruginous hawks and golden eagles are animal species associated with intact prairie dog colonies. These species include predators (American badger, ferruginous hawk and golden eagle) which are sensitive to human disturbance and are frequently found to be using only prairie dog towns distant from development and human disturbance. Other associated species use prairie dog burrows as habitat, most notably burrowing owls. Burrowing owls are most frequently found using abandoned prairie dog burrows for shelter and nesting. Many other species, including a variety of insects, small mammals, reptiles and amphibians, may also use the burrows in prairie dog colonies.

Each fall, OSMP staff map all of the black-tailed prairie dog colonies on fee properties, as well as a select number of conservation easements (those which OSMP manages). This allows staff to track the total acreage of colonies on the system as well as in certain Grassland Preserves.

During the mapping effort, evidence of other wildlife species that are associated with prairie dog colonies is also recorded.

Results and Discussion

In 2014, staff mapped a total of 2,072.7 acres of prairie dogs in the North TSA (**Map N8)**. These occupied areas occurred within all of the management designations, including Removal Area (148.3 acres), Transition Area (323.4 acres), Multiple Objective Area (180.5 acres), Prairie Dog Conservation Area (26.7 acres) and Grassland Preserve (1,393.9 acres). Results in **Table NA22** show associated species detected on prairie dog colonies during mapping or other site visits.

Table NA22. Sensitive associated species observations at North TSA prairie dog colonies

Property Name	Burrowing Owl	Northern Harrier	Golden Eagle	Ferruginous Hawk	Bald Eagle	Horned Lark	Prairie Rattlesnake	Tiger Salamander
Abbot	-	-	-	-	-	-	-	X
Axelson- Coot Lake	-	-	-	-	-	-	-	-
Belgrove- North	-	-	-	-	-	-	-	-
Belgrove- South	-	-	-	-	-	-	-	-
BLIP, East Beech- South	-	-	X	X	-	X	X	-
BLIP- Boulder Warehouse	X	X	X	-	X	X	X	-
BLIP Southwest	-	-	-	-	X	X	X	-
Axelson, BVR, Lore, Ellison	X	X	X	X	X	X	X	-
BVR 103 Corp-L pasture South	-	X	X	X	-	-	X	-
BVR 103 Corp-East	-	-	-	-	-	-	-	-
BVR 103 Corp-South	-	X	-	-	-	X	X	-
Axelson-Northwest	-	X	-	-	-	-	-	-
BVR 103 Corp-North	-	-	-	-	X	-	-	-
Campbell	-	-	-	-	-	-	-	-
Cowles	-	-	-	-	-	-	-	-
Johnson/Dawson- North	-	-	-	-	-	-	-	-
Johnson/Dawson- South	-	-	-	-	-	-	-	X
Ditzel	-	-	-	-	-	-	-	-
Dodd	-	X	-	-	-	-	-	-
East Beech	-	-	X	-	-	-	X	-
East Beech-Horseshoe	-	-	-	-	-	-	-	-

ERNI Moore	-	-	X	-	-	-	-	-
Gallagher	-	-	-	-	X	-	-	-
Gilbert	-	-	X	-	-	-	X	-
Hart- Jones	-	-	-	-	-	-	-	-
IBM CE	-	-	-	-	-	-	-	X
Johnson- Boulder Reservoir North	-	-	-	-	-	-	-	-
Johnson- Boulder Reservoir South	-	X	-	-	-	-	-	-
Johnson- Monarch	X	X	-	-	-	-	-	-
Johnson- North	-	-	-	-	-	-	-	-
Mann	-	-	-	-	-	-	X	-
Mesa Reservoir	-	-	-	-	-	-	-	-
Moore	-	-	-	-	-	-	X	-
NU- West	-	-	-	-	-	-	-	-
Oasis	-	-	-	-	-	-	-	-
Ryan- Middle	-	-	-	-	-	-	-	-
Ryan- North	-	X	-	-	-	-	-	-
Ryan- South	-	-	-	-	-	-	-	-
Schneider- East	-	-	X	-	-	X	-	-
Schneider- West	-	-	X	-	-	-	-	-
Schooley	-	-	-	-	-	-	-	-
Seigel	-	-	-	-	-	-	-	-
Steele- North	-	-	-	-	-	-	-	-
Steele- South	X	X	-	-	-	-	-	-
West Beech	-	-	-	X	-	-	-	-
Waldorf	-	X	-	X	-	-	-	-
Bennett	-	X	X	X	X	X	-	-
Brewbaker	-	X	-	X	X	-	-	-
Jacob/Andrea	-	-	-	X	-	-	X	-
Eisenberg	-	-	-	-	-	X	X	-
Schneider Family	-	X	-	-	-	-	-	-
Abbot North	-	-	-	-	-	X	-	-

Joder	-	-	X	-	-	-	-	-

N-Appendix A: Literature Cited

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N-Appendix B: Native Vegetation

Top: Bell's twinpod (Physaria bellii) Claudia Van Wie

Middle: Birds-foot violet (Viola pedatifida) OSMP staff

Bottom: Dwarf leadplant (Amorpha nana) Bill May

Rare and Sensitive Vegetation

One of the City of Boulder's OSMP Charter purposes is the preservation of rare and sensitive native plant species and their habitats. In order to achieve this objective, staff must maintain current and accurate information on the location, distribution, ecology and conservation status of these species.

The Colorado Natural Heritage Program (CNHP) has developed state conservation status ranks (S-Ranks) to best characterize the relative rarity or endangerment of a species or community element within the state (CNHP 2015). These assessments provide an estimate of extinction risk on a scale of one to five, where S1 rankings indicate critical imperilment and S5 rankings signify the species is demonstrably secure. Abundance, distribution, short- and long-term population trends, environmental specificity and range extent, and threats may be used to assign this ranking. OSMP Plant Ecologists use similar quantitative and qualitative factors to identify additional sensitive species that warrant local protection.

Previously documented rare plant species locations are inventoried on a regular basis across the OSMP system using a standardized methodology. Known subpopulations are resurveyed on a regular basis to best maintain accurate resource information. Surveys for additional rare plant occurrences are conducted in conjunction with routine inventories, or as part of specific projects. Newly discovered rare plant occurrences are added to the OSMP GIS rare plant database.

During each rare plant field survey a GPS unit is used to record a number of characteristics about the subpopulation. The surveys are intended to provide a snapshot in time and allow staff to track changes in occurrence size, general habitat characteristics, demographic information and threats to each subpopulation. The following characteristics are recorded for each occurrence during the surveys:

- Species
- Dimensions of the subpopulation
- Number of individuals
- Life stage
- Plant distribution within the area
- Soil conditions
- Associated species
- Threats to the subpopulation

Rare plant communities are mapped on OSMP as part of the Vegetation Mapping project following a modified version of the standards and methodology detailed in the International Vegetation Classification system (Grossman et al. 1998). All plant communities on OSMP are mapped to a minimum mapping unit of either one tenth or one quarter of an acre at the association level within the classification hierarchy. Rare vegetation types are those associations that have been evaluated and subsequently ranked by CNHP as S1 to S3, indicating they are critically imperiled to vulnerable (CNHP 2015).

