MONITORING AASE'S ONION (*ALLIUM AASEAE*) ON CITY OF BOISE RESERVES IN THE LOWER BOISE FOOTHILLS: 2021 RESULTS

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ABSTRACT
Aase's onion (*Allium aaseae*) is a rare plant species with a global distribution restricted to southwestern Idaho. The lower Boise foothills support a substantial portion of the species' global population. Much of Aase's onion habitat in the foothills has been degraded over time due to weed invasion, wildfires, recreational impacts, and other disturbances. In addition, urban expansion and development has destroyed portions of multiple Aase's onion populations in the foothills. Five City of Boise (COB) Reserves serve as a refuge for Aase's onion in the lower foothills – Military Reserve, Camels Back Reserve, Hulls Gulch Reserve, Polecat Reserve, and Hillside to Hollow Reserve. In 2021, as a response to growing conservation concerns for Aase's onion, the COB/Department of Parks and Recreation and the Idaho Native Plant Society teamed up to initiate a long-term monitoring program for Aase's onion populations located within these 5 Reserves. The objective of the monitoring program is to provide conservation status information to COB land resource managers that will help them meet stewardship objectives linked to maintaining populations of Aase's onion on lands they administer within a multiple-use management framework. To accomplish this, the monitoring program is designed to collect population, habitat, and disturbance trend information for Aase's onion populations. Monitoring data collection takes place in a 1/10 acre (37 ft. radius) circular plot. Overall, a total of 23 monitoring plots were established in 2021 within the Reserves. First year monitoring found Aase's onion abundance varied greatly in the plots, from <10 to an estimated 6000 individuals. This indicates the species is doing well at some subpopulations, but in danger of local extirpation at others. Native species dominated the vegetation at some plots but` were much less common than associated weed species at other plots. All plots had at least 1 type of ground disturbance, with most having 2 or more. Soil mounds from northern pocket gopher digging and deer tracks were the disturbances recorded in the most plots. Other disturbances included dog tracks, footprints, trails, weed invasion, and wildfire. Monitoring points to plant community-level habitat degradation due to invasive weed species and the associated loss of shrubs, bunchgrasses, and other native plant species important for soil stability to be the biggest threat to the persistence of Aase's onion within COB Reserves. Moving forward, the plan is to resample the plots every 3 years. This report outlines the monitoring protocol and summarizes the monitoring information collected in 2021.

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INTRODUCTION

Aase's onion (*Allium aaseae*) is a ground-hugging plant with a striking display of small pink flowers that bloom in early spring (Figure 1). It has a global distribution limited to southwestern Idaho, primarily in the Boise to Emmett foothills, but also with a several disjunct populations near Weiser. Aase's onion occupies dry, relatively sparsely vegetated, well-drained, sandy soil slopes, usually within bitterbrush (*Purshia tridentata*) or bitterbrush - big sagebrush (*Artemisia tridentata*) plant communities. Much of Aase's onion habitat in the Boise foothills has been degraded over time due to weed invasion, wildfires, recreational impacts, and other disturbances. Furthermore, urban expansion and development has destroyed portions of multiple Aase's onion populations in the foothills. Many known Aase's onion locations in the Boise foothills occur fully or partially on private property, but Ada County, City of Boise (COB), State, and Bureau of Land Management lands also support substantial populations. Aase's onion has been a species of conservation concern in Idaho for many years due to its restricted geographic range, the documented loss and degradation of habitat, especially in the Boise foothills, vulnerability of its habitat to multiple, ongoing threats, and the location of many populations on private land where conservation options are typically limited. Aase's onion is considered globally rare and imperiled by the Idaho Native Plant Society, and a globally imperiled/high endangerment special status plant species by the Idaho BLM (Mancuso et al. 2019, Idaho Native Plant Society 2020).

In 1996, The U.S. Fish and Wildlife Service (USFWS), COB, and Ada County developed a Boise Foothills Conservation Agreement (Conservation Agreement) for Aase's onion and two other rare plant species found in the Boise foothills, Mulford's milkvetch (*Astragalus mulfordiae*), and slickspot peppergrass (*Lepidium papilliferum*; Boise Parks and Recreation Department. 1996). The Conservation Agreement, revised in 2008, was put in place to help protect and ensure the long-term conservation of the three species and their habitats on property owned by COB, foothill properties with conservation easements held by COB, and the Ada County Sanitary Landfill. The Conservation Agreement recognized the need to have comprehensive and up-to-date conservation information for the three species in order to be effective. Projects to support the Conservation Agreement included Aase's onion surveys in several COB Reserves in 2008 (Idaho Department of Fish and Game 2008, Mancuso 2008) and in 2009 (Kinter 2009). These surveys updated location, abundance, habitat, and threat information for many previously known Aase's onion populations and documented multiple new locations. Efforts to update Aase's onion conservation status information on COB properties have been minimal since these surveys.

In 2021, recognizing this decade-plus information gap and in response to growing conservation concerns, the COB/Department of Parks and Recreation and the Idaho Native Plant Society (INPS) teamed up to initiate a long-term monitoring program for Aase's onion populations located within COB Reserves in the lower Boise foothills. The objective of the monitoring program is to provide conservation status information to COB land resource managers that will help them meet stewardship objectives linked to maintaining populations Aase's onion on lands they administer within a multiple-use management framework. The goal of the monitoring program is to collect population, habitat, and disturbance trend information for Aase's onion populations in COB Reserves. Monitoring information can be used to prioritize invasive species treatment areas, inform decisions where additional signage may be needed to educate the public about conservation efforts, help evaluate resource protection actions, and other possible pro-active management measures to benefit Aase's onion and its habitat. This project marks the first monitoring program ever undertaken for Aase's onion on COB property in the Boise foothills. This report outlines the monitoring protocol and summarizes the monitoring information collected in 2021.

