STATUS OF *CRYPTANTHA SUBCAPITATA* (OWL CREEK MINER'S CANDLE)
Fremont County, Wyoming

Prepared for the Bureau of Land Management
Wyoming State Office and Lander Field Office

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ABSTRACT

Surveys of *Cryptantha subcapitata* (Owl Creek miner's candle) were conducted in 2019-2020 to gather current information on species' distribution, habitat requirements and biology; and survey for new populations using potential distribution models and photointerpretation. It is a long-lived species and recent surveys indicate that species numbers may be only 8-27% of former numbers reported in 1989. Surveys were hampered by low flowering levels two years in a row, in 2019-2020. The prevalence of plants in vegetative state constrained the effectiveness of survey efforts and confounded the quantification of decline, but low flowering levels may help explain decline and identify a framework for further species' studies.

ACKNOWLEDGEMENTS

This work reflects the outstanding research of earlier botanists. I relied on their work and the resources of Rocky Mountain Herbarium to interpret recent survey results. Boysen State Park coordination was made available by John Bass, Superintendent of the Park. The editors of Madroño kindly provided permission to reprint the illustration appearing with the species' description. This study was conducted under the BLM Cooperative Agreement No. L1600389, Modification 1.

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Cover photo: *Cryptantha subcapitata* by Bonnie Heidel

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I. INTRODUCTION

Cryptantha subcapitata (Owl Creek miner's candle) is a state endemic located in Fremont County, west-central Wyoming. It is a Wyoming Bureau of Land Management (BLM) Sensitive species (USDI BLM 2010). It was discovered in 1980 above Boysen Dam and described as a new species by Robert Dorn and Robert Lichvar (Dorn and Lichvar 1981). Dorn later prepared the first status report for the species in 1989 for the U.S. Fish and Wildlife Service, based on collecting trips and surveys that he conducted along with Lichvar, Ronald Hartman and Keith Dueholm (Dorn 1989) in intervening years.

Later, revisits to known locations of *C. subcapitata* were made in 1991, 1992 and 1996 as part of three studies that aimed to survey potential habitat elsewhere for *C. subcapitata* (Marriott 1992, Fertig 1993, 1997). Just one of the studies expanded known distribution, extending the Boysen Reservoir population eastward toward the Birdseye Road (Fertig 1997). No new separate populations were discovered.

There has been no other new information since the report by Dorn (1989) apart from species potential distribution models (Fertig and Thurston 2003, Andersen et al. 2016). The purpose of this study was to provide current information on *Cryptantha subcapitata* by revisiting known locations, and to test potential distribution models and photointerpretation to systematically survey for it in unsurveyed locations.

II. METHODS

Records of *Cryptantha subcapitata* were downloaded and printed from the Wyoming Natural Diversity Database (WYNDD) with its spatially-explicit information based on field surveys, and secondary sources, specimens from the Rocky Mountain Herbarium (RM), scientific literature and unpublished reports.

Potential distribution of *Cryptantha subcapitata* has been characterized in two potential distribution modeling projects (Fertig and Thurston 2003, Andersen et al. 2016). In both models, the paucity of positive data points were limitations to model performance. Both modeling efforts used different forms of datasets as negative data.

Field surveys were conducted by the author to collect data on the biology, habitat, population size and conservation considerations for this species. Locations were mapped using a Garmin GPS unit (Oregon 600). The first surveys in June 4-6, 2019 were judged to have suboptimal conditions for surveys because flowering levels were extremely low, and had barely started. Fieldwork in 2020 was also judged suboptimal, when flowering levels were still poor, and

surveys in the second week of June 8-12, 2020 were too late for flowering. In addition, a separate survey trip was made on June 26, 2020.

This project represents a compilation of the results of all prior surveys where it was sought but not found (i.e., negative surveys). It also represents a refinement of distribution mapping. The intent to survey for the species in new habitat was scaled back as more information became available on habitat specificity and because detection of the species was hampered and less effective when the species is mainly in vegetative condition. In light of circumstances, a priority placed on photographic documentation (Appendix A).

III. RESULTS - SPECIES INFORMATION

A. Classification

1. Species Scientific name: *Cryptantha subcapitata* Dorn & Lichvar. The *Cryptantha* genus *sensu lato* has been divided into different genera, with the *Oreocarya* section being elevated to genus, following (Hasenstab-Lehman and Simpson 2012). This is a pending change that will appear in Flora of North America treatments, for future consideration in the Wyoming Checklist as maintained by Rocky Mountain Herbarium (Nelson 2018). Type specimen: USA: Wyoming, Fremont Co., T5N R6E S8, just w. of Boysen Dam, rocky calcareous ridge, 1775 m., 23 June 1980, Dorn *3459*. (Holotype: RM; isotypes: to be distributed).

2. Synonyms: *Cryptantha subcapitata* Dorn & Lichvar; to be transferred to *Oreocarya*.

3. Common name: Owl Creek miner's candle is the common name that has longstanding use (Fertig et al. 1994). The PLANTS database reports "Wallowa cryptantha" as its common name (even though "Wallowa" is an Oregon place name). Earlier, Dorn (1989) originally used a transliteration of the species epithet as common name, i.e., "subcapitate miner's candle". The WYNDD 2018 list update followed precedent of using the genus name as common name, i.e., Owl Creek cryptantha. In light of pending taxonomic revision to the *Cryptantha* genus, I propose returning to the Owl Creek miner's candle name, by or before it is transferred to a new genus (*Oreocarya subcapitata*).

4. Family: Boraginaceae (Borage Family)

5. Size of genus: The *Cryptantha* genus s.l. was reported as having about 200 species worldwide, mostly in dry habitats, two-thirds of them in western North America; the others in the Andean region of South America (Cronquist et al. 1984, Hasenstab-Lehman and

Simpson 2012). The *Flora of North America* treatment in progress splits the genus and elevates some sections to genera, as with the *Oreocarya* genus.

6. Phylogenetic relationships: *Cryptantha subcapitata* is in *Cryptantha* Sect. *Oreocarya*. It is closely related to *C. caespitosa*, a species with its center of distribution in southwestern Wyoming, also extending into other parts of Wyoming, adjoining Utah, and barely into Colorado and Idaho. Recent publications to date address support the monophyletic origin of the *Oreocarya* section (Higgins 1971, Hasenstab-Lehman and Simpson 2012) but not relationships within it.

B. Present legal or other formal status

1. National legal status: *Cryptantha subcapitata* was listed as a Category 2 (C2) species by the U.S. Fish and Wildlife Service (Federal Register of September 27, 1985). Category 2 species were taxa for which proposing to list them as endangered or threatened was possibly appropriate, but for which substantial data on biological vulnerability and threats were not known or on file to support immediate preparation of rules. It retained C2 status until 1996 when the C2 status was abolished and the term "candidate" and its definition were narrowed to apply only to Category 1 species under active consideration for listing. As such, it has no protection under the ESA. The state communication regarding this decision by the National Director of the Service and impending policy change was conveyed by Charles Davis on 21 August 1995.

Later, it was designated sensitive by the Wyoming BLM (USDI BLM 2001). This status applies only insofar as it occurs on BLM lands.

2. Global Heritage rank: Its rank was changed from G1 to G2 in 2002, based on prior survey results. The results from this study suggest that present species numbers may be only 10%-25% of those in the 1980s. This is the only available trend information, reflecting a level of decline that warrants a change of GRANK back to G1 or G1G2.

3. State Legal status: There is no state legal status for plants in Wyoming.

4. State Heritage rank: This value corresponds to GRANK for state endemics, and may warrant a change of SRANK toS1 or S1S2. (see above).

C. Description

1. General non-technical description: Owl Creek cryptantha is a mat-forming perennial herb usually less than 15 cm high. The leaves are linear to oblanceolate, 1-3 mm wide, and densely pubescent with both appressed, short hairs and longer, spreading, bulbous-based

hairs. The inflorescence is head-like, with white flowers 5-6 mm broad that barely exceed the calyx tube in length. The nutlets are wrinkled and bumpy on the back and are enclosed by the pubescent calyx lobes. The slender style persists in fruit and exceeds the nutlets by 1.5-2 mm (Dorn and Lichvar 1981, Dorn 2001, Fertig et al. 1994).

Even though the species is described as matted, it forms a loose mat in which individual shoots are visible and generally do not touch one another. There may be over 50 stems in a cluster, but the number of live stems observed in 2019-2020 was usually far fewer, and the live clusters (rosettes) were sometimes outnumbered by dead leaf clusters.