Map N7 displays the rare plant and vegetation types currently mapped in the TSA. For this report, specific rare plant locations have been generalized to protect the resources. More precise location data exists for each of the known occurrences and will be used for finer scale planning.

Plant species populations and subpopulations are grouped based on guidelines developed by NatureServe (2004). Populations are all occurrences of a species within a distance of 2 kilometers from each other when suitable habitat is present. Subpopulations are species occurrences within a distance of 50 meters.

Table NB1. Rare Plant Species in the North TSA

Species	Scientific Name	Ranking	Populations	Subpopulations	Target
Narrow-leaved Milkweed	*Asclepias stenophylla*	S2/G4G5	1	2	MGPM
Blue Toadflax	*Linaria canadensis var. texana*	SNR/SU/G5	1	1	MGPM
Wavy-leaf stickleaf	*Nuttallia sinuata*	S3/G3	3	104	MGPM
Slim-pod Venus' looking-glass	*Triodanis leptocarpa*	S1/G5?	1	1	MGPM
Grassy slope sedge	*Carex oreocharis*	S2/G3	1	To be determined	XTP
Birds-foot violet	*Viola pedatifida*	S1/G5	1	116	MGPM/XTP
Dwarf leadplant	*Amorpha nana*	S1S2/G5	1	69	MGPM/XTP
Bell's Twinpod	*Physaria bellii*	S2S3/G2G3	7	526	MGPM/XTP/AG
Waterthread pondweed	*Potamogeton diversifolius*	S1/G5	1	19	Wetlands and Riparian Areas

Colorado Natural Heritage Program Ranking Descriptions

CNHP designates conservation status with a number from 1 to 5, preceded by a letter that reflects the scale of the assessment
(G = global, S = subnational (e.g., state))
1= critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant and secure

An S or G rank followed by a "?" denotes a questionable rank due to insufficient information; "U" denotes that the taxon or community cannot be ranked due to insufficient information; "NR" denotes a need for review by CNHP.

Table NB2. Rare Vegetation Associations in the North TSA

Common Name	Scientific Name	Rank	Acres in the TSA	Targets
Western Wheatgrass - Green Needlegrass Herbaceous Vegetation	*Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation	S2/G3G4		Mixedgrass Prairie Mosaic

Common Name	Scientific Name	Rank	Acres in the TSA	Targets
Indian Ricegrass Shale Barren Herbaceous Vegetation	*Achnatherum hymenoides* Shale Barren Herbaceous Vegetation	S2/G2		Mixedgrass Prairie Mosaic
Needle-and-Thread Colorado Front Range Herbaceous Vegetation	*Hesperostipa comata* Colorado Front Range Herbaceous Vegetation	S1S2/G1G2		Mixedgrass Prairie Mosaic
New Mexico Needlegrass Herbaceous Vegetation	*Hesperostipa neomexicana* Herbaceous Vegetation	S3/G3		Mixedgrass Prairie Mosaic
			393	
Big Bluestem - Little Bluestem Western Great Plains Herbaceous Vegetation	*Andropogon gerardii - Schizachyrium scoparium* Western Great Plains Herbaceous Vegetation	S2/G2?		Xeric Tallgrass Prairie
Big Bluestem - Yellow Indiangrass Western Great Plains Herbaceous Vegetation	*Andropogon gerardii - Sorghastrum nutans* Western Great Plains Herbaceous Vegetation	S1S2/G2		Xeric Tallgrass Prairie
Big Bluestem - Prairie Dropseed Western Foothills Herbaceous Vegetation	*Andropogon gerardii - Sporobolus heterolepis* Western Foothills Herbaceous Vegetation	S1S2/G2		Xeric Tallgrass Prairie
Ponderosa Pine / Mountain-mahogany / Big Bluestem Tree Savannah Herbaceous Vegetation	*Pinus ponderosa / Cercocarpus montanus / Andropogon gerardii* Wooded Herbaceous Vegetation	S2?/G2		Xeric Tallgrass Prairie
			464	
Mountain-mahogany / Needle-and-Thread Shrubland	*Cercocarpus montanus / Hesperostipa comata* Shrubland	S2/G2		Upland Shrublands
Choke Cherry - (American Plum) Shrubland	*Prunus virginiana* - (*Prunus americana*) Shrubland	S3/G4Q		Upland Shrublands
Mountain-mahogany - Ill-scented Sumac / Big Bluestem Shrubland	*Cercocarpus montanus - Rhus trilobata / Andropogon gerardii* Shrubland	S2S3/G2G3		Upland Shrublands
			123	
Choke Cherry -	*Prunus virginiana* -	S3/G4Q		Wetlands and

Common Name	Scientific Name	Rank	Acres in the TSA	Targets
(American Plum) Shrubland	(*Prunus americana*) Shrubland			Riparian Areas
Western Snowberry Shrubland	*Symphoricarpos occidentalis* Shrubland	S3/G45		Wetlands and Riparian Areas
Big Bluestem - Yellow Indiangrass Western Great Plains Herbaceous Vegetation	*Andropogon gerardii - Sorghastrum nutans* Western Great Plains Herbaceous Vegetation	S1S2/G2		Wetlands and Riparian Areas
Threesquare Herbaceous Vegetation	*Schoenoplectus pungens* Herbaceous Vegetation	S3/G3G4		Wetlands and Riparian Areas
Saltgrass Herbaceous Vegetation	*Distichlis spicata* Herbaceous Vegetation	S3/G5		Wetlands and Riparian Areas
Nuttall Alkaligrass Herbaceous Vegetation	*Puccinellia nuttalliana* Herbaceous Vegetation	S3/G3?		Wetlands and Riparian Areas
Nebraska Sedge Herbaceous Vegetation	*Carex nebrascensis* Herbaceous Vegetation	S3/G4		Wetlands and Riparian Areas
Clustered Field Sedge Herbaceous Vegetation	*Carex praegracilis* Herbaceous Vegetation	S2/G3G4		Wetlands and Riparian Areas
American Mannagrass Herbaceous Vegetation	*Glyceria grandis* Herbaceous Vegetation	S2/G2?		Wetlands and Riparian Areas
Narrowleaf Cottonwood / Water Birch Woodland	*Populus angustifolia / Betula occidentalis* Woodland	S3/G3		Wetlands and Riparian Areas
Plains Cottonwood - (Peachleaf Willow) / (Coyote Willow, Sandbar Willow) Woodland	*Populus deltoides* - (*Salix amygdaloides*) / *Salix* (*exigua, interior*) Woodland	S3/G3G4		Wetlands and Riparian Areas
			138	

Colorado Natural Heritage Program Ranking Descriptions

CNHP designates conservation status with a number from 1 to 5, preceded by a letter that reflects the scale of the assessment
(G = global, S = subnational (e.g., state))
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An S or G rank followed by a "?" denotes a questionable rank due to insufficient information; "U" denotes that the taxon or community cannot be ranked due to insufficient information; "NR" denotes a need for review by CNHP.

