# *Triteleia grandiflora* Lindley (largeflower triteleia): A Technical Conservation Assessment


**Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project**

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## AUTHOR'S BIOGRAPHY

Juanita A. R. Ladyman received her B.Sc. degree (with First-class honors) in Biochemistry from London University, England. Her first professional position was as plant pathology laboratory technician and, later, as greenhouse research supervisor with the Arid Lands Research Center on Sadiyat Island in the United Arab Emirates. She obtained her Ph.D. degree in Botany and Plant Pathology from Michigan State University where she was also a research assistant with the D.O.E. Plant Research Laboratory. She worked as a plant physiological ecologist and plant scientist for Shell Development Company conducting research on the physiology, ecology, and reproductive biology of economically important plant species and their wild relatives. She then worked for a plant biotechnology company in their Genetic Transformation and Plant Tissue Culture Division. For the last 15 years, she has worked in the area of conservation, particularly on rare, endemic, and sensitive plant species in the southwest United States. For three years of that time, she was the botanist with the New Mexico Natural Heritage Program. She has conducted research and monitoring programs on both non-vascular and vascular species. She currently is a partner in *JnJ Associates* LLC, an environmental consulting company in Colorado.

## COVER PHOTO CREDIT

# SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *TRITELEIA GRANDIFLORA*

## *Status*

*Triteleia grandiflora* Lindley (largeflower triteleia) is known from southern British Columbia, Washington, Oregon, Montana, and northern California, with disjunct occurrences in Wyoming and Colorado. The NatureServe global rank for *T. grandiflora* is apparently secure (G4). *Triteleia grandiflora* is designated critically imperiled (S1) by the Colorado Natural Heritage Program and imperiled (S2) by the Wyoming National Diversity Database. It has been reported from Idaho, Montana, Oregon, Utah, and Washington but remains unranked (SNR) by the natural heritage programs in those states. In British Columbia, *T. grandiflora* is ranked apparently secure (S4). These global and subnational ranks have no regulatory status.

*Triteleia grandiflora* was placed on the Rocky Mountain Region (Region 2) Regional Forester's Sensitive Species list in 2003. The taxon has been also been considered as a candidate for sensitive species designation by the USDA Forest Service Intermountain Region (Region 4) but currently has no formal status. Yellowstone and Grand Teton national parks consider *T. grandiflora* a sensitive species. The Bureau of Land Management has not designated *T. grandiflora* a sensitive species in any state in which it occurs. The U.S. Fish and Wildlife Service has not considered *Triteleia grandiflora* for listing under the Endangered Species Act.

Several taxonomic treatments recognize two subspecies of *Triteleia grandiflora*: ssp. *howellii*, which is restricted to the west coast of the United States and Canada, and ssp. *grandiflora*, which extends from British Columbia into Idaho, Montana, Oregon, Utah, and Washington with isolated occurrences in Wyoming and Colorado. Some taxonomists have elevated *T. grandiflora* ssp. *howellii* to the specific level. Only the form *howellii* is found in California, where the California Natural Diversity Database rank is it critically imperiled (S1). In British Columbia, the form assigned to ssp. *howellii* is recognized as a full species and is ranked critically imperiled (S1).

## *Primary Threats*

Habitat loss, fragmentation, and degradation caused by human recreation, livestock grazing, resource development (timber and mineral), and invasive non-native plant species are potential threats to the long-term persistence of *Triteleia grandiflora* throughout its range, including Region 2. Soil disturbance from all of these sources is a potential threat to occurrence viability. *Triteleia grandiflora* occurrences are also vulnerable to the direct effects of herbivory, especially in areas where pressures from livestock grazing may be in addition to those from wildlife. If *T. grandiflora* relies on cross-pollination to produce seed, then a change in the assemblage of pollinator species or a decline in pollinator abundance is a potential threat. The role of fire in the life history of *T. grandiflora* is unknown. Although the species may occur in forested areas, it is typically found in areas with low or no tree canopy. Past fire suppression policies may have reduced the amount of *T. grandiflora* habitat available. Natural or prescribed fires that burn with high intensity may kill the buried corms and are potential threats to occurrence viability. Rangewide, threats from habitat loss and degradation are likely to be more significant in the near future as the human population increases. As for all species, environmental stochasticity poses potential threats to *T. grandiflora*. Direct and indirect consequences of global climate change (e.g., extended periods of drought and periodic increases in rodent populations above the evolutionary average) may negatively affect the taxon. Elements of genetic and demographic stochasticities are also potential threats, especially to small and isolated occurrences. *Triteleia grandiflora* corms can be transplanted, so an occurrence may be translocated if destruction of the occurrence site is unavoidable. However, translocation in itself involves threats to the plants being moved. Urbanization also leads to habitat loss, fragmentation, and degradation, and has been and continues to be a threat to some occurrences outside of Region 2. The current level of threats to the occurrence on National Forest System land in Region 2 does not appear to be substantially impacting overall population viability.

## *Primary Conservation Elements, Management Implications, and Considerations*

There are no formal management plans for *Triteleia grandiflora*, and it has no special status in most of its range. Although perceived as locally abundant in some areas, there is actually a dearth of information concerning its biology, response to common management practices, and the effects of historic and current land use. There are at least five main conservation elements to consider:

1) the likelihood of genetic uniqueness and enhanced evolutionary potential of disjunct populations, such as the population found in Colorado

2) the species' response in different life cycle stages (particularly corm sustainability and seed production) to management practices

3) the potential for inbreeding depression and pollinator dependency, especially for diploid individuals

4) the potential genetic variability among populations and the potential for outbreeding depression

5) the existence of diploid and polyploid forms of *T. grandiflora*, which may have different morphology and physiology.

*Triteleia grandiflora* is very rare within Region 2. The only extant occurrence known is on the San Juan National Forest. This occurrence has particular conservation value since populations at the edge of their range may represent genetically distinct individuals that are important for the long-term survival or evolution of the species. Isolated populations present the opportunity for speciation. The only other record of occurrence within USFS Region 2 is one made in 1929 on the Medicine Bow National Forest. This occurrence might be extirpated. The occurrences in Yellowstone National Park in northern Wyoming also appear to be in danger of extirpation, if they have not already been destroyed.

Some experts propose that Native Americans planted the San Juan National Forest occurrence at some historic time. Another interpretation of the observed distribution pattern of *Triteleia grandiflora* is that the disjunct occurrences in Colorado and Wyoming are remnants of a formerly wider range. In addition, occurrences have been extirpated in the far northwestern (British Columbia) and southwestern (California) parts of its range. This suggests the possibility that its range is contracting for some reason. A phylogeographic study of *T. grandiflora*, incorporating molecular and biochemical analyses, might shed light on the relationship between the occurrence on the San Juan National Forest in Colorado and occurrences elsewhere.

Little information has been derived experimentally to describe the life strategy of *Triteleia grandiflora*, but the corm appears to be a critical organ. The corm is an organ of dormancy and allows individuals to survive periods of environmental stress. Several years are needed for the corm to achieve a size that can send up a potentially reproductive shoot. Because of the importance of the corm to long-term sustainability, activities that lead to frequent or intense soil disturbance are likely to be detrimental the species. The corms of polyploid *T. grandiflora* individuals have been reported to undergo a higher amount of vegetative reproduction (corm division and cormlet proliferation) than those of diploid individuals. Corms of *T. grandiflora* polyploids are generally buried deeper in the soil than are those of diploids. The depths at which corms are located below the soil surface may determine the response of a population to factors such as fire, grazing, and timber harvesting. The effects of soil disturbance or fire on an occurrence may be subtle. If occurrences are composed of both diploids and polyploids, disturbance may preferentially kill the diploid individuals and thus affect the genetic composition of the occurrence. *Triteleia grandiflora* corms are edible and palatable. Native Americans and European settlers have used them as food. Rodents demonstrate a preference for the corms, as suggested by the common name "gophernuts." Livestock, especially sheep, use the aerial parts of the plant, and when conditions permit, they will pull up the corms and eat them as well. The effects of historic and current livestock grazing on *T. grandiflora* occurrences are unknown.

*Triteleia grandiflora* reproduces by producing seed, as well as vegetatively through division of the corm. Polyploid individuals have been reported to reproduce vegetatively substantially more vigorously than diploid individuals do. *Triteleia grandiflora* is likely to be primarily a cross-pollinating species. If so, an abundant, healthy, and appropriate assemblage of pollinators may be particularly important to the viability of *T. grandiflora* occurrences, especially where vegetative reproduction is minimal. If self-pollination can occur, a decline in abundance and/or a change in the assemblage of arthropod pollinators may force inbreeding, and the occurrence may experience a loss of fitness. The potential for inbreeding depression in *T. grandiflora* populations will most likely occur if it is primarily an outcrossing species and if the populations experience significant long-term declines in size and/or number due to habitat loss, direct destruction, or attrition due to poor reproductive output. Polyploidy may reduce the absolute requirement for cross-pollination since vigorous vegetative reproduction obviates the need for annual seed production.

Throughout its range, *Triteleia grandiflora* grows in several different habitat types, which suggests the evolution of ecotypes adapted to specific local conditions. Therefore, introducing non-local corms to existing *T. grandiflora* occurrences may lead to a loss in their fitness due to outbreeding depression.

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# INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Triteleia grandiflora* Lindley is the focus of an assessment because it is designated a sensitive species in Region 2 (USDA Forest Service 2003a, 2005a). According to Forest Service Manual 2670.5 (19), a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or in habitat capability that would reduce its distribution. A sensitive species requires special management, so knowledge of its biology and ecology is critical.

For more than a century, there has been a difference of opinion among taxonomists as to whether *Triteleia* is a unique genus or whether it should be absorbed into *Brodiaea* (Greene 1886, Jepson 1925, Hoover 1941, Niehaus 1971, 1980, Pires and Sytsma 2002). Current taxonomic studies support the original notion that although related, *Triteleia* is a distinct genus separate from *Brodiaea*. Because of this controversy, *T. grandiflora* has several synonyms, the most common of which is *B. douglasii* (see Systematics and synonymy section for more detail). Much of the literature relevant to *T. grandiflora* refers to it by the synonym accepted by the author at the time of publication. In addition, several authorities accept that there are two subspecies of *T. grandiflora*, ssp. *grandiflora* and ssp. *howellii* (Integrated Taxonomic Information System 2005, NatureServe 2005, USDA Natural Resources Conservation Service 2005). Some authorities have accepted ssp. *howellii* at the full species level (Douglas et al. 2001, BC Species and Ecosystems Explorer 2003, Committee on the Status of Endangered Wildlife in Canada 2003). Pires (2002) reports that the key characteristics separating ssp. *grandiflora* from ssp. *howellii* are not consistent; he advises against recognizing infraspecific taxa. When a publication is referenced in this document, the genus and species names used in the original publication are indicated.

Common names for *Triteleia grandiflora* include largeflower triteleia (USDA Natural Resources Conservation Service 2005), large-flowered triteleia, blue umber-lily, blue-lily, wild hyacinth, white hyacinth, fools onion, cluster lily, Douglas's brodiaea, triplet lily, and gophernuts. The large number of common names might reflect its historical importance to humans since the bulb-like corms of all *Triteleia* species are edible and were a source of food for both Native American peoples and early European settlers (Craighead et al. 1963, Parish et al. 1996, Lyons 1997, Moerman 1998, Pires 2002). In addition to being a food source, the corms have had mystical attributes attached to them and were included in the medicine bag by at least one indigenous tribe to "make the bag more potent" (Steedman 1928, Kershaw et al. 1998, Moerman 1998). Another indigenous tribe considered the corms to be poisonous (Moerman 1998).

## *Goal of Assessment*

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species, based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, it cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

## *Scope of Assessment*

This assessment examines the biology, ecology, conservation, and management of *Triteleia grandiflora* with specific reference to the geographic and ecological characteristics of Region 2. Although most of the relevant literature originates from field investigations outside the region, this document places that literature in the ecological and social context of the central and southern Rocky Mountains. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *T. grandiflora* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting this synthesis, but placed in a current context.

In producing the assessment, peer-reviewed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were consulted. Not all publications on *Triteleia grandiflora* may have been referenced in this assessment, but an effort was made to consider all relevant documents. The assessment emphasizes the peer-reviewed literature because this is the accepted standard in science. Some literature that was not peer-reviewed was used in the assessment because the information was otherwise unavailable. In some cases, publications and reports that have not been peer-reviewed may be regarded with greater skepticism. However, many not peer-reviewed reports or publications on rare plants are 'works-in-progress' or isolated observations on phenology or reproductive biology and are important sources of information. Unpublished data (e.g., Natural Heritage Program and particularly herbarium records) were important in estimating the geographic distribution and occurrence sizes for *T. grandiflora*. These data required special attention because of the diversity of persons and methods used to collect them. Records that were associated with an herbarium specimen collection location were weighted higher than observations alone.

Occurrence data were compiled from the Colorado Natural Heritage Program (2005b), the Wyoming Natural Diversity Database (2005a), specimens at the University of Colorado Herbarium (COLO), the Colorado State University Herbarium (CS), California State University Herbarium (CHSC), the Ray J. Davis Herbarium at Idaho State University (IDS), Montana State University Herbarium (MONT), University of Montana Herbarium (MONTU), C.E. Bessey Herbarium at University of Nebraska State Museum (NEB), R.L. McGregor Herbarium at University of Kansas (KANU), the Gray Herbarium at Harvard University (GH), the New York Botanical Garden Herbarium (NY), Natural History Collections Section of the Royal British Columbia Museum (BC), The Rocky Mountain herbarium at the University of Wyoming (RM), Stillinger Herbarium at University of Idaho (ID), Herbarium of the Idaho State Museum of Natural History, Idaho State University (IDS), Intermountain Herbarium, Utah State University (UTC), Academy of Natural Sciences Herbarium (PH), University of Oregon Herbarium (ORE), Morton E. Peck Herbarium, Willamette University (WILLU), Oregon State University Herbarium (OSC), The University of Washington Herbarium – Burke Museum (WTU), the California Native Plant Society (2005), and from the literature (**Table 1**, **Table 2**).

## *Treatment of Uncertainty in Assessment*

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. The geologist, T.C. Chamberlain (1897), suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). Ecological science is, in some ways, more similar to geology than physics because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide understanding of the world (Hillborn and Mangel 1997).

Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted approaches to understanding.

One element of uncertainty is related to the fact that *Triteleia grandiflora* is not tracked by any federal or state agency or any other authority in much of its range. Therefore, herbarium specimens and incidental or anecdotal observations of *T. grandiflora* must be relied upon to estimate range and abundance. Rarely is abundance information quantitatively reported on herbarium labels. Another important consideration is that herbarium records give a historical range, but some of those occurrences may no longer be extant.

## *Treatment of This Document as a Web Publication*

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (http//:www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

**Table 1.** Information for *Triteleia grandiflora* occurrences in Colorado and Wyoming. Measurement units are reported as in the original description.

| State No. | County | Management | Dates | Location | Habitat | Abundance & comments | Source |
|---|---|---|---|---|---|---|---|
| CO 1 | Montezuma | USDA Forest Service (USFS) Region 2<br>San Juan National Forest<br>House Creek Potential Conservation Area | 22-Jun-1998, 25-Jun-1998, 2000, 04-Jun-2004 | Approximately 7.5 miles northeast of Dolores; several sub-occurrences within 5 contiguous sections | 22-Jun-1998: Pine-oak vegetation type. Elevation: 7,500-7940 ft.<br>25-Jun-1998: Total tree cover: 30%. Total shrub cover: 30%. Total forb cover: 40%. Total graminoid cover: 25%. Total moss/lichen cover: 3%. Total bare ground cover: 10%. Associated plant community: Ponderosa pine, Gambel oak. Habitat type: *Pinus ponderosa/Quercus gambelii*. Aspect: south-southwest. Slope: 3%. Slope shape: straight. Light exposure: partial shade to open. Moisture: dry. Parent material: sandstone. Geomorphic landform: rolling upland. Soil texture: sandy-loam. Elevation: 7900-7960 ft.<br>2000: Open *Pinus ponderosa* stand; gentle south-facing slope, rocky soil<br>2004: Ponderosa pine-Gambel oak forest with rich understory of mixed forbs and grasses. Associated taxa: *Pinus ponderosa, Quercus gambellii, Artemisia ludoviciana, Erigeron flagellaris, Delphinium nuttallianum, Poa pratensis, Purshia tridentata, Amelanchier utahensis, Senecio multilobatus, Pseudocymopterus montanus, Wyethia,* and *Symphoricarpos oreophilus*. Elevation: 7,761 ft. | 2004: "Acreage approximately 26.8. 1,500 to 2,000 seems a bit high, but at least 700 to 1,000. Plants with one or two flowers open, the others in bud or early fruit. Very pale, almost chalky lilac color. Tall, wand-like, difficult to photograph in wind. Plants scattered in *Pinus ponderosa* and *Quercus gambelii*, both in open grassy areas and under shrubs." | *L. Stewart #4* 22 Jun 1998 COLO, RM; *D.W. Bainbridge #550 with L.D. Bainbridge 25-Jun-1998* COLO; *D.W. Bainbridge #814 with L.D. Bainbridge* 20 Jun 2000 COLO; Colorado Natural Heritage Program (2005) |
| WY 1 | Platte | USFS Region 2<br>Medicine Bow-Routt National Forest | 02-04-Aug-1929 | Medicine Bow Mountain. University of Wyoming Summer Camp [located on the Scenic Hwy.130 approximately 38 miles west of Laramie] | No information | No information | *F.B. Wann #8* UTC |
| WY 2 | Lincoln | USFS Region 4<br>Near Caribou-Targhee National Forest boundary, but probably on private land | 25-Jun-1984 | Northern Star Valley, "general area of original confluence of Salt River and Snake River, 1 mile west of Alpine, 0.4 miles east of the Idaho state line" | Growing in partly shaded aspen-grass; surrounding area of sagebrush flats at 5,620 ft. | In flower | *O.C. Harrison #360* 1984 RM; Wyoming Natural Diversity Database (2005) |
| WY 3 | Teton | Grand Teton National Park | 21-Jun-2000 | Near Moose-Wilson Rd. 1 km north of Granite Canyon parking area | Forest opening | No information | *K. McCloskey #s.n.; G.K. Schen #20601,* duplicate specimens UTC |

**Table 1 (cont.).**

| State No. | County | Management | Dates | Location | Habitat | Abundance & comments | Source |
|---|---|---|---|---|---|---|---|
| WY 4 | Teton | Grand Teton National Park | 2-Jul-1999 | Along Moose-Wilson Road 2001: Between Moose-Wilson Rd. and Teton Park Road. Sub-occurrences within 2 contiguous sections | On rocky dry slope at 6,500 ft. | No information | *H.J. Loring and T.A. Aschenbach #s.n.* 1999 KANU; *S. Markow #12145* 2001 RM |
| WY 5 | Teton | Grand Teton National Park and Private | 10-Jun- 1948, 18-Jun- 1956, 14-Jun- 1996, 18-Jun- 1997 | 1948: Jackson Hole, near the Entrance Station to Grand Teton National Park, and at the "ponds at Moose, 1.4 mi west of Moose."<br>1956: 1.4 mi west of Moose Ponds<br>1961: North of Teton Park HQ | 1956: Aspen woods on rich, rocky soil at 6,500 ft. | 1948: Assumed that collection was made when plants were in flower<br>1956: In flower<br>1997: 100-200 plants in bloom a couple hundred yards from the entrance station on both sides of the road; the population extended approximately 200 meters from the road on each side | *J.M. Reed #2224* 1948 RM; *W.G. Solheim #4446* 1956 RM, UTC; *C.S.Gilbert and H.F. Eppson #S-61-527* 1961 RM; Wyoming Natural Diversity Database (2005) |
| WY 6 | Teton | Grand Teton National Park | 03-Jul-1997, 17-Jun-1998, 28-Aug-2002 | 2002: Jackson Hole; three subpopulations: (1) Near west side of Snake River, ca 0.5 air miles north of Moose Visitor Center, ca 0.6 air miles northwest of Moose Jct (2) Moose Entrance Station . (3) South of Beaver Creek Resource Management Office. Sub occurrences within 2 contiguous sections | Two main vegetation types: (1) Floodplain with *Populus angustifolia, Carex*, and *Elymus*. (2) Old alluvial, glacial bank of the Snake River with no aspen and rich sagebrush (*Artemisia tridentata* ssp. *vaseyana* and *Purshia tridentata*). At 6,400-6,600 ft. | 1997: (Moose) 65 + 29 in flower, not counting vegetative; (Beaver Creek) 13 plants1998: Moose Entrance Station: Several hundred observed in bud on both sides of the road. Occurs with *Festuca idahoensis, Balsamorhiza sagittata,* and *Melica spectabilis*<br>2002: (flood plain) In fruit | *S. Madden, B. Heidel, and D. Ehle #s.n.* 2002; RM Wyoming Natural Diversity Database (2005) |

**Table 1 (cont.).**

| State No. | County | Management | Dates | Location | Habitat | Abundance & comments | Source |
|---|---|---|---|---|---|---|---|
| WY 7 | Teton | Grand Teton National Park | No date | On one of the small islands of cottonwoods on the Snake River floodplain. NPS plot # GT-0201085 | *Populus angustifolia / Symphoricarpos* (*albus, occidentalis, oreophilus*) Forest at 6,466 ft. | No slope, no particular aspect; plants in channel. Trees in these islands are not dense. The island was just large enough to contain 10x25m plot. Overstory height is 45-55 ft. tall. Only regeneration is a single *Pinus flexilis* seedling | K. Varga personal communication 2005 |
| WY 8 | Teton | USFS Region 4 Bridger-Teton National Forest | 02-Jul-1932, 03-Jul-1932 | Teton Range, Vicinity of Teton Pass, Canyon Creek | July 2: In timber at 7,500 ft. July 3: Along road | 02-Jul-1932: Flowers blue | *L. Williams #798* 02-Jul-1932 UTC, RM (2 sheets); *L. Williams #768* 03-Jul-1932 UTC; Wyoming Natural Diversity Database (2005) |
| WY 9 | Teton | USFS Region 4 Bridger-Teton National Forest | 08-Jun-1999 | Teton Range; Jackson Hole Mountain Resort, bottom of Apres-vous ski run, about 10 air miles north-northwest of Jackson | Steep roadside bank, rocky. At 6,900 ft. | Aerial specimen taken (bulbs not collected). RM specimen verified by E. Nelson | *C.R. Delmatier, H. Gansen, and A. Taylor. #8012* 1999 RM; Wyoming Natural Diversity Database (2005) |
| WY 10 | Teton | USFS Region 4 Caribou-Targhee National Forest | 28-Jun-1956 | Entrance to Treasure Mountain Scout Camp 6 miles E of Idaho state line in Teton Canyon | Frequent in drying soil on sagebrush hillside | No information | *L.C. Anderson #387* UTC |
| WY 11 | Teton | USFS Region 4 Caribou-Targhee National Forest | 16-Jun-1991 | West slope Teton Range: near entrance to Darby Canyon, about 4 miles southeast of Driggs, Idaho | Open area adjacent to irrigation canal. At 6,200 ft. | No information | *S. Markow #696* RM |
| WY 12 | Teton | USFS Region 4 Caribou-Targhee National Forest | 20-Jun-1991 | West slope Teton Range: Teton Canyon, just north of Teton Canyon Campground, about 6 miles east of Alta. At least 2 sub-occurrences within 2 contiguous sections | Mixed open slope and coniferous forest dominated by *Pseudotsuga, Prunus, Populus*, and *Symphoricarpos* between 7,000-7,300 ft. | No information | *S. Markow #1099* 1991 RM |

**Table 1 (concluded).**

| State No. | County | Management | Dates | Location | Habitat | Abundance & comments | Source |
|---|---|---|---|---|---|---|---|
| WY 13 | Teton | USFS Region 4 Caribou-Targhee National Forest | 26-Jul-1991 | West slope Teton Range: North Fork of Teton Creek within 1 mile of trail head; about 10 miles ENE of Driggs, Idaho. Possibly a sub-occurrence of WY-12 | Coniferous forests and openings on slopes and bottom of drainage between 7,000-7,800 ft. | No information | *R.L. Hartman #30501* 1991 RM |
| WY 14 | Teton | Yellowstone National Park, USFS Region 4 Caribou-Targhee National Forest | 26-Jun-1997 | Yellowstone Plateau; Cave Falls and about 0.9 miles east of the junction of Cave Falls Road and Bechler Ranger Station Road. Near Idaho state line. Sub-occurrences within 2 contiguous sections | Two sub-occurrences. A: south facing slope above aspen stand, occurs with *Helianthella uniflora, Balsamorhiza sagittata, Berberis repens, Eriogonum umbellatum, Melica spectabilis*, and *Ceanothus velutinus*. B: southeast facing slope just below trail, with *Balsamorhiza sagittata* and *Carex hoodii*. Elevation: 6,320-6,400 ft. | A: At least 50 blooms on both sides of the road at pullout (Forest). B: One plant observed in bloom (Park) | *J. Whipple #4723* 1997 YELLO; Wyoming Natural Diversity Database (2005) |
| WY 15 | Teton | Yellowstone National Park | Jul-1992, Jun-1993 | Yellowstone Plateau; Yellowstone Lake, West Thumb Geyser Basin, within area of boardwalks | Thermally altered soil with some heat flow (not hot ground, but warmer than ambient). At 7,775 ft. | 1992: Approximately 6 plants in flower 1993: A few plants (10+) | *J. Whipple #4041* 1992 YELLO; Wyoming Natural Diversity Database (2005) |
| WY 16 | Unreported | USFS Region 4 Bridger-Teton National Forest | 30-Jun-1927 | Southwest corner of the Harrison Ranch | Level ground in loam soil in open sagebrush | Extremely rare. "The specimens collected were the only ones seen." [Collected for USFS herbarium] | *F. Buchenroth #FB-47* RM |

[1] Abbreviations for information sources:

COLO – herbarium at University of Colorado, Boulder.