2. Technical description: Mat-forming perennial 5-15 cm high; leaves linear to linear oblanceolate, 8-28 mm long, 1-3 mm wide. Densely appressed strigose and with some slightly larger, spreading, pustulate hairs at least on abaxial surface and margins. The old whitish leaves persisting at base; stems greenish; inflorescence capitate or subcapitate; calyx 5-7 mm long, pubescent like the leaves; corolla white, the tube 3-4 long, the limb about 5-6 mm across; nutlets 2-3 ,mm long, ovate in outline, dorsal surface rugose at center, mostly tuberculate near margins, the ventral surface rugose and tuberculate, the scar open for most of length of nutlet, the opening triangular at base; style exceeding nutlets by 1.5-2 mm (Dorn 1989). Mature fruit are needed for positive identification.

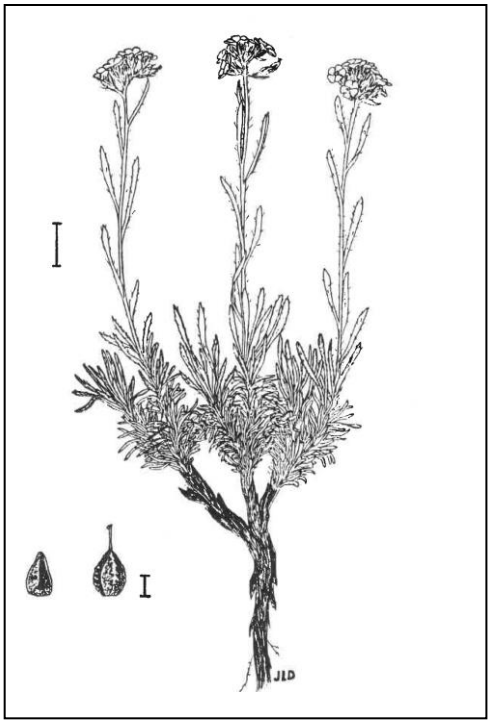

Figure 1a (left). *Cryptantha subcapitata*, by Jane Dorn, reprinted with permission from Madroño (Dorn and Lichvar 1981)

Figure 1b (above). *Cryptantha subcapitata*, by Charmaine Delmatier

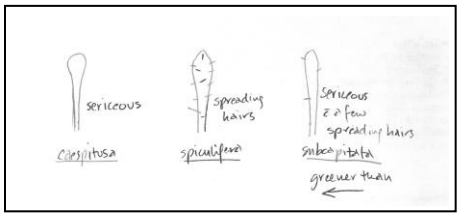

Figure 1c (left). *Cryptantha* leaf pubescence by Walter Fertig

3. Local field characters: There are nine species of *Cryptantha* present in Fremont County according to the Rocky Mountain Herbarium online database (Rocky Mountain Herbarium 2010). Five of them are annual (*C. ambigua, C. kelseyana, C. minima, C. scoparia* and *C. watsonii*). Among the biennial and perennial species, *C. celosioides* is usually single-stemmed and with no mat. The perennial species most closely resembling *C. subcapitata* are *C. caespitosa* and *C. cana* that have uniformly coarse and silky hairs, respectively. Note: The proximity of these three species was not flagged in other reports or surveys but is in this report. The similar *C. spiculifera* usually has an elongate inflorescence rather than a subcapitate one, and the nutlet scar is closed rather than open, but it is a species that is not known from Fremont County, but present in the Big Horn Basin and farther north. A schematic diagram of leaf pubescence traits to go with the Dorn and Lichvar (1981) table was sketched by Walter Fertig (Figure 1c).

Table 1. Selected characteristics of four species of *Cryptantha* (reprinted from Dorn and Lichvar 1981, with addition of *C. cana* information based on Higgins 1977)

Characteristic	***C. subcapitata***	***C. caespitosa***	***C. cana***	***C. spiculifera***
Leaf shape	Linear to linear-oblanceolate	Obovate to oblanceolate	Linear oblanceolate or broader	Oblanceolate
Leaf pubescence	Mixture of coarse, appressed, nonpustulate hairs, and fewer, spreading, slightly coarser, obviously pustulate hairs	Uniform, coarse, mostly appressed, not obviously pustulate hairs	Silky strigose or strigulose, with small, inconspicuous pustulate hairs on both leaf surfaces	Mixture of fine, somewhat appressed, mom-pustulate hairs and fewer, spreading, much coarser, obviously postulate hairs
Stems	Green	Straw colored	Green or straw colored	Green or straw colored
Inflorescence	Capitate or subcapitate	Usually elongate	Usually elongate	Usually elongate
Styles	Exceed nutlets by 1.5-2 mm	Exceed nutlets by <0.5 mm	Shorter than nutlet	Exceed nutlets by 1.5-2 mm
Mature nutlet margin	Same as body	Usually same as body	Without a distinct margin, sharply muricate	With narrow, smooth margin prominently set off from body by smoothness and color
Nutlet scar	Open	Open	Open, but narrowly triangular	Closed

4. Similar species: Dorn and Lichvar (1981) described discovery of *Cryptantha subcapita* as resembling *C. caespitosa*, but having a different aspect, supported in technical distinctions that included a longer style and different type of pubescence. They also noted similarity to *spiculifera* and prepared a table of comparisons (Dorn and Lichvar 1981). Their table is reprinted on the next page with addition of *C. cana* as another perennial species of *Cryptantha*, one with overlapping distribution. In general, these other species have more elongate inflorescences. The style length, nutlet scars and leaf pubescence characteristics are best examined under a hand lens, and they implicitly refer to the distinctive aspect of plants as being those with flowering stems.

In addition to morphological differences, Walter Fertig noted that "*Cryptantha subcapitata* is typically replaced by *C. celosioides* on shale outcrops and by *C. cana* on limestone" in text he prepared for Wyoming plant species abstracts. To this I add that it is typically replaced by *C. caespitosa* on sandstone and sandy plains.

All 2019-2020 field photographs are compiled into Appendix A as representing the pervasive nonflowering state of *Cryptantha subcapitata* observed in 2019-20 surveys. Stems were absent on most plants and leaves tended to be very short. Exactly one flowering plant had the same stature as represented by the technical illustration (Figure 1a) and in the species photograph (Figure 1b). The one healthy flowering plant is represented on the cover.

During 2019-2020 surveys, only four plants of *Cryptantha subcapitata* were recorded as being in flower, and seven in fruit, such that detection was impeded and most of the above characteristics were not verifiable in surveys. No collections were made in 2019-2020, but inflorescence fragments were collected for nutlet characteristics, and other species in the landscape were photographed (Appendix A) and one collected.

Most of the 11 flowering or fruiting plants seen in 2019-2020 had two flowering stems (highest count was ten). None of the plants had current or evidence of flowering stems like the photo in Figure 1b, that appears to have 21 flowering stems.

There is not a written record of the Fort Washakie specimen attributes to go along with the statement by Robert Dorn that "This specimen may belong to a different taxon." It was examined at RM as part of this study and has linear oblanceolate leaves and a mixture of hairs as described for *C. subcapitata*. The one style that was visible measured ca 3 mm long, longer than *C. subcapitata*. The inflorescence appeared to be elongate, with axillary flower buds, unlike the compact inflorescence of *C. subcapitata*.

D. Geographical distribution

1. Range: Known only from the Owl Creek Mountains and adjacent Wind River Basin in northern Fremont County, Wyoming. Maps of locations as originally mapped and 2019-2020 remapping (noting extirpations) are shown in Appendix B.

2. Extant sites: There are two or three extant occurrences, comprised of one to many discrete areas – Figure 2a. This current treatment is much the same mapping convention as in Dorn (1989). However, what he presented as one occurrence (at Boysen Reservoir), was later split into two in the WYNDD database, because there are over 6 km apart at north and west-central parts of the Reservoir. They are likely to have limited gene exchange, but it is possible that they were more contiguous before Boysen Dam was constructed.