METHODS

An initial step was to query the Idaho Fish and Wildlife Information System (IFWIS) database to obtain the most current information for Aase's onion locations on COB property in the Boise foothills (Idaho Department of Fish and Game 2021). The database verified the presence of 10 Aase's onion Element Occurrences (EO) located fully or partially on 5 COB open space reserves, including Military, Camels Back, Hulls Gulch, Polecat, and Hillside to Hollow (Figure 2). An EO is "an area of land in which a species is or was present" (NatureServe 2002), and represents geospatial data used in natural heritage program methodology to map a species' distribution. Most Aase's onion EOs consist of multiple subpopulations, discrete groupings of the species in relatively close proximity to each other separated by gaps of unoccupied or unsuitable habitat. We established a minimum of 1 monitoring plot in each of the 10 EOs located within the COB Reserves. One or more additional monitoring plots were established in 7 of the larger EOs consisting of >3 subpopulations. To facilitate planning and subsequent plot establishment, several days of pre-monitoring reconnaissance verified the location and best way to access many of the EOs/subpopulations. Overall, a total of 23 monitoring plots were established in 2021. Data collection consisted of counting or estimating the number of Aase's onion plants and recording plant community, weed species, and disturbance factor information within a 1/10 acre (37 ft. radius) circular plot. A set of photographs were also taken at each plot. Moving forward, the plan is to resample the plots every 3 years.

Plot establishment: Plot center for each plot was pre-determined using GIS-generated centroid point for each EO subpopulation included in the monitoring program. Coordinates for the centroid point were loaded into a hand-held GPS unit to guide monitoring team members to the plot center point. Team members were required to move the plot center point if the pre-selected area lacked Aase's onion, had habitat not representative of the subpopulation, or had soil too unstable and erosive to sample without causing excessive researcher disturbance. If moving the plot proved necessary, team members found the closest suitable portion of the subpopulation and randomly choose a new plot center point, documenting its location with new GPS coordinates. Plot center was temporarily marked with a pinflag. A measuring tape was then used to delineate the plot perimeter with additional pinflags. The plots were not permanently marked using stakes or other hardware, and will be relocated in the future using GPS coordinates. All data were recorded on forms designed for the project.

Aase's onion census: Census information is collected by counting or estimating the number of Aase's onion plants in the plot. Census estimates use 11 abundance categories: 1-10; 11-50; 51-100; 101-200; 201-300; 301-500; 501-1000; 1001-2000; 3001-5000; 5001-10,000; >10,000. Observers indicate whether the census is based on counting or estimating the number of Aase's onion plants in the plot. Estimating may be aided by counting Aase's onion plants is several representative $1m^2$ subplots, taking the average, and extrapolating for the plot's entire 0.1 acre ($405\ m^2$) area.

Ground disturbances: Ground disturbance information is collected by indicating which of 10 disturbance factors occur anywhere within the plot. If detected, other disturbances not included in this list should also be noted on the data form.

1. Animal digging - Applies to mounds/piles of soil deposited by a digging animal, and/or burrow holes. These can be recent or old.
2. Wildlife tracks - Applies to animal tracks in the plot other than dog. In some cases the tracks may be too ill defined to allow confident species identification.
3. Dog tracks - Applies to dog prints in the plot.
4. Livestock Use - Applies to cattle and sheep tracks or feces in the plot, or grazing evidence.

5. Trail - Applies to pathways used by people, whether maintained or not.
6. Non-motorized recreation - Applies to footprints or bicycle tracks in the plot.
7. Motorized recreation - Applies to tracks or other disturbances caused by ATVs, motorcycles, or e-bikes
8. Road - Applies to a roadway with vehicle tracks.
9. Wildfire - Applies to plot areas with evidence of past wildfire such as burned shrub skeletons.
10. Weed invasion - Applies to situations where non-native weedy species are abundant and appear to be overwhelming the native vegetation.

Vegetation: Plant community habitat information is acquired by visually estimating shrub, native bunchgrass, native forb, and non-native weedy species abundance.

Shrubs - Bitterbrush, big sagebrush, and gray rabbitbrush (*Ericameria nauseosa*) are the most likely shrub species to co-occur with Aase's onion in the Boise foothills. Abundance information is obtained by assigning each of the 3 species to 1 of 5 canopy cover classes: 0% (if absent), <10%, 10-25%, 26-50%, or >50%. In addition, total shrub canopy cover is assigned a cover class value based on the abundance of all shrub species in the plot. If other shrub species are found in the plot, they should be noted, assigned a canopy cover class, and be included in the total shrub cover assessment.

Native bunchgrass species: All native bunchgrasses species in the plot are recorded and assigned to 1 of 4 canopy cover abundance classes: <10%, 10-25%, 26-50%, or >50%. In addition, total bunchgrass canopy cover is assigned a cover class value based on the abundance of all bunchgrass species in the plot.

Native forb species: The 4 most common native forb species in the plot are recorded and assigned to 1 of 5 relative abundance categories: Trace = only a few individuals, easy to overlook; Sparse = spotty and perhaps not seen at first glance, but unlikely to overlook in careful observation; Scattered = widespread, somewhat common, and not overlooked in careful observation; Common = frequent and widespread, obvious at first glance unless very small; and Dominant = very abundant, a community dominant. Adding a list of other native forb species and their abundance category in the plot is optional.

Non-native weed species: The 8 most common non-native weedy forb species in the plot are recorded and assigned to 1 of 5 relative abundance categories: Trace = only a few individuals, easy to overlook; Sparse = spotty and perhaps not seen at first glance, but unlikely to overlook in careful observation; Scattered = widespread, somewhat common, and not overlooked in careful observation; Common = frequent and widespread, obvious at first glance unless very small; and Dominant = very abundant, a community dominant. Adding a list of other weedy forb species and their abundance category in the plot is optional.