CS – herbarium at Colorado State University.

GH – Gray Herbarium; one of the herbaria at Harvard University.

MO – herbarium at Missouri Botanical Garden.

RM – Rocky Mountain Herbarium, University of Wyoming, Laramie, Wyoming.

YELLO – Yellowstone National Park Herbarium.

**Table 2.** Information for *Triteleia grandiflora* occurrences in California (CA), Idaho (ID), Montana (MT), Oregon (OR), Utah (UT), Washington (WA). The occurrences that are mapped in **Figure 5** are denoted by "Y" in the column marked "Map." Measurement units are reported as in the original description.

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| CA 1 | Modoc | USDA Forest Service (USFS)Region 5 Modoc National Forest, or State | 1980-2000 | Y | Big Swamp Quad | *howellii* | No information | No information | California Native Plant Society (2005) |
| CA 2 | Modoc | USFS Region 5 Modoc National Forest | 1980-2000 | Y | Rimrock Lake Quad | *howellii* | No information | No information | California Native Plant Society (2005) |
| CA 3 | Siskiyou | USFS Region 5 Modoc National Forest, or U.S. Fish and Wildlife Service | 1980-2000 | Y | Hatfield Quad | *howellii* | No information | No information | California Native Plant Society (2005) |
| CA 4 | Siskiyou | USFS Region 5 Klamath National Forest | 1980-2000 | Y | Secret Spring Mountain Quad | *howellii* | No information | No information | California Native Plant Society (2005) |
| CA 5 | Siskiyou | USFS Region 5 Klamath National Forest | 1980-2000 | Y | Panther Rock Quad | *howellii* | No information | No information | California Native Plant Society (2005) |
| CA 6 | Not reported | Undetermined | 1880 | N | California | N/A | No information | No information | *G. Vasey s.n.* NEB |
| ID 1 | Adams | City of Boise | 14-Apr-2000 | Y | Camels Back Park, Boise | *grandiflora* | At 3,158 ft. / 962 m | Tall scape of one to two ft. in height with blue-purple flowers. Original id: *Brodiaea douglasii* | *P.N. McWilliams #11* WTU |
| ID 2 | Adams | USFS Region 4 Payette National Forest | 31-May-2000 | Y | West Mountains, along Forest Rd 718 just north of Mill Creek Summit | *grandiflora* | Riparian area with mixed conifer overstory. Elevation: 4,800 to 4,900 ft. | Flowering | *J. Handley #4617* RM |
| ID 3 | Adams | USFS Region 4 Payette National Forest | 19-Jun-1999 | Y | West Mountains Area, above Forest Road 180, near Fourbit Creek | *grandiflora* | Steep, mostly south-facing slope; rocky basalt soil, much of it moist from seeps; dominated by *Artemisia ludoviciana*, *Lomatium*, and *Allium tolmiei* var. *persimile*. Elevation: 5,350 to 5,700 ft. | Flowers and fruit | *J. Handley #542* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 4 | Adams | USFS Region 4 Payette National Forest | 26-May-2000 | Y | Indian Valley: north shore of Ben Ross Reservoir, about 12 miles east southeast of Cambridge | *grandiflora* | Lakeside dominated by grass and *Wyethia*. Elevation: 3,100 to 3,300 ft. | Flowers and fruit | *J. Handley# 4270* RM |
| ID 5 | Adams | Right of way in USFS Region 4 Payette National Forest | 23-May-2000 | Y | Weiser River Valley: Mesa Road off U.S. Hwy 95, about 12 miles east northeast of Cambridge | *grandiflora* | Roadside grass and shrubland. Elevation: 2,950 to 3,200 ft. | Flowers and fruit | *J. Handley #4114* RM |
| ID 6 | Adams | USFS Region 4 Payette National Forest | 22-Jun-1999 | Y | West Mountains Area: Warm Springs Trail (203), along east side of Warm Spring Creek, off Forest Road 186 | *grandiflora* | Basalt soil; moderately steep, mostly west facing slopes. Elevation: 3,750 to 4,300 ft. | Flowers and fruit | *J. Handley #659* RM |
| ID 7 | Adams | USFS Region 4 Payette National Forest | 27-Jun-1999 | Y | Cuddy Mountains Area: Greasewood Flats on Washington County Line, along Forest Road 038, about 9 miles west of Council; 12 miles north northeast of Cambridge | *grandiflora* | Dominated by *Artemisia tridentata*, *Wyethia helianthoides*, and *Balsamorhiza sagittata*, with *Veratrum californicum* near streams; several small streams running through. Elevation: 5,650 to 5,750 ft. | Flowering | *J. Handley #1049 with P. Lawrence* RM |
| ID 8 | Adams | USFS Region 4 Payette National Forest | 06-Jun-2000 | Y | Cuddy Mountains: Orchid Canyon, about 7 miles west of Council and 12 miles north-northeast of Cambridge. Extends across boundary of 2 contiguous sections | *grandiflora* | Moist canyon with *Abies grandis* and mixed conifer overstory, adjacent to timber harvest treatments. Elevation: 4,500 to 5,000 ft. | Flowering | *J. Handley #4900* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 9 | Adams | Bureau of Land Management | 11-Jun-2000 | Y | Cuddy Mountains: Goodrich Creek Research Natural Area: along Goodrich Creek, about 9 miles southwest of Council and 8 miles north northeast of Cambridge. Extends across boundary of three contiguous sections | *grandiflora* | Roadside riparian area in grass and shrub rangeland. Elevation: 3,100 to 3,867 ft. | Flowers and fruit | *J. Handley #5255 with D.L. Fairbanks* RM |
| ID 10 | Adams | Right of way in USFS Region 4<br>Payette National Forest | 18-May-2000 | Y | Weiser River Valley: South Exeter Road behind golf course in Council | *grandiflora* | Flat, open roadside by pastures and housing. Elevation: 3,000 ft. | Flowers and fruit | *J. Handley #3796* RM |
| ID 11 | Adams | Right of way in USFS Region 4<br>Payette National Forest | 23-May-2000 | Y | Weiser River Valley: along old U.S. Hwy 95 S of Fruitvale, about 4.5 to 5.5 miles north of Council | *grandiflora* | Roadside grass and shrubland. Elevation: 3,000 ft. | Flowering | *J. Handley #4215* RM |
| ID 12 | Adams | USFS Region 4<br>Payette National Forest | 27-Jun-1999 | Y | Cuddy Mountains Area: below Stony Point on Forest Road 041, about 14 miles north-northeast of Cambridge | *grandiflora* | Aspen grove with small creek running through; dominated by *Populus tremuloides* and *Veratrum californicum*; mostly southeast-facing slopes. Elevation: 5,600 to 5,700 ft. | Flowering | *J. Handley #979 with P. Lawrence* RM |
| ID 13 | Adams | USFS Region 4<br>Payette National Forest | 12-Jun-1999 | Y | Cuddy Mountains Area: Summit Creek Road, just east of powerlines, about 13.5 miles northwest of Council | *grandiflora* | East to southeast facing slopes of *Artemisia tripartita*, *Balsamorhiza sagittata*, and *Elymus spicatus*; basalt soil. Elevation: 4,250 to 4,450 ft. | Flowers and fruit | *J. Handley #260* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 14 | Adams | USFS Region 4 Payette National Forest | 24-Jun-1999 | Y | West Mountains Area: Beaver Creek, across from Fire Gulch, about 6.5 miles south southwest of New Meadows | *grandiflora* | Dry scab patch inclusion in mixed conifer forest (*Pseudotsuga menziesii*, *Pinus ponderosa*, *Abies grandis*, and *Larix occidentalis*); basalt soil. Elevation: 4,600 ft. | Flowers and fruit | *J. Handley #803* RM |
| ID 15 | Adams | USFS Region 4 Payette National Forest | 30-May-2000 | Y | West Mountains: along the Weiser River just north of Evergreen, about 7 miles southwest of New Meadows | *grandiflora* | Mixed conifer overstory on west-facing river bank and roadside. Elevation: 3,800 to 3,950 ft. | Flowers and fruit | *J. Handley #4554* RM |
| ID 16 | Adams | Bureau of Land Management | 20-Jun-2000 | Y | Salmon River Mountains: west-facing slope of Meadows Hill, just north of Fish Lake, about 5 miles southeast of New Meadows. Extends over boundary of two contiguous sections | *grandiflora* | West-facing grassy slope. Elevation: 4,800 to 5,200 ft. | Flowering | *J. Handley #5697* RM |
| ID 17 | Adams | USFS Region 4 Payette National Forest | 18-Jun-1999 | Y | Above Fawn Creek, above Forest Road 123, about 15 miles west-northwest of New Meadows; about 21 miles north-northwest of Council | *grandiflora* | Rocky basalt soil; grassland dominated by *Elymus spicatus*, *Allium tolmiei* var. *persimile*, also *Balsamorhiza sagittata* and *Artemisia tripartita*; south to southwest-facing slope, moderately steep. Elevation: 5,300 to 5,500 ft. | Flowers and fruit | *J. Handley #443* RM |
| ID 18 | Adams | USFS Region 4 Payette National Forest, may extend onto private land | 18-Jun-1999 | Y | Lick Creek Riparian Demonstration Area: south bank of tributary of Lick Creek to fence, about 16 miles west of New Meadows | *grandiflora* | Meadow; dominated by *Poa* sp., *Carex* sp., and mesic forbs. Elevation: 4,400 to 4,700 ft. | Flowering | *J. Handley #474* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 19 | Adams | USFS Region 4 Payette National Forest | 19-May-2000 | Y | Cuddy Mountains: Wildhorse Canyon across Wildhorse River from Trail Hill, about 20.5 miles northwest of Council | *grandiflora* | Open east-facing hillside dominated by grasses and *Symphoricarpos* sp. Elevation: 3,200 to 4,000 ft. | No information | *J. Handley #3838* RM |
| ID 20 | Adams | USFS Region 4 Payette National Forest | 29-Jun-1999 | Y | Cuddy Mountains Area: Rocky Comfort Flat, about 21 miles northwest of Council; about 20.5 miles west of New Meadows | *grandiflora* | Rocky basalt soil dominated by *Elymus spicatus* and *Festuca idahoensis*, interspersed with scablands of *Poa secunda* and *Artemisia tripartita*. Elevation: 4,350 to 4,600 ft. | Flowers and fruit | *J. Handley #1126* RM |
| ID 21 | Adams | USFS Region 4 Payette National Forest | 12-Jun-1999 | Y | Cuddy Mountains Area: Ditch Creek Road, just W of Crooked River, about 19 miles west southwest of New Meadows. Extends over two contiguous sections | *grandiflora* | Mesic meadow with *Pinus ponderosa* overstory; rich, dark soil, basalt parent material. Elevation: 4,300 to 4,400 ft. | Flowering | *J. Handley #297* RM |
| ID 22 | Adams | USFS Region 4 Payette National Forest | 25-May-2000 | Y | Southwest edge of Lost Valley Reservoir along Forest Road 089, about 16 miles north of Council; about 9 miles west of New Meadows. Extends over three contiguous sections | *grandiflora* | Mixed conifer-dominated lake shore and roadsides. Elevation: 4,800 ft. | Flowering | *J. Handley #4215* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 23 | Adams | USFS Region 4 Payette National Forest | 17-Jun-2000 | Y | Salmon River Mountains: Bear Basin and along Forest Road 452, about 7 miles ESE of New Meadows. Extends over boundary of two contiguous sections | *grandiflora* | Roadside, moist, mixed conifer overstory. Elevation: 5,300 to 5,400 ft. | Flowering | *J. Handley #5555 with D.L. Fairbanks* RM |
| ID 24 | Adams | USFS Region 4 Payette National Forest | 10-Jun-1999 | Y | Forest Road 106, from Council-Cuprum Road to gate of Copper Cliff Mine, about 21 miles northwest of New Meadows | *grandiflora* | Sub-occurrence A: Roadside; overstory of scattered *Pseudotsuga menziesii*, *Pinus ponderosa*, *Picea engelmannii*, and *Abies grandis*. Sub-occurrence B: Riparian area and road cutbank; overstory of scattered *Abies grandis*, *Picea engelmannii*, and *Pseudotsuga menziesii*. Elevation: 4,500, 4,600, and 5,000 ft. | Flowering | *J. Handley #173* RM; *J. Handley #228* RM |
| ID 25 | Adams | USFS Region 4 Payette National Forest | 03-Jul-1999 | Y | Flat just west of Summit Gulch and east of head of Boulder Creek, about 21.5 miles west-northwest of New Meadows | *grandiflora* | Disturbed scabland; rocky basalt soil. Elevation: 5,100 ft. | Flowers and fruit | *J. Handley #1375* RM |
| ID 26 | Adams | USFS Region 4 Payette National Forest | 10-Jun-1999 | Y | Hells Canyon-Seven Devils Scenic Area: Kleinschmidt Grade above the road, about 4.5 miles west-southwest of Cuprum. Extends over two contiguous sections | *grandiflora* | Old burn on basalt soil with *Symphoricarpos*, *Physocarpus malvaceus*, *Calamagrostis rubescens*, *Elymus spicatus*, and a few *Pinus ponderosa* and *Pseudotsuga menziesii*. Elevation: 3,150 to 3,600 ft. | Flowers and fruit | *J. Handley #144* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 27 | Adams | USFS Region 4 Payette National Forest | 05-Jul-1999 | Y | Little Bear Creek Trail (226), off Forest Road 110, about 5.5miles northeast of Bear; about 18 miles northwest of New Meadows. Extends over two contiguous sections | *grandiflora* | Mixed moist conifer overstory; *Abies grandis*, *Pinus ponderosa*, *P. contorta*, *Pseudotsuga menziesii*, *Picea engelmanni*, and *Larix occidentalis*. Elevation: 4,850 to 5,250 ft | Flowers and fruit | *J. Handley #1475* RM |
| ID 28 | Adams | USFS Region 4 Payette National Forest | 01-Jul-1999 | Y | Cow Camp Trail (181) from Forest Road 074 to Pollock Creek, about 14 miles north-northwest of New Meadows | *grandiflora* | Moist mixed conifer forest; *Abies grandis*, *Picea engelmannii*, *Pseudotsuga menziesii*, *Pinus contorta*, and *Larix occidentalis*. Elevation: 4,550 to 4,650 ft. | Flowering | *J. Handley #1218* RM |
| ID 29 | Adams | USFS Region 4 Payette National Forest (Scenic area) | 16-Jun-1999 | Y | Hells Canyon-Seven Devils Scenic Area: Eckels Creek Trail, about 2-3 miles northwest of Cuprum. Extends over two contiguous sections | *grandiflora* | Rocky basalt soil; mixed shrub grassland, dominated *by Elymus spicatus*; also *Rhus radicans*. Elevation: 2,600 to 3,400 ft. | Flowers and fruit | *J. Handley #408* RM |
| ID 30 | Adams | USFS Region 4 Payette National Forest (Scenic area) | 20-May-2000 | Y | Hells Canyon-Seven Devils Scenic Area: Kinney Creek Trail (Forest Service Trail 221), about 24 miles northwest of New Meadows. Extends over three contiguous sections | *grandiflora* | Dry basalt canyon with creek. Elevation: 1,700 to 3,400 ft. | Flowering | *J. Handley #3966* RM |
| ID 31 | Adams | USFS Region 4 Payette National Forest (Scenic area) | 01-Jun-2000 | Y | Hells Canyon-Seven Devils Scenic Area: along Forest Road 454 at Schoolmarm Gulch, about 7 miles north of Cuprum | *grandiflora* | Roadside of steep canyon dominated by grasses and shrubs, especially *Rhus*. Elevation: 1,800 to 2,100 ft. | Flowers and fruit | *J. Handley #4678* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 32 | Adams | USFS Region 4 Payette National Forest | 02-Jun-1999 | Y | Trail from Eagle Bar to Red Ledge Mine along Snake River, 18 miles west of Pinehurst. Extends over three contiguous sections | *grandiflora* | Rocky volcanic canyon land along river; *Elymus spicatus* and annual grasses with scattered shrubs. Elevation: 1,760 to 3,240 ft. | Flowers and fruit | *R.L. Hartman #64289 with J. Handley* RM |
| ID 33 | Adams | Weiser National Forest (now absorbed into USFS Region 4 Payette National Forest) | 20-May-1930 | N | Windy Ridge (Now in Hells Canyon-Seven Devils Scenic Area) | N/A | On 20% slope in small gravel, clay soil in open grass with bunch grass, balsam root. Distributed in low grass ranges | Plentiful. Ungrazed | *V.M. Brewer #B-85* RM |
| ID 34 | Bannock | Private | 05-Jun-1909, 19-May-1932 | Y | Pocatello | *grandiflora* | 1909: Mountains and plains | No information | *G.S. Sperry #45* 1909 RM; *J. Slaughter #17* RM; *R.J. Davis #83-32* RM |
| ID 35 | Bear Lake | Likely private | 17-Jun-1931 | Y | Along highway 11 miles north-northwest of Georgetown, just inside county | N/A | Dry grassy ticket | Perianth violet. *Brodiaea douglasii* determined by Aven Nelson. Annotated by T. Niehaus 1975 | *E.T. Wherry s.n.* PH |
| ID 36 | Boise (?) | Likely private | 1916 | Y | Near Boise | N/A | No information | No information | *S. Gageby s.n.* RM |
| ID 37 | Boise (?) | Likely private | 27-May-1911 | Y | Boise | N/A | Steep sandy hillside. Elevation: 2,880 ft. | *Brodiaea douglasii* determined by Aven Nelson. Annotated by T. Niehaus 1975 | *J.A. Clark #39* PH, RM |
| ID 38 | Boise (?) | Likely private | 10-Jun-1938 | Y | Boise River | *grandiflora* | No information | No information | *W. Marshall s.n.* UTC |
| ID 39 | Boise | Likely private | 27-May-1911 | N | Steep sandy hillside | N/A | Elevation: 2,880 ft. and 3,500 ft. | Specimens annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | [MONT Acc. No. 20767] |
| ID 40 | Boise | Likely private | 10-May-1936 | Y | Near Arrowrock Dam | *grandiflora* | Hills | No information | *A. Croquist #122-36* UTC |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 41 | Boise | Likely private | 08-May-1911 | Y | Squaw Creek (Sweet) | N/A | Moist open inclines | Specimens annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 21116; *J.F. Macbride #814* RM |
| ID 42 | Bonneville | Reported USFS Region 4 Caribou-Targhee National Forest, maybe private | 09-Jun-1979 | Y | Just past bridge near Palisades Reservoir | N/A | Habitat type - *Pinus contorta/Thalictrum occidentale*. Elevation: 5,800 ft. | No information | *G. Dieffenbach*, *M. Holte, and V. Pearson #102* RM |
| ID 43 | Bonneville | USFS Region 4 Caribou-Targhee National Forest | 11-Jun-1991 | Y | Snake River Range: U.S. Hwy 26, Blowout Canyon, about 10 miles northwest of Alpine, Wyoming | *grandiflora* | Forest with some conifers (*Pinus* sp., *Picea* sp., *Pseudotsuga* sp.) and *Populus* sp. and adjacent open slopes dominated by forbs and shrubs (Species of *Amelanchier*, *Symphoricarpos*, and *Prunus*). Elevation: 5,800 ft. | No information | *S. Markow #403* RM |
| ID 44 | Bonneville | USFS Region 4 Caribou-Targhee National Forest | 14-Jun-1991 | Y | West slope Big Hole Mountains: Black Canyon, about 9 miles from Kelly Canyon Ski Area, adjacent to and north of Snake River | *grandiflora* | Open hillside dominated by grasses and shrubs. Elevation: 5,300 to 5,500 ft. | No information | *S. Markow #567* RM |
| ID 45 | Bonneville | USFS Region 4 Caribou-Targhee National Forest | 14-Jun-1991 | Y | Southwest slope Big Hole Mountains: Table Rock Canyon, about 2.5 miles southeast of Kelly Canyon Ski Area. Occurrences composed of several sub-occurrences over four contiguous sections | *grandiflora* | Dry stream bed and flood plain dominated by *Populus angustifolia*, *Prunus*, and *Amelanchier*. Elevation: 5,200 ft. | No information | *S. Markow #645* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 46 | Bonneville | USFS Region 4 Caribou-Targhee National Forest | 18-Jun-1991 | Y | Southwest slope Big Hole Mountains: Slope overlooking Fleming Canyon. Occurrences composed of several sub-occurrences over two contiguous sections | *grandiflora* | Coniferous forest dominated by *Pseudotsuga menziesii* and *Pinus contorta*. Elevation: 6,400 to 7,000 ft. | No information | *S. Markow #855* RM |
| ID 47 | Bonneville | USFS Region 4 Caribou-Targhee National Forest | 28-Jun-1991 | Y | West slope Snake River Range: Rainey Creek from entrance to National Forest to Corral Canyon, about 3 miles east of Swan Valley. Occurrences composed of several sub-occurrences over three contiguous sections | *grandiflora* | Juniper/grassland, dominated by *Juniperus scopulorum* and bunchgrass, some riparian. Elevation: 5,400 to 5,800 ft. | No information | *S. Markow #1603* RM |
| ID 48 | Canyon | Undetermined | 28-May-1910 | Y | Big Willow | N/A | Steep loamy hills at 3,000 ft. | *Brodiaea douglasii*; annotated *Triteleia grandiflora* by J.C. Pires 2005 | *J.F. MacBride #135* RM |
| ID 49 | Canyon [now Payette] | Private | 10-May-1911 | Y | New Plymouth | *grandiflora* | Sunny slope at 2,200 ft. | No information | *A. Nelson and S.F. MacBride #801* RM |
| ID 50 | Caribou | Undetermined | 15-Jun-1978 | Y | Aspen Range, Middle Sulphur Canyon at west boundary of forest; 5 miles east of Soda Springs | N/A | Common on south-facing rocky slope with *Artemisia tridentata* and *Elymus cinereus* | No information | *L.M. Shultz and J.S. Shultz #2571* UTC |
| ID 51 | Caribou | USFS Region 4 Wasatch-Cache National Forest | 29-May-1925 | N | Unspecified but within 1.6 km from the mouth of South Fork Pebble Creek [UTC estimated location from a duplicate specimen] | N/A | South slope. Sagebrush and aspen type; sandy loam soil. (Additional locality information taken from a duplicate specimen) | No information | *C.B. Arentson s.n.* UTC |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 52 | Not reported | USFS Region 4 Wasatch-Cache National Forest | No date | N | Cache National Forest | N/A | No information | Determined *Hookera douglasii* by Tidestrom | Collected by USFS “grazing reconnaissance No: 26204” RM |
| ID 53 | Clark | Undetermined | 28-Jun-1939 | Y | Above West Camas Creek 10 miles above Kilgore | N/A | Under aspen hillside | No information | *A. Cronquist #2031* UTC |
| ID 54 | Clark | USFS Region 4 Caribou-Targhee National Forest | 14-Jun-1992 | Y | Centennial Mountains: Willow Creek, about 32 miles northeast of Ashton | *grandiflora* | Open site in coniferous forest, dominated by forbs and grasses. Elevation: 6,700 ft. | No information | *S. Markow #7680* RM |
| ID 55 | Clark | USFS Region 4 Caribou-Targhee National Forest | 14-Jun-1992 | Y | Centennial Mountains: at intersection of Dry Creek and road leading from Kilgore to Island Park, about 8 miles northeast of Kilgore. Extends over two contiguous sections | *grandiflora* | Open area, mostly forbs, some grasses. Elevation: 6,500 ft. | No information | *S. Markow #7698* RM |
| ID 56 | Elmore | USFS Region 4 Sawtooth National Forest | 02-Jun-1931 | N | Shake Creek Ranger Station | N/A | In coarse gravel on 12 degree slope at 4,700 ft. In grass with wheatgrass, bluegrass, *Bromus tectorum* | Moderate grazing, no forage value. 10-18 in. high; flowers May 20 to June 15 seed dissemination July and August. Identified as *Hookera douglassii*. [Collected for USFS Herbarium] | *R.B. Johnson #226* RM |
| ID 57 | Elmore | USFS Region 4 Boise National Forest | 03-Jul-1930 | N | Elk Creek Summit | N/A | At moist sites in granite, coarse sand soil. Grass vegetation type with wheatgrass and sage | Common. Low forage value, moderate use by sheep. 1 to 2 ft. tall. Flowering in June. Common name fool’s onion. [Collection made for USFS herbarium] | *F.G. Renner #1176* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 58 | Franklin | USFS Region 4 Wasatch-Cache National Forest | 03-Jul-1998 | Y | Highway 36 heading northwest of Preston, Strawberry Canyon, south up Mill Hollow road about 0.5 mile | N/A | Found on the side of the dirt road growing in soft clayey soil. More numerous on the west side of the road | No information | *A. Davis and J.L. Hart #241* UTC |
| ID 59 | Franklin | Undetermined | 04-Jul-1967 | Y | Bear River Range near Bloomington Lake Area | N/A | Rare on hillside | No information | *R.L. Andersen s.n.* UTC |
| ID 60 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 12-Jun-1992 | Y | Approximately 3 miles northwest of Island Park | N/A | Mostly forbs and graminoids with scattered *Pinus contorta* | No information | *S. Markow #7589* KANU |
| ID 61 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 07-Jun-1992 | Y | Henrys Lake Mountains: 0.5 miles SW of Targhee Pass, along Howard Creek, about 9.5 miles west of West Yellowstone, Montana | *grandiflora* | Riparian, dominated by *Salix* and *Carex*. Elevation: 6,800 to 7,000 ft. | No information | *S. Markow #7117* RM |
| ID 62 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 07-Jun-1992 | Y | Henrys Lake Mountains: Raynolds Pass, about 3.5 miles northwest of Henrys Lake; about 17 miles northwest of West Yellowstone, Montana | *grandiflora* | Sagebrush flat dominated by *Artemisia*, forbs, and grasses. Elevation: 6,800 to 6,900 ft. | No information | *S. Markow #7153* RM |
| ID 63 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 10-Jun-1992 | Y | Island Park Plateau: above and about 0.5 miles east of Warm River, about 8 miles northeast of Ashton | *grandiflora* | Clearcut in coniferous forest dominated by grasses and forbs, some sapling *Pinus contorta*. Elevation: 5,400 ft. | No information | *S. Markow #7292* RM |
| ID 64 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 19-Jun-1993 | N | Island Park Plateau: about 16 miles north northwest of Ashton | *grandiflora* | Aspen forest and openings with *Lupinus argenteus*, *Thalictrum occidentale*, and *Maianthemum racemosum* | No information | *E.F. Evert #25081* RM |
| ID 65 | Fremont | USFS Region 4 Caribou-Targhee National Forest, or private | 02-Jun-1937 | Y | Between Ashton and St. Anthony | N/A | Rocky soil, in sagebrush | [Collected for USFS herbarium] | *L. Ellison and E.J. Woolfolk #W-133* |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 66 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 18-Jun-1991 | N | Approximately 13 miles northeast of Ashton near Forest Service Road 150 | N/A | Adjacent to Beaver pond with *Floerkea proserpinacoides* and *Plagiobothrys scouleri*. Elevation: 6,000 ft. | No information | *E. Evert #20907* RM |
| ID 67 | Fremont | Undetermined | 18-Jun-1993 | Y | About 5 miles south of Split Butte, about 12 miles NNW of Ashton | N/A | Disturbed grassland at edge of mined area, south of road forks and stock pond with *Carex douglasii*, *Alyssum alyssoides*, and *Bromus tectorum*. Elevation: 5,700 ft. | No information | *E.F. Evert #25022* RM |
| ID 68 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 06-Jun-1936 | Y | Pasture at Porcupine. [Maybe sub-occurrence in ID 58] | N/A | In open moist sites in park vegetation type with weeds, loam soil | Common name Bluebell. [Collected for USFS herbarium] | *R.H. Hall #RH60* RM |
| ID 69 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 12-Jun-1992 | Y | Island Park Plateau: Mill Creek, about 3 miles northwest of Island Park | *grandiflora* | Mostly forbs and graminoids with scattered *Pinus contorta*. Elevation: 5,400 ft. | No information | *S. Markow #7589* RM |
| ID 70 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 29-Jun-1990 | Y | Approximately 11 miles northeast of Island Park along Black Canyon Loop Road | N/A | Lodgepole pine-Douglas fir forest and roadside openings with *Rubus parviflorus*, *Osmorhiza occidentalis*, and *Sorbus scopulina*. Approximately 6,700 ft. | No information | *E. Evert #19328* RM |
| ID 71 | Fremont | USFS Region 4 Caribou-Targhee National Forest | 10-Jul-1992 | Y | Yellowstone Plateau: area around intersection of Fish Creek Road and road to Snow Creek Butte, about 16 miles northeast of Ashton | *grandiflora* | Coniferous forest dominated by *Pinus contorta* and *Pseudotsuga menziesii*. Elevation: 6,700 to 6,800 ft. | No information | *S. Markow #9115* RM |
| ID 72 | Fremont | Undetermined | 10-Jul-1920 | Y | Henry Lake | N/A | Shady places at edge of swamp at 6,000 ft. | No information | *E.B. Payson and L.B. Payson #1941* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 73 | Fremont | USFS Region 4 Caribou-Targhee National Forest, or private | 10-Jun-1935 | N | Fremont County burning project | N/A | In deep sandy clay loam soil in sagebrush swales with *Artemisia tridentata* and *Agropyron dasytachyum*. Elevation: 6,000 ft. | Moderate abundance; moderate use by livestock. Flowering | *J.F. Pechanec #35-47* RM |
| ID 74 | Gooding | Undetermined | 31-May-2003 | Y | Gooding City of Rocks, along Four Mile Creek | *grandiflora* | Elevation: 5,004 ft. | No infomration | *J.F. Smith #4480* MONTU 129697 |
| ID 75 | Kooskia | USFS Region 1 Clearwater National Forest | 12-May-1974 | Y | Clearwater River, along north side of highway at Maggie's Bend | *grandiflora* | Southerly aspect, 30% slope. Rocky basalt substrate. *Pinus ponderosa*, *Balsamorhiza* sp., and poison ivy | Original id: *Brodiaea douglasii* | *C.A. Wellner #125* WTU, ID |
| ID 76 | Idaho | USFS Region 4 Payette National Forest | 24-May-1911 | N | River bank | N/A | Loose sandy loam | No information | *F.J. Ryder s.n.* UTC; *F.J. Ryder #75* RM |
| ID 77 | Idaho | Undetermined | 1915 | N | Main Gorse Creek | N/A | Elevation: 4,000 ft. | *Hookera douglasii*; annotated *Triteleia grandiflora* by J.C. Pires 2005 | *H. Graft #101* RM (collected for USFS Herbarium) |
| ID 78 | Idaho | Undetermined | 04-Jun-1978 | N | On northeast side of Pittsburg Road., about 4 miles west of Salmon River | N/A | Steep, rocky slope. Extremely dry grassland, southwest exposure | Sparse; corolla purple. Determined by M. Merryma | *J.D. Detzer #214 with M. Sacks* CHSC |
| ID 79 | Idaho | Undetermined | 29-May-1944 | Y | Six miles south of Grangeville | N/A | Dry knoll | No information | *C.L. Hitchcock and C.V. Muhlick #8465* UTC |