Vegetation Monitoring: Grassland Ecosystem Management Plan

The success of Grassland Ecosystem Management Plan implementation is measured by monitoring the status of viability indicators across the Grassland Plan planning area. The Grassland Plan upland vegetation monitoring project was designed and initiated in 2009, and monitoring has been conducted annually since then. In 2009 and 2010, the complete set of 160 transects was monitored, and between 2011 and 2014 a quarter of these permanent transects were monitored each year. In 2015 and 2016, the full set of vegetation monitoring transects will be resampled. The monitoring project design, which used the GRITS methodology (Stevens and Olsen 2004), placed transects randomly across the Grassland Planning area, stratified by the three major upland grassland conservation targets: Mixedgrass Prairie Mosaic, Xeric Tallgrass Prairie, and Mesic Bluestem Prairie. A point-intercept method is used, and data is collected with a Cover Point Optical Devise.

Preliminary analyses were conducted in 2009 and 2010 to assess the status of four major viability indicators for the attributes of vegetation composition and structure: absolute cover of bare soil, relative cover of native species, native species richness and conservative species richness. Preliminary system wide vegetation monitoring results for the Xeric Tallgrass Prairie and the Mixedgrass Prairie Mosaic, two of the largest North TSA conservation targets, indicted that the overall condition was fair. Grassland Plan vegetation monitoring data analyses for the North TSA area have produced similar results. Data analyses comparing the data collected in years when all transects are monitored (2009, 2010, 2015 and 2016) will contribute to a better understanding of the condition of these conservation targets. Lists of the most frequent native and non-native species documented by Grassland Plan monitoring in the Xeric Tallgrass and Mixedgrass Prairie Mosaic are included at the end of this appendix.

Grassland vegetation monitoring, North TSA – staff photo

Vegetation Mapping

Vegetation has been mapped across the OSMP land system using a standard methodology which employs the United States National Vegetation Classification (USNVC). Vegetation mapping data is the basis for conservation target and habitat delineation in the Grassland Plan, North TSA Inventory Report and other OSMP management plans. Mapping was updated in 2014 for a large portion of the North TSA, and the remaining areas will be updated in 2015.

Methods

The USNVC can be used to classify all types of vegetation, and provides a standardized approach for assessments of conservation status, trends, and management practices for ecological communities across local, regional and national landscapes. Existing vegetation is classified within a nested hierarchy, the finest level of which is called the *Association.* Upper levels of the hierarchical classification are based largely on vegetation structure and physiognomy and the lowest levels are defined by dominant and diagnostic species.

The USNVC has the following key attributes:

- It is based upon current vegetation;
- It uses a systematic approach to classify vegetation communities across environmental continuums;
- It emphasizes natural and existing vegetation;
- It uses a combined physiognomic-floristic hierarchy;
- It identifies vegetation units based on both qualitative and quantitative data; and
- It is appropriate for mapping at multiple scales.

OSMP vegetation communities are delineated using a combination of photo interpretation and field work that is organized and processed in a GIS. Additionally, wetland and riparian areas were mapped to the Association level within the USNVC hierarchy, using CNHP's Field Guide to the Wetland and Riparian Plant Associations of Colorado (Carsey et al. 2003). Although published mapping methods that utilize the USNVC usually involve sample plots taken from a cross section of different vegetation types at the targeted level of mapping, OSMP has found it most effective to visit the majority of the system. Woodland and forest types with more than 25 percent tree cover are first outlined using aerial photos prior to field work and tree density is verified through site visits. Forest openings, grasslands, wetlands and riparian areas are comprehensively investigated in the field. This approach allows for data collection at scales consistent with OSMP's level of management, and it eliminates errors introduced by aerial image interpretation. The method is practical due to the relatively small study area and ease of access to mapping sites, as compared to vegetation mapping conditions in large national parks and other large public land units.

The minimum mapping unit (MMU) is 0.1 ha (0.25 acre) for all types except wetlands, where the MMU is set at 0.04 ha (0.10 acre). The MMU both sets the standard lower size limit used to represent vegetation communities in the map, and defines the area of interest or scale at which vegetation community patterns are assessed in the field. Relatively small MMU's have been selected because the local environment, the Great Plains-Southern Rocky Mountain ecotone, is characterized by patchy, small-scale differences in vegetation. Mapping at this finer scale increases the likelihood that these complex mosaics are detected and provides the data needed to analyze the ecological relationships among patch types. Finely resolved data also provide options for generalizing information, equipping OSMP with the data to inform both localized and system-wide management decisions.

Using aerial photographs as a guide in hard copy or electronic format, field investigators systematically visit sites and delineate boundaries between different community types. Published potential Alliance and Association descriptions have been compiled and used by ecologists to distinguish vegetation types (NatureServe 2015). The Alliance and appropriate Association is assigned to each mapped polygon. In cases where communities cannot be matched with existing published types or clearly differentiated, plot data are collected to assist with additional attribution work in the office. Plot data have not been a necessity for determining most Alliance and Association types, because existing OSMP types have been widely sampled, documented and described.

Mapping data is stored using the OSMP GIS, and can be linked to attributes such as the Grassland Plan conservation targets.

Plant Species Lists from Grassland Plan Upland Vegetation Monitoring

Table NB3. Native species found in the Mixed Grass Prairie Mosaic conservation target within the North TSA in 2010 (N=37 transects), ranked from most frequently occurring (based on percent of transects species were found in) to least frequently occurring species. Monitoring was conducted as part of the system-wide upland grassland monitoring. *OSMP scientific names are based on Weber and Wittmann, 2001.