Photo point photographs: Photographs provide a visual record of each monitoring site. Repeat photo monitoring can be useful to document site-specific change or lack of change to landscape features of interest (Hall 2001). The plot center point serves as the photo-point reference mark to take photos. Landscape oriented photographs are taken using a digital camera set at wide-angle. Showing the horizon with some sky helps replicate the repeat photo in future monitoring years. A minimum of four photos are taken at each plot using the cardinal direction azimuths, 0°, 90°, 180°, and 270°. Additional photos to show plant close-ups, plant community patterns, disturbances, or other landscape features are optional.

RESULTS

A total of 23 monitoring plots were established in five COB Reserves located in the lower Boise Foothills – Military Reserve, Camels Back Reserve, Hulls Gulch Reserve, Polecat Reserve, and Hillside to Hollow Reserve. Data collection took place April 1 - April 5, 2021. Plots occupied upper to lower slope positions on southeast to southwest-facing hillsides ranging in steepness from 10 - 50%, at elevations from approximately 2860 - 3280 ft. (Table 1). All plots had sandy soil, often with a coarse texture. Plot vegetation usually had an open appearance consisting of a sparse to moderately dense shrub layer and a variable mix of native and non-native herbaceous species dominated by grasses. Native species dominated the plant community at some plots, but were much less common than associated weed species at other plots. A hand-held GPS unit was used to verify the location coordinates and map each plot site (Appendix 1). Monitoring data recorded on field data sheets (Appendix 2) were converted to EXCEL spreadsheet format (Appendix 3) to facilitate compilation, synthesis, and future analysis of the dataset.

Aase's onion

Aase's onion abundance varied greatly, with plots containing <10 to an estimated 6000 individuals (Table 2). Four of the 6 plots with <100 Aase's onion plants occurred in Military Reserve. Overall, the monitoring plots supported approximately 29,160 Aase's onion plants in 2021. Aase's onion density in the plots ranged from <1 to 15 plants/m^2, but averaged approximately 3.4 plants/m^2 for all plots. Aase's onion average plot density ranged from 1.9 plants/m^2 at Hulls Gulch Reserve to 8.1 plants/m^2 at Polecat Reserve. The plots in Polecat Reserve had 2 to 4 times higher average Aase's onion density than the other Reserves. Aase's onion distribution within plots varied from more or less uniform to very spotty or clumped in 1 or a few clusters.

Shrubs

All plots contained between 1 and 3 shrub species (Table 3). Bitterbrush, gray rabbitbrush, and big sagebrush were the only shrub species recorded in the plots. The only exception being 1 small gray horsebrush (*Tetradymia canescens*) in a plot at Hillside to Hollow Reserve. Shrub canopy cover exceeded 10% in all but 6 plots, and was >25% in 3 plots. Bitterbrush was present in all Military, Hulls Gulch, and Polecat reserve plots, but absent from the plots in Hillside to Hollow and Camels Back reserves. When present, bitterbrush tended to be the dominant or co-dominant shrub in the plot. Gray rabbitbrush occurred in all but 4 plots, and had the greatest cover of any shrub in 7 plots. It was the main shrub species in at least 1 plot for each Reserve. Big sagebrush occurred at low cover in 4 plots, including in 1 plot in all Reserves except Camels Back.

Native bunchgrass species

Five native bunchgrass species were recorded in the plots, including threeawn (*Aristida purpurea* var. *longiseta*), needle-and-thread grass (*Hesperostipa comata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Sandberg bluegrass (*Poa secunda*), and squirreltail (*Elymus elymoides*; Table 4). Plots each contained 1 – 4 bunchgrass species, with all but 2 plots supporting at least 2 species. Threeawn was the only bunchgrass present in every plot, and had canopy cover estimates ranging from <10% to >50%. It was the dominant bunchgrass in 17 plots and a co-dominant in the other 6 plots. Sandberg bluegrass was the only other bunchgrass species recorded in at least half of the plots, but it exceeded 10% cover in only 1 plot. Needle-and-thread grass cover was ≥10% in 1 plot. Bluebunch wheatgrass cover was ≥10% in 2 plots. Total bunchgrass canopy cover ranged from <10% to >50%, and was ≥10% in all but 4 plots, and ≥25% in 12 plots.

Native forb species

Monitoring recorded 23 species to be among the most common native forb in 1 or more plots (Table 5). The list of native forbs included 15 perennial and 8 annual species. Eleven forb species were recorded in only 1 plot (Appendix 4). Silverleaf phacelia (*Phacelia hastata*) and common yarrow (*Achillea millefolium*) where the only forbs recorded in at least half of the monitoring plots. Other native forb species found in 5 or more plots included arrowleaf balsamroot (*Balsamorhiza sagittata*), annual willowherb (*Epilobium brachycarpum*), strict buckwheat (*Eriogonum strictum*), hoary aster (*Dieteria canescens*), and large-flower tritelia (*Tritelia grandiflora*). Individual forb species abundance was usually assessed to be scattered, sparse, or trace. Only 2 plots had 1 or more native forbs recorded as common.