| ID 80 | Idaho | USFS Region 4 Payette National Forest | 31-Jul-1999 | Y | Salmon River Mountains Area: Smiths Knob below lookout, about 8.5 miles east northeast of Warren | *grandiflora* | *Pseudotsuga menziesii*/ mixed shrub on south and east-facing slopes. Elevation: 6,650 to 6,900 ft. | Flowers and fruit | *J. Handley #2724* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 81 | Idaho | USFS Region 4 Payette National Forest | 21-May-2000 | Y | Salmon River Canyon: Along Forest Road 103 via Vinegar Creek boat ramp, about 13 miles north of Burgdorf. Extends over parts of three contiguous sections | *grandiflora* | North facing slope of river canyon dominated by *Pinus ponderosa* and *Pseudotsuga menziesii*. Elevation: 1,900 to 2,100 ft. | Flowers and fruit | *J. Handley #4028* RM |
| ID 82 | Kootenai? | Undetermined | 05-Jun-1909 | Y | Fernan (?) Lake | N/A | Open woods and meadows | No information | *Anon #117* RM |
| ID 83 | Latah | Undetermined | 28-Apr-1940 | Y | 4 miles south of Juliaetta along Potlatch Creek | N/A | Sandy soil | No information | *M. Ownbey and R.P. Ownbey #2027* UTC |
| ID 84 | Latah | Undetermined | 30-May-1894 | Y | Moscow | *grandiflora* | Wheat fields | No information | *L.F. Henderson s.n.* CS |
| ID 85 | Latah | USFS Region 1 Idaho Panhandle National Forest | 31-May-1931 | Y | St. Joe National Forest | N/A | On 30 % slope, west facing on shaley clay soil with arrowwood, serviceberry, wild cherry at 3,600 ft. | Sparse abundance. May-June flowering period. Browse, area not grazed. Identified as *Hookera douglasii* | *A.E. Schneider #4* RM |
| ID 86 | Lemhi | USFS Region 4 Salmon-Challis National Forest | Aug-1930 | N | Allan Lake on Ditch Creek | N/A | Dry hillsides in woodland meadow. On southeast slope in silty soil at 8,000 ft. | Scattering. 16-24 inches tall. [Collection for USFS herbarium] | *A.H. Wheeler #64 (Salmon no: 697)* RM |
| ID 87 | Nez Perce | Undetermined | 15-May-1935 | Y | Lewiston Hill, Lewiston | N/A | Rocky slope. Elevation: 1,800 ft. | MONTU specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | *C.L. Hitchcock and E. Samuel #2507* UTC, MONTU, RM; *C.L. Hitchcock and E. Samuel #2535* PH |
| ID 88 | Nez Perce | Likely Nez Perce tribal land | 23-Apr to 10-May-1902 | Y | Along the Clearwater, east of Lewiston on Nez Perce Reservation | N/A | No information | Collection made as part of the Sandberg Expedition, U.S. Dept. of Agriculture | *A.A. Heller #30* PH |
| ID 89 | Nez Perce | Undetermined | 24-Apr-1892 | Y | Valley of Hatwai Creek | *grandiflora* | Hillsides and bottoms | No information | *J.H. Sandberg #30 with D.T. McDougal and A.A. Heller* CS |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 90 | Nez Perce | Undetermined | 27-Apr-1896 | N | Undetermined | N/A | Elevation: 1,000 ft. | *Triteleia grandiflora* | *A.A. and E.G. Heller #2971* |
| ID 91 | Oneida | Undetermined | 22-May-1910 | Y | Preston Worm Creek foothills | N/A | No information | No information | *C.P. Smith #2149* UTC |
| ID 92 | Owyhee | Undetermined | 07-Jun-1946 | Y | Seven miles SW of Mud Flat on Juniper Mountain Road | N/A | Frequent. Sagebrush slopes along dried up watercourse | No information | *B. Maguire and A.H. Holmgren #26324* UTC |
| ID 93 | Teton | USFS Region 4 Caribou-Targhee National Forest | 23-Jun-1991 | Y | Big Hole Mountains: along Patterson Creek, about 8.5 miles southwest of Driggs | *grandiflora* | Steep slope with scattered vegetation. Elevation: 6,400 ft. | No information | *B.E. Nelson #21244 with S. Markow and M. Nelson* RM, MONTU |
| ID 94 | Teton | USFS Region 4 Caribou-Targhee National Forest | 23-Jun-1991 | Y | Big Hole Mountains: along Mahogany Creek, about 6.5-7 miles southwest of Driggs | *grandiflora* | Open slope of mountain shrub. Elevation: 6,300 to 6,400 ft. | No information | *B.E. Nelson #21188 with S. Markow and M. Nelson* RM |
| ID 95 | Teton | USFS Region 4 Caribou-Targhee National Forest Jedediah Smith and Winegar Hole Wilderness | 24-Jun-1991 | Y | Snake River Range: above and E of Nordell Canyon, about 11 miles south of Driggs. Over two contiguous sections | *grandiflora* | Open aspen woods with scattered large Douglas fir. Elevation: 6,450 to 6,700 ft. | No information | *B.E. Nelson #21269 with S. Markow and M. Nelson* RM |
| ID 96 | Teton | USFS Region 4 Caribou-Targhee National Forest Jedediah Smith and Winegar Hole Wilderness | 18-Jun-1991 | Y | Snake River Range: Mike Harris Creek Road, near intersection with Ida Hwy 33, 3 miles south of Victor. Over two contiguous sections | *grandiflora* | Coniferous forest dominated by *Pseudotsuga*, *Pinus contorta*, *Amelanchier*, and *Symphoricarpos*. Elevation: 6,400 to 6,500 ft. | No information | *S. Markow #937* RM |
| ID 97 | Teton | USFS Region 4 Caribou-Targhee National Forest | 04-Jul-1991 | Y | East Slope Big Hole Mountains: Superior Creek, about 1.5 miles SW of confluence with Horseshoe Creek; about 11 miles southwest of Driggs | *grandiflora* | Valley bottom bordered by coniferous forest and creek, dominated by forbs, grasses and riparian vegetation. Elevation: 6,400 to 6,600 ft. | No information | *S. Markow #2068* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 98 | Teton | USFS Region 4 Caribou-Targhee National Forest | 10-Jul-1991 | Y | East Slope Big Hole Mountains: trail along Corral Creek to Red Creek, about 5.5 miles west of Victor Over two contiguous sections | *grandiflora* | Coniferous forest dominated by *Pinus contorta*, *Abies lasiocarpa*, and *Pseudotsuga menziesii*, with some riparian. Elevation: 6,800 to 7,300 ft. | No information | *S. Markow #2662* RM |
| ID 99 | Valley | USFS Region 4 Payette National Forest | 14-Jul-1999 | Y | Salmon River Mountains Area: Fourmile Creek Trail (090) off Forest Road 674, about 20.5 miles east-southeast of McCall | *grandiflora* | Mixed moist conifer overstory; granite soil. Elevation: 4,190 to 4,840 ft. | Flowers and fruit | *J. Handley #1867 with A. Hansen* RM |
| ID 100 | Valley | USFS Region 4 Payette National Forest | 23-Jul-1999 | Y | Salmon River Mountains Area: Zena Creek Road end/trail (Forest Road 361), about 11 miles south of Warren | *grandiflora* | Mixed conifer overstory; granite soil. Elevation: 6,000 to 6,100 ft. | Flowers and fruit | *J. Handley #2235* RM |
| ID 101 | Valley | USFS Region 4 Boise National Forest | 25-Jun-1985 | Y | Salmon River Mountains, along headwaters of South Fork Salmon River, about 1 mile south of Stolle Meadows | N/A | No information | No information | *E.F. Evert #7965* RM |
| ID 102 | Valley | Ponderosa State Park | 15-Jun-2000 | Y | Long Valley, north of McCall, about 10 miles east of New Meadows. Over parts of four contiguous sections | *grandiflora* | Mixed conifer forest with open meadows and marshes. Elevation: 5,000 ft. | Flowers and fruit | *J. Handley #5461with D.L. Fairbanks* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 103 | Washington | Bureau of Land Management | 03-Jun-2000 | Y | Hitt Mountains: Hixon Sharptail Preserve, Fairchild Reservoir, about 8 miles west of Midvale. Occurrence over parts of three contiguous sections | *grandiflora* | In clayey soil around reservoir. Elevation: 3,650 to 3,850 ft. | Flowers and fruit | *J. Handley #4746* RM |
| ID 104 | Washington | USFS Region 4 Payette National Forest | 14-Jun-1999 | Y | Hitt Mountains Area: Hitt Creek, hillside across Forest Road 573. Occurrence over parts of four contiguous sections | *grandiflora* | Steep south and southwest-facing slopes; rocky basalt soil; dominated by *Elymus spicatus* and *Balsamorhiza sagittata*. Elevation: 4,400 to 5,000 ft. | Flowers and fruit | *J. Handley #358* RM |
| ID 105 | Washington | Bureau of Land Management | 01-Jun-1999 | Y | Approximately 12.5 miles south of Brownlee Dam | *grandiflora* | Volcanic rocky soil, mixed shrub/grassland, steep slope with ephemeral stream. Elevation: 3,550 to 3,720 ft. | Flowers and fruit | *R.L. Hartman #64136 with J. Handley* RM |
| ID 106 | Washington | USFS Region 4 Payette National Forest | 08-Jun-1999 | Y | Lorton Pass Gulch above Mill Creek Road and Blue Spring Creek, about10.5 miles west-northwest of Cambridge. Occurrence over parts of three contiguous sections | *grandiflora* | Riparian area of steep walled, rocky, ephemeral stream; basalt soil; dominated by *Physocarpus malvaceus*/*Prunus emarginata* in *Artemisia tridentata*/*Purshia tridentata*/*Elymus spicatus* grassland. Elevation: 4,400 to 4,700 ft. | Flowering | *J. Handley #26* RM |
| ID 107 | Washington | USFS Region 4 Payette National Forest | 08-Jun-2000 | Y | Hitt Mountains: along logging road just east of Wash Pan Creek, about 13 miles northwest of Cambridge. Occurrence over parts of two contiguous sections | *grandiflora* | Mixed conifer overstory with many areas of recent timber harvest. Elevation: 5,000 to 5,300 ft. | Flowering | *J. Handley #4984* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 108 | Washington | USFS Region 4 Payette National Forest | 25-Jun-1999 | Y | Cuddy Mountains Area: Little Pine-Cow Creek-Johnson Trail, about 10.5 miles north-northwestW of Cambridge. Occurrence over parts of two contiguous sections | *grandiflora* | Basalt parent material, mixed conifer forest with inclusions of sagebrush/ grassland and scabland. Elevation: 4,700 to 5,350 ft. | Flowering | *J. Handley #850 with P. Lawrence* RM |
| ID 109 | Washington | USFS Region 4 Payette National Forest | 08-Jun-1999 | Y | Middle Brownlee Creek Road, above Middle Brownlee Creek and below road, about 14.5 miles northwest of Cambridge | *grandiflora* | Sub occurrence A: Bench and ridge; basalt, rocky soil; *Artemisia tridentata*/ *Purshia tridentata*/*Elymus spicatus* with scattered *Pinus ponderosa*. Sub-occurrence B: Northeast-facing slope; basalt, rocky soil; *Elymus spicatus*/*Balsamorhiza sagittata* with scattered *Pinus ponderosa*. Elevation: 4,000 to 4,100 ft. | Flowers and fruit | *J. Handley #89* RM; *J. Handley #53* RM |
| ID 110 | Washington | USFS Region 4 Payette National Forest | 13-Jun-2000 | Y | Hitt Mountains: along 4WD trail at the top of Neil Gulch, just north of Arrowhead Spring, about 17 miles northwest of Cambridge. Occurrence over parts of two contiguous sections | *grandiflora* | *Pinus ponderosa* plantation (approx. 25 yrs old) in mixed conifer forest. Elevation: 5,000 to 5,550 ft. | Flowering | *J. Handley #5294 with D.L. Fairbanks* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 111 | Washington | USFS Region 4 Payette National Forest | 01-Jul-1999 | Y | Cuddy Mountains Area: Forest Road 048 between Olive and Dry creeks, about 11.5 miles northwest of Council | *grandiflora* | Ridge and northwest-facing slope; basalt soil; *Elymus spicatus*/*Festuca idahoensis* with mixed shrubs and scattered *Pinus ponderosa*. Elevation: 4,400 to 4,700 ft. | Flowers and fruit | *J. Handley #1300* RM |
| ID 112 | Washington | USFS Region 4 Payette National Forest | 03-Jun-1972, 14-May-1923 | Y | 1972: Spur road from Spring Creek Campground, Mann Creek;<br>1923: East side Mann Creek (then in Weiser National Forest) | N/A | 1972: No information<br>1923: Steep south slope, in rocky soil with "*Cogswellia*, *Carum*, yellow violet, wheatgrass" | 1972: No information<br>1923: wide distribution; fairly common | *M.E. Lewis #2182 1972* UTC; *H.J. Helm #1 1923* RM |
| ID 113 | Idaho | USFS Region 1 Nez Perce National Forest | 10-May-1918 | Y | Between Stormy Point and Wild Horse Butte, west of John Day Creek | N/A | On west facing slope in thin gravelly soil at 3,100 ft. Associates balsamroot, lupine, wooly weed | Wide distribution, not abundant. May to July flowering period; June to August period of seed dissemination. No forage value | *C.H. Hurst #RX 45* RM |
| ID 114 | Idaho | USFS Region 1 Nez Perce National Forest | 07-Jul-1957 | N | Selway River drainage. Approximately 1.5 miles below Indian Hill lookout on road to Meadow Creek | N/A | On grassy steep slope | No information | *A.R. Kruckeberg #4100* RM |
| ID 115 | Unreported [Idaho] | USFS Region 1 Nez Perce National Forest | 18-May-1914 | Y | Near Jungle Creek and Sheep Creek [estimated from directions] | N/A | On flat soil south slope at 2,100 ft. | No information | *T. Crossley #38 or 46* RM |
| ID 116 | Idaho | Undetermined | 08-Apr-1928 | Y | Divide Creek | N/A | Dry rocky hillside | No information | *J.H. Skillin and F.A. Warren #737* PH |
| ID 117 | Washington | Undetermined | 06-May-1883 | Y | West of Weiser City | N/A | No information | No information | *W. Cleburne s.n.* NEB |
| ID 118 | Washington | Undetermined | 04-May-1884 | Y | From high bluffs above Snake River, 12 miles below Weiser City | N/A | No information | No information | *W. Cleburne s.n.* NEB |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| ID 119 | Unreported | Undetermined | Jun-1892 | N | Idaho | N/A | Hillside | No information | *A.I. Mulford s.n.* NEB |
| ID 120 | Unreported | USFS Region 4 Wasatch-Cache National Forest | 07-Jun-1923 | Y | Summit Ranger Station, Cache National Forest | N/A | On 5% slope in gravel loam soil in sage areas at 6,100 ft. | Closely grazed by livestock. Plentiful | *A.R. Standing #43* RM |
| ID 121 | Unreported | Likely private | 11-May-1914 | N | Hope | N/A | No information | No information | *M.B. Dunkle #415* RM |
| ID 122 | Unreported | USFS Region 4 Caribou-Targhee National Forest | 20-Jun-1926 | N | Jensen sheep allotment | N/A | East slope in clay soil in aspen-sagebrush | Scattered in sagebrush types. Common name wild onion; grazed by sheep and goats. Forage value - poison plant. 20 inches high, flowering. Seed dissemination September. Identified as *Hookera douglasii*. [Collected for USFS herbarium] | *A. Peterson #P-4*; Caribou National Forest no. 440 RM |
| MT 1 | Deer Lodge | Undetermined | No date | N | [No specific location other than County] | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12814 |
| MT 2 | Broadwater | Undetermined | 10-Jun-1956 | N | Approximately 20 miles east of Townsend | *grandiflora* | Open Douglas fir forest and creek bottom | No information | *W.E. Booth #56* RM |
| MT 3 | Flathead | Undetermined | 31-May-1894 | Y | Holt | N/A | Flathead River | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12809 |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 4 | Flathead | Undetermined | 31-May-1894, 15-Jul-1894 | Y | Columbia Falls | N/A | No information | MONT specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2. Now in densely urbanized area | *R.S. Williams s.n.* 31-May-1894 RM; MONT Acc. No. 74700 15-Jul-1894 |
| MT 5 | Lake | Undetermined | 14-Jun-1937 | Y | Flathead Lake | N/A | Elevation: 3,500 ft. | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 26767 |
| MT 6 | Gallatin | USFS Region 1 Gallatin National Forest | 28-Jun-1928 | Y | Foot of Mt. Baldy, on the east side of Bridger Range | N/A | Open hillside | Specimen at MONT annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | *D.B. Swingle s.n.* CS, MONT, RM |
| MT 7 | Gallatin | Private, or USFS Region 1 Gallatin National Forest | 25-Jun-1957, 05-Jun-1921 | Y | Bridger Canyon | N/A | 1957: deep moist soil | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 54167, 1957; MONT Acc. No. 26101, 1921 |
| MT 8 | Gallatin | USFS Region 1 Gallatin National Forest | 17-Jul-1967 | Y | Bridger Bowl (Bridger Range) | N/A | Meadows near old chalet common on lower slopes only | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 63805 |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 9 | Gallatin | USFS Region 1 Gallatin National Forest | 14-Jun-1897 | Y | Bridger Mountains | N/A | Elevation: 7,000 ft. | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12815 |
| MT 10 | Gallatin | USFS Region 1 Gallatin National Forest,and/or private | 18-Jul-1945 | Y | Bridger Mountains. 3 miles north of Brackett Creek | N/A | Open parks in Douglas fir forest | No information | *C.L. Hitchcock and C.V. Muhlick #12444* UTC, RM |
| MT 11 | Gallatin | USFS Region 1 Gallatin National Forest | 15-Jul-1917 | N | Sourdough Divide (Gallatin Range) | N/A | Bear Creek | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12808 |
| MT 12 | Gallatin | Undetermined | 15-Jun-1933 | N | Meadow Creek Road | N/A | Moist field at 5,000 ft. | Specimen at MONT annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | *D.B. Swingle s.n.* UTC, MONT, RM |
| MT 13 | Gallatin | Private | 1897, 16-Jun-1905 | Y | Bozeman | N/A | No information | MONT specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12813, 1897; *J.W. Blakenship #474* 1905 PH |
| MT 14 | Gallatin | Private | 02-Jul-1883 | Y | Bozeman Pass | N/A | No information | Collection made as part of the Northern Transcontinental survey, Division of Economic Botany, W.M. Canby in charge | *N. Waulagy #315* PH |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 15 | Gallatin | Private | 10-Jun-1921 | Y | East of Bozeman | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 26003 |
| MT 16 | Gallatin | Private | 31-May-1901 | Y | Belgrade | N/A | No information | No information | *E.J. Moore s.n.* RM |
| MT 17 | Gallatin | USFS Region 1 Gallatin National Forest; may extend into private land | 22-Jun-1992 | Y | Gallatin Range: Bear Creek Canyon: about 8 miles southeast of Bozeman. Occurrence within two contiguous sections | N/A | Meadow openings in coniferous forest with *Lupinus argenteus*, *Iris missouriensis*, and *Antennaria rosea*. Elevation: 6,200 to 6,400 ft. | Flowers and fruit | *E.F. Evert #23161* RM |
| MT 18 | Gallatin | Undetermined | 27-Jun-1996 | Y | Madison Range foothills: Ouzel Falls on West Fork Gallatin River, 6 miles west of Mont. Hwy 191 | *grandiflora* | At forest edge north of falls with *Carex hoodii* and *Melica spectabilis*. Elevation: 6,500 ft. | No information | *E.F. Evert #31621* RM |
| MT 19 | Gallatin | Undetermined | 07-Jul-1946 | Y | Junction Burnt Fork Trail Skalkaho Road | *grandiflora* | No information | No information | *C.L. Hitchcock and C.V. Muhlick #14494* UTC, RM |
| MT 20 | Lake | Undetermined | 22-Jun-1953 | Y | Rollins | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Accession No. 74699 |
| MT 21 | Lake | USFS Region 1 Flathead National Forest | 25-Jun-1932 | Y | Near Flathead Picnic Area [Estimated by author] | N/A | On 30 degree west slope in rocky loam soil in timber at 3,000 ft. | Scattered abundance; unknown forage value; 12 inches tall; flowering June and seed dissemination July | *C.W. Jackson #31* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 22 | Lincoln | Undetermined | 05-May-1973 | Y | Directly north of Libby | N/A | Among grasses on riverbank | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Accession No. 74697 |
| MT 23 | Mineral | Undetermined | Jul-1954 | Y | Three miles northwest of Lincoln | N/A | South side of river in grassland | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | *Anonymous s.n* |
| MT 24 | Mineral | Undetermined | 21-May-1944 | N | Fish Creek, Superior | *grandiflora* | On steep mountain slope near road, alt. 5,500 ft. | Flowers bright-blue with deep-blue stripes running through center of perianth lobes | *M. Lamm s.n.* (supervised by *H.N. Moldenke #17039* RM) |
| MT 25 | Missoula | Private | 03-May-1935 | Y | Mt. Jumbo | N/A | "seems to like a hard baking soil" elev. 3,210 ft. | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Accession No. 74696 |
| MT 26 | Missoula | Private | 25-May-1938 | Y | Platt: West face of Mount Sentinel. Leithead: Mount Sentinel | N/A | No information | MONT specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | *W. Platt #6* PH, MONT; *H. Leithead #36* RM |
| MT 27 | Missoula | Private | 07-Jun-1897 | N | Lucea | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Accession No. 12811 |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 28 | Missoula | Private | 31-May-1933 | Y | South east Missoula at foot of Mt. Sentinel | *grandiflora* | Rocky soil elev. 3,300 ft. | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | *C.L. Hitchcock #1612* RM; MONT Accession No. 21538 |
| MT 29 | Missoula | Undetermined | 25-May-1938 | N | Grassland | N/A | Low sunny grassland | No information | *F.A. Barkley #2360* UTC |
| MT 30 | Missoula | Undetermined | 25-May-1939 | N | River Road | N/A | Open woods | No information | *M. Brunsvold and M. Carter #11* UTC |
| MT 31 | Missoula | Undetermined | 16-May-1941 | Y | Montana forest, Lolo Creek, Missoula | N/A | Montane forest | No information | *L. Jones and A. Zimmerman #3* PH |
| MT 32 | Park | USFS Region 1 Gallatin National Forest | 22-Jun-1992 | Y | Gallatin Range: along north side of Pine Creek and Forest Road 978, 20 miles southeast of Bozeman | N/A | Wet soil along springs and seeps with *Senecio triangularis*, *Alnus incana*, and *Carex rostrata* | Flowers and fruit | *E.F. Evert #23131* RM |
| MT 33 | Powell | Private | Jun-1892 | Y | Deer Lodge | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12812 |
| MT 34 | Powell | USFS Region 1 Beaverhead-Deerlodge National Forest, or Private | 18-Jun-1962 | Y | Near Deer Lodge | N/A | Thick to scattered in meadow hay field | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 74698 |
| MT 35 | Powell | USFS Region 1 Beaverhead-Deerlodge National Forest | 26-Jun-1961 | Y | Burnt Hollow about 6 miles south east of Deer Lodge | N/A | At lower edge of Deer Lodge National Forest with geraniums | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 57833 |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 36 | Ravalli | Private | 15-May-1915 | Y | Como | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 12810 |
| MT 37 | Ravalli | USFS Region 1 Bitterroot National Forest | 14-Jun-1930 | N | Warm Springs Creek Drainage | N/A | Hot dry sites in Douglas Fir, arnica, sedge. Dry gravelly loan, granitic soils. Westerly steep slope at 4,800 ft. | No use, fairly common; probably of botanical importance only; 18-24 in. tall. Identified as *Hookera douglasii* | *H.R. Flint #12-30* RM |
| MT 38 | Ravalli | USFS Region 1 Bitterroot National Forest | 17-Jun-1959 | Y | Spring Gulch - transect | N/A | On 10% slope with west exposure in grass, weed vegetation type with species of *Carex*, *Poa*, *Fescue*, *Stipa*, *Arnica*, and Balsam root | Blue flowers; 12-24 in. tall | *W. Pavlat #10* RM |
| MT 39 | Sanders | Private | 05-May-1941 | Y | Perma | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 40287 |
| MT 40 | Stillwater | Private | 17-Jun no year | Y | Absarokee | N/A | No information | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 32999 |
| MT 41 | Stillwater | Undetermined | 05-Jun-1996 | Y | Along the east side of the Stillwater River at Whitebird Fishing Access and Campground, 6 miles southwest of Columbus | *grandiflora* | Disturbed riparian community with *Populus balsamifera*, *Betula occidentalis*, and *Rudbeckia laciniata* | No information | *E.F. Evert #30831* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| MT 42 | Yellowstone | Undetermined | 13-Jun-1955 | Y | Approximately 5 to 6 miles north of Billings | N/A | Friable clay loam in swale spot | Specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 | MONT Acc. No. 49588 |
| MT 43 | Unreported | USFS Region 1 Gallatin National Forest | 25-Jun-1921 | N | Squaw Creek Administrative Pasture | *grandiflora* | On north and east slopes, dry soil, thin vegetation | Identified as *Hookera douglasii*. Collected for USFS Herbarium | *W.A. Chipperfield #227* RM |
| MT 44 | Probably MT (might be Oregon) | Undetermined | Jun-1914 | N | Rattlesnake Valley | N/A | No information | No information | *C. Lively s.n.* NEB |
| OR 1 | Unreported | State or USFS (unit unknown) | 20-Apr-1889 | N | Rooster R[ock] | *howellii* | No information | Original det: *Brodiaea howellii* last annotated 1974 | *J.F. Drake s.n. ORE* |
| OR 2 | Baker | Undetermined | 07-Jun-1936 | N | Vicinity of Kings Mountain | N/A | No information | No information | *J.W. McKay s.n.* UTC, RM |
| OR 3 | Baker | Undetermined | 23-Jun-1957 | Y | Near Head's Cabin | N/A | Sandy loam soil; meadow area; with grasses, species of *Tragopogon*, *Symphoricarpos*, and *Potentilla*. Elevation: 1,158 m | Original det: *Brodiaea douglasii* S. Wats. Last annotated Feb. 14, 1989 | *S.C. Head #951* OSC |
| OR 4 | Baker | Undetermined | 20-May-1967 | Y | Six miles east of Halfway | *grandiflora* | Grassland near *Pinus ponderosa* woodland | Perianth deep blue, inner series ruffled, flared at level distinctly above that of outer series; anthers blue | *C.L. Hitchcock #25428* RM |
| OR 5 | Baker | Undetermined | 20-May-1967 | Y | Three miles north of Richland | *grandiflora* | On open sagebrush covered hills | Perianth all deep blue, tepals all dissimilar, inner series ruffled, flared 1-2mm above the outer series; anthers blue; filaments inserted at very different levels all thicker than wide | *C.L. Hitchcock #25426* RM |
| OR 6 | Douglas | USFS Region 6 Umpqua National Forest | 31-Jul-1916 | Y | Rogue-Umpqua divide, 18 miles west of Crater Lake | *howellii* | Bog | Original det: *Triteleia howellii* Wats. | *M.E. Peck #7336* WILLU |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| OR 7 | Douglas | USFS Region 6 Umpqua National Forest | 29-Jun-1979 | Y | Calapooya Mtns.; east and below Skipper Lakes, near Balm Mtn., upper Deer Creek drainage (tributary of North Umpqua River) | *howellii* | With *Heracleum* sp. | not annotated since accessioned | *J. Fosback and O. Fosback s.n.* OSC |
| OR 8 | Gilliam | Undetermined | 13-Apr-1938 | Y | Bank of Columbia River, 3 miles west of Arlington | *howellii* | Bank of Columbia River | Original det: *Brodiaea bicolor* Suksd. not annotated since accessioned | *M.E. Peck #19846* WILLU |
| OR 9 | Gilliam | Undetermined | 28-Apr-1950 | Y | OSC: 1 mile above the mouth of Rock Creek. UTC, KANU: Along John Day River 1 mile above the mouth of Rock Creek | *howellii* | Among sagebrush on rocky (basaltic) west slope along John Day river | OSC: Original det: *Brodiaea douglasii* Lindl. var. *howellii* (Wats.) last annotated 14-Feb-1989. Perianth nearly white except for the light blue stripe sown the midrib of each segment | *A. Cronquist #6210* OSC; *A. Cronquist #6210* UTC, KANU |
| OR 10 | Gilliam | Undetermined | 19-May-1967 | Y | Along Hwy 206, 13 miles northwest of Condon | *howellii* | Open grassy field | Perianth nearly white to pale blue, tube more or less longer than tepals; tepals spreading at same level and more or less flat; anthers and pistil blue; filaments flat, equally inserted and very unequal to almost equal | *C.L. Hitchcock #??518* RM [1st 2 digits illegible] |
| OR 11 | Jackson | Undetermined | 28-Jun-1976 | Y | West side of Hyatt Lake, 4 miles north of Hwy. 66 at Green Springs Summit | N/A | Grassy area in open woods. With *Lupinus albicaulis* and *Phacelia heterophylla* | Original det: *Brodiaea douglasii* (Lindl.) Wats. last annotated 14-Feb-1989 | *V.L. Crosby #654* OSC |
| OR 12 | Jackson | Undetermined | 25-Aug-1916 | Y | East slope of Mt. Pitt [renamed Mount McLoughlin] | *howellii* | Bog. Elevation: 3,200 m | Original det: *Triteleia howellii* Wats. last annotated 1998 | *M.E. Peck #7303* WILLU |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| OR 13 | Jackson | USFS Region 6 Umpqua National Forest | 04-Jul-1979 | Y | Siskiyou Mountains; Angel Camp Spring, Applegate Creek (tributary of Cow Creek), east of Goolaway Gap and just south of Douglas County line | *howellii* | Marsh, with *Hypericum anagalloides* and *Lilium pardalinum* | Original det: *Triteleia howellii* S. Watson not annotated since accessioned | *J. Fosback s.n.* OSC |
| OR 14 | Jefferson | Undetermined | 18-Jul-1999 | Y | Metolius River area on top of Green Ridge at Prairie Farm | *howellii* | Small colony in grassy swale under *Pinus ponderosa* beside the meadow. Elevation: 1,356 m | Original det: *Triteleia howellii* (S. Watson) Greene not annotated since accessioned | *K.L. Chambers and H.L. Chambers #6165* OSC |
| OR 15 | Jefferson | Bureau of Land Management and State | 26-Jun-1905 | Y | The Island RNA/ ACEC [within the confines of The Cove Palisades State Park] | *grandiflora* | No information | No information | Halvorson (2004) |
| OR 16 | Linn | Undetermined | 25-Jul-1899 | Y | Calapooia Valley [Label reads “Calapooya Valley”] | N/A | Ground baked, hard and dry | No information | *M.A. Barber s.n.* KANU |
| OR 17 | Sherman | Private | 11-Apr-1953 | Y | Biggs | *howellii* | Scattered in sandy soil, among *Purshia* sp., grassland zone. Elevation: 91 m | Original det: *Brodiaea bicolor* Suksd. Last annotated 14-Feb-1989 | *A.N. Steward and C.B. Steward #6281* OSC |
| OR 18 | Sherman | Undetermined | 19-May-1967 | Y | Six miles southeast of Wasco | *howellii* | Open grassy area | Perianth very pale blue, fading to deeper blue; anthers and pistil blue; tepals alike spreading from same level; anthers broad and flat, nearly equally inserted but very unequal in length | *C.L. Hitchcock #24516* RM |