Scientific name*	Common name	% of MGPM transects
Pascopyrum smithii	Western wheatgrass	86
Psoralidium tenuiflorum	slimflower scurfpea	78
Gutierrezia sarothrae	broom snakeweed	73

Scientific name*	Common name	% of MGPM transects
Gaura coccinea	scarlet gaura	70
Sphaeralcea coccinea	coppermallow	68
Virgulus falcatus	white prairie aster	68
Aristida purpurea	purple three-awn	65
Artemisia frigida	silver sage	65
Liatris punctata	dotted gayfeather	59
Heterotheca villosa	hairy goldenaster	54
Yucca glauca	yucca	54
Chondrosum gracile	blue grama	51
Oligosporus dracunculus ssp. glaucus	wild tarragon	51
Artemisia ludoviciana	prairie sage	49
Adenolinum lewisii	blue flax	46
Buchloe dactyloides	buffalograss	46
Opuntia macrorhiza	twistspine prickly-pear cactus	46
Astragalus shortianus	Short's milk vetch	43
Bouteloua curtipendula	sideoats grama	41
Evolvulus nuttallianus	shaggy dwarf morning-glory	38
Helianthus pumilus	rough sunflower	38
Astragalus drummondii	Drummond's milk vetch	35
Grindelia squarrosa	curly-cup gumweed	32
Erigeron colo-mexicanus	running fleabane	30
Hesperostipa comata	needle-and-thread grass	30
Nassella viridula	green needlegrass	30
Dalea candida var. oligophylla	white prairie colver	27
Rosa sayi	wild rose	27
Schedonnardus paniculatus	tumblegrass	27
Agaloma marginata	snow-on-the-mountain	24
Ambrosia psilostachya var. coronopifolia	Western ragweed	24
Brickellia eupatorioides	false boneset	24
Chrysothamnus nauseosus ssp. nauseosus	dwarf rabbitbrush	24
Machaeranthera pinnatifida	lacy tansyaster	24
Oxybaphus linearis	narrow-leaved umbrellawort	24
Penstemon secundiflorus	sidebells penstemon	24
Viola nuttallii	Nuttall's violet	24

Scientific name*	Common name	% of MGPM transects
Allium cernuum	nodding onion	22
Astragalus bisulcatus	two grooved milk vetch	22
Ratibida columnifera	prairie coneflower	22
Andropogon gerardii	big bluestem	19
Chamaesyce glyptosperma	ribseed sandmat	19
Elymus elymoides	squirreltail	19
Oenothera howardii	Howard's evening primrose	19
Opuntia polyacantha	plains prickly-pear	19
Oxytropis sericea	silver locoweed	19
Rhus aromatica ssp. trilobata	three-leaf sumac	19
Tragia ramosa	stinging spurge	19
Astragalus flexuosus	wiry milk vetch	16
Cirsium ochrocentrum	Wavyleaf thistle	16
Comandra umbellata ssp. pallida	bastard toadflax	16
Eriogonum brevicaule	yellow buckwheat	16
Helianthus annuus	common sunflower	16
Hybanthus verticillatus	green violet	16
Koeleria macrantha	prairie Junegrass	16
Mertensia lanceolata	prairie bluebells	16
Musineon divaricatum	leafy wildparsley	16
Quincula lobata	Chinese lantern	16
Adenolinum pratense	meadow flax	14
Argemone hispida	rough prickly poppy	14
Astragalus agrestis	purple milk vetch	14
Dalea purpurea	purple prairie clover	14
Iva axillaris	povertyweed	14
Lomatium orientale	salt-and-pepper	14
Plantago patagonica	woolly plantain	14
Polygonum douglasii	devil's shoestring	14
Sporobolus cryptandrus	sand dropseed	14
Thelesperma megapotamicum	Hopi tea	14
Aphyllon fasciculatum	clustered broomrape	11
Argemone polyanthemos	crested prickly poppy	11
Dyssodia papposa	fetid marigold	11
Glandularia bipinnatifida	showy vervain	11

Scientific name*	Common name	% of MGPM transects
Hesperostipa neomexicana	New Mexico feathergrass	11
Hymenopappus filifolius var. cinereus	fineleaf hymenopappus	11
Lesquerella montana	mountain bladderpod	11
Opuntia phaeacantha	New Mexico prickly-pear cactus	11
Paronychia jamesii	James' nailwort	11
Tithymalus brachyceras	Rocky Mountain spurge	11
Allium textile	textile onion	8
Asclepias viridiflora	green-flowered milkweed	8
Aster porteri	Porter aster	8
Chenopodium incanum	mealy goosefoot	8
Chondrosum hirsutum	hairy grama	8
Coryphantha missouriensis	nipple cactus	8
Hedysarum boreale	chainpod	8
Heterotheca foliosa	hairy goldenaster	8
Ipomopsis spicata	spike gilia	8
Leucocrinum montanum	sand lily	8
Pterogonum alatum	singed buckwheat	8
Senecio spartioides	broom groundsel	8
Achnatherum hymenoides	Indian ricegrass	5
Asclepias pumila	dwarf milkweed	5
Astragalus laxmannii	prairie milk vetch	5
Calochortus gunnisonii	mariposa lily	5
Carex pensylvanica ssp. heliophila	sun sedge	5
Chenopodium pratericola	desert goosefoot	5
Delphinium carolinianum ssp. virescens	plains larkspur	5
Descurainia pinnata	Western tansymustard	5
Drymocallis fissa	bigflower cinquefoil	5
Lithospermum incisum	narrow-leaved puccoon	5
Monarda pectinata	beebalm	5
Onosmodium molle ssp. occidentale	Western marbleseed	5
Orophaca tridactylica	three-fingered milk vetch	5
Oxytropis lambertii	Colorado locoweed	5
Packera pseudaurea	falsegold groundsel	5
Phyla cuneifolia	fogfruit	5

Scientific name*	Common name	% of MGPM transects
Physalis hederifolia var. comata	ivyleaf ground cherry	5
Physalis heterophylla	clammy ground cherry	5
Poa agassizensis	Rocky Mountain bluegrass	5
Rosa woodsii	Woods' rose	5
Sporobolus asper	dropseed	5
Toxicoscordion venenosum	meadow death camas	5
Vicia americana	American vetch	5
Vicia linearis	mat vetch	5
Virgulus ericoides	white heath aster	5
Achillea lanulosa	Western yarrow	3
Asclepias stenophylla	narrow-leaved milkweed	3
Astragalus parryi	Parry's milk vetch	3
Atriplex canescens	four-winged saltbush	3
Brickellia rosmarinifolia ssp. chlorolepis	false boneset	3
Brickellia spp.	unknown brickellbush	3
Campanula rotundifolia	common harebell	3
Carex spp. 1	unknown sedge 1	3
Castilleja sessiliflora	plains paintbrush	3
Cerastium strictum	mouse-eard chickweed	3
Chenopodium berlandieri	pitseed goosefoot	3
Chrysothamnus parryi ssp. parryi	Parry's rabbitbrush	3
Critesion jubatum	foxtail barley	3
Delphinium geyeri	Geyer's larkspur	3
Distichlis stricta	inland saltgrass	3
Echinocereus viridiflorus	green-flowered hedgehog cactus	3
Elymus lanceolatus	thickspike wheatgrass	3
Erigeron divergens	spreading fleabane	3
Erigeron flagellaris	whiplash fleabane	3
Erigeron pumilus	low daisy	3
Eriogonum umbellatum	wild buckwheat	3
Erysimum capitatum	Western wallflower	3
Gaura mollis	velvetweed	3
Hedeoma hispida	rough false pennyroyal	3
Juncus arcticus ssp. ater	arctic rush	3