Non-native weed species

Monitoring recorded a total of 16 weed species, including 4 grass and 12 forb species (Table 6). Most are annuals, with bulbous bluegrass (*Poa bulbosa*), rush skeletonweed (*Chondrilla juncea*), and donkey-tail spurge (*Euphorbia myrsinites*) being the only perennials. One species, rush skeletonweed, is on the Idaho noxious weed in list (Idaho State Department of Agriculture 2021). The number of weed species in a plot ranged from 2 to 11. Cheatgrass (*Bromus tectorum*) was the only one found in every plot, being recorded as dominant in 2 and common in 11 others. Rush skeletonweed occurred in all plots except for 1 in Military Reserve. It was rated dominant in 1 plot and common in 14 others. Other weed species occurring in more than half of all plots included bulbous bluegrass, blue bachelor button (*Centaurea cyanus*), desert alyssum (*Alyssum desertorum*), redstem storksbill (*Erodium cicutarium*), and tumblemustard (*Sisybrium altissimum*). Cheatgrass and rush skeletonweed tended to be more abundant in plots at Military, Camels Back and Hulls Gulch reserves compared at Polecat and Hillside to Hollow reserves. Blue bachelor button occurred in most plots at Military Reserve and Hulls Gulch Reserve, but was absent from plots in Polecat Reserve and all but 1 plot at Hillside to Hollow Reserve. Redstem storksbill and desert alyssum tended to be more abundant in plots at Polecat and Hillside to Hollow reserves compared to Military and Hulls Gulch reserves, even though both species were recorded as dominant or common in at least 1 plot within each Reserve.

Ground disturbance

Seven disturbance factors were recorded in the plots, including animal digging, wildlife tracks, dog tracks, trails, non-motorized recreation, weed invasion, and wildfire (Table 7). All plots had at least 1 type of disturbance, with most having 2 or more. Animal digging was recorded in 21 plots, wildlife tracks in 18 plots, and weed invasion in 13 plots. Other disturbance factors occurred in 6 or fewer plots. Sand piles from tunnel/burrow excavation were the most common form of animal digging disturbance in the monitoring plots. The digging is associated with northern pocket gopher (*Thomomys talpoides*) activity in most, if not all cases. Some dig piles appeared fresh, but others were from a previous year. Plots could have either fresh or old mounds, or both. Although not quantified during data collection, dig pile abundance in a plot varied from just 1 or 2, to numerous. Mule deer (*Odocoileus hemionus*) were responsible for most, if not all wildlife tracks. Although not quantified as part of the data collection process, wildlife track abundance varied from just a few to numerous within a plot. Dog tracks were associated with plots located adjacent to or near recreation trails. Although not quantified as part of the data collection process, dog track abundance varied from just a few to many within a plot. Several plots were adjacent to maintained or user-created trails. Aase's onion was observed adjacent to a trail, but never directly in the trail. Off-trail footprints were the only non-motorized recreation disturbance present in any of the plots. Footprints were typically limited in number within a plot. Weed invasion was listed as a disturbance in plots judged to be overrun by weedy species. Disturbances associated with livestock use, motorized recreation traffic, or roads were not observed in any of the monitoring plots.

Photo point photographs

A total of 146 labeled photographs provide visual documentation to supplement the monitoring data (Appendix 5).

DISCUSSION

Aase's onion abundance in the monitoring plots indicates the species is doing well at some subpopulations, but in danger of local extirpation at others. Historically, shrub-steppe vegetation dominated native plant communities in the lower Boise foothills. Bitterbrush was probably the dominant shrub on most late seral Aase's onion sites in the area, often joined by big sagebrush. However, both shrub species have been diminished or lost from many Aase's onion foothill sites due to increased fire frequency and reduced seedling survival related to competition from non-native plants (Kinter 2009). Among the suite of perennial grass species originally inhabiting Aase's onion sites, needle-and-thread grass and bluebunch wheatgrass were likely the most ubiquitous. They too have been lost or reduced to remnant status in many locations. Fires, livestock grazing, and other disturbances in the past 100+ years have converted most Aase's onion sites to mid- or early seral plant communities characterized by an abundance of non-native weedy species and reduced levels of native plant species. Even in areas where weeds may be less prominent, plant community composition tends to skew towards native species better adapted to the local disturbance history, such as threeawn. The biggest threat to Aase's onion within the COB Reserves continues to be plant community-level habitat degradation due to invasive weed species and the associated loss of shrubs and bunchgrasses important for soil stability (Kinter 2009).

Monitoring in 2021 points to the deleterious effect of invasive weeds on Aase's onion and its habitat. Six plots supported <100 Aase's onion in 2021 - 4 in Military Reserve, 1 in Camels Back Reserve, and 1 in Hulls Gulch Reserve (Table 2). All had high weed cover. Cheatgrass was recorded as dominant in the 2 plots with the fewest Aase's onion (AA-7 and AA-9). It was common in 3 of the other 4 plots with <100 Aase's onion. Rush skeletonweed was dominant in the 1 Hulls Gulch Reserve plot, and common in 4 of the other plots with <100 Aase's onion. One plot in Polecat Reserve (AA-17) had substantially less Aase's onion compared to the other 3 plots in this Reserve. It was only plot in Polecat Reserve with rush skeletonweed rated as common. One plot in Hillside to Hollow Reserve (AA-24) had substantially less Aase's onion compared to the other 3 plots in this Reserve. It was the only plot in Hillside to Hollow Reserve with cheatgrass and rush skeletonweed rated as common. Weeds are a prominent, if not dominant part of the vegetation at most monitoring plots. Yet, Aase's onion appears to be persisting at some subpopulations much better than others. Multiple interacting factors may be involved, but weed abundance seems to be an important one. There may be some threshold of weed abundance and associated competition that once exceeded, accelerates the loss of Aase's onion from a site. This threshold has perhaps been breached at subpopulations where Aase's onion seems to be barely hanging on. Cheatgrass and rush skeletonweed appear to be the main contributors to exceeding the threshold.