| OR 19 | Sherman | Undetermined | 19-May-1967 | Y | Eight miles east of Wasco along road to Rock Creek | *howellii* | Open grassy flat | Perianth very pale blue, almost white; tepals alike, slightly deeper blue on midnerve; anthers and pistil blue; filaments broad, nearly equally inserted but very unequal in length | *C.L. Hitchcock #24512* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| OR 20 | Umatilla | Private | 01-May-1882 | Y | Umatilla | N/A | None | Original det: *Brodiaea douglasii* Watson. last annotated 14-Feb-1989 | *T. Howell #214* OSC; *T. Howell s.n.* PH |
| OR 21 | Umatilla | Undetermined | 17-May-1896 | Y | Banks of Umatilla River, Pendleton | *grandiflora* | Banks of Umatilla River | Original det: *Brodiaea douglasii* last annotated November 2003 | *M.W. Gorman #20* WILLU |
| OR 22 | Union | USFS Region 6 Wallowa-Whitman National Forest | 10-Jul-1966 | N | Near junction of route 244 and Tim Trough Road, Starkey Experiment Range | *grandiflora* | Near stream in narrow meadow in pine woods | Occasional. Flowers blue | *C. Feddema #3449* RM |
| OR 23 | Union | Undetermined | 02-Jul-1931 | Y | Blue Mountains, 15 miles northwest of Elgin | N/A | Dry grassy flat in open woods; soil slightly acid | T. Niehaus 1975. Original det: *Hookera douglasii* | *E.T. Wherry s.n.* PH |
| OR 24 | Union | USFS Region 6 Umatilla National Forest | 23-Jun-1941 | Y | Umatilla Starkey Range | N/A | On south slope in open timber and grass with *Poa secunda*, *Potentilla*, and *Arnica*. Clay loam soil. Elevation: 4,800 ft. | Scattered. 4-6 dm high; blue flowers; flowering June seed disemination June-July. MONT specimen annotated Feb. 2005 by J.C. Pires, Wisconsin State Herbarium (WIS), as *Triteleia grandiflora* Lindley for Flora of North America / Jepson Manual ed. 2 [RM specimen collected for USFS herbarium] | *N.F. Keil #1075* RM; MONT Acc. No. 28885 |
| OR 25 | Wallowa | Undetermined | 13-Jul-1950 | Y | West side of Wallowa Lake | N/A | On meadows at head of lateral moraine | No information | *A.R. Kruckberg #2278* RM |
| OR 26 | Wallowa | Undetermined | 05-Jun-1966 | Y | 8 miles south of Wallowa | *grandiflora* | East facing slope; steep with ponderosa pine and Douglas fir | No information | *G. Davidse and A.W. Collotzi #529* UTC, CS |
| OR 27 | Wallowa | Undetermined | 19-Jun-2002 | Y | Along State Hwy. 3, about 28.5 miles north of Enterprise at the Joseph Canyon Viewpoint | N/A | With species of *Pinus*, *Delphinium*, *Sedum*, *Microseris*, *Lupinus*, and *Geum*. Elevation: 1,347 m | Original det: *Triteleia grandiflora* Lindley not annotated since accessioned | *R.R. Halse #6208* OSC |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| OR 28 | Wasco | Undetermined | 25-May-1940 | Y | 4 miles east of Mosier Columbia River Gorge | N/A | Open meadows and in light shade of *Quercus garryana*. Altitude 100 ft. | Bulb globose, fibrous-coated; perianth light bluish-purple to nearly white. RM specimen identified as variety *howellii* | *L. Constance and A.A. Beetle #2671* UTC |
| OR 29 | Wasco | Undetermined | 17-Apr-1806 | Y | The Dalles along the Columbia River | N/A | No information | No information | PH-LC |
| OR 30 | Wasco | Undetermined | 01-Apr-1953 | Y | Cherry Heights, the Dalles | N/A | Herb in arid, shallow, rocky, clay loam. Elevation: 122 m | Original det: *Brodiaea hyacinthina* (Lindl.) Baker. last annotated April 2002 | *M.W. Nielson s.n.* OSC |
| OR 31 | Wasco | Undetermined | 12-May-1923, 29-May-1933 | Y | Tygh Valley | *howellii* | 1923: dry sandy slopes and hillsides.<br>1933: shady bank | 1923: original determination: *Hookera* sp. not annotated since accessioned.<br>1933: original determined *Brodiaea bicolor* Suksd. last annotated November 2003 | *M.W. Gorman #6109* 1923 ORE; *M.E. Peck #17374* 1933 WILLU |
| OR 32 | Wasco | Undetermined | 29-May-1933 | N | 10 miles north of Wapautia | *howellii* | Dry open ground | Original det: *Brodiaea bicolor* Suksd.not annotated since accessioned | *M.E. Peck #17392* WILLU |
| OR 33 | Wasco | Undetermined | 30-May-1933 | Y | 20 miles southeast of Government Camp, Mt. Hood | *howellii* | Dry ground | Original det: *Brodiaea bicolor* Suksd. not annotated since accessioned | *M.E. Peck #17410* WILLU |
| OR 34 | Wasco | Possibly USFS Region 6<br>Mt. Hood National Forest | 06-May-1906 | Y | Foothills of Mt. Hood | N/A | Timbered foothills. In dry soil | No information | *J. Lunell s.n.* RM |
| OR 35 | Wasco | Undetermined | 09-May-1957 | Y | About 10 miles west southwest of Maupin on Highway #52 | *howellii* | No information | No information | BC accession #CBO0003782 |
| OR 36 | Wasco | Undetermined | 10-May-1957 | Y | Along Columbia River 3 miles east of Hood River near Wasco-Hood River county boundary | *howellii* | No information | No information | BC accession #CBO0003783 |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| OR 37 | Wheeler | Undetermined | 28-Apr-1965 | Y | 6 miles south of Malheur Reservoir | N/A | Dry sandy soil; open sagebrush and cattle range | No information | *T. Olsen s.n.* UTC |
| OR 38 | Unreported | Likely Native American Tribal land | 09-Jun-1948 | Y | North slope of Blue Mountains, 12 miles southeast of Pendleton | N/A | Wet thickets on slope of ravine | Annotated *Brodiaea douglasii* by T. Niehaus 1975 | *S.L. Glowenke #11258* PH |
| OR 39 | Wheeler | Warm Springs tribal land | 20-Jun-1932 | N | Blue Mountains | *grandiflora* | No information | No information | *F.B. Wann #4634* UTC |
| OR 40 | Wheeler | USFS Region 6 Ochoco National Forest | No date | Y | Ochoco National Forest | N/A | Moist sandy soil. Elevation: 1,463 m | Original det: *Brodiaea douglasii* Wats. last annotated Feb. 14, 1989 | *S. Warg s.n.* OSC |
| OR 41 | Harney | Recreation land or private | 25-May-1935 | Y | Stein's Mountain, west base [Now referred to as Steen's Mountain] | N/A | Wet meadowland and moist hillsides, 4,000 ft. | No information | *P. Train s.n.* NEB |
| OR 42 | Grant | Probably National Park Service | May-1880 | Y | Currant [Current] Creek. [Currant Creek is in John Day National Monument] | N/A | No information | No information | *J. Howell s.n.* PH |
| OR 43 | Grant | USFS Region 6 Wallowa-Whitman National Forest | 28-May-1935 | N | Blue Mountain Experimental Forest | N/A | On hillsides (25% south slopes) in open timber with weeds, lupine, bitterbrush. Deep clay loam soils | Sparsely scattered. 15 to 18 inches high. [Collected for USFS herbarium] | *L.R. Kauffman #46* RM |
| OR 44 | Baker | Private | 08-May-1905 | Y | Huntington | N/A | No information | Ex. Herb. Albert R. Sweetser | *Anonymous s.n.* PH (Ex Herb. Albert R. Sweetser) |
| OR 45 | Unreported | USFS Region 6 Umatilla National Forest | 13-Jul-1912 | N | Umatilla National Forest | N/A | Light and gravelly soil at 5,000 ft. | Fair forage value for sheep. [Collected for USFS herbarium] | *C.R. McAlistair #42* RM |
| OR 46 | Unreported | USFS Region 6 Ochoco National Forest | 05-Jun-1919 | N | Wolf Creek, Ochoco National Forest | N/A | On 10 degree west slope associated with *Artemisia tridentata*, *Kunzia tridentata*, and *Poa sandbergii*. Elevation: 3,600 ft. | Wide distribution on Ochoco; scattering abundance. Too scattering to be important though grazed by all stock | *D.C. Ingram #B-816* RM |
| OR 47 | Unreported | USFS Region 6 Wallowa-Whitman National Forest | 28-May-1914 | N | Auburn Hill, Whitman National Forest | N/A | No information | Identified as *Hookera douglasii*. [Collected for USFS herbarium.] Determined by Tidestrom | Unknown collector, No. 23243 RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| UT 1 | Salt Lake | Private | 06-Jun-1905 | Y | Salt Lake | *grandiflora* | Elevation: 5,500 ft. | Originally identified *Brodiaea capitata;* annotated *Triteleia grandiflora parviflora* by T. Niehaus | *A.O. Garrett s.n.* PH |
| UT 2 | Salt Lake | Private | 30-Jun-1908 | Y | East Bountiful | *grandiflora* | No information | *Triteleia grandiflora* | *Mrs. J. Clemens s.n.* PH |
| UT 3 | Wasatch | Undetermined | 01 and 02-Jul-1938 | N | Route 40, Devils Canyon, northeast of Heber | *grandiflora* | Coniferous (Coniferost) grove, 7,800 to 7,900 ft. | No information | *F.W. Pennell and R.L. Schaeffer*, *Jr. #22538* PH |
| UT 4 | Salt Lake | Undetermined | 12-Jun-193[1] | Y | Parleys Canyon, 15 miles east of Salt Lake City | *grandiflora* | Thickets on steep mountainside | Original determination: *Brodiaea douglasii*. Annotated *Triteleia grandiflora* Niehaus 1975 | *E.T. Wherry s.n.* PH |
| UT 5 | Cache | Private | 23-Jun-1983 | Y | Avon-Liberty Road about 4 miles south of Avon | *grandiflora* | Infrequent; loam; assoc w/ *Acer grandidentatum* and *Lathyrus* sp. | No information | *R.J. Shaw #3162* UTC |
| UT 6 | Box Elder | Private | 12-Jun-1947 | Y | Park Valley | *grandiflora* | Slag bottomland. Location unknown probably Park Valley in Box Elder County | No information | *L.A. Stoddart and C.W. Cook s.n.* UTC |
| UT 7 | Box Elder | USFS Region 4 Wasatch-Cache National Forest | 28-May-1941 | Y | Mantua Nursery (USFS) | *grandiflora* | On 15% slope in moist humus sites with deep clay loam soils in Mountain brush community with *Acer grandidentatum* and *Prunus melanocarpa* at 5,000 ft. | Scarce. Unknown forage value | *R.M. Hurd #140* RM |
| UT 8 | Cache | USFS Region 4 Wasatch-Cache National Forest | 16-Jun-1935 | Y | West Hodges Pasture, Logan Canyon | *grandiflora* | Moist sage type | No information | *H.B. Passey #24* UTC |
| UT 9 | Cache | USFS Region 4 Wasatch-Cache National Forest | 30-Jun-1991 | Y | Forest Service Road #047 that connects Logan Canyon & Blacksmith's Fork Canyon Herd Hollow | *grandiflora* | With aspen, *Prunus virginiana*, and *Lupinus* sp. | No information | *R.J. Shaw #4952* UTC |
| UT 10 | Cache | USFS Region 4 Wasatch-Cache National Forest | 03-Jul-1936 | Y | Bear River Range Tony Grove Creek | *grandiflora* | Under aspen | No information | *B. Maguire #13931* UTC |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| UT 11 | Cache | USFS Region 4 Wasatch-Cache National Forest | 26-May-1962 | Y | Bear River Range at base of mountain just south of Dry Canyon | *grandiflora* | With bigtooth maple and bitterbrush | No information | *N.H. Holmgren #147* UTC |
| UT 12 | Cache | USFS Region 4 Wasatch-Cache National Forest | 16-May-1960 | Y | Foothills mouth Dry Canyon | *grandiflora* | Rare, dry | Location unknown probably Cache County Utah | *J.F. Squires #43* UTC |
| UT 13 | Davis | Likely USFS Region 4 Wasatch-Cache National Forest | 14-May-1881 | Y | Farmington | *grandiflora* | No information | No information | *M.E. Jones #2156* UTC, RM |
| UT 14 | Davis | Likely USFS Region 4 Wasatch-Cache National Forest | 12-May- 1962 | Y | Bountiful Canyon | *grandiflora* | No information | No information | *A. Collotzi #47* UTC |
| UT 15 | Salt Lake | Undetermined | 19-May- 1966 | N | South of U.S. 40 and Utah 239 intersection | *grandiflora* | Growing in rich soil among grasses, maple, oak, choke cherry | No information | *G. Davidse #403* UTC |
| UT 16 | Salt Lake | Undetermined | 02-Jun-1968 | Y | Red Butte Canyon, Wasatch Range Southeast - facing slope north of road about 0.3 miles NE of head of reservoir | *grandiflora* | In a grassy clearing in oak with *Berberis repens*, *Allium acuminata*, and *Arabis holboellii* | No information | *L. Arnow #1389* UTC |
| UT 17 | Salt Lake | Department of Defense | 17-May-1994 | Y | Camp W.G. Williams Training Area, Traverse Mountain Range | *grandiflora* | Slope 30; North aspect; mountain hollow, mid slope; Igneous and sedimentary; Horrocks extremely stony loam; *Quercus gambelii* | Native perennial herb, blue flower | *M. Reynolds and M. Hysell #629* UTC |
| UT 18 | Salt Lake | Undetermined | 11-Jun-1905 | Y | Red Rock Canon near Salt Lake City [Red Rock Butte Canon near Salt Lake City?] | *grandiflora* | No information | No information | *P.A. Rydberg #6077* RM |
| UT 19 | Unreported | Undetermined | 27-Jun-1896 | N | Near Alta summit, Central Railroad, Parley's Canyon | *grandiflora* | Elevation: 6,700 ft. | No information | *W. Cleburne s.n.* NEB |
| UT 20 | Weber | Private | 14-May- 1939 | Y | Ogden | *grandiflora* | East Sandy field | No information | *A.O. Garrett #8075* KANU |
| UT 21 | Wasatch | Undetermined | 29-Jun-1979 | Y | Strawberry Valley | *grandiflora* | Alluvium, riparian community | No information | *R. Foster #8105* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 1 | Asotin | USFS Region 6 Umatilla National Forest | 25-Jun-1949 | Y | 30 miles southwest of Asotin summit of Blue Mountains overlooking Indian Tom Creek | *grandiflora* | Rocky, gravelly soil in open places. Elevation: 5,200 ft. | Flowers rather light blue or blue-lavender | *A. Cronquist and Q. Jones #5897* UTC, KANU |
| WA 2 | Asotin | Private | 25-May-1965 | Y | Within 1 km of Hoskins Gulch head; south east end of Weissentels Ridge | N/A | Open grassy flat | Perianth deep blue | *C.L. Hitchcock #23493* KANU |
| WA 3 | Chelan | Undetermined | 24-May-1964 | Y | Swakane Canyon, about 4 miles west of the Columbia River | N/A | No information | No information | *C.L. Hitchcock #23443* KANU |
| WA 4 | Chelan | USFS Region 6 Wenatchee National Forest | 23-May-2003 | Y | Approximately 8 miles southwest of Wenatchee, in lower end of Peavine Canyon along Forest Road 7101 | N/A | Open *Pinus ponderosa* woods with shrubby thickets along small flowing creek. Elevation: 2,500 ft. / 762 m | Tepals pale blue, inner 3 ruffled; anther filaments keeled; plants abundant in area. Original id: *Brodiaea douglasii* | *B. Legler #436* WTU |
| WA 5 | Chelan | Private | 14-Jun-1907 | Y | Wenatchee | N/A | No information | No information | *A.L. Brown s.n.* NEB |
| WA 6 | Chelan | USFS Region 6 Wenatchee National Forest, Swakane StateWildlife Research Area | 15-Jun-1942 | N | East of Burch Mountain [according to directions at the time] | N/A | Distributed in open grassland in sandy soil, in open yellow pine, some weeds, with balsam root, lupine, vetch at 1,800 ft. | Moderate abundance, moderate use by livestock; no forage value. 12 inch high perennial. Collected for USFS Herbarium | *H.W. Elofson #E24* RM |
| WA 7 | Chelan | Swakane StateWildlife Research Area | 14-May-2004 | Y | Swakane Canyon Road, about 1.5 km from junction with State Road Alt. 97. Steep north-facing slope on south side of road | *grandiflora* | Grasses dominant on slope, with *Sambucus* sp., *Rosa woodsii*, and *Clematis ligusticifolia* growing along stream at base of slope. Elevation: 915 ft. / 278 m | Corollas blue, fading to white; most plants past flowering; plants with bulb to 2 cm wide | *D. Giblin #04-58 with B. Legler and D. Knoke* WTU |
| WA 8 | Douglas | Private (possibly Friends of Badger Mountain) | 01-Jun-1940, 18-Jun-1948 | Y | 1940: Badger Mt. 1948: Badger Mt., 12 miles south of Waterville | *grandiflora* | 1940: Open slopes 1948: Sagebrush flats | 1940: No information 1948: perianth blue | *J. William Thompson #14625* 1940 UTC; *C.L. Hitchcock #17431* 1948 RM |
| WA 9 | Douglas | Private (possibly Friends of Badger Mountain) | 17-Jun-1948 | Y | 13 miles north of Wenatchee on Badger Mt. | *grandiflora* | In deep loam | Flowering. Original id: *Brodiaea douglasii* determined by M. Barkworth 1974 | *C.L. Hitchcock #17394* WTU |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 10 | Ferry | Sherman Creek State Wildlife Recreation Area | 20-May-1995, 05-Apr-1954 | Y | 1995: Along Sherman Creek, about 4 miles west southwest of Kettle Falls and about 0.5 miles south of junction of highways 3 and 20<br>1954: Beetle colony #4; Washington State Game Dept. IERC | *grandiflora* | 1995: Flat benches on both sides of road, gravel bank of road cut west/ northeast exposure, ravine of creek; ponderosa pine flats, gravel pit, disturbed roadside, mixed forest creekside, 1,700 to 1,800 ft.<br>1954: Park, weed-browse vegetation type with Wheatgrass, goatweed, downy brome, Kentucky blue, beardless, Collinsia. Shallow rocky sandy loam at 2,400 ft. | 1995: Flowering<br>1954: Distributed throughout understory; moderately abundant. 4-6 in. tall, no forage value | *J. Wood #53* 1995 RM; *A.B. Evanko #ABE-266* 1954 RM. Two sub occurrences |
| WA 11 | Ferry | Private | 22-May-1956 | N | 1 mile south of Curlew Lake | *grandiflora* | Grass-forb vegetation type with Idaho fescue, yarrow, blue grass in sandy gravel, flat slope at 2,000 ft. | Blue-veined [flowers] | *W.F. Mueggler #56M5* RM |
| WA 12 | Ferry | USFS Region 6 Colville National Forest | 03-Jun-1995 | Y | Swan Butte, about 11 miles south southwest of Republic; northeast of Forest Road 5314 | *grandiflora* | Douglas fir/pinegrass mixed forest; rock outcrops. Elevation: 3,800 to 3,900 ft. | Flowering | *J. Wood #788* RM |
| WA 13 | Ferry | Private and possibly Bureau of Land Management | 20-May-1996 31-May-1996 | Y | 20 May: French Point, west bank of Columbia River, about 10 miles southwest of Kettle Falls<br>31 May: Barstow Flats on Kettle River, about 1 mile south southeast of Barstow store. Sub-occurrences over 4 contiguous sections | *grandiflora* | May 20: Ponderosa pine/pinegrass open forest to riverbank and rocky islands at 1,300 ft.<br>May 31: Riverbank and sandy flood plain with ponderosa pine; heavily infested with cheatgrass and *Poa bulbosa* at 1,300 ft. | Flowering | *J. Wood #3860* 20-May-1996 RM; *J. Wood #4376* 31-May-1996 RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 14 | Garfield | USFS Region 6 Umatilla National Forest | 28-Jun-1997 | Y | Scoggin Ridge. Mountain Road 2 miles south of Bartels Road. "Scoggin's Bone Yard" ca 1/2 mile north of National Forest Boundary. Blue Mountains | *grandiflora* | Slope to south side of road forested with ponderosa pine. Soil moist and rich. Elevation: 4,500 ft. / 1,371 m | Pale blue, 6 fused petals; 5-8 flowers branch from top of single 12-18 inch stem. 1 or 2 grass-like leaves. Bulbs 6-8 inches underground. Meadow under ponderosa pine. Original id: *Brodiaea douglasii* | *D. Williams #19 with R. Goff* WTU |
| WA 15 | Garfield | USFS Region 6 Umatilla National Forest | 29-Jun-1997 | Y | Forest road 46 near junction with road 4610. Below Forest Road 46 | *grandiflora* | Moist, shaded woods below open area adjacent to road. *Abies grandis*, *Acer glabrum*, *Ribes* sp., and *Symphoricarpos* sp. Open dry area. Elevation: 5198 ft. / 1,584 m | Pale blue flowers with darker blue veins. Flowering. Original id: *Brodiaea douglasii* | *T. Fuentes #61* WTU |
| WA 16 | Garfield | Undetermined | 28-Apr-1996 | N | Lower Granite Dam, between 0.5 and 2.5 miles south of dam on west side of river | N/A | Moist rocky soil beside a cliff associated with small ferns, grasses, Brassicaceae, Scrophulariaceae, Boraginaceae, Rosaceae, Apiaceae, and Saxifragaceae | No information | *J.C. Tague #26 with S. Stearns* RM |
| WA 17 | Grant | Private or state | 02-May-1931 | Y | Near Coulee City | N/A | Moist ravine in the sage-brush plains | No information | *J. William Thompson s.n.* PH |
| WA 18 | Grant | Undetermined | Apr-1973 | Y | Approximately 3 miles west of Vernita Bridge across river | N/A | No information | No information | BC accession no: CBD0043387 |
| WA 19 | Kittitas | Undetermined | 07-May-1938 | Y | 15 miles south of Ellensburg | *grandiflora* | Upper Sonoran Life Zone; grassy hillside | No information | *C.L. Hitchcock #3429 with J.S. Martin* RM |
| WA 20 | Kittitas | Undetermined | 22-May-1944 | Y | 10 miles northwest of Ellensburg on road to Teanaway Junction | N/A | Perianth pale blue midnerve bright robin-egg blue on rocky slope | No information | *C.L. Hitchcock and C.V. Muhlick #8161* UTC |
| WA 21 | Kittitas | Undetermined | 02-May-1897 | Y | 6 miles northwest of Ellensburg | N/A | No information | No information | *K. Whited s.n.* NEB |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 22 | Klickitat | U.S. Fish and Wildlife Service - Conboy National Wildlife Refuge | 23-May-2004 | Y | Conboy National Wildlife Refuge, along Glenwood Road 3.8 miles south of Glenwood | *howellii* | Open marshland, wet fields, and stands of *Populus tremuloides*. Elevation: 1,800 ft. / 548 m | Corolla tube light blue, sepals whitish, inner 3 not exserted or ruffled; plants scattered | *B. Legler #1643* WTU |
| WA 23 | Klickitat | Undetermined | 06-May-1997 | Y | Rock Creek | *howellii* | No information | No information | *E. Habegger #36* WTU |
| WA 24 | Klickitat | Undetermined | Jun-1879 | N | No details | *grandiflora* | No information | Original id: *Brodiaea howellii*. This is the type specimen | *T.J. Howell s.n.* (*W.N. Suksdorf s.n.* on same sheet) PH |
| WA 25 | Klickitat | Undetermined | 19-May-1967 | N | Along "High Prairie Road" 3 miles NE of Lyle | *howellii* | On open, grassy, basaltic cliffs | Plants with 2 basal leaves starting to wither by anthesis; perianth pale blue, the tepals alike, deeper bluish center-lined; filaments nearly equally inserted, but very unequal, all greatly broadened; anthers and pistil bluish | *C.L. Hitchcock #24510* RM |
| WA 26 | Klickitat (label states Clark) | Private | 06-Apr-1934 | Y | Top of grade from Roosevelt to Bickelton | *grandiflora* | Generally scattered in stony bunchgrass flat | No information | *F.L. Pickett*, *R.L. McMurray*, *and L.A. Dillon #1450* UTC |
| WA 27 | Klickitat (label states Clark) | Undetermined | 04-Apr-1934 | N | River road, Carley-Roosevelt | *grandiflora* | Along river and upland | No information | *F.L. Pickett*, *R.L. Murray*, *and L.A. Dillon #1416* UTC [duplicate specimen might be at IDS] |
| WA 28 | Lincoln | Undetermined | 20-Apr-1940 | Y | South side of Columbia River at Keller Ferry | *grandiflora* | Sandy bench | No information | *H.T. Rogers #297* PH, IDS, UTC |
| WA 29 | Lincoln | Private | 31-May-1952 | Y | Harrington Nursery | N/A | Grassland, weed-grass in Hesseltine Sandy Loam. With cheatgrass, Sandberg bluegrass, needlegrass, big sagebrush. Interspersed with other vegetation | Only occasional plant. Lavender flower color, 18-24 inches tall; flowering May and June. [Collected for USFS herbarium] | *A.B. Evanko #ABE-152* RM |
| WA 30 | Okanogan | Colville tribal land | 25-May-1978 | Y | Reserve near Kettle Falls | N/A | No information | No information | BC accession no. CBO0050583 |
| WA 31 | Skagit | Undetermined | 30-May-1937 | Y | Clear Lake | *grandiflora* | No information | No information | *R.C. Stillinger #54* UTC |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 32 | Spokane | Private | 05-Jul-1895, 03-May-1906, 24-May-1933 | Y | 1895 and 1906: Spokane, Washington<br>1933: Along highway, vicinity of Spokane | *grandiflora* | 1895 and 1933: No information<br>1906: In dry soil | No information | *Mrs. L. Tucker s.n.* 1895 PH; *J. Lunell s.n.* 1906 RM; *A. Nelson and R.A. Nelson #636* 1933 RM |
| WA 33 | Spokane | Likely private | 24-May-1893 | Y | Hangman Creek | N/A | Elevation: 1,570 ft. | Original id: *Brodiaea douglasii* | *J.H. Sandberg and J.B. Leiberg s.n.* PH |
| WA 34 | Spokane | Undetermined | Jun-1884 | N | Prairies | N/A | Prairies | Original id: *Brodiaea douglasii* | *W.N. Suksdorf s.n.* PH |
| WA 35 | Spokane | Spokane County | 04-Jun-1993 | Y | Valley Ford County Park, south of Spokane | *grandiflora* | Moist, open ponderosa pine woodland. Growing with grasses | Original id: *Brodiaea douglasii* | *S. Gage #G&R 909 with T. Leyens* WTU |
| WA 36 | Spokane | Undetermined | 23-May-1913 | N | Waitiki (?) | N/A | No information | Identified as *Hookera douglasii* | *G.W. Turesson s.n.* RM |
| WA 37 | Stevens | Spokane tribal land | 21-Apr-1940 | Y | East side of Columbia River 6 miles above mouth of Spokane River | *grandiflora* | Gravelly south slope | No information | *H.T. Rogers #307* UTC, IDS |
| WA 38 | Stevens | Undetermined | 21-Apr-1940 | Y | East side of Columbia River 6 miles above mouth of Spokane River | N/A | Gravelly south slope below 1,290 ft. | No information | *H.T. Rogers #307* PH |
| WA 39 | Stevens | Private | 21-May-1995 | Y | Columbia River Benches: about 5 road miles north of Cedonia on Wash Hwy 25. NE1/4 S5 | *grandiflora* | Bench and east riverbank on west side of road; *Pinus ponderosa*; silt/sand | Flowering | *J. Wood #126* RM |
| WA 40 | Stevens | Undetermined | 21-May-1995 | Y | Western Colville National Forest and Vicinity: Columbia River Benches: about 5 road miles north of Cedonia on Hwy 25 | *grandiflora* | Bench and east riverbank on west side of road; *Pinus ponderosa*; silt/sand | Flowering | *J. Wood #145* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 41 | Stevens | Spokane tribal land | 21-May-1995 | Y | Western Colville National Forest and Vicinity: east side of Columbia River, about 2.5 miles east of Daisy at the base of Gold Hill | *grandiflora* | West facing bench with small rocky outcrop and small seasonal creek; ponderosa pine and Douglas fir/ninebark, with birch and aspen in wetter area | Flowering | *J. Wood #181* RM; *J. Wood #193* RM |
| WA 42 | Stevens | Private or Federal land (Not USFS but agency not specified) | 07-Jun- 1995, 29-May-1996 | Y | 1995: Columbia River: China Bend: along north shore of river, about 9 miles southwest of Northport<br>1996: North shore of Columbia River at China Bend, about 9 miles SW of Northport; east bank of mouth of Flat Creek and 1 mile N along river bank. Occurrence in parts of 2 contiguous sections | *grandiflora* | 1995: Riverside and cliffs at 1,300 ft.<br>1996: Riverbank above and below flood line; sand, cobble patches, ponderosa pine at 1,300 ft. | Flowers and fruit | *J. Wood #1026* 1995 RM; *J. Wood #4330* 1996 RM |
| WA 43 | Stevens | Private | 22-May-1996 | Y | Bear Creek, west side of Columbia River, about 1.5 air miles west of Northport. Private land owned by Bear Creek Nursery | *grandiflora* | Mixed woods and shrublands with limestone outcrops overlooking the river | Flowering | *J. Wood #3991* RM |
| WA 44 | Stevens | U.S. Fish and Wildlife Service - Little Pend Oreille Wildlife Refuge | 27-May-1996 | Y | Pine savannah at intersection of Narcisse Road and Bear Creek Road on Little Pend Oreille Wildlife Refuge | *grandiflora* | Open ponderosa pine forest with pinegrass; small creek with aspen and birch | Flowering | *J. Wood #4274* RM |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 45 | Stevens | Private and maybe Bureau of Land Management | 04-Jun-1996 | Y | Tramway region of Huckleberry Creek drainage, about 3 air miles northwest of Waitts Lake; about 7 air miles southwest of Chewelah | *grandiflora* | Rock outcrops and bald ridges with occasional large Douglas fir and ponderosa pine; mixed woods in draws | Flowering | *J. Wood #4566 with S. Brock* RM |
| WA 46 | Stevens | U.S. Fish and Wildlife Service - Little Pend Oreille Wildlife Refuge | 23-Jun-1996 | Y | Little Pend Oreille Wildlife Refuge, about 6 air miles southeast of Colville; access from Buffalo-Wilson Rd. | *grandiflora* | Rolling terrain with ponderosa pine and smaller Douglas fir encroaching | Fruit | *J. Wood #4941* RM |
| WA 47 | Walla Walla | Private | 24-May-1944 | Y | 2 miles south of Walla Walla | *grandiflora* | Open grassland, *Agropyron-Stipa* association | No information | *C.L. Hitchcock and C.V. Muhlick #8263* UTC, RM |
| WA 48 | Whitman | Undetermined | 19-Apr-1936 | N | Granite Point 1 mile above Wawawai Snake River Canyon | *grandiflora* | Dry soil | No information | *S.S. Maxson #16* UTC |
| WA 49 | Whitman | Private | 18-Apr-1951 | Y | Along Wawawai Canyon 4 miles east of Wawawai | *grandiflora* | North facing slope. Road side | *Brodiaea douglasii* determined by M. Barkworth 1974 | *S.W. Harris #171* WTU |
| WA 50 | Whitman | Private | 01-Jun-1883, 06-May-1894, 10-May-1928 | Y | Pullman | *grandiflora* | 1928: Abundant in wet meadows and also under shades | 1928: Abundant in wet meadows and also under shades | *C.V. Piper s.n.* 1883 RM; *C.V. Piper s.n.* 1894 RM; *A.E. Fontamilla #951* 1928 PH |
| WA 51 | Unreported | Private | May-1914 | Y | Pullman | N/A | No information | No information | *J.E. Weaver s.n.* NEB |
| WA 52 | Whitman | Private | 02-Jun-1922 | Y | 5 miles east of Pullman | N/A | In moist land along bank of stream | No information | *C.S. Parker s.n.* NEB |
| WA 53 | Whitman | Private | 07-Jun-1993 | Y | Hillside east of Poe Asphalt Company, Pullman | *grandiflora* | No information | Original id: *Brodiaea douglasii* | *S. Gage #G&R 970 with T. Leyens* WTU |
| WA 54 | Whitman | Private, [or possibly in Kamiack Butte State Park] | 12-May-1928 | Y | Kamieck [likely Kamiack] Butte | N/A | Elevation: 3,000 ft. | No information | *G. Davis s.n.* PH |