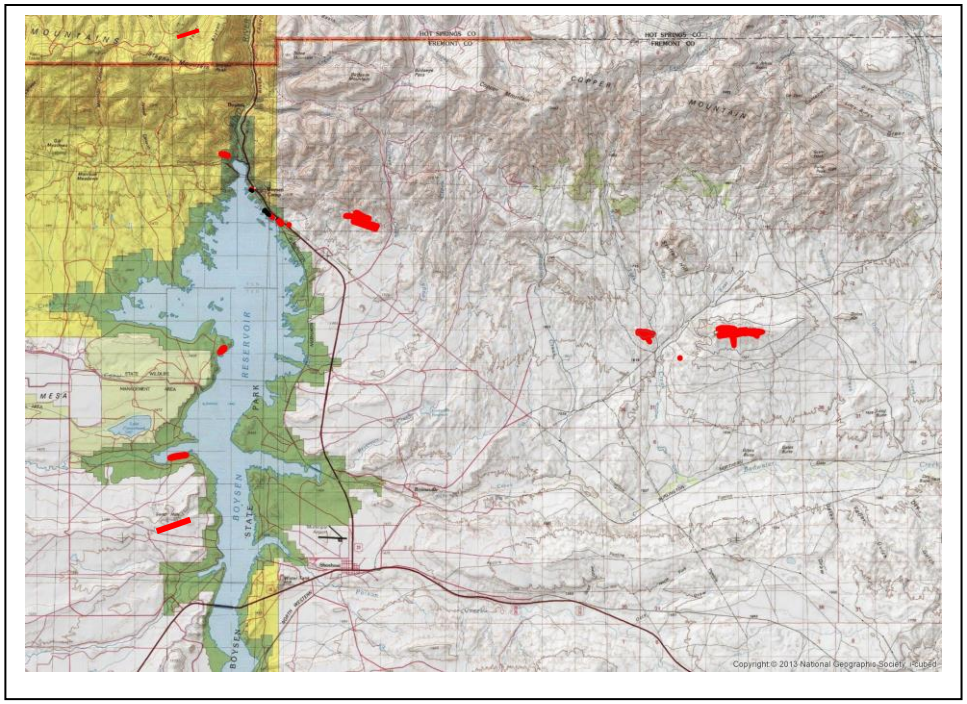

Figure 2a. *Cryptantha subcapitata* current distribution (see Appendix B for map details)

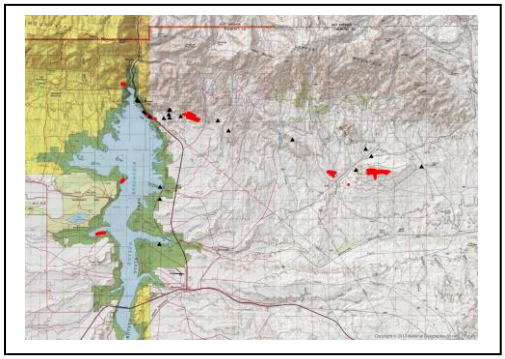

Figure 2b. Negative surveys for *Cryptantha subcapitata* (black triangles) added to above

The original objectives of 2019-2020 surveys included testing the potential distribution model and try to expand distribution. However, both years of surveys had such poor levels of flowering that detection reliability was low. The objective of conducting new surveys was scaled back, the only new locations were minor extensions in the same sections as known locations or in adjoining ones. Only eight areas were surveyed where the species was absent (Figure 2b).

3. Historical sites: There is one historical collection by James Carrig (J.R. Wight s.n. RM) made in 1958 near Fort Washakie on the Wind River Indian Reservation that botanists have not tried to survey, and that may represent a different taxon (Dorn 1989). The specimen is represented in the RM database under *C. subcapitata* without resolving its taxonomic status. Its distinctions are highlighted in the species description.

It was next collected by J.R. Wight 1.5 miles southeast of Boysen Camp in the same county on 3 June 1964. Robert Dorn and Robert Lichvar next collected it near Boysen Dam on 23 June 1980 and described the species. It was subsequently collected by Ronald Hartman and Keith Dueholm and Robert Dorn at two additional locations (Dorn 1989). The 1960s and 1980s collections have all been relocated.

Table 2. Location information for known occurrences of *Cryptantha subcapitata*

EO#[1]	**Site Name**	**Legal Description**	**Elevation (ft)**	**USGS 7.5' Quad (s)**	**Managed Area**[2]
001	Boysen Reservoir north end	005N 006E Sec. 8, 16, 17, 21, 22; T40N R94W Sec 22, 31, 32, 34	4760-5370	Birdseye Pass, Boysen	Boysen State Park, Bureau of Land Management
004	Fort Washakie	002N 001E or 001N 001W	5400	(Possibly Fort Washakie, Ethete, Lander NW, Mule Butte or Ray Lake)	(Wind River Indian Reservation)
005	Cedar Ridge	T39N R92W Sec. 15, 16, 17, 19, 20, 21,22; T39N R93W Sec 24	5400-6000	Gates Butte, Piccard Ranch	Bureau of Land Management, State Trust land
007	Boysen Reservoir south end	004N 006E Sec. 8, 31	4700-4750	Bonneville SW	Boysen State Park

[1] The numbering is not sequential because it reflects past splitting and lumping of occupied habitat into occurrences.
[2] All 2019-20 surveys were conducted on public land, whereas the 1989 maps indicate that one of the Boysen Reservoir north locations is on private land and another may extend onto Wind River Indian Reservation. Many Boysen State Park parcels, including all on the west side of the reservoir, are within 0.25 miles of the reservoir.

There were originally 18 discrete locations (polygons) mapped prior to this project, and all but one are on public land and resurveyed in 2019-2020. There were at least three polygons where habitat has been destroyed in the Boysen Reservoir population of Boysen State Park, a fourth that could not be relocated and a fifth that was either mismapped or has been 90% destroyed. It is not clear from the Dorn (1989) report whether or not he observed this habitat loss and decline in the Park between the original collections in 1980 and the surveys in 1989. The 2019-20 surveys refined boundaries at some of the 15 earlier locations (including splitting a polygon), and added points or small polygons, for a total of 17 extant places on public land.

4. Unverified/Undocumented reports: None.

The potential distribution model shows the highest probability for potential habitat at the northern end of the Boysen Reservoir (Figure 3 in burghundy and bright red), extending east and west from it. Moderate probability potential habitat is shown in pink in the same figure, covering much of the Wind River and Big Horn Basins.

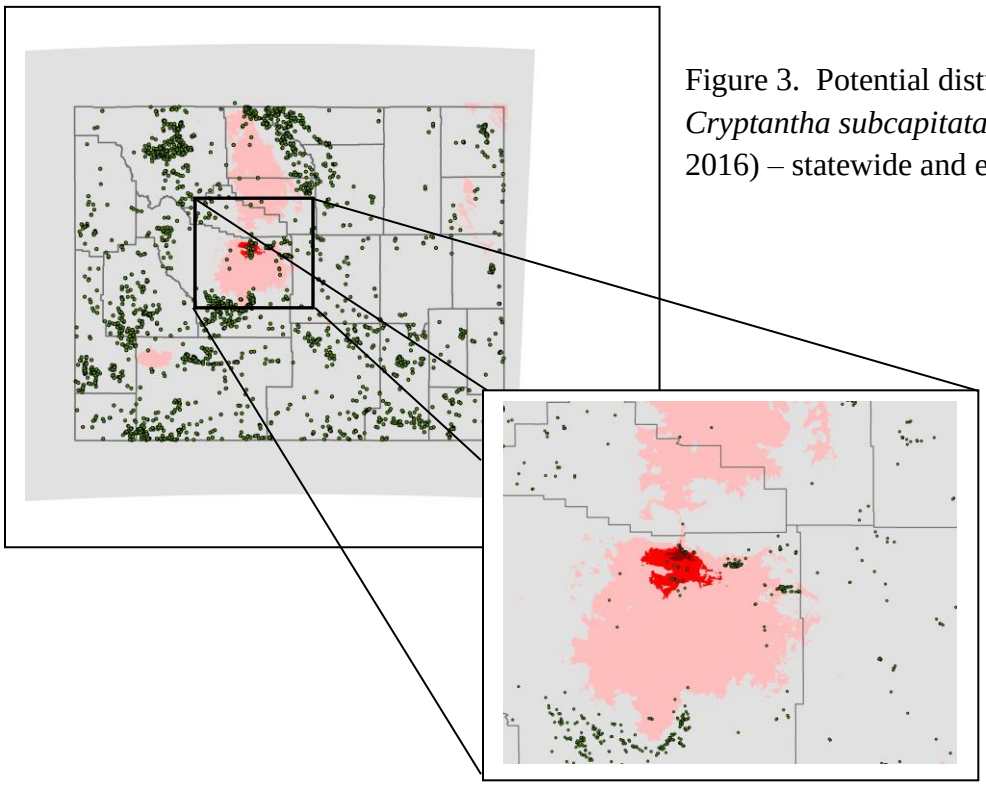

Figure 3. Potential distribution of *Cryptantha subcapitata* (Andersen et al. 2016) – statewide and enlargement

5. Sites where present status not known: The Fort Washakie area where it was collected in 1958 has not been resurveyed. One polygon on private land was not surveyed, and the outermost boundaries of one polygon on public land might have been mapped as extending onto Wind River Indian Reservation. No survey work took place outside of public land.