Weed species abundance has increased within COB Reserves over the past few decades. One example is rush skeletonweed, now a prevalent invasive weed in Military, Camels Back, Hulls Gulch, Polecat, and Hillside to Hollow reserves. Site visits in 1992 to each of these areas except what would become Polecat Reserve, did not note rush skeletonweed in any Aase's onion EOs (Moseley et al. 1992). But by 1995, rush skeletonweed was included in a list of weed species that may contribute to the decline of Aase's onion habitat (Mancuso 1995). By 2008-2009, rush skeletonweed was present in every Aase's onion EOs/subpopulations in Military Reserve (Mancuso 2008), and Camels Back and Hulls Gulch reserves (Kinter 2009). A rare plant survey in 2008 reported rush skeletonweed to be common and widespread in Polecat Reserve as well

(Idaho Department of Fish and Game 2008). In Military Reserve it was already reported to be the most common forb species in multiple Aase's onion subpopulations (Mancuso 2008). Monitoring in 2021 suggests rush skeletonweed has become even more abundant since 2008-2009, at least in some locations. Five subpopulations in Military Reserve (AA-1, AA-3, AA-4, AA-5, AA-8) had rush skeletonweed abundance rated as scattered (4 plots) or trace (1 plot) in 2008 (Mancuso 2008). Plots within these 5 subpopulations all had rush skeletonweed abundance rated as common in 2021.

Some level of pocket gopher digging disturbance was present in most plots. The direct effect of this digging on Aase's onion remains unknown. Indirectly, the soil mounds provide microsites readily colonized by invasive weed species (Kinter 2009). Earlier surveys also found pocket gopher activity in most Aase's onion sites in Military, Camels Back and Hulls Gulch reserves (Mancuso 2008, Kinter 2009). The 2008 Aase's onion survey in Military Reserve noted the digging disturbance usually appeared more prevalent on adjacent areas not occupied by Aase's onion and that the soil mounds often had relatively high density of weed species (Mancuso 2008). Monitoring documented the presence of deer tracks in the majority of plots in 2021. This ground disturbance probably has minimal direct impact on Aase's onion, but may possibly contribute to weed species establishment or persistence. The same applies to dog tracks, another widespread disturbance in the foothills, with impacts to Aase's onion habitat probably more consequential than directly to the plants.

The COB Reserves support an extensive recreation trail network very popular with hikers, runners, dog walkers, and mountain bikers. Several Aase's onion monitoring plots occurred adjacent to or near a trail. Monitoring in 2021 found footprints in only a few plots, and bicycle tracks in none, suggesting people were mostly stay on the trail. Earlier surveys reported a range of impacts associated with the trail system. Despite heavy recreation use in the general area, off-trail footprints or bicycle treads were not observed during a survey of Aase's onion EOs in Military Reserve in 2008 (Mancuso 2008). That same year, a comprehensive Aase's onion survey in Polecat Gulch found the largest single impact to the species was the removal or burial of plants during construction of the trail system (Idaho Department of Fish and Game 2008). A similarly thorough survey in Camels Back and Hulls Gulch reserves in 2009 found off-trail tracks from people, dogs, or cyclists in many subpopulations (Kinter 2009).

Wildfire was recorded as a disturbance in only 1 monitoring plot in 2021, indicating the absence of old, charred fire-killed shrub skeletons in the other plots. Although past fires impacted multiple Aase's onion sites in the COB Reserves, enough time has apparently passed to remove the burned visible evidence. Wildfires during the heat of summer will not directly affect Aase's onion because the bulbs lay dormant underground. But fire could impact the species indirectly by promoting habitat degradation associated with the loss of stabilizing shrub cover and increasing weed species abundance. Fire-fighting actions could potentially cause adverse impacts to Aase's onion habitat if it involved a lot of ground disturbance.

Most southerly-facing slopes in the lower Boise foothills underlain by the appropriate sandy geologic units likely supported Aase's onion in pre-settlement times (Moseley et al. 1992). Over the years, some populations on private property have been lost outright due to housing developments. City of Boise Reserves in the lower foothills serve as a refuge for Aase's onion and other rare plant species. The occurrence of multiple rare plant species highlights the biodiversity value of the Bose foothills. They also shine a spotlight on the challenges confronting conservation of the biological and ecological values that help make the foothills a special place. The conservation of Aase's onion and other Boise foothill rare plant species will likely become more challenging as the human population in the Boise metropolitan area continues to grow.

The Aase's onion monitoring program provides population, habitat condition, and disturbance information relevant to land managers tasked with formulating conservation priorities and actions that benefit the species and its habitat in the COB Reserve system.

POTENTIAL CONSERVATION ACTIONS

The Open Space Matters Reserve Management plan, implemented in 2015, provides management framework for City-owned open spaces and outlines a need for protection and enhancement of natural resources like rare plants (Focus Area 3). Loss or decline of native plant communities due to invasive species is likely the primary cause of overall decline of Aase's onion populations in the lower Boise Foothills. Invasive plants such as cheatgrass, redstem storksbill, rush skeletonweed compete with native plants for soil and water resources and do not fill the structural and functional roles that native plants provide. Based on monitoring information collected in 2021, the COB sees the opportunity for several potential conservation actions to benefit Aase's onion and its habitat, including targeted weed treatments, short sections of fencing, and educational signage

MONITORING PROTOCOL RECOMMENDATIONS

Data collection in 2021 provided a good test for the monitoring protocol. Based on this initial experience, several changes to the protocol are recommended moving forward. These changes will improve and make the information collected more comprehensive and useful, but add only an estimated 10 minutes time to the data collection process.

1. Estimating shrub and native bunchgrass canopy cover includes 4 abundance categories: <10%, 10-25%, 26-50%, or >50%. We recommend changing the lower end categories to be <2% and 2 - <10%. This allows recognition of shrub and bunchgrass species that occur at very low/trace cover within a plot, a not uncommon feature.

2. The monitoring protocol includes listing and assigning an abundance category to the 3 most common native bunchgrass species in the plot. We recommend changing this to all bunchgrass species in the plot. This will provide a fuller appreciation of native plant diversity at the plot, information that may be useful for future conservation planning and prioritizing options.