Scientific name*	Common name	% of MGPM transects
Lappula redowskii	beggar's tick	3
Lathyrus leucanthus	white peavine	3
Monarda fistulosa var. menthifolia	horsemint	3
Nothocalais cuspidata	prairie false dandelion	3
Nuttallia sinuata	leechleaf blazingstar	3
Opuntia fragilis	brittle cactus	3
Oxalis dillenii	slender yellow woodsorrel	3
Oxybaphus hirsutus	hairy umbrellawort	3
Oxytropis spp.	unknown locoweed	3
Packera plattensis	prairie groundsel	3
Padus virginiana ssp. melanocarpa	chokecherry	3
Phlox multiflora	flowery phlox	3
Physalis virginiana	Virginia ground cherry	3
Physaria bellii	Bell's twinpod	3
Physocarpus monogynus	mountain ninebark	3
Populus deltoides ssp. monilifera	plains cottonwood	3
Ribes aureum	golden currant	3
Ribes cereum	wax currant	3
Schizachyrium scoparium	little bluestem	3
Scutellaria brittonii	Britton's skullcap	3
Sporobolus airoides	alkali sacaton	3
Stanleya pinnata	prince's plume	3
Thermopsis divaricarpa	spreadfruit goldenbanner	3
Townsendia hookeri	Easter daisy	3
Tradescantia occidentalis	spiderwort	3

Table NB4. Nonnative species found in the Mixed Grass Prairie Mosaic conservation target within the North TSA in 2010 (N=37 transects), ranked from most frequently occurring (based on percent of transects species were found in) to least frequently occurring species. Monitoring was conducted as part of the system-wide upland grassland monitoring.*OSMP scientific names are based on Weber and Wittmann, 2001.

Scientific name*	Common name	% of MGPM transects
Alyssum parviflorum	alyssum	100
Tragopogon dubius ssp. major	yellow salsify	89
Bromus japonicus	Japanese brome	86

Scientific name*	Common name	% of MGPM transects
Convolvulus arvensis	bindweed	86
Lactuca serriola	prickly lettuce	76
Erodium cicutarium	redstem filaree	57
Anisantha tectorum	cheatgrass	49
Podospermum laciniatum	false salsify	49
Carduus nutans ssp. macrolepis	musk thistle	46
Sisymbrium altissimum	Jim Hill mustard	43
Bromopsis inermis	smooth brome	38
Camelina microcarpa	littlepod false flax	38
Acosta diffusa	diffuse knapweed	35
Melilotus officinale	yellow sweet clover	30
Neolepia campestris	fieldcress	30
Salsola australis	prickly Russian-thistle	30
Lepidium densiflorum	peppergrass	24
Polygonum arenastrum	devil's shoestrings	24
Medicago lupulina	black medic	22
Taraxacum officinale	common dandelion	19
Agropyron desertorum	crested wheatgrass	16
Silene antirrhina	sleepy catchfly	16
Verbascum thapsus	common mullein	16
Breea arvensis	Canada thistle	11
Chenopodium album	goosefoot	11
Fallopia convolvulus	black bindweed	11
Linaria genistifolia ssp. dalmatica	Dalmation toadflax	11
Melilotus albus	white sweet clover	11
Poa pratensis	Kentucky bluegrass	11
Descurainia sophia	herb sophia	8
Melilotus spp.	unknown sweetclover	8
Plantago lanceolata	English plantain	8
Poa compressa	Canada bluegrass	8
Rumex crispus	curly dock	8
Salvia aethiopis	Mediterranean sage	8
Tridens muticus var. elongatus	slim tridens	8
Verbena bracteata	bigbract verbena	8
Ambrosia artemisiifolia var. elatior	annual ragweed	5

Scientific name*	Common name	% of MGPM transects
Bromus briziformis	rattlesnakegrass	5
Dipsacus fullonum	common teasel	5
Elytrigia repens	quackgrass	5
Glaucium corniculatum	blackspot horned poppy	5
Hypericum perforatum	St. Johnswort	5
Marrubium vulgare	horehound	5
Medicago sativa	alfalfa	5
Solanum rostratum	buffalobur nightshade	5
Thinopyrum intermedium	intermediate wheatgrass	5
Thlaspi arvense	pennycress	5
Arctium minus	lesser burdock	3
Atriplex heterosperma	twoscale saltbush	3
Bassia sieversiana	kochia	3
Chamaesyce serpyllifolia	thymeleaf sandmat	3
Cichorium intybus	chicory	3
Conyza canadensis	horseweed	3
Cuscuta epithymum ssp. approximata	dodder	3
Cylindropyrum cylindricum	jointed goatgrass	3
Dactylis glomerata	orchardgrass	3
Festuca arundinacea	tall fescue	3
Galium spurium	cleavers	3
Hordeum vulgare	barley	3
Nepeta cataria	catnip	3
Pseudognaphalium canescens	Wright's cudweed	3
Salsola spp.	unknown Russian thistle	3
Saponaria officinalis	soapwort	3
Securigera varia	crownvetch	3
Spergularia media	sand spurry	3
Stenactis strigosa	daisy fleabane	3
Thinopyrum ponticum	tall wheatgrass	3
Trifolium pratense	red clover	3
Trifolium repens	white dutch clover	3
Ulmus pumila	Chinese elm	3
Veronica peregrina ssp. xalapensis	purslane speedwell	3

Table NB5. Native species found in the Xeric Tallgrass Prairie conservation target within the North TSA in 2010 (N= 5 transects), ranked from most frequently occurring (based on percent of transects species were found in) to least frequently occurring species. Monitoring was conducted as part of the system-wide upland grassland monitoring. *OSMP scientific names are based on Weber and Wittmann, 2001.