In addition, there was one polygon where the species could not be relocated in recent surveys but it had what appears to be a different species present (Heidel #4987 RM). The voucher is in flower rather than fruit but appears to be *C. cana* rather than *C. subcapitata*. If this is correct, then one of the original ten locations of Boysen Reservoir north may have been based on a misidentification.

6. Areas surveyed but species not located: Surveys were conducted between the Boysen Reservoir and Cedar Ridge populations, in locations that had not been surveyed by either Robert Dorn or Walter Fertig. Distribution data and past surveys were superimposed on potential distribution models (Andersen et al. 2016, Fertig and Thurston 2003) and surface management layers representing public land prior to the field season. No new populations were found. A map and table of the waypoints where it was sought but not found are represented in Appendix D.

E. Habitat: The habitat has generally been described as sandy-gravelly slopes and desert ridges, mainly on sandstones and conglomerates derived from the Wind River Formation. These are in settings of foothills ridges, foothill benches, nearby basin ridges and toeslopes below, capped by gravel pavement, with underlying sedimentary bedrock.

1. Associated vegetation: The vegetation ranges from cushion plant community and bunchgrass community to mixed grass prairie, often in the sparsest portions of these vegetation types.

2. Frequently associated species: The most frequently associated species include those identified as such by Dorn (1989). Later, *Artemisia capitata* and *A. nova* were referred to as common associates (Marriott 1992, Fertig 1993, Fertig et al. 1994). Other species have been added from collection labels and associated species noted in 2019-2020 surveys (Table 3). In 2019-20 surveys, the following species were the most consistent associates: *Eremogone hookeri, Phlox muscoides, Tetraneuris acaulis, Xanthisma grindelioides* and tufted milkvetches (*Astragalus* spp.); as consistent with Dorn (1989).

3. Topography: The species is at the top of gravel-capped ridges, benches and knolls, and on gravelly colluvial fan toeslopes. Some of the ridges have a sharp drop-off rim and, in those settings, the species is concentrated at the rim. Its topographic position differs from one locale to the next, making it difficult to model. Moreover, the original mapping of its distribution, as

used in the most recent model (Andersen et al. 2016) showed the species spanning top-to-bottom slopes of Cedar Ridge. More recent surveys found it to be primarily on top of the linear ridge and finger ridges, tops of isolated little knolls below, and only occasionally present on toeslopes below; absent from the extensive slopes that make up most of the ridge.

Table 3. Species frequently associated with *Cryptantha subcapitata*[3]

Scientific name	Common name	Boysen area	Cedar Ridge area
Achnatherum hymenoides	Indian ricegrass	**x**	**x**
Aristida purpurea var. fendleri	Fendler's threeawn	**x**	**x**
Artemisia capitata	Rock tansy		x
Artemisia tridentata ssp. wyomingensis	Wyoming big sage		**x**
Astragalus sericoleucus	Silky milkvetch	**x**	**x**
Astraglus simpllicifolius	Little bun milkvetch	**x**	**x**
*Astragalus spatulatus**	Tufted milkvetch		**x**
Bouteloua gracilis	Blue grama	**x**	**x**
Carex filifolia	Thread-leaved sedge	**x**	**x**
Commandra umbellata	Bastard toadflax	**x**	
Elymus spicatus	Bluebunch wheatgrass	**x**	**x**
*Erigeron pulcherrimums**	Basin fleabane	**x**	**x**
*Eremogone hookeri**	Hooker's sandwort		**x**
*Eriogonum brevicaule**	Shortstem buckwheat	**x**	
*Eriogonum pauciflorum**	Fewflower buckwheat	**x**	
Gutierrezia sarothrae	Broom snakeweed	**x**	**x**
Hesperostipa comata	Needle-and-thread	**x**	
*Hymenopappus filifolius**	Manyhead hymenopappus	**x**	
*Juniperus osteosperma**	Utah juniper		**x**
Linanthus cespitosus	Mat prickly phlox	**x**	**x**
*Oxytropis besseyi**	Bessey's locoweed	**x**	
*Phlox muscoides**	Moss phlox	**x**	**x**
Poa secunda	Sandberg's bluegrass	**x**	**x**
Stenotus acaulis	Stemless mock goldenweed		**x**
Tetraneuris acaulis	Stemless four-nerve daisy	**x**	**x**
Townsendia incana	Hoary Townsend daisy	**x**	**x**
*Wyethia scabra**	Badlands mule-ears		**x**
*Xanthisma grindelioides**	Rayless tansyaster	**x**	**x**

[3] Species that are asterisked were those first reported by Dorn (1989) as frequent associates. The original list by Dorn (1989) did not include *Artemisia nova* or *A. capitata* (syn. *Sphaeromeria capitate*), both of which are characteristic of limestone, and did not appear to be directly associated with *C. subcapitata* in 2019-20 surveys except the latter, locally, at Cedar Ridge.

4. Soil relationships: Soils are generally sandy and gravelly, shallow and poorly developed. (Dorn 1989) characterized soils as derived directly from a sandstone that is difficult to distinguish at a glance from similar sandstones in the area. Soils are not mapped for the Boysen area of Fremont County, but the Cedar Ridge soils are mapped as Oceanet-Rock outcrop-Persayo complex, hilly (Iiams et al. 1993). Both the Oceanet and Persayo soil series are shallow, well-drained soils on hills and ridges formed in residuum and slope alluvium derived dominantly from sandstone, mildly alkaline. The geology of the area is mapped as Wind River Formation (Eocene), which includes not only bedrock erosion deposits in situ but also alluvium and colluvium. Some of the gravels in the Boysen Reservoir locations are rounded and weathered consistent with long-distance alluvial transport, while others are blocky consistent with short-distance transport of colluvium. The Birdseye Rd occupied habitat was described by Walter Fertig (1997) as: on low, south-facing benches of whitish-tan, clay-sandy sandstone and conglomerate at the toe of a dry limestone ridge."

Dorn (1989) noted that *Cryptantha subcapitata* is rarely on adjacent limestone although the type location is described by him as a calcareous ridge. There is one other place in Boysen State Park where it was mapped as present on limestone though it was the only place where relocation was unsuccessful in 2019-20 surveys and recorded as "failed to find". However, a different *Cryptantha* was collected and provisionally determined as *C. cana*. The latter location also had *Artemisia capitata* and *A. nova* present. It is possible that this one locale is based on a misidentification, that the species was missed, or that the species is extirpated locally. I collected the *Cryptantha* material, in flower with no fruits. In general, underlying bedrock of *Cryptantha subcapitata* habitat is often white or whitish, but this reflects its igneous quartz content rather than calcareous sedimentary bedrock.

1. Regional climate: Boysen Dam (BOYSEN DAM, WYOMING - 481000) climate data is reported in the Western Region Climate Center summaries covering 1949-2020 (NOAA 2021). A data summary for 1980-2010 indicates that mean annual precipitation was 9.05 in (). Mean monthly minimum/maximum daily temperatures were 33.8°F and 60.0°F ().

Climatological data was downloaded for the Boysen Dam station to characterize climate (1949-2020) trends (Figures 3-9), compared with 2019-20 weather conditions (Tables 4-10).