3. The monitoring protocol includes listing and assigning an abundance category to the 4 most common native forbs in the plot. We recommend keeping this part of the protocol, but adding a field on the data form to list and assign an abundance category for all other native forb species in the plot if a person well-versed in the local flora is part of the data collection team. Most, if not all plots contain >4 native forb species, even though they may occur at only trace cover. A more complete list will provide a fuller appreciation of native plant diversity at the plot, information that may be useful for future conservation planning and prioritizing options.

4. The monitoring protocol includes listing and assigning an abundance category for up to 8 non-native weed species in the plot. We recommend changing this to all non-native species in the plot. It is difficult to know which weed species may become more problematic in the future. Furthermore, this provides a way to document the presence of any new weed species into the plot, which may appear uncommon at first and otherwise not be recorded.

5. The monitoring protocol includes recording disturbances present in the plot. But it does not include an assignment to any sort of abundance category. This prevents assessing how prevalent and problematic a disturbance may (e.g., does the plot contain a single dog track or dozens). We recommend adding the assignment of an abundance category for each

disturbance in the plot. The dominant, common, scattered, sparse, and trace categories used for weeds and native forbs should be adequate.

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Figure 1. Image of Aase's onion.
Photo by Robert Moseley.

Figure 2. Map of City of Boise Reserves included in the Aase's onion monitoring program.

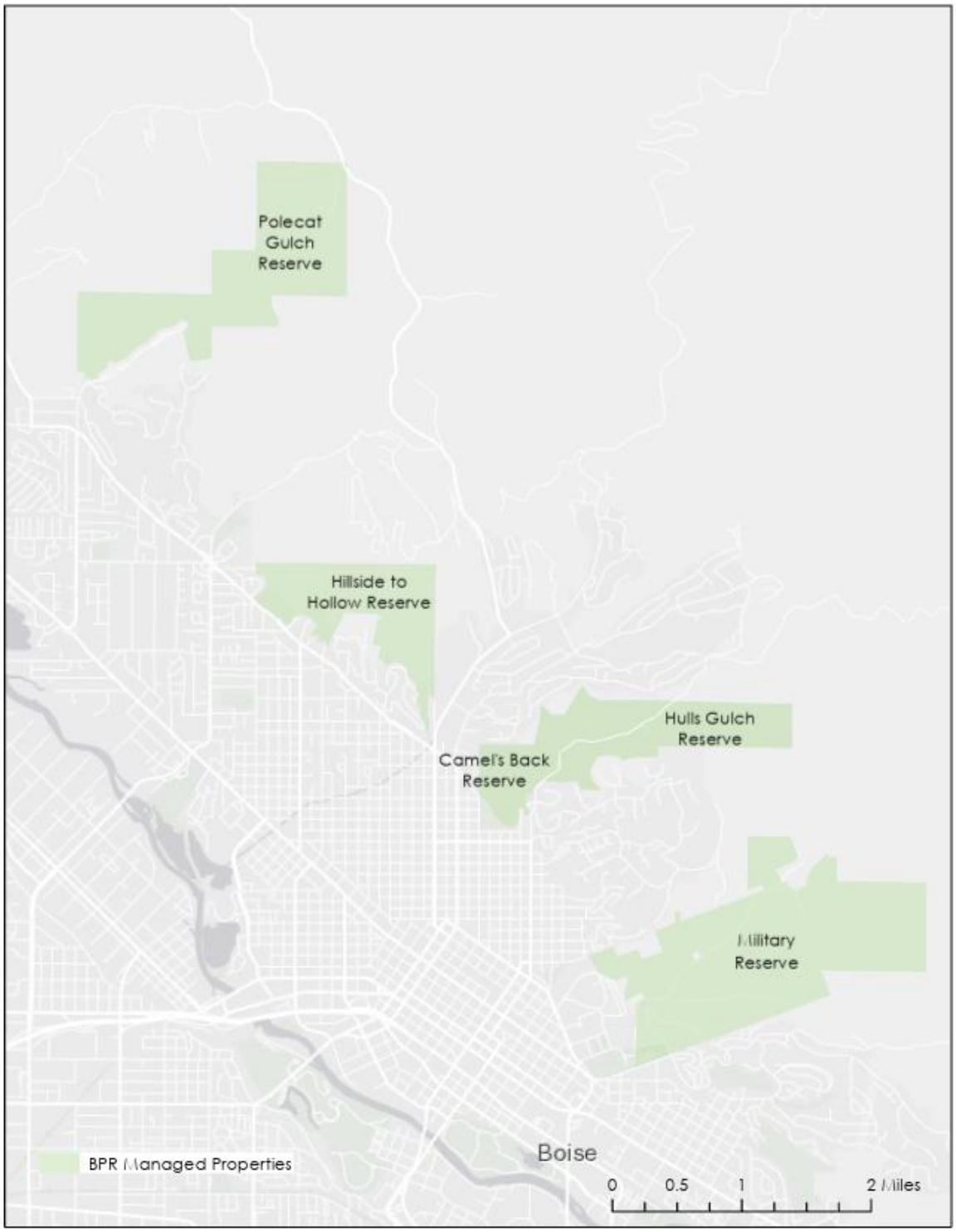

Table 1. Aase's onion monitoring plot information.