Scientific name	Common name	% of XTG transects
Ambrosia psilostachya var. coronopifolia	Western ragweed	100
Andropogon gerardii	big bluestem	100
Artemisia frigida	silver sage	100
Artemisia ludoviciana	prairie sage	100
Carex pensylvanica ssp. heliophila	sun sedge	100
Erigeron colo-mexicanus	running fleabane	100
Hesperostipa comata	needle-and-thread grass	100
Koeleria macrantha	prairie Junegrass	100
Opuntia macrorhiza	twistspine prickly-pear cactus	100
Poa agassizensis	Rocky Mountain bluegrass	100
Yucca glauca	yucca	100
Bouteloua curtipendula	sideoats grama	80
Cerastium strictum	mouse-eard chickweed	80
Chenopodium pratericola	desert goosefoot	80
Elymus lanceolatus	thickspike wheatgrass	80
Helianthus pumilus	rough sunflower	80
Heterotheca villosa	hairy goldenaster	80
Phacelia heterophylla	scorpionweed	80
Psoralidium tenuiflorum	slimflower scurfpea	80
Allium cernuum	nodding onion	60
Campanula rotundifolia	common harebell	60
Cirsium ochrocentrum	yellowspine thistle Wavyleaf thistle	60
Dalea purpurea	purple prairie clover	60
Elymus elymoides	squirreltail	60
Eriogonum umbellatum	wild buckwheat	60
Erysimum capitatum	Western wallflower	60
Gaillardia aristata	blanketflower	60
Gaura coccinea	scarlet gaura	60
Grindelia squarrosa	curly-cup gumweed	60
Oxybaphus hirsutus	hairy umbrellawort	60
Padus virginiana ssp. melanocarpa	chokecherry	60

Scientific name	Common name	% of XTG transects
Penstemon virens	blue mist penstemon	60
Physalis virginiana	Virginia ground cherry	60
Rosa sayi	wild rose	60
Schizachyrium scoparium	little bluestem	60
Sporobolus cryptandrus	sand dropseed	60
Tradescantia occidentalis	spiderwort	60
Tragia ramosa	stinging spurge	60
Virgulus falcatus	white prairie aster	60
Allium textile	textile onion	40
Aristida purpurea	purple three-awn	40
Asclepias viridiflora	green-flowered milkweed	40
Aster porteri	Porter aster	40
Astragalus flexuosus	wiry milk vetch	40
Chondrosum gracile	blue grama	40
Comandra umbellata ssp. pallida	bastard toadflax	40
Drymocallis fissa	bigflower cinquefoil	40
Geranium caespitosum ssp. caespitosum	Western purple crane's bill	40
Heuchera parvifolia	littleleaf alumroot	40
Lathyrus leucanthus	white peavine	40
Lesquerella montana	mountain bladderpod	40
Liatris punctata	dotted gayfeather	40
Onosmodium molle ssp. occidentale	Western marbleseed	40
Opuntia polyacantha	plains prickly-pear	40
Oxalis dillenii	slender yellow woodsorrel	40
Oxybaphus linearis	narrow-leaved umbrellawort	40
Pascopyrum smithii	Western wheatgrass	40
Ratibida columnifera	prairie coneflower	40
Rhus aromatica ssp. trilobata	three-leaf sumac	40
Ribes cereum	wax currant	40
Senecio spartioides	broom groundsel	40
Asclepias spp.	unknown milkweed	20
Astragalus agrestis	purple milk vetch	20
Astragalus laxmannii	prairie milk vetch	20
Astragalus shortianus	Short's milk vetch	20
Boechera drummondii	Drummond's rockcress	20
Brickellia californica	California brickellbush	20

Scientific name	Common name	% of XTG transects
Bromopsis lanatipes	woolly brome	20
Cercocarpus montanus	mountain mahogany	20
Chamaesyce glyptosperma	ribseed sandmat	20
Cystopteris fragilis	brittlefern	20
Descurainia pinnata	Western tansymustard	20
Dichanthelium oligosanthes var. scribnerianum	Scribner's rosette grass	20
Echinocereus viridiflorus	green-flowered hedgehog cactus	20
Erigeron pumilus	low daisy	20
Evolvulus nuttallianus	shaggy dwarf morning-glory	20
Gutierrezia sarothrae	broom snakeweed	20
Harbouria trachypleura	whiskbroom parsley	20
Helianthus annuus	common sunflower	20
Hesperostipa spartea	porcupine grass	20
Lathyrus eucosmus	peavine	20
Leucopoa kingii	kingspike fescue	20
Monarda fistulosa var. menthifolia	horsemint	20
Muhlenbergia montana	mountain muhly	20
Muhlenbergia wrightii	spike muhly	20
Nassella viridula	green needlegrass	20
Nuttallia sinuata	leechleaf blazingstar	20
Oenothera villosa ssp. strigosa	common evening-primrose	20
Oligosporus dracunculus ssp. glaucus	wild tarragon	20
Oreobatus deliciosus	Boulder raspberry	20
Oryzopsis asperifolia	rough-leaved ricegrass	20
Oxytropis sericea	silver locoweed	20
Pediocactus simpsonii var. minor	ball cactus	20
Penstemon secundiflorus	sidebells penstemon	20
Physalis hederifolia var. comata	ivyleaf ground cherry	20
Poa nemoralis ssp. interior	inland bluegrass	20
Prunus americana	American plum	20
Rhus glabra	smooth sumac	20
Scutellaria brittonii	Britton's skullcap	20
Sorghastrum avenaceum	yellow Indiangrass	20
Sporobolus asper	dropseed	20
Sporobolus heterolepis	prairie dropseed	20

Scientific name	Common name	% of XTG transects
Tithymalus brachyceras	Rocky Mountain spurge	20
Toxicodendron rydbergii	poison-ivy	20

Table NB6. Nonnative species found in the Xeric Tallgrass Prairie conservation target within the North TSA in 2010 (N= 5 transects), ranked from most frequently occurring (based on percent of transects species were found in) to least frequently occurring species. Monitoring was conducted as part of the system-wide upland grassland monitoring. *OSMP scientific names are based on Weber and Wittmann, 2001.

Scientific name	Common name	% of XTG transects
Alyssum parviflorum	alyssum	100
Bromus japonicus	Japanese brome	100
Lactuca serriola	prickly lettuce	100
Poa compressa	Canada bluegrass	100
Tragopogon dubius ssp. major	yellow salsify	100
Anisantha tectorum	cheatgrass	80
Sisymbrium altissimum	Jim Hill mustard	80
Verbascum thapsus	common mullein	80
Silene antirrhina	sleepy catchfly	60
Breea arvensis	Canada thistle	40
Camelina microcarpa	littlepod false flax	40
Carduus nutans ssp. macrolepis	musk thistle	40
Chenopodium album	goosefoot	40
Erodium cicutarium	redstem filaree	40
Galium spurium	cleavers	40
Lepidium densiflorum	peppergrass	40
Linaria genistifolia ssp. dalmatica	Dalmation toadflax	40
Ambrosia artemisiifolia var. elatior	annual ragweed	20
Bromopsis inermis	smooth brome	20
Convolvulus arvensis	bindweed	20
Conyza canadensis	horseweed	20
Marrubium vulgare	horehound	20
Neolepia campestris	fieldcress	20
Panicum capillare	witchgrass	20
Pseudognaphalium canescens	Wright's cudweed	20
Secale cereale	cereal rye	20
Taraxacum officinale	common dandelion	20