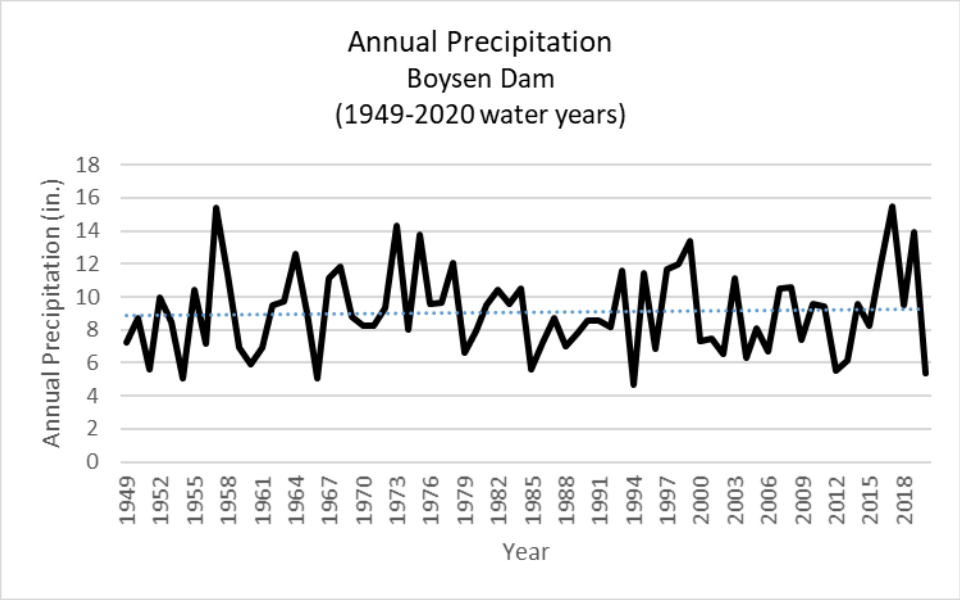

Table 4. Recent years annual ppt compared to mean	
2018	-4%
2019	52%
2020	-41%

Figure 4. Annual precipitation at Boysen Dam (1949-2020)

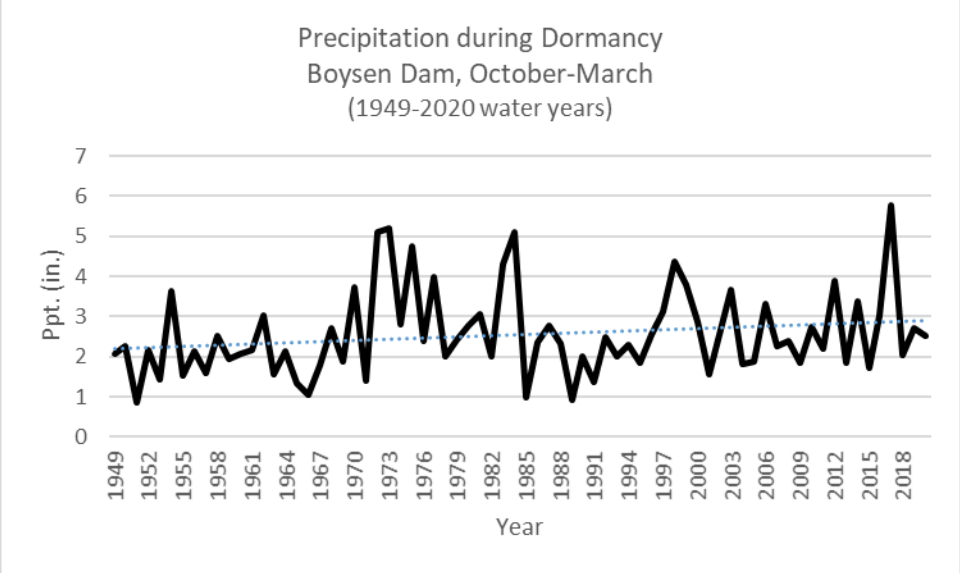

Table 5. Recent years dormancy ppt compared to mean	
2018	-21%
2019	6%
2020	-1%

Figure 5. Precipitation during dormancy at Boysen Dam (1949-2020)

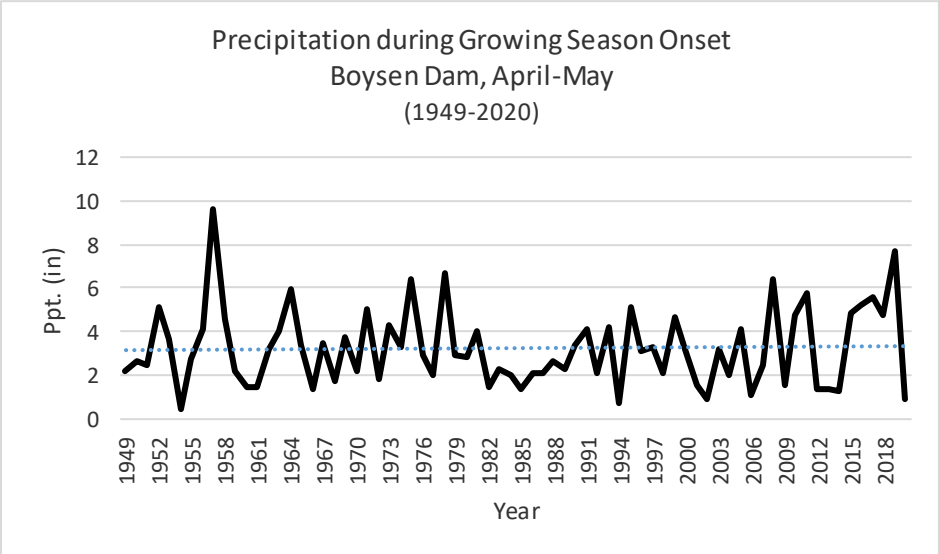

Table 6. Recent years early ppt compared to mean

2018	146%
2019	239%
2020	-27%

Figure 6. Precipitation during growing season onset at Boysen Dam (1949-2020)

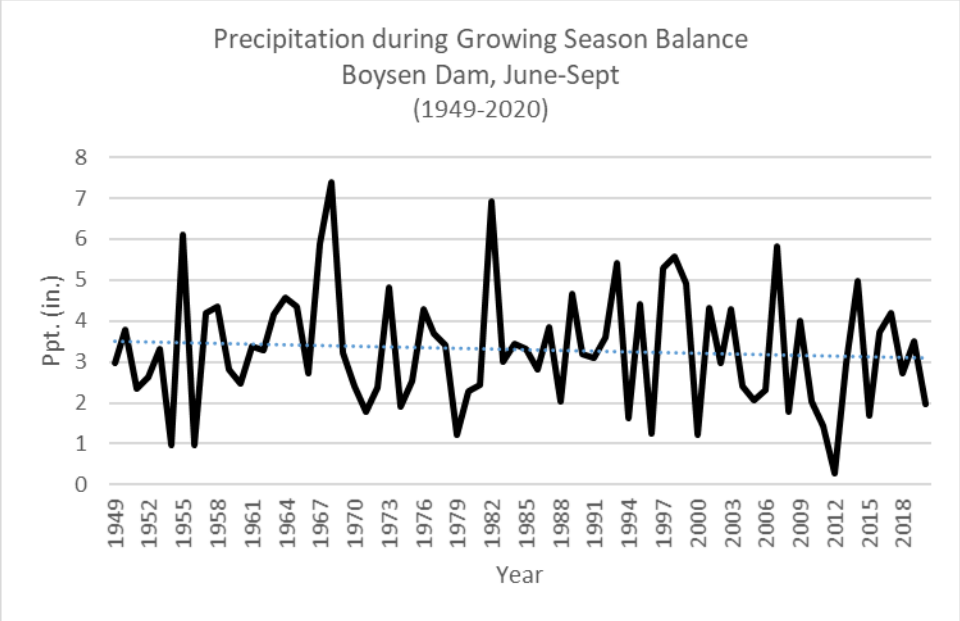

Table 7. Recent years balance ppt compared to mean

2018	-18%
2019	5%
2020	-40%

Figure 7. Precipitation during growing season balance at Boysen Dam (1949-2020)

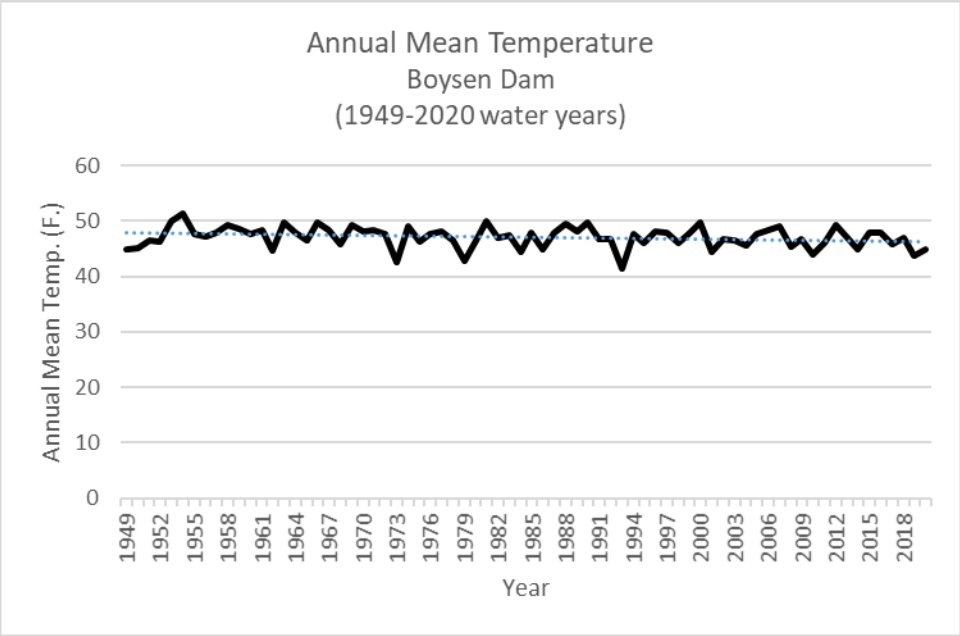

Table 8. Recent years temp compared to mean annual temp

2018	0
2019	-7%
2020	-4%

Figure 8. Annual mean temperature at Boysen Dam (1949-2020)