Plot	Location	Aspect	Slope (%)	Elevation (ft.)	Substrate
AA-1	Military Reserve	SSW	12	3080	sandy
AA-2	Military Reserve	WSW	40	3090	coarse sand
AA-3	Military Reserve	SSW	20	3110	sandy
AA-4	Military Reserve	S	38	2960	coarse sand
AA-5	Military Reserve	SSW	15	2900	coarse sand
AA-6	Military Reserve	WSW	50	2970	sandy
AA-7	Military Reserve	SE	25	2950	sandy
AA-8	Military Reserve	S	25	3150	sandy
AA-9	Camels Back Reserve	ESE	41	2860	coarse sand
AA-10	Hulls Gulch Reserve	ESE	15	3000	orangish sand
AA-11	Hulls Gulch Reserve	S	38	3040	sandy
AA-12	Hulls Gulch Reserve	SSE	35	3040	deep sand
AA-13	Hulls Gulch Reserve	S	25	3070	coarse sand
AA-14	Hulls Gulch Reserve	E	20	2960	deep sandy
AA-15	Hulls Gulch Reserve	S	30	3040	deep coarse
AA-17	Polecat Reserve	S	38	3160	coarse sand
AA-18	Polecat Reserve	SSW	41	3280	coarse sand
AA-19	Polecat Reserve	S	16	3320	coarse sand
AA-20	Polecat Reserve	ESE	39	3060	coarse sand
AA-23	Hillside to Hollow Reserve	S	38	3110	coarse sand
AA-24	Hillside to Hollow Reserve	WSW	12	2960	coarse sand
AA-25	Hillside to Hollow Reserve	SE	14	3130	coarse sand
AA-26	Hillside to Hollow Reserve	WSW	33	3180	coarse sand

Table 2. Aase's onion abundance in the monitoring plots, 2021.
Mid-point of estimated range used to calculate plot density and total abundance.

Plot	# plants - counted	# plants - estimated	Density (# plants/m^2)
Military Reserve			
AA-1	20		0.05
AA-2		3000-5000	9.9
AA-3		2000-3000	6.2
AA-4	69		0.2
AA-5	117		0.3
AA-6		11-50	0.07
AA-7	3		0.007
AA-8		300-500	1.0
Mean			2.2
Camels Back Reserve			
AA-9	17		0.04
Hulls Gulch Reserve			
AA-10		100-200	0.4
AA-11		300-500	1.0
AA-12		2000-5000	8.6
AA-13		300-500	1.0
AA-14	81		0.2
AA-15	144		0.4
Mean			1.9
Polecat Reserve			
AA-17	148		0.4
AA-18		3000	7.4
AA-19		6000	14.8
AA-20		4000	9.9
Mean			8.1
Hillside-Hollow Reserve			
AA-23		2000	4.9
AA-24	191		0.5
AA-25	2194		5.4
AA-26		2500	6.2
Mean			4.2
Total	2984	26180	

Table 3. Percent cover for shrub and native bunchgrass species in Aase's onion monitoring plots, 2021.

	Shrub species % cover				Bunchgrass species % cover					
	Bitterbrush	Big sagebrush	Gray rabbitbrush	Total shrub	Threeawn	Needle-and-thread	Bluebunch wheatgrass	Sandberg bluegrass	Squirreltail	Total bunchgrass
Military Reserve										
AA-1	10-25	x	<10	10-25	25-50	25-50	x	x	x	>50
AA-2	25-50	x	<10	25-50	10-25	x	<10	x	x	10-25
AA-3	10-25	<10	<10	10-25	>50	<10	x	x	x	>50
AA-4	10-25	x	<10	10-25	10-25	<10	<10	<10	x	10-25
AA-5	10-25	x	<10	25-50	10-25	x	10-25	x	x	25-50
AA-6	10-25	x	<10	10-25	25-50	x	10-25	x	x	>50
AA-7	10-25	x	<10	10-25	25-50	<10	x	10-25	x	25-50
AA-8	10-25	x	x	10-25	>50	x	<10	x	x	>50
Camels Back Reserve										
AA-9	x		<10	<10	<10	<10	x	<10	x	<10
Hulls Gulch Reserve										
AA-10	<10	x	10-25	10-25	<10		<10	<10	<10	<10
AA-11	<10	x	<10	<10	25-50	<10	x	<10	<10	25-50
AA-12	10-25	x	x	10-25	10-25	x	<10	<10	<10	10-25
AA-13	<10	<10	<10	<10	10-25	x	<10	<10	<10	10-25
AA-14	<10	x	10-25	10-25	25-50	x	x	x	x	25-50
AA-15	10-25	x	<10	10-25	<10	x	x	x	x	<10
Polecat Reserve										
AA-17	<10	x	<10	<10	<10	x	x	<10	x	<10
AA-18	<10	x	x	<10	10-25	<10	x	x	x	10-25
AA-19	<10	<10	10-25	10-25	10-25	x	x	<10	<10	10-25
AA-20	10-25	x	x	10-25	10-25	x	<10	x	x	25-50
Hillside-Hollow Reserve										
AA-23	x	x	<10	<10	25-50	x	x	<10	<10	25-50
AA-24	x	x	10-25	10-25	10-25	x	x	<10	x	10-25
AA-25	x	<10	<10	10-25	25-50	x	x	<10	x	25-50
AA-26	x	x	25-50	25-50	<10	x	<10	<10	<10	25-50

Table 4. Abundance class category for native forb species present in two or more Aase's onion monitoring plots, 2021.
CM = common; SC = scattered; SP = sparse; TR = trace