Scientific name	Common name	% of XTG transects
Ulmus pumila	Chinese elm	20

Table NB7. Average cover of substrate and total vegetation (± 1 standard error of the mean) found in the Mixed Grass Prairie Mosaic (MGPM) and Xeric Tallgrass Prairie (XTP) conservation targets within the North TSA in 2010

	MGPM	XTP
Number of transects	37	5
Bare soil/ground cover	13.1 ± 2.0	1.6 ± 0.7
Litter cover	29.5 ± 2.1	18.4 ± 2.0
Rock cover	3.9 ± 0.8	18.0 ± 4.1
Total vegetation cover	53.4 ± 2.1	62.0 ± 2.6

N-Appendix B: Literature Cited

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N-Appendix C: Invasive Plant Species

Top: Common teasel (Dipsicus fullonum) dominated wetland OSMP staff

Bottom: Jointed goatgrass(Cylindropyrum cylindricum) swath along trail OSMP staff

Invasive plant species have the ability to thrive and spread aggressively outside their native range and can change ecological processes (Mummey and Rilling 2006 and Stinson et al. 2006), can promote more frequent fires (Coffman et al. 2010 and Balch et al. 2013), and reduce biomass and diversity of native flora and fauna (Gould and Gorchov 2000, Burghardt et al. 2009, Spyreas et al. 2010, Tallamy et al. 2010, and Hanula and Horn 2011). An "invasive species" is defined as a species that is 1) non-native (or alien) to the ecosystem under consideration, and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (U.S. Department of Agriculture 2012). Most invasive plant species tracked and managed by OSMP are also noxious weeds that are alien (not native to the state) where the plant and parts of the plant have been designated by rule as being noxious as defined by the Colorado Noxious Weed Act, §§ 35-5.5-101 through 119, C.R.S. (2003). The Colorado Noxious Weed Act (35-5.5 CRS) established a noxious weed list with prioritized management goals for the weeds on the A, B, C, and Watch lists. Each noxious weed is required to be eradicated, contained or controlled (A and B lists only). Elimination means the removal or destruction of all emerged, growing plants of a population of List A or List B species designated for elimination by the Commissioner. Plants mandated for elimination must not be allowed to spread. Containment means maintaining an intensively managed buffer zone that separates infested regions, where suppression activities prevail, from largely infested regions where elimination activities prevail. Suppression means reducing the vigor of noxious weed populations within an infested region, decreasing the propensity of noxious weed species to spread to surrounding lands and mitigating the negative effects of noxious weed populations on infested lands. **Maps N5 and N6** show the known locations of List A and List B species, respectively mandated for elimination within the North TSA planning area. Even though OSMP actively treats invasive plant species through various integrated methods, including noxious weeds as described in the Colorado Noxious Weed Act, preventing the spread of invasive plant species is the first and most efficient management method (Wittenberg & Cock 2001, Leung et al. 2002). Reducing the spread of invasive plant species, especially in areas with low presence (**Map N4**) is accomplished by containing known infestations through multiple active integrated methods and minimizing or eliminating human associated disturbance, limiting soil disturbances, establishing or maintaining competitive native plant communities, and preventing movement of propagules along disturbance routes and on users and equipment. Propagules are often moved along roadways on vehicles and

machinery, as well as, recreationists (Potito 1995, Pyle 1995, Sheley et al. 1996).

OSMP monitors the distribution and/or abundance of 116 invasive or alien plants species (**Table NC1**) and actively treats approximately 65 species on OSMP-managed lands each year. The management of invasive plant species on OSMP lands is a key focus of the department and integrated pest management considerations factor into most management decisions. A key to effective weed management is having accurate and consistent mapping of weed occurrences across the system. **Map N4** "Density of Priority Invasive Plant Species" is a visual representation of invasive plant densities in mapped areas of the North TSA.

In 2006 staff began mapping invasive plant species across the OSMP system using methods developed by Utah State University and referred to as Rapid Assessment Mapping (RAM). The primary objective of this project is to document the distribution and abundance of targeted invasive plant species across the range of native habitats and areas of management within Boulder OSMP lands. The information from this inventory is useful in the city's ongoing efforts to improve strategic planning, to increase the effectiveness of field operations associated with invasive plant management and conservation efforts and to assist with recreation driven planning and construction projects.

Invasive plant mapping in 2006, 2007 and 2014 focused on large portions of the North TSA (**Map N4**). RAM inventories are conducted between June and August. Staffing and timing restrictions limit the amount of mapping possible in any given year so mapping is focused on more contiguous portions of the OSMP system and new properties. Additional portions of the North TSA will be mapped as resources become available.

Field searches were conducted at the finest scale required to be confident that 90 percent or more of all targeted invasive plant infestations 0.01 acre or larger within the inventory area were detected. Mapping consisted of walking transects from one side of a property to the other covering the entire unit. Transect swaths varied in width based on topography, vegetation cover and target species. Widths ranged from less than 25 meters in denser riparian areas to 100 meters in open grasslands. Geo XT GPS units were used to navigate along inventory transects and to collect data related to each weed occurrence using a RAM specific data dictionary. For each invasive plant patch the mapper recorded the species name, size of the infestation and percent cover in five categories ranging from a trace (less than one percent) to a majority (51-100 percent). Scattered patches separated by less than 50 meters were considered one distinct patch.

Map N4 displays a weighted density of the RAM invasive plant inventory data currently completed within the North TSA. To account for the size of the infestation and the percent cover, an importance value, or weight, was assigned to each mapped weed occurrence. The importance value was calculated as acreage multiplied by percent cover and then multiplied by a constant value to assure all cells had an integer value. The density analysis was performed using a 500 foot search radius to obtain the value of each cell in the map. The spectrum of low to high weed

densities on the map represents areas with increasingly higher invasive plant cover and larger infestation sizes. The density could be attributed to one individual species or a combination of multiple species occurrences. It is important to note that this map displays a subset of the RAM data collected to date. Species with incomplete mapping were omitted from the analysis as their populations are not well represented throughout the entire mapped portion of the North TSA. Large portions of the North TSA still require mapping and will be a focus of upcoming field seasons. Current mapping data are based on the best available data and may change as additional mapping is completed.

Maps N5 and N6 display the mapped locations of List A species and List B species that are designated for elimination in all of Boulder County or a portion of Boulder County. These maps don't include List B species designated for elimination only along public parking lots, roads and within 15 feet of the mean high water mark of perennial and intermittent streams. Preventing the species depicted in **Maps N5 and N6** from spreading, and with the ultimate goal of elimination, is mandated by state law. Mapping of species mandated for elimination is updated yearly as new patches are found. This mapping data is instrumental to planning processes to ensure these species don't spread either through soil disturbance or through seeds or vegetative propagules on equipment, staff and visitors.