**Table 2 (cont.).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 55 | Whitman | Private | 1924, 27-Apr-1935 | Y | 1924: Almota Canyon 1935: Almota Canyon above Almota | N/A | Dry south slopes upper Sonoran Zone. At approximately 600 ft. | *Brodiaea grandiflora* | *L. Constance, L. Machlis and B. Rogers #1047* UTC, PH, *and with R.C. Rollins* RM; BC Accession #CBO0050581 1924 |
| WA 56 | Yakima | Private | 16-Apr-1933 | Y | Cowiche Ridge, 6 miles west of Yakima | *howellii* | Rocky slope | Flowering. Determination #1: *Brodiaea bicolor* Suksd. Determined by M. Barkworth *Brodiaea howellii* 1974 | *F.A. Warren #1925* WTU |
| WA 57 | Yakima | Private or Department of Defense | 30-Apr-1974 | Y | 5 miles north of Yakima | *howellii* | No information | No information | BC Accession no: CBO0003780 |
| WA 58 | Yakima | Yakima tribal land | 18-May-1967 | Y | Approximately 12.5 miles north of Satus Pass | *howellii* | Sagebrush hills | Leaves strongly concave; perianth nearly all white, with blue mid-vein on tepals, to whitish based and blue-tepaled, to rather light blue all over; tube longer than tepals, inner and out tepals similar; filaments broadened, very unequal but both series freed at about the same level - no variation in this feature | *C.L. Hitchcock #24505* RM |
| WA 59 | Yakima | Yakima tribal land | 18-May-1967 | Y | Approximately 19.5 miles north of Satus Pass | *howellii* | Sagebrush-grassy hills | Perianth almost pure white, but tepals faintly blue-midveined to light blue, fading to somewhat deeper blue; anthers blue at anthesis; filaments all broad, very unequal in length but inserted at nearly same level; tepals alike, spreading at nearly same level; pistil blue | *C.L. Hitchcock #24508* RM |
| WA 60 | Unreported [Whitman] | Palouse Falls State Park (since June 3, 1951) | 30-Apr-1938 | Y | Palouse Falls | N/A | Bunchgrass prairies | Albino form | *R.F. Daubenmire #38411* RM |