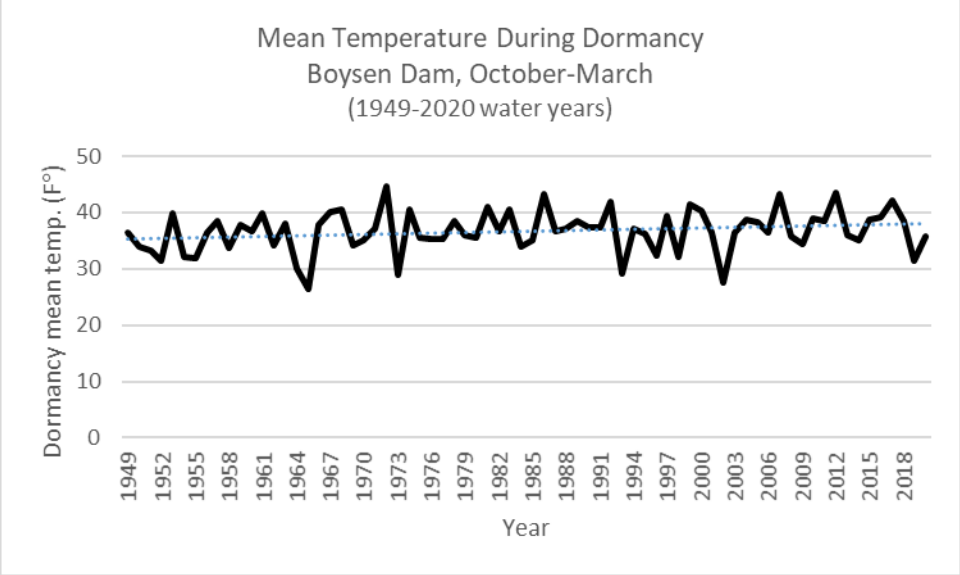

Table 9. Recent years dormancy temp compared to mean

2018	-3%
2019	-18%
2020	-15%

Figure 9. Mean temperature during dormancy at Boysen Dam (1949-2020)

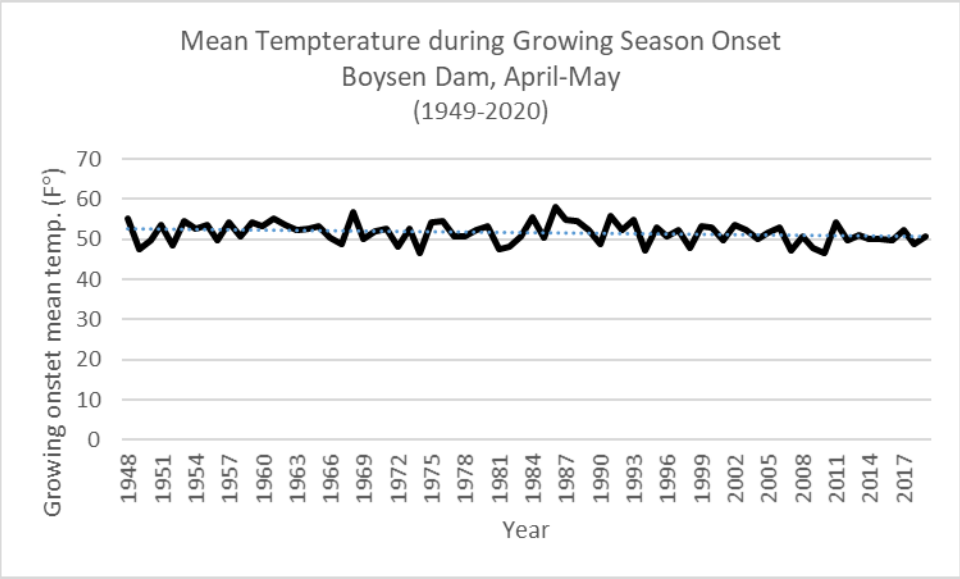

Table 10. Recent years onset temp compared to mean temp

2018	1
2019	-6%
2020	-2%

Figure 10. Mean temperature during growing season onset at Boysen Dam (1949-2020)

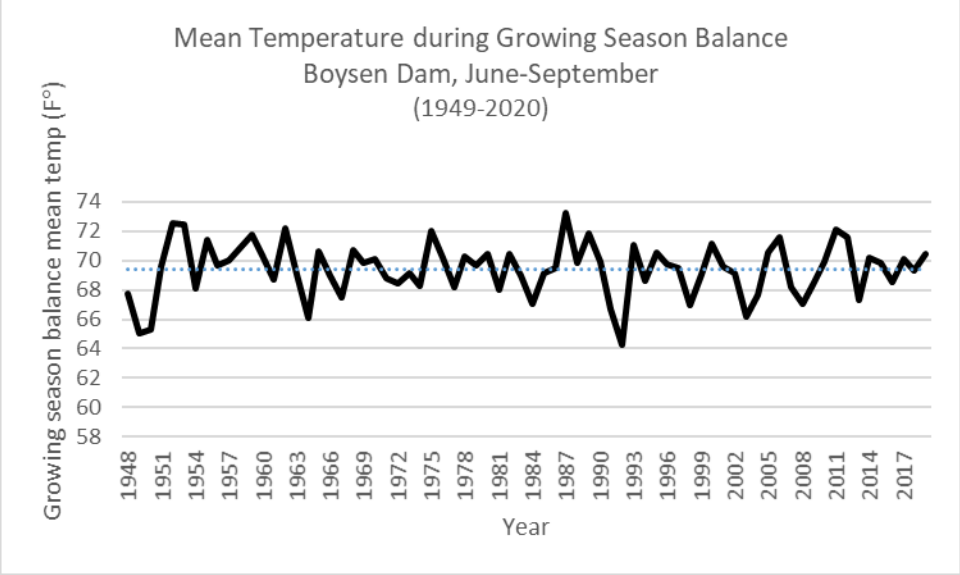

Table 11. Recent years balance temp compared to mean

2018	1%
2019	0
2020	1%

Figure 11. Mean temperature during growing season balance at Boysen Dam (1949-2020)

The preceding pages show eight climate graphs. Data are converted to water year representations, e.g., the 2020 water year started on 1 Oct 2019. All graphs have a trend line added for reference, and a table beside them that compares their mean with 2018-2020 weather conditions.

In addition to annual datasets for net precipitation and mean temperatures, the monthly data are grouped into three periods of the year based on the inferred activity of *Cryptantha*

subcapitata: dormancy (October-March, spring growth and flowering at the onset of the growing season (April-May), and summer fruiting and senescence during the balance of growing season (June-September). This exploratory treatment is for purposes of discerning seasonal changes that might affect the species and be masked in annual datasets.

Finally, the monthly 2018-2020 values (i.e., inclusion of data from one year prior) are compared against the 61-year averages so as to determine the relative percentile that they are above or below those averages documenting that 2019 was a relatively moist year and 2020 relatively dry. These comparison tables are inserted beside the corresponding graphs (Tables 4-11, on the following pages).

Annual precipitation and annual temperature trend lines suggest a static trend (Figures 3 and 7). However, an increase in precipitation is indicated during dormancy (Figure 4) but a decrease in precipitation during the latter part of the growing season (Figure 6). Temperatures may be rising during dormancy (Figure 8) but decreasing during the onset of the growing season (Figure 10). The mean temperature trend line during dormancy is rising well above freezing. This may translate to increased snowmelt, increased frequency of freeze-thaw cycles over time, prolonged water erosion and/or decreased length of the growing season.

2, Local microclimate: As Dorn (1989) pointed out, direct exposure to the sun likely makes the sites warmer than macroclimatic data indicate. The topographic positions and coarse soil texture are consistent with droughty conditions that compound evaporative water loss.

F. Population biology and demography. Available data suggests that *Cryptantha subcapitata* is a long-lived perennial. It has a woody caudex, and Dorn (1989) stated that "The plants form small mats and as such are long-lived". Longevity is an important consideration for interpreting the following information.