	Native forb species										
	Common yarrow	**Fiddleneck**	**Arrowleaf balsamroot**	**Annual willowherb**	**Slenderbush buckwheat**	**Strict buckwheat**	**Nine-leaf biscuitroot**	**Hoary aster**	**Silverleaf phacelia**	**Slender plagiobothrys**	**Large-flower triteleia**
Military Reserve											
AA-1	CM	-	CM	-	CM	-	-	CM	-	-	-
AA-2	SC	-	-	-	SC	-	-	SC	SC	-	-
AA-3	-	SC	-	-	-	-	-	-	SC	-	SC
AA-4	SP	-	-	-	-	-	-	SP	SC	-	SC
AA-5	SP	-	SC	-	-	-	-	-	SC	-	SC
AA-6	SC	-	-	-	SC	-	SC	SC	-	-	--
AA-7	TR	-	-	TR	-	-	-	-	TR	-	TR
AA-8	SC	-	-	-	-	-	SC	-	-	-	-
Camels Back Reserve											
AA-9	-	-	TR	TR	-	-	-	-	SP	-	SP
Hulls Gulch Reserve											
AA-10	TR	-	-	-	-	-	-	-	SP	-	-
AA-11	TR	-	-	-	-	-	-	-	TR	-	SC
AA-12	-	SC	-	-	-	-	TR	-	SP	-	SC
AA-13	TR	-	-	-	-	-	-	TR	SC	-	SC
AA-14	TR	-	-	TR	-	-	-	-	CM	-	SC
AA-15	SP	-	-	TR	-	-	-	-	SC	-	SC
Polecat Reserve											
AA-17	-	SP	-	-	SP	SP	-	-	-	-	-
AA-18	-	TR	-	-	-	TR	-	-	TR	-	-
AA-19	-	TR	-	TR	-	-	-	-	-	TR	-
AA-20	-		-	-	-	TR	-	-	TR	TR	-
Hillside-Hollow Reserve											
AA-23	-	-	SP	-	-	SP	-	-	SC	-	-
AA-24	SC	-	-	-	-	SC	-	-	SC	-	-
AA-25	-	-	SP	-	-	TR	TR	-	SP		-
AA-26	-	-	SC	-	-	SC	-	-	SC	--	-

Appendix 4 includes 12 native forb species recorded in only 1 plot and not included in this table.

Table 5. Abundance class category for non-native weed species in Aase's onion monitoring plots, 2021.
DO = dominant; CM = common; SC = scattered; SP = sparse; TR = trace

Plot	Grasses				Forbs										
	Cheatgrass	Bulbous bluegrass	Cereal rye	Medusahead	Desert alyssum	Blue bachelor button	Rush skeletonweed	Flixseed	Redstem storksbill	Donkey-tail spurge	Jagged chickweed	Prickly lettuce	Russian thistle	Tumblemustard	Yellow salsify
Military Reserve															
AA-1	CM	-	SC	CM	-	CM	CM	-	-	-	-	-	SC	-	SP
AA-2	SP	-	-	-	-	-	-	-	-	-	-	-	-	SP	-
AA-3	CM	-	-	-	CM	-	CM	-	SC	-	-	-	-	-	-
AA-4	CM	SC	TR	SP	SC	CM	CM	TR	CM	-	-	-	-	SP	TR
AA-5	SC	SC	SP	-	SP	SC	CM	-	SP	-	-	-	-	SP	TR
AA-6	SC	-	-	SP	-	SC	CM	-	-	-	-	TR	-	-	SC
AA-7	DO	SP	CM	-	-	SP	SP	-	-	SC	-	-	SC	-	-
AA-8	CM	-	-	CM	CM	CM	CM	-	CM	-	-	-	-	-	-
Camels Back Reserve															
AA-9	DO	SC	CM	-	CM	SP	CM	-	CM	-	-	-	SC	SC	-
Hulls Gulch Reserve															
AA-10	CM	SP	-	-	CM	SC	CM	-	SC	-	-	-	-	SP	TR
AA-11	CM	SP	-	-	-	SC	CM	-	CM	-	TR	-	-	-	TR
AA-12	CM	TR	-	-	DO	CM	CM	-	SC	-	-	-	-	TR	-
AA-13	CM	TR	-	-	DO	CM	CM	-	CM	-	-	-	-	-	-
AA-14	CM	-	-	-	SC	CM	DO	-	-	-	-	-	-	TR	-
AA-15	CM	-	-	-	CM	CM	CM	-	SC	-	TR	-	-	SP	-
Polecat Reserve															
AA-17	SC	SC	-	-	DO	-	CM	-	SP	-	-	-	-	SP	-
AA-18	SC	-	-	-	CM	-	SP	-	DO	-	SP	-	-	-	-
AA-19	SP	SP	-	-	SP	-	SC	-	SC	-	-	TR	-	-	TR
AA-20	SC	-	TR	-	SP	-	SC	-	CM	-	-	-	-	TR	-
Hillside-Hollow Reserve															
AA-23	SC	SP	-	-	CM	-	SP	-	CM	-	-	-	-	-	TR
AA-24	CM	SC	TR	-	SP	SP	CM	-	CM	-	-	-	-	TR	TR
AA-25	SP	CM	-	-	SP	-	SC	-	DO	-	-	-	-	TR	-
AA-26	SP	-	-	-	SP	-	TR	-	TR	-	-	TR	-	-	-

Spring whitlow grass (*Draba verna*), a tiny non-native ephemeral spring annual, not included in the table because it was not consistently recorded on the data sheets. It was present in most, if not all plots.

Table 6. Disturbance factors in Aase's onion monitoring plots, 2021

Plot	Type of disturbance						
	Animal digging	**Wildlife tracks**	**Dog tracks**	**Trails**	**Non-motor recreation**	**Weed invasion**	**Wildfire**
Military Reserve							
AA-1	X	X				X	
AA-2	X	X					
AA-3	X					X	
AA-4	X	X					
AA-5	X	X					
AA-6	X	X				X	
AA-7	X	X	X	X	X	X	X
AA-8						X	
Camels Back Reserve							
AA-9	X		X	X		X	
Hulls Gulch Reserve							
AA-10	X	X				X	
AA-11	X	X	X				
AA-12	X	X	X			X	
AA-13	X		X	X	X	X	
AA-14	X	X				X	
AA-15	X	X				X	
Polecat Reserve							
AA-17	X	X				X	
AA-18	X	X					
AA-19	X	X	X	X			
AA-20	X	X					
Hillside-Hollow Reserve							
AA-23	X	X					
AA-24	X			X	X	X	
AA-25	X	X		X			
AA-26		X					