**Table 2 (concluded).**

| State/ No/ | County | Management | Dates observed | Map | Location | Subspecies (if assigned)[1] | Habitat | Abundance and comments | Source[2] |
|---|---|---|---|---|---|---|---|---|---|
| WA 61 | Unreported | Undetermined | 28-Apr-1899 | N | Gulch No. 2 | N/A | No information | No information | *K. Whited s.n.* NEB |
| WA 62 | Unreported | Native American Tribal lands in 1811. Current management unknown | 1811 | N | Columbia Plains, America | N/A | No information | No information | *T. Nuttall s.n.* PH |
| WA 63 | Unreported | USFS Region 6 Colville National Forest | 10-May-1915 | N | Colville National Forest | *grandiflora* | In sandy loam at various altitudes "12 to 5,500 feet" | Good forage value; root eaten by Indians. Common name blue camas; identified as *Hookera douglasii* (S. Wats) Piper [Collected for USFS Herbarium] | *C.O. Reid #128* RM |

[1]N/A = not assigned

[2]Abbreviations of the herbaria cited above:

CHSC: Herbarium, Biological Sciences Department, California State University, Chico, California

ID: Stillinger Herbarium, Biological Sciences Department, University of Idaho, Moscow, Idaho

IDS: Herbarium-Biological Sciences Department, Idaho State Museum of Natural History, Idaho State University, Pocatello, ID

KANU: R. L. McGregor Herbarium, Bridwell Botanical Research Laboratory, University of Kansas, Lawrence, Kansas

MONT : Montana State University Herbarium Bozeman, Montana

MONTU: University of Montana Herbarium, Biological Sciences Division, Missoula, Montana

NEB: C. E. Bessey Herbarium, University of Nebraska State Museum, Lincoln, Nebraska

ORE: Herbarium, Biology Department, University of Oregon, Eugene, Oregon

OSC: Herbarium, Botany and Plant Pathology Department, Oregon State University, Corvallis, Oregon

PH: Herbarium, Botany Department, Academy of Natural Sciences, Philadelphia, Pennsylvania

RM: Rocky Mountain Herbarium, University of Wyoming, Laramie, Wyoming.

UTC: Intermountain Herbarium, Biology Department, Utah State University, Logan, Utah

WILLU: Morton E. Peck Herbarium, Willamette University, Salem, Oregon

WTU: University of Washington Herbarium, Burke Museum, University of Washington, Seattle Washington

### *Peer Review of This Document*

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This report was reviewed through a process administered by the Society for Conservation Biology, employing two recognized experts on this or related taxa. Peer review was designed to improve the quality of writing and to increase the rigor of the assessment.

## MANAGEMENT STATUS AND NATURAL HISTORY

### *Management Status*

*Triteleia grandiflora* has been reported in Washington, Oregon, northern California, Idaho, Wyoming, Utah, and southwestern Colorado in the United States and in British Columbia in Canada. It is a sensitive species in USFS Region 2, but not in USFS Regions 1, 4, or 6 (USDA Forest Service 2003b, 2005a). The Bureau of Land Management does not designate *T. grandiflora* a sensitive species in any state in which it occurs (USDI Bureau of Land Management 2000, 2002a, 2002b, 2005). *Triteleia grandiflora* is a sensitive species in Grand Teton National Park (USDI Fish and Wildlife Service and National Park Service 2005, Varga personal communication 2005) and in Yellowstone National Park (Whipple personal communication 2005).

NatureServe and state natural heritage and conservation programs rank taxa at state (S) and global (G) levels on a scale of 1 to 5. A ranking of 1 indicates the most vulnerable and 5 the most secure taxa (see Ranks in the **Definitions** section). The NatureServe (2005) rounded global rank for *Triteleia grandiflora* is apparently secure (G4). It is designated critically imperiled (S1) by the Colorado Natural Heritage Program and imperiled (S2) by the Wyoming National Diversity Database (Keinath et al. 2003, Colorado Natural Heritage Program 2005a, NatureServe 2005). *Triteleia grandiflora* occurs in Idaho, Montana, Oregon, Utah, and Washington, but it is unranked (SNR) in all of those states (Oregon Natural Heritage Information Center 2004, Alton personal communication 2005, Miller personal communication 2005, NatureServe 2005).

NatureServe (2005) and several other authorities recognize two varieties of *Triteleia grandiflora* while some authorities have elevated each variety to the full species level (see Systematics and synonymy section). The California Natural Diversity Database (2005) has designated *T. grandiflora* var. *howellii* critically imperiled (S1). In Canada, the British Columbia Conservation Data Center ranks *T. grandiflora* as apparently secure (S4) but designated *T. howellii* imperiled (S2) (British Columbia Species and Ecosystems Explorer 2003, Committee on the Status of Endangered Wildlife in Canada 2003). Conservation status ranks conferred by NatureServe or state natural heritage programs confer no regulatory status and serve only to indicate the apparent vulnerability of the taxon.

### *Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies*

There are no management plans that specifically address the conservation of *Triteleia grandiflora*. The majority of known *T. grandiflora* occurrences on public lands are in areas managed for multiple uses (**Table 1**, **Table 2**). Some occurrences are on private lands where land management is at the discretion of the owner.

Within the states in USFS Region 2, *Triteleia grandiflora* is known from one occurrence in Colorado and approximately 16 occurrences in Wyoming. On National Forest System land within Region 2, *T. grandiflora* is known from two locations, and only one of those is extant. This occurrence (CO-1 in **Table 1**) was found in 1998 on the San Juan National Forest in Colorado and has been revisited periodically (Gildar personal communication 2005, Stewart personal communication 2005). Since *T. grandiflora* was listed as a Region 2 sensitive species in 2003, maintaining the viability of this occurrence has been considered in management of that area. The only other occurrence reported from National Forest System land in Region 2 was observed in 1929 on the Medicine Bow National Forest in Wyoming (WY-1 in **Table 1**). The status of this occurrence is unknown, and there have been no surveys for *T. grandiflora* on that national forest (Proctor personal communication 2005).

In Wyoming, approximately seven occurrences of *Triteleia grandiflora* are known from Yellowstone and Grand Teton national parks. The National Park Service generally manages these lands for their scenic or historical significance. Logging, mining, and other activities allowed in national forests are usually prohibited in national parks (Environmental Media Services 2001). *Triteleia grandiflora* is a species of special concern in Grand Teton National Park and as such is considered in park planning (USDI Fish and Wildlife Service and National Park Service 2005, Varga personal communication 2005). *Triteleia grandiflora* is considered a species of concern in Yellowstone National Park, and occurrences have been visited periodically over the last decade to check their condition (Whipple personal communication 2005). The status of the occurrences in Yellowstone National Park is uncertain but appears to be declining (Whipple personal communication 2005). One occurrence has apparently been replaced by aggressive weed species that invaded the site after an adjacent area was developed into a parking lot (Whipple personal communication 2005).

*Triteleia grandiflora* is known from several locations on National Forest System land in Region 4, which includes parts of Wyoming, Utah, and Idaho. In 2000, it was evaluated for designation as a forest watch species and as an addition to the Region 4 sensitive species list (Prendusi personal communication 2005). According to Forest Service Manual 2670.22, a "watch species" is any species recognized by a Forest Supervisor that is either not known to occur on National Forest System land but is predicted to occur there on the basis of suitable habitat, or is known to occur on National Forest System land but has no immediate or predicted threats to population viability. One significant benefit derived from a sensitive or watch list status is that the taxon is specifically targeted during surveys and occurrences are recorded if found. This information facilitates the evaluation of a taxon's range, abundance, and the past and present impacts to the populations. Currently, *T. grandiflora* has neither sensitive nor watch list status in Region 4 since there was no consensus among various authorities (e.g., heritage programs and federal agencies) to consider it a species of conservation concern (Prendusi personal communication 2005).

Although *Triteleia grandiflora* is not designated a sensitive species in Region 4, the taxon was included in a review of sensitive species occurring on National Forest system land in Region 4 because the Wyoming Natural Diversity Database designates it imperiled (Fertig 1998, Fertig 2000). Possibly for the same reason, the Bridger-Teton National Forest is the only national forest in Region 4 that informally tracks *T. grandiflora* (Pioneer Environmental Services Inc. 2000, Hanson personal communication 2005, Lehman personal communication 2005, Ozenberger personal communication 2005). Conservation of *T. grandiflora* was specifically considered in the Environmental Assessment (EA) prepared before the Jackson Hole Mountain Resort was permitted to offer guided backcountry skiing (Bridger-Teton National Forest 2004).

Within the range of *Triteleia grandiflora*, at least three occurrences (WA-22, WA-44, and WA-46 in **Table 2**) are known from national wildlife refuges managed by the U.S. Fish and Wildlife Service. The National Wildlife Refuge System focuses on wildlife conservation; any recreational uses are required to be compatible with that mission, but hunting is allowed. Conservation of threatened and endangered species has become a major objective of refuge management programs, but because *T. grandiflora* has no federal status, it will not be considered in refuge management.

At least two *Triteleia grandiflora* occurrences outside Region 2 are in wilderness areas (e.g., ID-82 and ID-83 in **Table 2**). Under the Wilderness Act of 1964 (16 U.S.C. 1131-1136, 78 Stat. 890 - Public Law 88-577, September 3, 1964) wilderness is defined as "…an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions…" Although Congress has granted exemptions, commercial activities, motorized access, roads, bicycles, structures, and facilities are generally prohibited in wilderness areas. In addition, the size of visitor groups may be limited in some circumstances, which moderates the potential for intense disturbance.

## *Biology and Ecology*

### Classification and description

#### *Systematics and synonymy*

*Triteleia*[1] is a genus of the Liliaceae, commonly known as the lily family (Pires 2002, USDA Natural Resources Conservation Service 2005). The Liliaceae is a very large family of monocotyledonous plants. Evidence strongly supports dividing this extensive family into a series of smaller, more homogenous families (Rudall et al. 1995, Angiosperm Phylogeny Group 1998, Wilson and Morrison 2000). Approximately 30 segregate families have been

[1]The genus name of *Triteleia* is derived from the Greek *tri*- (meaning three) and *teleios* (meaning terminus) referring to the minutely three-lobed stigma (Weber and Wittmann 2001). Scholars may argue about the meaning of *teleios* as in some contexts it is translated as meaning perfect, finished, or complete (Arndt and Gingrich 1957). This too seems an appropriate way to describe the attractive inflorescence (**Figure 1**). The specific epithet, *grandiflora*, must reflect its large and handsome inflorescence.

recognized within Cronquist's (1981, 1988, 1993) very broadly circumscribed Liliaceae, but not all of them are universally accepted (Utech 2002). Greene (1886) pointed out that one challenge to working with members of the Liliaceae was that herbarium specimens were often difficult to study because the very delicate flowers and stems, which have vital taxonomic characters, are difficult to preserve during the drying process. Since many taxonomists must work primarily from dried specimens, this poses a problem.

The genera *Triteleia*, *Bloomeria, Brodiaea, Androstephium, Dichelostemma, Milla, Muilla*, and *Triteleiopsis* have variously been placed in the Liliaceae (Greene 1886, Cronquist 1981), Amaryllidaceae (Niehaus 1971, Traub 1972), Alliaceae (Dahlgren et al. 1985), and Themidaceae (Salisbury 1866, Fay and Chase 1996). The Themidaceae is based on *Themis ixioides*, now *Triteleia ixioides* (Fay and Chase 1996). Dorn (2001) accepted this latter treatment and placed *Triteleia* in Themidaceae in the most recent Wyoming flora. In the most recent Colorado Flora, Weber and Wittmann (2001) accepted the treatment of Dahlgren et al. (1985) and placed *Triteleia*, along with *Allium* and *Androstephium*, in the Alliaceae (onion family). Utech (2002) retains *Triteleia* in the Liliaceae. The most current supra generic name updates can be referenced in the *Index Nominum Supragenericorum Plantarum Vascularium* Project (see **References** section for Web site address).

The 12 genera that comprise the Themidaceae have historically been split into two complexes (Moore 1953). Five genera have been placed in the *Milla* complex (*Milla, Bessera, Dandya, Jaimehintonia*, and *Petronymphe*) that is centered in Mexico, while seven genera (*Androstephium, Bloomeria, Brodiaea, Dichelostemma, Muilla, Triteleia*, and *Triteleiopsis*) have been placed in the *Brodiaea* complex that is centered in California. (Pires 2000). For more than a century, the affinities of taxa within the *Brodiaea* complex have been the subject of controversy and debate (Baker 1871, Green 1886, Piper 1906, Abrams 1923, Jepson 1925, Munz 1959, Niehaus 1971, 1980). As early as 1886, Greene indicated that there were differing opinions as to how the taxa should be treated, and he may have illustrated the sentiments of many taxonomists when he wrote an article entitled "Some genera which have been confused under the name *Brodiaea*" (Greene 1886).

The relationships among all seven genera within the *Brodiaea* complex (*Androstephium, Bloomeria, Brodiaea, Dichelostemma, Milla, Muilla, Triteleia*, and *Triteleiopsis*) have been the subject of several cladistic analyses (Hoover 1941, Pires 2000). Although *Triteleia* and *Brodiaea* species have been combined under *Brodiaea* in the past (Jepson 1925, Peck 1961, Hitchcock and Cronquist 1973), it is currently accepted that the two genera are clearly separate (Pires 2002). The National Center for Biotechnology Information (2001) published some information on specific gene sequences in *T. grandiflora*.

*Triteleia grandiflora* is the type species of the genus (Hoover 1941, Pires 2002). Several authorities recognize the treatment that maintains two subspecies of *T. grandiflora*, ssp. *howellii* and ssp. *grandiflora* (Integrated Taxonomic Information System 2005, NatureServe 2005, USDA Natural Resources Conservation Service 2005). Some authorities recognize ssp. *howellii* as a full species, *T. howellii* (Barkworth 1977b, Pojar 2001, Douglas et al. 1994, 2001, Committee on the Status of Endangered Wildlife in Canada 2003). More information on *T. howellii* can be found in the Appendix of this assessment. Hitchcock and Cronquist (2001) treat the taxon as *Brodiaea howellii* after Watson (1879b). Apparently, some of the characteristics that distinguish the two subspecies are variable, and individuals that represent intergrades have been found (Hoover 1955, Pires 2002). These observations led Pires (2002) to suggest that infraspecific divisions are not warranted. Barkworth (1977b), who maintained the two species and treated them at the time as *B. douglasii* and *B. howellii*, found that they had different and distinct pigment profiles when methanol flower extracts were analyzed by two-dimensional chromatography. The differences were not related to flower color (Barkworth 1977b).

The many synonyms for *Triteleia grandiflora* may reflect the interest in the complex as well as the difficulty of satisfactorily classifying the species within it. Synonyms and relevant publications for the authorship of the binomials and trinomials are listed in **Table 3**. It may be that *Brodiaea bicolor* is also synonymous with the form assigned to subspecies *howellii*. Suksdorf (1902), who described *B. bicolor* as a new species from Klickitat in Washington, placed it in synonymy with *B. howellii* var. *lilacina*.

When considering historical records, it is important to note that there are two taxa that are not synonyms but may be mistakenly attributed to *Triteleia grandiflora*. *Brodiaea grandiflora* as described by Smith (e.g., "*B. grandiflora* Smith" specimens collected by both *J. Torrey s.n.* PH and *J.H. Redfield #368* PH in 1872 in Yosemite, California) is synonymous with *B.*

**Table 3.** Synonyms of *Triteleia grandiflora* Lindley and their authors, according to Pires (2002).

| Synonym | Author reference |
|---|---|
| *Brodiaea bicolor* Suksdorf | Suksdorf (1902) |
| *Brodiaea douglasii* S. Watson | Watson (1879a) |
| *Brodiaea douglasii* var. *howellii* (S. Watson) M. Peck[1] | in Pires (2002) |
| *Brodiaea grandiflora*[2] (Lindley) J. F. Macbride | Macbride (1918) |
| *Hookera bicolor* (Suksdorf) Piper | Piper (1906) |
| *Hookera douglasii* (S. Watson) Piper | Piper (1906) |
| *Hookera grandiflora* (Lindley) Kuntze | Kuntze (1891) |
| *Hookera howellii* (S. Watson) Piper | Piper (1906) |
| *Milla grandiflora* (Lindley) Baker | Baker (1871) |
| *Triteleia bicolor* (Suksdorf) A. Heller | Heller (1910) |

[1]*B. grandiflora* var. *grandiflora* and *B. grandiflora* var. *howellii* were new combinations in Peck (1961)

[2]*B. grandiflora* in Smith (1811) is not synonymous with *Triteleia grandiflora* Lindley

*coronaria* (Hooker 1830). The collection details of the isotype of a variety of *B. grandiflora* Smith, collected by K.T. Hartweg (*s.n.*, no date) in California is on the New York Botanical Garden Herbarium (2003) web site. It should also be noted that *Milla bicolor* is not a synonym for either *T. bicolor* or *B. bicolor*.

### *History of species*

*Triteleia grandiflora* is believed to have been first collected at The Dalles along the Columbia River in Wasco County, Oregon, on 17 April 1806 by the Lewis and Clark Expedition (OR-28 in **Table 2**; Reveal et al. 1999). An additional specimen was collected on 20 April 1806 at Celilo Falls, Klickitat County, Washington (Reveal et al. 1999). *Triteleia grandiflora* was commonly referred to as wild hyacinth at the time (Reveal et al. 1999), but this common name has also been applied to *Leucocrinum montanum* (Chesnut and Wilcox 1901). This shared common name may confuse interpretation of anecdotal historical records with regard to range and palatability issues of the two species (Chesnut 1898/1899, Chesnut and Wilcox 1901).

John Lindley, a professor of botany at the University of London in Britain, first published the description of *Triteleia grandiflora* from a live specimen "growing in the Garden of the [British] Horticultural Society, where it flowers in July" (Lindley 1829). Mr. David Douglas had collected the original specimen in "North-west America" naming the specimen, *Triteleia*, in his notes (Hooker 1831). Apparently, Douglas had transported viable corms or seed, as well as an herbarium specimen, to Britain where they were grown successfully.

In Region 2, *Triteleia grandiflora* appears to have been first collected from Platte County, Wyoming, in August 1929 (*F.B. Wann #8* UTC, WY-1 in **Table 1**). The taxon is very rare in this area, and this occurrence would represent the eastern edge of its range in Wyoming. Currently, occurrences are known to be extant only in Teton County, Wyoming (Wyoming Natural Diversity Database 2005a, 2005b). The status of the Lincoln County occurrence (WY-2 in **Table 1**) is unknown. *Triteleia grandiflora* was discovered in 1998, in southwestern Colorado by Leslie Stewart (CO-1 in **Table 1**; Colorado Natural Heritage Program 2005b).

### *Non-technical description*

*Triteleia grandiflora* is an herbaceous perennial plant. The stems and leaves grow from fibrous-coated bulb-like structures known as corms. The following description is derived from Hoover (1941), Stevens (2001 onwards), Pires (2002), and Skinner (2005). Each plant has one or two basal leaves that have narrow lance-shaped blades that are 20 to 70 cm long and 4 to 10 mm wide. The flowering stem is erect, cylindrical in shape, 20 to 75 cm tall, 1 to 5 mm in diameter, and topped by a cluster of flowers. Each flower consists of six whitish to blue, vase-shaped to narrowly bell-shaped, fused segments forming a 1.5 to 2 cm long tube. The corolla lobes, which are about as long as the tube, are in two spreading, petal-like whorls. In the outer whorl, the three lobes are broadly lanceolate, whereas the inner three lobes are oblong-egg-shaped and all are slightly ruffled. Each flower has six stamens that usually curve away from the stigma. The stamens are attached alternately at two-levels. The filaments are slender, somewhat triangular, 1 to 4 mm long, and apical appendages may be present or absent. The anthers are colored yellow or purple. The style is 2 to 4 mm long and the stigma weakly 3-lobed. The fruit consists of a stalked, egg-shaped capsule containing rounded seeds that are ridged on one side. The seeds are black when mature. **Figure 1** is a photograph of a pale flower colored individual; **Figure 2** is a photograph of an individual whose flowers are darker in color.

Features of the androecium, particularly stamen height, filament length, and insertion relative to the perianth, and the presence of apical filament appendages


**Figure 1.** Photograph of a pale-colored *Triteleia grandiflora* flower. Inset shows close-up of flower. Photographs courtesy of Ben Legler, University of Washington Herbarium, used with permission.

**Figure 2.** Photograph of *Triteleia grandiflora* growing in Utah. Photograph courtesy of Teresa Prendusi, USDA Forest Service Region 4.

are among the most important diagnostic characters within *Triteleia* (Pires 2002). These characters are easily seen in the field with a hand lens (Pires 2002). When collecting flowering specimens, Pires (2002) notes that one should make a point of mounting a few dissected flowers in a manner that displays these critical characters. *Triteleia grandiflora* is very uniform throughout its range outside of the west coast of North America where *T. grandiflora* ssp. *howellii* occurs (Hoover 1955, Barkworth 1977a). Variability in plant size within *T. grandiflora* can largely be attributed to ploidy level; polyploid plants are generally larger than their diploid progenitors (Barkworth 1977a, 1977b).

### *References to technical descriptions, photographs, and line drawings*

A detailed technical description and a line drawing of *Triteleia grandiflora* can be found in Pires (2002). Other technical descriptions are published in Greene (1886), Peck (1961, under *Brodiaea*), Mansfield (2000), Dorn (1984), Dorn (2001), and Weber and Wittmann (2001). An illustration and a description are also in Taylor (1974), Cronquist et al. (1977), Hitchcock and Cronquist (2001, under *Brodiaea*), and Pojar (2001). A photograph and description of *T. grandiflora* are in Kershaw et al. (1998) and Earle (2001), and as *B. grandiflora* in Rickett (1971, 1973) and Jolley (1988).