1. Phenology: In flower and fruit from late May- late June (July). Specifically, Dorn (1989) said that flowering begins in late May and continues through June. Fruits begin to mature in mid June and go into July. Fruits are shed beginning in mid July."

Flowering is indeterminate on the flowering stem, and may have lasted for a couple weeks in favorable conditions, as indicated in the 1989 report. These generalizations have been aggregated from collection and survey data, and may not apply to the phenology every year. For example, almost none of the populations had started to flower in 2019 by the first week of June, whereas almost all of the populations had finished flowering in 2020 by the second week of June. In both years, the numbers of flowers per flowering stalk and numbers of flowering stalks per mat were low.

The species is more conspicuous when in flower, although in certain years, such as 2019-2020, plants may not produce any flowering stems, and those that flower may have very short flowering stems. Throughout the entire 2019-20 surveys, I only noted a total of four plants in flower, and seven plants in fruit. The flowering plants were in both the Boysen and Cedar Ridge areas, and only one was taller than 5 cm. The fruiting plants were noted in the Boysen area at the type locality in particular (Appendix A).

G. Population size and condition: Dorn (1989) estimated the total population to be ca 38,000 over an area of ca 1460 acres in stable condition. He estimated about 23,000 plants at Boysen Reservoir and about 15,000 at Cedar Ridge. Since 1989, there have been a new location for it added west of Birdseye Road, with an estimate of 3000-5000 more plants. By adding the latter to 1989 tallies, there could have been 41,000 – 43,000 plants at one time. The 2019-2020 surveys and estimates were made in years of poor flowering and stunted growth, so the population estimates are rough, and they were prepared as brackets (high and low estimates based on running tallies and high and low terms for extrapolation).

1. Trends: Population estimates in 2019-20 were impaired by detection difficulties, but the consistently low numbers and the pervasive vegetative condition support an interpretation that there has been major decline. Rough estimates made in 2019-2020 indicate that they are in the range of 3500-11,000 plants, i.e., on the order of 8%-27% of earlier population numbers. There were poor flowering conditions and inaccuracy of estimating population size from vegetative plants. Boysen Reservoir was reported by Dorn (1989) as supporting the largest population but has had habitat loss and greater decline than the Cedar Ridge population. Though both have declined, the Cedar Ridge population declined less than at Boysen Reservoir and is now the largest population.

Boundaries did not appear to show much change but there were some boundaries mapped in greater detail, particularly on Cedar Ridge. The most extensive population of *Cryptantha subcapitata* is at Cedar Ridge, where the species was originally mapped as present in 3.5 miles of ridge spanning over 1360 ac. This mapping indicates that it occupies ridge slopes, but no ridge slope locations were found in recent surveys. It is present at low knolls below the ridges, but not continuous between the ridgetop and knolls at the base of the ridge. It was remapped as much less than 200 ac.

Table 12. Size and extent of *Cryptantha subcapitata* occurrences

Site name	**Population size (Dorn 1989+Fertig 1997 addition)**	**Population size (2019-2020)**	**Extent (Dorn (Dorn 1989+Fertig 1997 addition) (ac)**	**Extent (2019-2020) (ac)**
Boysen north end	1989 (10 locations): 23,000 1996: 3000-5000 (in 2 added locations)=26,000-28,000	1000-4500	100+20=120	Over 100 ac (excluding pvt and extirpated)
Fort Washakie	?	?	?	?
Cedar Ridge	15,000	2300-6500	1360	240[4]
Boysen south end	(included in Boysen N tally)	42-62	24	16
TOTAL	41,000-43,000	3,500-11,000	1500	340

1. Reproductive biology

a. Type of reproduction: Reproduces by seed, with no sign of vegetative reproduction. Dorn estimated that 90% of all plants were in flower in 1989 surveys, whereas in 2019-2020, about 5% of all plants were in flower. Furthermore, individual plants had far fewer flowering stems in recent years compared to earlier years, with many of the recent flowering plants having only 1-2 flowering stems; none were seen with as many as 10 (Figure x).

b. Fecundity: If app 90% of 38,000 plants were flowering in the 1980s, then there would have been over 34,000 flowering plants. By contrast, I noted only four plants in flower and seven in fruit over the two years of survey. It is likely that reproductive plants were overlooked in both years since flowering stems were stunted. But even if I detected on 1% or 10% of flowering and fruiting activity, this means that reproduction levels were 30X-300X lower in recent years than the 1980s. This decline in flowering levels exceeds the decline in population estimates and provides possible context for the life history changes behind them.

The *Cryptantha* genus produces four nutlets (fruits) per flower, but of these, some species routinely only ripen one of the fruits, and other species such as *C. flava* are plastic in ripening 1-4 of the fruits depending on the growing season conditions (Casper 1984). Abortion of all fruits is widespread. The level of seed production is not known for *C. subcapitata*. The long-

[4] 2019-2020 surveys of Cedar Ridge indicate that the original mapping extended about a mile too far east beyond suitable habitat, included unoccupied side slopes of the ridge, and omitted outlier colonies to the west.

term decline in precipitation after flowering (June-September; Figure 6) may impede fruit maturation and germination, as well as survival.

c. Longevity: Dorn (1989) characterized most *Cryptantha subcapitata* plants as "older", based on the size of the mat diameters. It is possible that some mat-forming plant species with woody caudices live for decades (e.g., *Shoshonea pulvinata*; Heidel 2001). Dorn (1989) made no mention of dieback within individual plants, and none of the 1980s or 1990s photographs of the species show dead rosettes. However, about 90% of the plants observed in 2019-2020 had dead rosettes. Many had about half or more of the rosettes dead. Some had fragmented mats in which the rosettes apparently died some years ago and decayed in intervening years (Appendix A). Despite the ubiquity of dieback, very few plants were observed that were entirely dead.

Fertig surveyed the species in the Birdseye segment of the Boysen North population in 1996 (Fertig 1997) and did not note any dieback. He reported that most plants were 5-17 cm across. In 2019-20 surveys, most plants had mats that were within this range, although dieback was almost ubiquitous, with part of the mat area dead.

d. Pollination biology: Visitation by a mid-size bee was noted by Dorn (1989) and by a medium-sozed butterfly with orange checkered wings by Fertig (1996 survey records) but there have been no pollination studies. Perennial members of the *Cryptantha* genus are generally regarded as obligate outcrossers, requiring transfer of the pollen from one plant to the stigma of a different individual, referred to as xenogamy (Casper 1984).

e. Seed dispersal and biology: Dorn (1989) noted that nutlets are likely wind-blown to some extent but because of the rocky habitat probably do not go far before becoming wedged in the rocks. He also inferred that rainwater may also carry the nutlets short distances.

f. Recruitment: Dorn (1989) said that moisture is probably not adequate in most years for seedling establishment and he speculated that seeds may not be produced in some years. The poor flowering levels of 2019-20 are consistent with the latter. The complete absence of small healthy plants indicates that there have not been recruitment events in recent years. Fertig (1996 survey records) said there were no seedlings, and Dorn (1989) said there were no small plants present.

G. Population ecology

1. General summary: Populations are irregularly distributed within and between occupied habitat. Highest numbers and density are generally found at topographic high points.

2. Competition: The species is inferred to be a poor competitor because its numbers and density are inversely related to vegetation cover. Mat-forming plants in general captures wind—borne sediment so that they sometimes become "nurseries" for other plants to become established. No signs of *Cryptantha subcapitata* colonizing other mats was evident, but both bunch grasses and other mat-forming species were sometimes present in *C. subcapitata* mats, particularly those that died in the center.

3. Herbivory: No signs of herbivory were noted. The hairness of the plant overall, bristliness of the inflorescence in particular, and generally short height deter browsing by wildlife and grazing by livestock. The BLM occupied habitats are part of grazing allotments. All but the locations along Highway 20 signify secondary range, and signs of livestock use were uncommon.

4. Hybridization: No evidence.

5. General summary: Populations exhibit patchy distribution pattern with highest numbers and density in the most suitable habitat found at high points, and with outliers on finger ridges and at lower slopes.

6. Competition: None noted.

7. Hybridization: None noted.

H. Land ownership: One of the three extant populations is almost entirely on BLM lands at Cedar Ridge. The portion of the Boysen population that retains high numbers is the Birdseye segment, also on BLM lands.