Table NC1. List of invasive plant species tracked and/or treated by the OSMP IPM program and species with known populations in the North TSA.

Common Name	Scientific Name	STATE DESIGNATION	PRESENT IN NORTH TSA
Absinth wormwood	***Artemisia absinthium***	**B+**	**Yes**
Bermudagrass	*Cynodon dactylon*		
Black locust	*Robinia pseudoacacia*		Yes
Bladder senna	*Colutea arborescens*		Yes
Bohemian knotweed	***Polygonum bohemica***	**A**	**Yes**
Bouncingbet	***Saponaria officinalis***	**B+**	**Yes**
Bull thistle	***Cirsium vulgare***	**B+**	**Yes**
Canada thistle	***Cirsium arvense***	**B**	**Yes**
Cattail	*T. angustifolia & x glauca*		Yes

Cheatgrass	*Bromus tectorum*	C	Yes
Chicory	***Cichorium intybus***	**C**	**Yes**
Common buckthorn	*Rhamnus cathartica*		
Common Bugloss	*Anchusa officinalis*	Watch	
Common burdock	***Arctium minus***	**C**	**Yes**
Common mullein	*Verbascum thapsus*	C	Yes
Common reed	*Phragmities australis var australis*		
Common tansy	***Tanacetum vulgare***	**B+**	**Yes**
Common teasel	***Dipsacus fullonum***	**B +**	**Yes**
Corn chamomile	*Anthemis arvensis*	B	
Cotoneaster	*Cotoneaster sp.*		Yes
Crack Willow	*Salix Fragilis*		Yes
Creeping buttercup	*Ranunculus repens*		Yes
Crown vetch	***Securigera [Coronilla] varia***		**Yes**
Cutleaf teasel	***Dipsacus laciniatus***	**B+**	**Yes**
Cypress spurge	*Euphorbia cyparissias*	A	
Dalmatian toadflax	***Linaria genistifolia subsp. dalmatica***	**B +**	**Yes**
Dame's rocket	***Hesperis matronalis***	**B +**	**Yes**
Diffuse knapweed	***Centaurea diffusa***	**B+**	**Yes**
Dyer's woad	*Isatis tinctoria*	A	
Eurasian watermilfoil	*Myriophyllum spicatum*	B	
European barberry	*Berberis vulgaris*		
European privet	*Ligustrum vulgare*		Yes

Field bindweed	*Convulvulus arvensis*	C	Yes
Garden loosestrife	*Lysimachia vulgaris*		Yes
Garlic mustard	*Alliaria petiolata*	Watch	Yes
Giant knotweed	*Polygonum sachalinense*	A	
Green Ash	*Frazinus pennsylvanica var. lanceolata*		Yes
Hairy willow-herb	***Epilobium hirsutum***	**A**	**Yes**
Himalayan blackberry	*Rubus armeniacus*	Watch	
Hoary cress	***Cardaria draba***	**B+**	**Yes**
Honeysuckle	*lonicera morrowii* and *l. tatarica*		Yes
Houndstongue	***Cynoglossum officinale***	**B+**	**Yes**
Japanese barberry	*Berberis vulgaris*		
Japanese brome	*Bromus japonicus*		Yes
Japanese knotweed	***Polygonum cuspidatum***	**A**	
Jointed goatgrass	***Aegilops cylindrical***	**B+**	**Yes**
Honeylocust	*Gleditsia triacanthos*		Yes
Kochia	*Kochia scoparia*		Yes
Leafy spurge	*Euphorbia esula*	B +	Yes
Mayweed chamomile	*Anthemis cotula*	B	
Mediterranean sage	***Salvia aethiopis***	**A**	**Yes**
Moth mullein	***Verbascum blattaria***	**B +**	**Yes**
Musk thistle	***Carduus nutans***	**B**	**Yes**
Myrtle spurge	***Euphorbia myrsinites***	**A**	**Yes**

Orange hawkweed	***Hieracium aurantiacum***	**A**	**Yes**
Oxeye daisy	***Chrysanthemum leucanthemum***	**B +**	**Yes**
Perennial pepperweed	***Lepidium latifolium***	**B+**	**Yes**
Perennial sowthistle	***Sonchus arvensis***	**C**	**Yes**
Perennial sweetpea	***Lathyrus latifolius***		**Yes**
Plumeless thistle	*Carduus acanthoides*	B+	
Poison hemlock	*Conium maculatum*	C	Yes
Puncturevine	*Tribulus terrestris*	C	Yes
Purple loosestrife	***Lythrum salicaria***	**A**	**Yes**
Quackgrass	*Elytrigia repens*	B	Yes
Queen of the Meadow	*Filipendula ulmaria*		
Red horned poppy	*Glaucium corniculatum*		Yes
Redstem filaree	*Erodium cicutarium*		Yes
Reed canarygrass	*Phalaris arundinacea*		Yes
Rush skeletonweed	*Chondrilla juncea*	A	
Russian knapweed	***Acroptilon repens***	**B+**	**Yes**
Russian-olive	***Elaeagnus angustifolia***	**B**	**Yes**
Salt cedar	*Tamarix chinensis, T. parviflora* and *T. ramosissima*	B+	Yes
Scentless chamomile	*Matricaria perforata*	B +	
Scotch thistle	***Onopordum acanthium, O. tauricum***	**B**	**Yes**
Siberian elm	*Ulmus pumila*		Yes

Spotted knapweed	***Centaurea maculosa***	**B+**	**Yes**
Squarrose knapweed	*Centaurea virgata*	A	
Sulfur cinquefoil	***Potentilla recta***	**B+**	**Yes**
Sweetbriar rose	*Roso rubiginosa*		Yes
Tall oatgrass	*Arrhenatherum elatius*		Yes
Tansy ragwort	*Senecia jacobaea*	A	
Tree of Heaven	*Ailanthus altissima*		Yes
Wayfaring Tree	*Viburnum lantana*		Yes
White campion	*Silene alba*		Yes
White Horehound	*Marrubium vulgare*		Yes
Wild caraway	*Carum carvi*	B	
Wild four o'clock	*Mirabilis nyctaginea*		
Yellow iris	*Iris pseudacorus*		Yes
Yellow starthistle	*Centaurea solstitialis*	A	
Yellow toadflax	***Linaria vulgaris***	**B +**	**Yes**

Bold used in Invasive Plant Density Map

(Map N4)

B+ species mandated for elimination in Boulder County or a portion of Boulder County (*does not include species where elimination is only mandated along public parking areas, roads and within 15 feet of the mean high water mark of perennial and intermittent streams*).

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