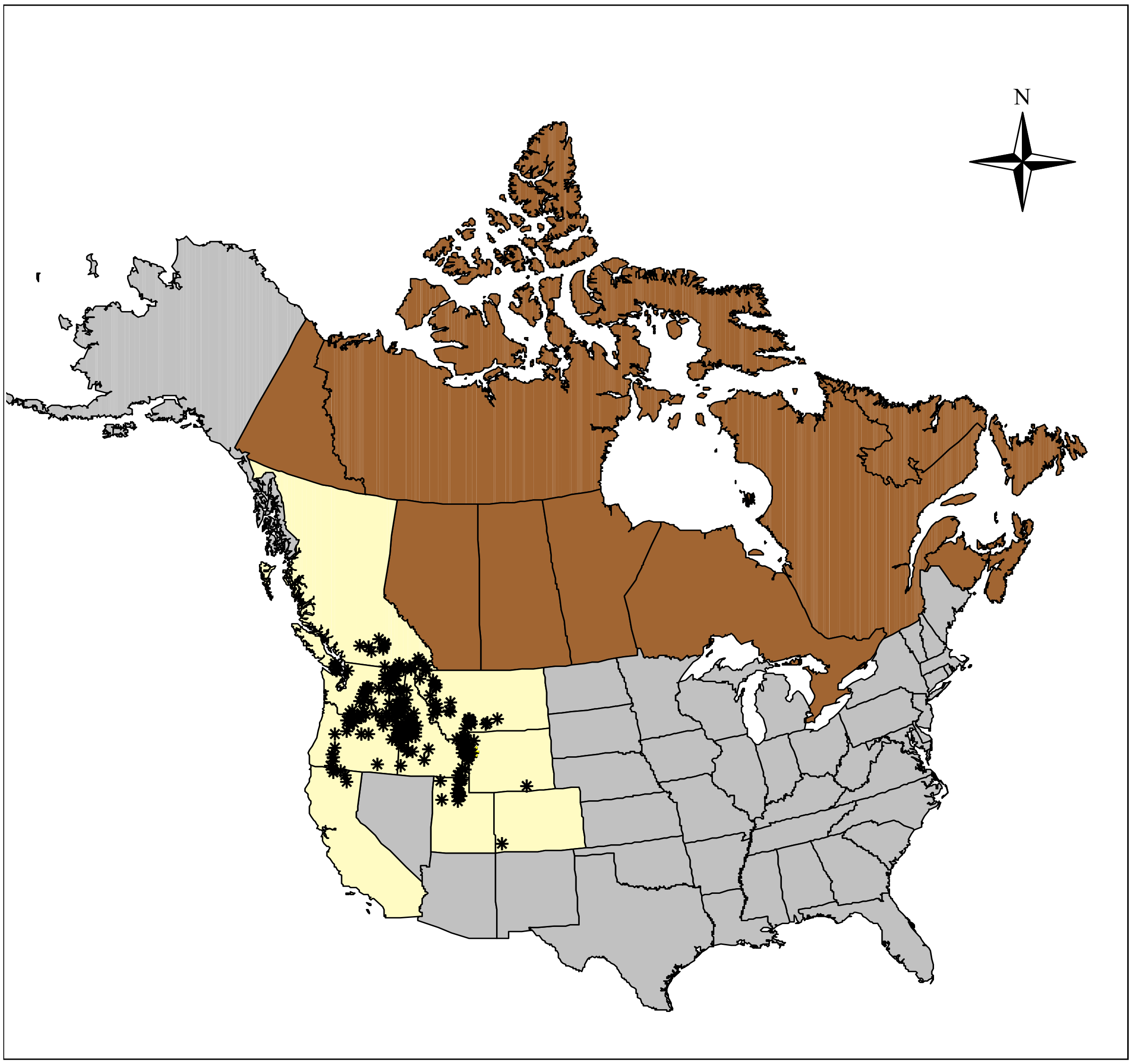
### Distribution and abundance

*Triteleia* species are widely distributed west of the Rocky Mountains, but the geographical center of the genus' distribution and the area with the highest level of endemism is in the Klamath area of southwestern Oregon and northwestern California (Hoover 1941, Pires 2002). *Triteleia grandiflora* has been reported from British Columbia in Canada, and Washington, Oregon, California, Idaho, Utah, Montana, Wyoming, and Colorado in the United States (**Table 1**, **Table 2**).

Most of the occurrences in **Table 1** and **Table 2** are plotted on the maps in **Figure 3** and **Figure 4**. Some occurrences were not plotted because of insufficient information to estimate even approximate coordinates. The non-plotted occurrences include WY-16 (**Table 1**) and those marked with an N in the "Map" column in **Table 2**.

Only one occurrence of *Triteleia grandiflora* has been documented in Colorado. It is located on the San Juan National Forest in Montezuma County (CO-1 in **Table 1**), where 700 to 2,000 individuals are distributed over approximately 10.8 ha. In 2005, surveys for *T. grandiflora* were completed on an additional 445 ha in the San Juan National Forest, but no additional occurrences of the taxon were found (Gildar personal communication 2006).

In Wyoming, one of the known *Triteleia grandiflora* occurrences is located on National Forest




**KEY:**

* ***Triteleia grandiflora* occurrences**

**Figure 3.** Global range of *Triteleia grandiflora*. *Triteleia grandiflora* occurs in the states and provinces shaded yellow; otherwise the Canadian provinces are shaded brown and the United States is shaded gray.

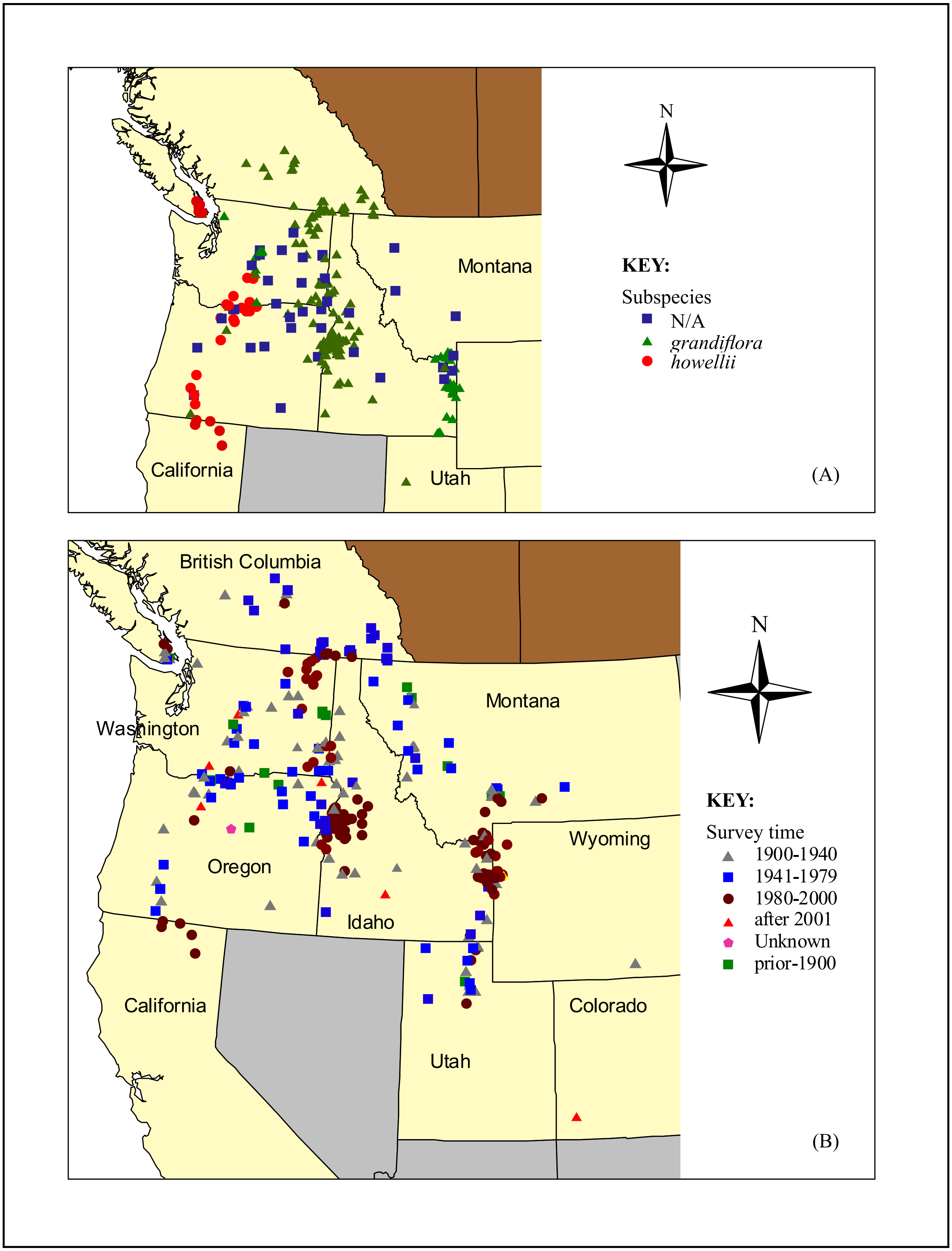



**Figure 4.** Distribution of *Triteleia grandiflora* by (A) subspecies and (B) date of observation.

System land managed by Region 2, eight occurrences are on land managed by USFS Region 4, and eight occurrences are located on land managed by either the National Park Service or private landholders. The Wyoming occurrence in Region 2 (WY-1 in **Table 1**) may no longer be extant. However, no searches have been made for *T. grandiflora* on the Medicine Bow National Forest (Proctor personal communication 2005), so it is possible that it has been overlooked. *Triteleia grandiflora* occurrence sizes in Wyoming range from an isolated individual (WY-14 in **Table 1**), six to ten individuals (WY-15 in **Table 1**), to more than 200 individuals (WY-6 in **Table 1**). More details about the distribution of *T. grandiflora* and *T. howellii* outside of Region 2 are in **Appendix**.

The Wyoming and Colorado *Triteleia grandiflora* occurrences vary in numbers of individuals between years but suggest that the approximate size of an occurrence is maintained over time. For example, at a small occurrence (WY-15 in **Table 1**), six individuals were counted in 1992 and just over 10 individuals were counted in 1993, whereas the population in Colorado was estimated to be 1,500 to 2000 in 1998 and 700 to 1,000 in 2004 (CO-1 in **Table 1**). Based on these observations, one might expect that the numbers of plants at a given occurrence will remain within the same order of magnitude over time. However, monitoring is needed to determine if the number of flowering stalks is a good indication of the number of corms (plants below ground) and how widely the numbers of plants sending up stalks in any given year can vary.

The paucity of information across much of the range of *Triteleia grandiflora* makes it difficult to make meaningful generalizations regarding its overall abundance. However, considering all the available *T. grandiflora* records, it seems clear that the numbers of plants in occurrences varies widely. Recorded comments include "Abundant in wet meadows and also under shades" (WA-50 in **Table 2**), "Wide distribution, not abundant" (ID-113 in **Table 2**), "Sparse abundance" (ID-85 in **Table 2**), and "Scarce abundance" (UT-7 in **Table 2**). More quantitative observations have ranged from "only a few plants (10+)" to an estimate of several thousand individuals within an occurrence (CO-1 in **Table 1**). Since individuals tend to be scattered singly or in patches, estimating the number per occurrence without making a comprehensive survey of the whole area may be difficult. This kind of patchy distribution with widely varying densities can easily lead to either over- or underestimates of abundance, depending upon whether the sparser or denser patches happen to be sampled. In addition, apparent abundance at a site can vary from year to year without a change in the actual numbers of individuals, because the corms do not always send up a flowering stalk every year.

Most of the *Triteleia grandiflora* occurrence information in **Table 1** and **Table 2** is derived from herbarium specimens or from relatively casual observations, which do not provide quantitative information on the abundance of plants or the spatial extent of each occurrence. There is even less information available for assessing the current status of populations. One definition of a population, and one that can be equated with occurrence in this assessment, is that it is "a group of individuals of the same species that occurs in a given area" (Guralnik 1982). A more restrictive definition is that a population is "a group of individuals of the same species living in the same area at the same time and sharing a common gene pool or a group of potentially interbreeding organisms in a geographic area" (National Oceanic and Atmospheric Administration 2004). Without knowing the precise seed dispersal range and pollination biology of *T. grandiflora*, it is not possible to delineate what comprises a single interbreeding population. Knowing the number and structure of populations delineated by this more restrictive definition is most useful for conservation planning purposes, but its application to *T. grandiflora* is not appropriate until more information about the biology and ecology of the species is available.

*Triteleia grandiflora* tends to grow in patches, and one occurrence of the taxon may consist of several sub-occurrences. In this report, occurrences encompass plants that are either solitary or within patches (sub-occurrences) separated by apparently suitable or potential habitat. In some cases, occurrence delineation was limited by not knowing the habitat conditions between occurrences; for example, WY-13 may be more accurately viewed as a sub-occurrence of WY-2 in **Table 1**. In other cases, there may be insufficient location information associated with the occurrence report to identify exactly where it is situated. This is especially true among older reports where location descriptions are minimal or vague. Similarly, a site may have been revisited, but due to imprecise location information in the reports, it has been designated a unique occurrence. For example, MT-6, MT-9, and MT-10 in the Bridger Mountains (**Table 2**) may all be in the same area. Another factor to consider in re-locating older occurrences is that due to changes in the size of urban areas, location relative to the distance from a town or city also changes over time.

The isolation of the *Triteleia grandiflora* occurrence in the San Juan National Forest in Montezuma County, Colorado prompted Weber and Wittmann (2001) and others (Stewart personal communication 2005) to suggest that Native Americans may have introduced the taxon at some historic time. There is archaeological evidence of a Ute encampment near the *T. grandiflora* occurrence. However, no occurrences of *T. grandiflora* have been found near other Native American sites, so a purposeful introduction appears to be a relatively remote possibility. It is possible that *T. grandiflora* corms or seed were carried by chance and inadvertently dropped. The hypothesis that Native Americans introduced the taxon into Colorado requires further study.

Disjunctions are not uncommon, and many plant and animal species occur in both the Pacific coastal ranges and the Rocky Mountains (Daubenmire 1978, Ogilvie 1998, Marcot et al. 2003, Klaus and Beauvais 2004). Several hypotheses, all of which need to be tested, attempt to explain this type of distribution (Brunsfeld et al. 2001). Daubenmire (1978) discussed the pattern of coastal species with disjunct occurrences in the interior and suggested that the "coastal element" was originally a widespread mesophytic group of species, ranging from the coast throughout the interior. Following the uplift of the Cascade Mountains and the formation of arid rain shadow conditions in the interior, most of this mesophytic flora was eliminated except west of the Coast-Cascade Mountains and a few disjunct occurrences in the moister parts of the interior (Daubenmire 1978).

Although there are some data to support the persistence of multiple refugia during past epochs, paleobotanical data are few (Brunsfeld et al. 2001). More phylogeographic research is necessary to understand the principles and processes that determine the geographic distributions of closely related genotypes. An example of disjunction that is particularly relevant to *Triteleia grandiflora* is that of *Hesperochiron pumilis*, which also occurs primarily in the northwestern United States east of the Cascade Mountains (Hitchcock and Cronquist 2001) but is known from old records from southwestern Colorado (Weber and Wittmann 2001). Other examples of disjunction include a population of the fern *Adiantum capillus-veneris*, which occurs at Fairmont Hot Springs in British Columbia 900 km north of the northern edge of the range of its other occurrences, and the forest forb *Dicentra cucullaria* that occurs in east-central North America and again west of the Rocky Mountains (Daubenmire 1978). The converse disjunct pattern also exists; there are several examples of species (e.g., *Juniperus scopulorum, Lonicera utahensis, Stipa nelsonii*, and *Opuntia fragilis*) with disjunct occurrences in the drier southeastern parts of Vancouver Island and the Gulf Islands, while the main part of their range is in the mountains of the dry interior (Ogilvie 1998).

### Population trend

The data in the literature, associated with herbarium specimens, or at the state Natural Heritage Programs are insufficient to determine accurately long-term population trends for *Triteleia grandiflora*. Just as there are few quantitative data for current occurrences, there is little information on past abundance. At least 30 *T. grandiflora* occurrences in Idaho, 28 in Washington, 29 in Montana, 20 in Oregon, 11 in Utah, and four in Wyoming were reported prior to 1960. Judging from the number of historic occurrences, *T. grandiflora* appears to have been a relatively common species within its range, sometimes locally abundant but in other areas, it may have always existed in low numbers. Historically, *T. grandiflora* must have been abundant on the Colville National Forest, USFS Region 6, since it was described as providing good forage there (Dayton 1960). *Triteleia grandiflora* appears to remain a commonly encountered taxon near the Colville National Forest, but its abundance within the national forest is less well documented (**Table 2**).

Some occurrences of the form assigned to *Triteleia grandiflora* ssp. *howellii* (see Systematics and synonymy section) have been extirpated in California, southwestern Oregon, and British Columbia (Pires 2002, Douglas and Penny 2003, British Columbia Conservation Data Center 2005, California Native Plant Society 2005). *Triteleia grandiflora* has probably been extirpated from southern Vancouver Island, British Columbia (Pojar 2001). Urbanization may have led to the extirpation of several more *T. grandiflora* occurrences (e.g., in the greater Salt Lake City, Utah [UT-1, UT-2, UT-13, UT-16, and UT-20 in **Table 2**], the Walla Walla Washington [WA-47 in **Table 2**], the Missoula, Montana [MT-25, MT-26, and MT-28 in **Table 2**] ,and the Spokane, Washington [WA-32, WA-33, WA-34, and WA-35 in **Table 2**] metro areas). A golf course is now near the 1893 Hangman Creek occurrence near Spokane, Washington (WA-33). In addition to direct urbanization, considerable habitat loss and fragmentation have occurred due to highway expansion, resource extraction, and recreational use throughout this species' range. Since the corms are very palatable, the effects of intense livestock grazing, especially by sheep in the mid to late nineteenth and early part of the twentieth centuries, may have been substantial (Chesnut and Wilcox 1901; see Community ecology and Threats sections).

Few records of *Triteleia grandiflora* exist in Wyoming and Colorado (**Table 1**). The occurrences in these states represent the eastern edge of its range. The number of extant occurrences in the states of Region 2 appears to be in decline. Two records exist in Yellowstone National Park; one of these consists of only one plant and is considered a sub-occurrence of a larger occurrence on the Targhee National Forest (WY-14 in **Table 1**). The status of the Yellowstone occurrences (WY-14 and WY-15 in **Table 1**) is not known definitively, but they are likely to be extirpated (Whipple personal communication 2005). No *T. grandiflora* plants have been observed at either site in the last five years. A visitor development project has highly impacted the occurrence on a slope above the thermal area at West Thumb (WY-15 in **Table 1**). The adjacent area is now a parking lot, and non-native weeds have invaded the area (Whipple personal communication 2005). The status of the occurrence in the Medicine Bow National Forest is unknown, but *T. grandiflora* has not been collected on that forest in recent times (Proctor personal communication 2005).

The *Triteleia grandiflora* occurrence on the San Juan National Forest was first found in 1998, and there are insufficient data to determine any trends. The population on this forest has been relatively stable between 1998 and 2005, and fluctuations in the number of stems observed between years can be attributed to environmental conditions (Stewart personal communication 2005). Since a corm does not send up a flowering stem each year, long-term annual monitoring is required to determine statistically significant trends in species abundance.

## Habitat

The only known extant *Triteleia grandiflora* occurrence in Region 2 (CO-1 in **Table 1**, **Figure 5**) is in a *Pinus ponderosa* (ponderosa pine) - *Quercus gambelii* (Gambel oak) community, where the pines are less than 80 years old (Stewart personal communication 2005). *Triteleia grandiflora* plants are found in patches in open to partially shaded areas. At this occurrence, the total tree canopy cover is approximately 30 percent, shrub canopy cover is approximately 30 percent, forb canopy cover is approximately 40 percent, grass and grass-like plants cover is approximately 25 percent, moss and lichen cover is approximately 3 percent, and bare ground is approximately 10 percent (Stewart 1998).

Range-wide, *Triteleia grandiflora* grows between 100 and 3,000 m (Pires 2002). The occurrence in Colorado is at approximately 2,366 m elevation (Lyon 2004), and occurrences in Wyoming have been reported between 1,713 and 2,377 m.

*Triteleia grandiflora* is reported to grow in full sunlight to partial shade in meadows, grasslands, sagebrush, pinyon-juniper woodlands, aspen woodlands, pine forests, and scattered woodlands (Pires 2002; **Table 1**, **Table 2**). Within these communities, *T. grandiflora* grows in a wide range of habitat types (**Table 1**, **Table 2**). Some habitats have been loosely described as being "very dry" while others "very wet." The variability of habitat conditions ranges from bogs and marshes to rocky dry pastures and hard, dry, baked ground (compare WY-4, WY-6, WY-11, and WY-13 in **Table 1** and compare OR-6, OR-13, OR-16, and OR-30 in **Table 2**). *Triteleia grandiflora* has been found on level ground and steeply inclined slopes. The taxon also appears to grow on sites facing any compass direction, but those with westerly and southerly aspects appear most common. Plant taxa associated with *T. grandiflora* are listed in **Table 4**.

*Triteleia grandiflora* is often associated with rocky and gravelly sites, but it may also grow in loam or clay soils. Soils in which it grows have been variously described as alluvial, sandy, sandy loam, cobbly sandy loam, and as having a high shale or clay component (**Table 1**, **Table 2**; Douglas and Penny 2003, Colorado Natural Heritage Program 2005b, Wyoming Natural Diversity Database 2005a). The most commonly reported parent material in Idaho is basalt, a volcanic rock. In the Colorado occurrence, *T. grandiflora* grows in soil derived from sandstone (Stewart personal communication 2005), specifically the Jemco series of fine-loamy, mixed, superactive, frigid Typic Haplustalfs (Stewart personal communication 2005). The historic occurrence on the Medicine Bow National Forest in Wyoming was probably on soils derived from sedimentary or volcanic rocks (Love and Christiansen 1985).

The varied range of habitats occupied by *Triteleia grandiflora* plants may be partly a reflection of the variation in the taxon's ploidy level (see Reproductive biology and autecology section). Barkworth (1977a) reported that polyploids and diploids of *T. grandiflora* generally occupy different habitats. Polyploid populations of *T. grandiflora* tended to grow on steep hillsides, road banks, and other sites where soil was unstable. Diploid populations tended to occupy flatter areas or where vegetation density

**Figure 5.** Photographs of *Triteleia grandiflora* habitat at the occurrence in the San Juan National Forest, in Colorado (Region 2). Plants are growing in partial shade to full sun, and with a range of competition (compare plants in the foreground to those in the insets). Photographs provided by Cara Gildar, San Juan Public Lands, Dolores Public Lands Office, Dolores, Colorado, used with permission.