IV. CONSERVATION CONSIDERATIONS

A. Potential threats to currently known populations: There have been losses of portions of the Boysen Reservoir population with recreational developments, road construction and quarrying, that involved bulldozing and sometimes excavation. It is present along much of the transmission line corridor running east of US Hwy 20, but is not restricted to the right-of-way 2-track that follows the corridor. It does not seem to be under threat because of this man-made feature unless indiscriminate herbicide spraying took place. The BLM portion of the Boysen Reservoir population is part of a large grazing allotment that includes the transmission line corridor. The Cedar Ridge habitat has many old uranium mining claims, roads bladed along many ridgetops, and connecting two-tracks. The overlap between species' distribution and uranium mining activity has already been pointed out (Heidel et al.

2014) but there were no signs of recent activity. Inactive oil and gas wells are at the base of Cedar Ridge.

At present, invasive species are infrequent and have low density. *Halogeton glomeratus* (Halogeton) overlapped at the western end of the westernmost Boysen Reservoir polygon, and was spreading locally around the reservoir margins immediately below. *Bromus tectorum* (Cheatgrass) was localized in parts of the Boysen and Cedar Ridge landscapes. Boysen State Park has cheatgrass establishment in places along roads. The Cedar Ridge landscape has at least one extremely dense area of cheatgrass at an upper slope position near the ridge top, though not directly extending into occupied habitat. *Alyssum desertorum* (Desert madwort) is widespread in parts of Boysen State Park occupied habitat, but may not be as direct a competitor as these other species. The cover photo was taken in Boysen State Park and has small plants of both cheatgrass and desert madwort in the photo.

B. Present considerations:

1. Notification of BLM personnel of locations on BLM lands: This report is submitted to the BLM Lander Field Office and the BLM State Office.

2. Status notes: BLM lands support high proportions of *Cryptantha subcapitata* numbers and had none of the habitat loss.

Results of this survey point to widespread decline in species numbers with no known management causes (apart from habitat loss in the state park). Three things are recommended based on recent work:

- The recent population estimates and mapping were greatly impeded by difficulty in detecting the species. Renewed survey efforts are recommended if conditions return to favorable. The weather conditions for defining favorability are elusive; 2019 had significant above average precipitation at the start of the growing season and 2020 had below average precipitation. If there are not rebounds in species' flowering within the next two years, then a monitoring program is advised. In either case, further mapping of Cedar Ridge outliers on isolated knolls is warranted.

- Further analysis of climate data trends overall and in comparison with recent conditions may help determine whether or not the two-year study period had exceptional conditions. From the pilot review of climate data, four long-term trends and three recent patterns in 2018-2020 may warrant closer analysis (long-term: trends in precipitation and temperature during dormancy months, trends in temperature early in the growing season [April-May], and trends in precipitation late in the growing

season [June-October]. Recent condition patterns to evaluate include: annual precipitation, precipitation early in the growing season, and temperature during the dormant months. The aggregation of monthly data into three periods is based on inferred *Crytantha subcapitata* phenology dividing the year into periods of high, low and no physiological activity. An analysis without this aggregation may also be warranted.

- A monitoring program may be needed to document life history phenomena and responses in more favorable and less favorable years. Baseline monitoring would also provide basic data re. fecundity trends, rosette mortality trends, and to look closer for any sign of seedlings. If flowering levels do not rebound in the coming two years, then fieldwork in both years is best directed to monitoring design.

3. Summary: This status survey project did not appreciably expand known distribution of *Cryptantha subcapitata* but it more accurately mapped parts of local distribution and it provided records of local extirpation at Boysen Reservoir. Most importantly, it suggested a need for evaluating population decline.

4. Other considerations: *Cryptantha subcapitata* was in the Center for Plant Conservation (CPC) National Collections (CPC No. 1140) as collected by James Locklear in 1988 and profiled by him. Collection information and Research Needs are no longer addressed in the CPC species profiles, but previously identified research needs posted by the CPC included: additional surveys, population monitoring, and exact habitat characterization. The 2019-2020 surveys contributed toward the first and third research needs. The *ex situ* needs identified in the species profile were for seed germination studies, and this line of study is recommended if there are no rebounds or at least stabilization of population trends.

Conveyance of this report to Boysen State Parks is appropriate, along with a record of locations. Conveyance of this report to Wind River tribal governments might be considered.

State and global rank updates will be made pending report review. Finally, the Wyoming Field guide entry for this species has also been updated to reflect 2019-2020 survey results.

V. LITERATURE CITED

Andersen, M.D., B. Heidel, and G.P. Beauvais. 2016. Predictive Distribution Modeling of BLM Threatened, Endangered, and Sensitive Plant Species in Wyoming. Report prepared by the Wyoming Natural Diversity Database, Laramie, Wyoming, for the Wyoming BLM. http://www.uwyo.edu/wyndd/_files/docs/reports/wynddreports/u16and01wyus.pdf

Casper, B.B. 1984. On the Evolution of Embryo Abortion in the Herbaceous Perennial *Cryptantha flava*. Evolution, Vol. 38(6): pp. 1337-1349.

Center for Plant Conservation. 2020. Plant profiles: Owl Creek Miner's Candle (*Cryptantha subcapitata*). Posted electronically at: https://saveplants.org/search/?search=cryptantha%20subcapitata

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1984. Intermountain Flora; Vascular Plants of the Intermountain West, U.S.A. Volume 4: Subclass Asteridae. New York Botanical Garden, Bronx, NY.

Dorn, R. D. 1989. Report on the status of *Cryptantha subcapitata*, a Candidate Threatened species. Unpublished report prepared for the U.S. Fish and Wildlife Service by Mountain West Environmental Services, Cheyenne, WY.

Dorn, R. D. 2001. Vascular Plants of Wyoming, third edition. Mountain West Publishing, Cheyenne, WY.

Dorn, R. D. and R. W. Lichvar. 1981. A new species of *Cryptantha* (Boraginaceae) from Wyoming. Madroño 28:159-162.

Evert, E. F. 2010. Vascular Plants of the Greater Yellowstone Area: Annotated Catalog and Atlas. Park Ridge, IL.

Fertig, W. 1993. Field survey for *Cryptantha subcapitata*, *Physaria eburniflora*, and *Sphaeromeria simplex* on Bureau of Land Management lands in Central Wyoming. Unpublished report prepared for the Casper District, Bureau of Land Management by the Wyoming Natural Diversity Database, Laramie, WY.

Fertig, W. and G. Jones. 1997. Plant species of special concern and plant associations of the Copper Mountain ecosystem, Fremont County, Wyoming. Unpublished report prepared for the Bureau of Land Management Wyoming State Office by the Wyoming Natural Diversity Database, Laramie, WY.

Fertig, W. and R. Thurston. 2003. Modeling the potential distribution of BLM Sensitive and USFWS Threatened and Endangered plant species in Wyoming. Unpublished report prepared for the Bureau of Land Management Wyoming State Office by the Wyoming Natural Diversity Database, Laramie, WY.

Fertig, W., C. Refsdal, and J. Whipple. 1994. Wyoming Rare Plant Field Guide. Wyoming Rare Plant Technical Committee, Cheyenne, WY.

Hasenstab-Lehman, K. E. and M. G. Simpson. 2012. Cat's eyes and popcorn flowers: Phylogenetic systematics of the genus *Cryptantha s.l.* (Boraginaceae). Syst. Bot. 37: 738--757.

Heidel, B. 2018. Wyoming plant species of concern. March 2018. Wyoming Natural Diversity Database, Laramie, WY. Accompanied by Wyoming plant species of potential concern, with tables of additions and deletions.

Heidel, B., M. Andersen and J. Handley. 2014. Evaluating potential threats to Wyoming Threatened, Endangered and Sensitive plants. Wyoming Natural Diversity Database, Laramie, WY.

Iiams, J.E., C.E. Dillahunty, S.J. Jelden, J.P. Moore, C Paris, H.B. Ravenholt, M.C. Suhr and G.F. Bautz. 1993. Soil survey of Fremont County, East Part and Dubois Area, Wyoming. USDA Soil Conservation Service in cooperation with USDI Bureau of Land Management and University of Wyoming. Agricultural Experiment Station.

Marriott, H.J. 1992. Field survey for *Claytonia lanceolata* var. *flava, Cryptantha subcapitata and Shoshonea pulvinata* in the Owl Creek and southeastern Absaroka Mountains. Prepared for the Bureau of Land Management by the Wyoming Natural Diversity Database, Laramie, WY.

Nelson, B. E. 2018. Checklist of the Wyoming Flora following nomenclature of the Rocky Mountain Herbarium. Posted at: https://www.rockymountainherbarium.org/ .

Rocky Mountain Herbarium, 2020. Online specimen database. Posted electronically at: http://rmh.uwyo.edu/data/search.php .