**Table 4.** Plant species reported to be associated with *Triteleia grandiflora*. This is not an exhaustive list and represents only the observations listed in **Table 1** and **Table 2**.

| State | Associated plant species[1] | State | Associated plant species[1] | State | Associated plant species[1] |
|---|---|---|---|---|---|
| ID, WA | *Abies grandis* | CO | *Erigeron flagellaris* | ID | *Prunus emarginata* |
| ID | *Abies lasiocarpa* | CO | *Erigeron* sp. | UT | *Prunus melanocarpa* |
| WA | *Acer glabrum* | CO | *Eriogonum racemosum* | ID, WY | *Prunus* spp. |
| UT | *Acer grandidentatum* | CO, WY | *Eriogonum umbellatum* | CO, UT | *Prunus virginiana* |
| CO | *Achillea lanulosa* | CO | *Erodium cicutarium* | CO | *Pseudocymopterus montanus* |
| CO | *Adenolinum lewisii* | CO | *Erythronium grandiflorum* | ID, WY | *Pseudotsuga menziesii* |
| CO | *Agoseris glauca* | CO | *Festuca arizonica* | CO | *Pseudostellaria jamesiana* |
| WA | *Agropyron* sp. | ID | *Festuca idahoensis* | CO | *Pterospora andromedea* |
| UT | *Allium acuminata* | CO | *Fragaria virginiana* | OR | *Purshia* sp. |
| ID | *Allium tolmiei* var. *persimile* | CO | *Frasera speciosa* | CO, ID, WY | *Purshia tridentata* |
| MT | *Alnus incana* | BC | *Galium aparine* | CO, UT | *Quercus gambelii* |
| CO | *Amelanchier alnifolia* | CO | *Gallium septentrionale* | OR, BC | *Quercus garryana* |
| ID | *Amelanchier* sp. | MT | *Geraniums* | CO | *Ranunculus inamoenus* |
| CO | *Amelanchier utahensis* | OR | *Geum* sp. | CO | *Ranunculus testiculata* |
| CO | *Androsace septentrionalis* | CO | *Gutierrezia sarothrae* | ID | *Rhus radicans* (also reported as poison ivy) |
| CO | *Anisantha tectorum* | WY | *Helianthella uniflora* | ID, WA | *Ribes* sp. |
| CO | *Antennaria parvifolia* | CO | *Heliomeris multiflora* | CO, WA | *Rosa woodsii* |
| MT | *Antennaria rosea* | OR | *Heracleum sp.* | MT | *Rudbeckia laciniata* |
| CO | *Apocynum androsaemifolium* | CO | *Heterotheca villosa* | ID | *Salix* sp. |
| UT | *Arabis holboellii* | OR | *Hypericum anagalloides* | WA | *Sambucus* sp. |
| OR | *Arnica* sp. | CO | *Ipomopsis aggregata* | BC | *Sanicula crassicaulis* var. *crassicaulis* |
| CO, ID | *Artemisia ludoviciana* | CO, MT | *Iris missouriensis* | OR | *Sedum* sp. |
| ID | *Artemisia* spp. | ID | *Juniperus scopulorum* | CO | *Senecio integerrimus* |
| ID | *Artemisia tridentata* | CO | *Koeleria macrantha* | CO | *Senecio multilobatus* |
| WY | *Artemisia tridentata* ssp. *vaseyana* | ID | *Larix occidentalis* | MT | *Senecio triangularis* |
| ID | *Artemisia tripartita* | CO | *Lathyrus leucanthus* | CO | *Silene scouleri* |
| CO | *Aster* sp. | UT | *Lathyrus* sp. | CO | *Solidago* sp. |
| CO | *Astragalus flexuosus* | CO | *Ligusticum porteri* | CO | *Solidago velutina* |
| ID, WY | *Balsamorhiza sagittata* | OR | *Lilium pardalinum* | CO | *Stellaria crassifolia* |
| ID | *Balsamorhiza* sp. | CO | *Lithospermum multiflora* | CO | *Stipa comata* |
| MT | *Betula occidentalis* | BC | *Lolium perenne* | WA | *Stipa* sp. |
| CO | *Boechera drummondii* | ID | *Lomatium* sp. | WY, BC | *Symphoricarpos albus* |
| CO | *Boechera retrofracta* | CO | *Lotus wrightii* | WY | *Symphoricarpos occidentalis* |
| CO | *Bromopsis inermis* | OR | *Lupinus albicaulis* | CO, WY | *Symphoricarpos oreophilus* |
| CO | *Bromopsis lanatipes* | MT | *Lupinus argenteus* | CO | *Symphoricarpos rotundifolius* |
| BC | *Bromus carinatus* | OR, UT | *Lupinus sp.* | ID, MT, WA, WY | *Symphoricarpos* spp. |
| BC | *Bromus hordeaceus* | CO, UT, WY | *Mahonia repens* (reported as *Berberis repens* in UT, WY) | CO | *Taraxacum officinale* |
| BC | *Bromus rigidus* | MT, WY | *Melica spectabilis* | CO | *Thalictrum fendleri* |

| State | Associated plant species[1] | State | Associated plant species[1] | State | Associated plant species[1] |
|---|---|---|---|---|---|
| BC | *Bromus* spp. | BC | *Melica subulata* | ID | *Thalictrum occidentale* |
| BC | *Bromus sterilis* | CO | *Mertensia fusiformis* | CO | *Thermopsis montana* |
| ID | *Calamagrostis rubescens* | OR | *Microseris* sp. | CO | *Toxicoscordion venenosum* |
| BC | *Camassia leichtlinii* | CO | *Microsteris gracilis* | CO, OR | *Tragopogon* sp. |
| BC | *Camassia quamash* | CO | *Muhlenbergia montana* | CO | *Trifolium* sp. |
| BC | *Camassia* spp. | CO | *Navarretia breweri* | CO | *Valeriana edulis* |
| CO | *Campanula rotundifolia* | CO | *Noccaea montana* | ID | *Veratrum californicum* |
| CO | *Capsella bursa-pastoris* | CO | *Oreobroma nevadensis* | CO | *Verbascum thapsus* |
| CO | *Carduus nutans* | CO | *Packera neomexicana* | CO | *Vicia americana* |
| MT, WY | *Carex hoodii* | CO | *Penstemon linearioides* | BC | *Vicia sativa* |
| MT | *Carex rostrata* | CO | *Penstemon strictus* | BC | *Vicia species* |
| CO, ID, WY | *Carex* spp. | CO | *Pentaphylloides floribunda* | BC | *Viola praemorsa* ssp. *praemorsa* |
| CO | *Castilleja* sp. | OR | *Phacelia heterophylla* | ID | *Wyethia helianthoides* |
| CO | *Ceanothus fendleri* | ID | *Physocarpus malvaceus* | CO | *Wyethia* x *magna* |
| WY | *Ceanothus velutinus* | ID | *Picea engelmannii* | CO, ID | *Wyethia* sp. |
| CO | *Cerastium strictum* | ID | *Picea* sp. | | |
| CO | *Cirsium tracyi* | ID | *Pinus contorta* | **State** | **Reported as common name** |
| CO | *Claytonia lanceolata* | CO, ID, OR, WA | *Pinus ponderosa* | ID | arrowwood |
| WA | *Clematis ligusticifolia* | ID, OR | *Pinus* spp. | ID, WA | aspen |
| CO | *Collinsia parviflora* | CO | *Plantago* sp. | ID | balsamroot |
| CO | *Collomia linearis* | CO, WA | *Poa bulbosa* | UT | big tooth maple |
| CO | *Comandra umbellata* | CO | *Poa congesta* | WA | birch |
| CO | *Coriflora hirsutissima* | CO | *Poa fendeleriana* | UT | bitter brush |
| CO | *Crataegus rivularis* | CO, BC | *Poa pratensis* | ID, WA | bunchgrass |
| BC | *Dactylis glomerata* | ID, OR | *Poa secunda* | WA | cheatgrass |
| CO | *Delphinium nuttallianum* | ID | *Poa* sp. | UT | choke cherry |
| OR | *Delphinium* sp. | WA | *Populus tremuloides* | MT, WA | Douglas fir |
| BC | *Dodecatheon hendersonii* | CO | *Polygonum douglasii* | ID | lupine |
| ID | *Elymus cinereus* | ID, WY | *Populus angustifolia* | UT | maple |
| CO | *Elymus lanceolatus* | MT | *Populus balsamifera* | WA | nineback |
| CO | *Elymus longifolius* | ID, WY | *Populus* sp. | WA | pinegrass |
| ID | *Elymus spicatus* | ID, UT | *Populus tremuloides* | ID, OR, WY | sagebrush |
| WY | *Elymus* spp. | CO | *Potentilla hippiana* | ID | serviceberry |
| CO | *Epilobium* sp. | CO | *Potentilla pulcherrima* | ID | wheat wild cherry |
| CO | *Eremogone congesta* | MT, OR | *Potentilla* sp. | ID | wooly weed |
| CO | *Erigeron divergens* | | | ID | |

[1]Synonyms: The reference in parenthesis refers to a Flora in Region 2 in which the synonym is used:

*Arabis holboellii* = *Boechera crandallii* (Weber and Wittmann 2001)

*Artemisia tridentata* ssp. *vaseyana* = *Seriphidium vaseyanum* (Weber and Wittmann 2001)

*Juniperus scopulorum* = *Sabina scopulorum* (Weber and Wittmann 2001)

*Juniperus monosperma* = *Sabina monosperma* (Weber and Wittmann 2001) was higher (Barkworth 1977a). No investigations to determine if there are distinctly defined ecotypes of *T. grandiflora* that are adapted to specific habitat niches have been conducted. More information on the habitat of the form assigned to *T. howellii* is in the Appendix to this assessment.

### Reproductive biology and autecology

*Triteleia grandiflora* is a perennial species. Plants are iteroparous, flowering in multiple years before they die. They reproduce vegetatively through division of the corm and proliferation of cormlets, as well as by seed (Barkworth 1977a). *Triteleia grandiflora* flowers from April through July throughout its range. The variation in the times and rates of flowering observed between years has been attributed primarily to different environmental conditions. A dry winter and spring was believed to be the cause of the early bloom exhibited by plants at CO-1 (**Table 1**) in 2000 (Colorado Natural Heritage Program 2005b, Lyon personal communication 2005, Stewart personal communication 2005). Fewer plants flowered in 2000 than in 1998 (**Table 1**). Observations of *T. grandiflora* indicate that individuals are likely to exhibit prolonged dormancy and may not necessarily flower every year.

The base chromosome number of *Triteleia grandiflora* is x = 8 (Barkworth 1977a). The species exists as several cytotypes, with chromosome numbers of 2n = 16 (diploid), 24 (triploid), 32 (tetraploid), 40 (pentaploid), 48 (hexaploid), and 56 (heptaploid). It is possible that other chromosome levels exist (Barkworth 1977a). Burbank (1941) reported *T. grandiflora* to have a chromosome number of 2n = 32. Presumably, she examined a tetraploid specimen. *Triteleia* pollen grains are smooth, lack exine ornamentation, and are roundly tapered at both ends (Davidson 1975). Although polyploid individuals tend to have larger-sized pollen than diploid individuals, the ranges in diameters overlap, so size is not a reliable indicator of ploidy level (Davidson 1975).

Stebbins (1971) classed polyploids based on their origin. Allopolyploids arise through interspecific hybridization and chromosome doubling whereas autopolyploids arise from conspecific parents (Stebbins 1971, Grant 1981, Soltis and Soltis 2000). Polyploids may also arise within diploid populations through somatic chromosome doubling or more commonly through unreduced gametes (Bretagnolle and Thompson 1995, Ramsey and Schemske 1998, Bretagnolle 2001, Levin 2002). Autopolyploids frequently exhibit irregularities such as bridges and multivalent formation at meiosis (Soltis and Soltis 2000). Both univalent and multivalent formations were fairly common at meiosis in polyploid cells of *Triteleia grandiflora* (Barkworth 1977a). Although the presence of meiotic irregularities (e.g., multivalents) does not guarantee which type of polyploidization is operating, the various cytotypes of *T. grandiflora* suggest that autoploidy is most likely. Additional evidence for autoploidy comes from Barkworth's observations (1977a, 1977b) that there was no consistent variation in gross chromosome morphology, except for small quantitative features such as length, among the polyploids of both *T. grandiflora* and *T. howellii*. Autopolyploids are characterized by polysomic inheritance and may originate repeatedly (Soltis and Soltis 1993, Ramsey and Schemske 2002). This type of polyploid species ("neopolyploid") is often adapted to an expanded range of ecological conditions and represents genotypes with new evolutionary potential (Levin 1983, 2002). In Washington, *T. grandiflora* occurrences are uniformly polyploid, uniformly diploid, or contain diploid and polyploid individuals (Barkworth 1977a, 1977b). This distribution of chromosome races is consistent with recent, spontaneous, and recurrent autopolyploid formation.

Barkworth (1977a, 1977b) studied morphological and physiological variations within *Triteleia grandiflora* in relation to ploidy level and reported that polyploid plants are generally larger, flower later, produce more contractile roots, and have more effective vegetative reproduction by corms than do their diploid progenitors. In garden studies, diploid plants produced few corms generally limited to the upper 8 cm of the soil, while polyploid plants were more likely to reproduce vegetatively by corms, which were more deeply buried (Barkworth 1977a). The position of the corm is likely to be related to the size and number of contractile roots, which are specialized organs that swell with moisture in the wet season but shrink vertically as the soil dries, drawing the corm down into the ground. Larger and stronger contractile roots can draw a corm deeper into the soil. Corms of *T. grandiflora* individuals in the Colorado population appear to be buried particularly deeply at 30 to 40 cm (Stewart personal communication 2005), suggesting that these individuals are polyploid. However, it is not possible to know with certainty the ploidy level without conducting a cytological study.

The success of vegetative reproduction (cormlet production) by *Triteleia grandiflora* plants may not be entirely due to ploidy level; it may also be influenced by environmental conditions. Very few corms divided when grown in soil in a research garden, but almost all corms grown in sand in a greenhouse produced several, in some cases as many as 14, cormlets (Barkworth 1977a). It is likely that differences in plant morphology among *T. grandiflora* occurrences are due to a combination of ploidy level and local environmental factors that are sometimes difficult to separate (Keator 1968, Barkworth 1977a, 1977b). For example, plants in a tetraploid *T. howellii* population were larger than those in adjacent diploid populations (Barkworth 1977b). However, the tetraploid occurrence was growing in deep soil near the bottom of a south-facing slope protected from grazing, whereas the diploid populations were growing in rocky soil in heavily grazed areas.

In one study of *Triteleia grandiflora* populations, both diploid and polyploid individuals produced viable seed (Barkworth 1977a). In two diploid populations, seed germination was 97 and 95 percent. Seed from three polyploid populations germinated at rates of 94, 82, and 73 percent (Barkworth 1977a). *Triteleia grandiflora* seeds exhibit a physiological dormancy and require cold stratification before germination (Skinner 2005). The success of seedling establishment in populations with different ploidy levels was not measured, and rates of seedling mortality and rates of recruitment were not reported (Barkworth 1977a). Seedlings and immature corms produce only one leaf during the growing season (Barkworth 1977a). It may take a *T. grandiflora* plant three to four years after germination to mature and bloom for the first time (Neely and Cilimburg 2005). In transplantation experiments, only mature corms developed a flowering shoot during the two years of the study (Barkworth 1977a). Some mature corms failed to produce a flowering shoot until the second year after transplantation, producing just one leaf in the intervening year (Barkworth 1977a).

*Triteleia grandiflora* propagation by seed and production of corms has been researched at the Plant Materials Center in Pullman, Washington (Skinner 2005). Seeds can be collected directly into an envelope when the capsule begins to split, or the whole capsule can be collected. The capsules are stored in envelopes or paper bags at room temperature until the seeds are removed from the capsules and the capsule fragments cleaned away (Skinner 2005). Clean seed was stored in controlled conditions at 5 °C and 40 percent relative humidity (Skinner 2005). Seeds needed a pretreatment of at least 30 days of cool, moist stratification in order to germinate (Skinner 2005). Seeds sown in late November and early December began to germinate in late March and early April and continued for three weeks. Some of these seeds germinated only after a second winter (Skinner 2005). Seedlings needed to be maintained outside under cool growing conditions (Skinner 2005). Growing conditions were apparently best in an outdoor environment rather than in a greenhouse, which is not surprising since Pullman (Washington) is within the range of *T. grandiflora* (**Table 1**). Even though seeds germinated in the greenhouse, none of the seedlings survived, and seedlings from seed that had been germinated outside died when placed in the greenhouse (Skinner 2005). Plants developed one true leaf in the first season and went dormant in mid to late June. It took three years for a plant to produce corms that were approximately 0.6 cm in diameter (Skinner 2005). These small corms were planted about 5.1 cm deep in October (Skinner 2005).

The reproductive strategies of *Triteleia grandiflora* have not been researched in detail. Successful reproduction in *T. grandiflora* may rely on seed production, through either sexual or asexual agamospermous methods, or on vegetative reproduction through corm division. In studies in the Pacific Northwest, *T. grandiflora* plants produced abundant seed (Barkworth 1977a), but the way in which the seed was produced was not known. Production of seed might be through apomixis, self-pollination, or cross-pollination. The consequences of crossing and selfing have been observed incidentally to cytological and taxonomic studies. Results from limited cross-pollination experiments suggested that *Triteleia* species are predominantly out-crossing, but some species are likely to be self-compatible to some extent (Burbank 1941, 1944). Other evidence suggests that some species of *Brodiaea* (Niehaus 1971) and *Dichelostemma* (Burbank 1941) are self-incompatible.

The reproductive mechanism *Triteleia grandiflora* employs may depend on ploidy level, and different occurrences may have different reproductive strategies. Triploids, pentaploids, and heptaploids are typically unable to reproduce sexually (Grant 1981). In order to maintain themselves, these plants must reproduce asexually. *Triteleia grandiflora* plants with odd sets of chromosomes may rely on corm division and cormlet production, or they might be agamospermous, producing seeds exclusively through asexual (apomictic) processes (Grant 1981). There is no specific information as to whether *T. grandiflora* is apomictic. Some species within the Liliaceae are agamospermous while others are not (Grant 1981). In some cases, pollination, not fertilization, triggers apomictic seed development (Rudall et al. 2000). Observations of *Triteleia* style morphology suggest that if *T. grandiflora* is apomictic, seed formation is not dependent on pollination (pseudogamy). Like all members of the Themidaceae, *Triteleia* species possess hollow styles rather than the solid styles of the Alliaceae (Rudall et al. 2002). A solid style has been theorized to be an adaptive characteristic that permits more rapid chemical signaling between stigma and placenta after pollination, and solid styles have been used as evidence to support the evolutionary likelihood of apomictic success (Rudall et al. 2000). Using the same reasoning, the hollow tubes of *Triteleia* indicate that the species is unlikely to rely on apomictic seed formation that depends on pseudogamy.

Seed production may be most important to diploid forms of *Triteleia grandiflora*, which appear to produce corms less prolifically than polyploids (Barkworth 1977a). If *T. grandiflora* is neither apomictic nor self-pollinated, then seed set depends upon a suitable pollen vector. The large and showy flowers indicate that *Triteleia* species are most likely insect pollinated. Nectar originating in sepal nectaries is likely to be a significant attractant to insect pollinators (Ravenna 2000).

Interspecific crosses among *Triteleia* species appear to be rare. Several mechanisms, such as pollinator specificity, temporal differences in pollinator activity or flowering time, or dominance of self-pollination systems, exist to keep sympatric taxa genetically isolated from each other and the resulting hybrids (Grant 1981). For example, the range of *T. hyacinthina* overlaps some parts of the range of *T. grandiflora*, but the former species usually flowers six to eight weeks later than *T. grandiflora* (Barkworth 1977a). The frequency with which intermediates between forms assigned to the subspecies *howellii* and *grandiflora* have been found appears contradictory, but it may be a reflection of research in different geographic areas (Barkworth 1977a, 1977b, Pires 2002). Hybrids are rare but exist in the genus *Brodiaea*. Interspecific crosses of *Brodiaea* typically produced little seed, but some hybrids did produce seed that germinated (Niehaus 1971). Although the majority of these hybrid progeny were sterile, some fertile hybrids were produced (Niehaus 1971).

*Triteleia grandiflora* seed dispersal mechanisms are not known. Given the palatability of the species, rodent or ant gathering and caching activities may be important. *Triteleia grandiflora* seeds and fruits do not have any characteristics (e.g., barbs that attach to fur) that suggest that they are typically dispersed long distances by animals. The patchy and clumped nature of some occurrences suggests that short distance dispersal is common. If the capsule dehisces while still on the plant, the seeds are most likely to fall close to the parent plant. The triggers for *T. grandiflora* capsule dehiscence have not been studied. Wind may contribute to dispersal, and in general, wind-dispersed seeds move only short distances (Silvertown 1987). Other dispersal mechanisms may include sheet flow during intense downpours. Polyploid populations tended to grow on steep hillsides, road banks, and other sites where soils are unstable (Barkworth 1977). Seeds from these occurrences would be easily washed away during periods of precipitation. Transport by sheet flow may be less important for diploids that, at least in one survey, tended to occupy flatter sites, or where a high density of vegetation would trap seeds (Barkworth 1977a). Seeds, and perhaps even corms, from *T. grandiflora* occurrences near streams (e.g., WY-11 in **Table 1**) and rivers may be transported downstream.

## Demography

No studies have addressed the demographics of *Triteleia grandiflora* populations directly. Demographic information for *T. grandiflora* has typically been incidental to studies that address taxonomic questions. No data have been collected to help determine which life history stages are critical to occurrence viability. Elasticity analyses of matrix projection models can suggest which stage in the life cycle is critical to the species' persistence (Silvertown et al 1993). These factors are very important when considering the management of a species. For example, if successful seed set and dispersal are critical life stages, then the timing of livestock grazing can be adjusted to allow them to occur. If corm longevity is critical, then management prescriptions can recommend that soil disturbance be minimized.

The longevity of mature *Triteleia grandiflora* plants is unknown, but several years are required for a cormlet to reach an adequate size for flowering (Barkworth 1977a, Skinner 2005). *Triteleia grandiflora* plants are iteroparous, but plants do not necessarily flower every year (Barkworth 1977a) and seed production appears to be irregular. The corm appears to serve as the organ of dormancy during times of environmental stress. These observations suggest that a long-lived corm is particularly critical to occurrence persistence. Ploidy level may influence reproductive strategy. The observation that corm reproduction by diploids is far less than by polyploids suggests that seed production is more important to the viability of a diploid population than to a polyploid population. A large and persistent seed bank may also be particularly important to diploid *T. grandiflora* populations, where vegetative propagation is low and seed production is unreliable. Seed longevity has been proposed as a viable alternative to long-distance seed dispersal (Harper and White 1974). On the other hand, a large and persistent seed bank is a typical characteristic in the model of a species whose habitats are subjected to temporary and unpredictable disturbance (Grime et al. 1988). This suggests that polyploids that colonize steep unstable slopes would also benefit from a robust seed bank.

**Figure 6** is a simple life-cycle model for *Triteleia grandiflora*. This species is a vernal geophyte, blooming in the spring but using the corm to survive periods of environmental stress. Grime et al. (1988) classified this life strategy as a stress tolerant ruderal strategist. *Triteleia grandiflora* can also be described as a K-selected or stress tolerant species in the system proposed by MacArthur and Wilson (1967).

Limits to *Triteleia grandiflora* population growth are not known but may include a combination of habitat availability, reproductive success, and dispersal efficiency. Appropriate soils and local microhabitat conditions are likely to influence both the establishment and persistence of occurrences. Because polyploid plants appear to be more effective vegetative reproducers than diploid plants, the length of time a site is occupied may differ between diploid and polyploid occurrences. Polyploidy might also permit colonization of different habitat types and may confer the ability to maximize the fitness of *T. grandiflora* to changing environments.

### Community ecology

*Triteleia grandiflora* grows in a wide variety of local habitats throughout its range (see Habitat section). The habitat conditions that have been reported for *T. grandiflora* occurrences in Wyoming are summarized in **Table 5**. These habitat conditions may be particularly useful to consider when searching for additional occurrences in Region 2. Seasonally moist openings in forested areas appear to be a common habitat type, but *T. grandiflora* plants are also found in dry areas within shrub-grassland communities. In the only occurrence known to be extant in Region 2, *T. grandiflora* is found in open to partially shaded areas in a *Pinus ponderosa/Quercus gambelii* community. In this occurrence, patches of *T. grandiflora* plants are associated with varying degrees of cover by other species. Since some *T. grandiflora* patches grow in dense vegetation, it is likely that the plants can tolerate some competition from other species. Barkworth (1977a) hypothesized that the shorter growth period of diploid plants resulted in them flowering one to three weeks earlier than the majority of species in her study area, which may have been significant in reducing competition for available nutrients where there was a high density of other plants (Barkworth 1977a).

The role of *Triteleia grandiflora* in its ecosystem has not been studied in detail. *Triteleia grandiflora* corms are documented as an important source of food for rodents (Neely and Cilimburg 2005). The common name "gophernuts" probably reflects their attractiveness to rodents. In addition, the oft-repeated warnings to protect *Triteleia* species in horticultural or garden settings suggest that the plants are a good food source for many species of wildlife (Anderson and Roderick 2003, 2004, Suncrest Nurseries, Inc 2000-2005). The use of *T. grandiflora* by deer, elk, and other species of wildlife is otherwise not documented. Livestock find both the corms and the aerial parts of *T. grandiflora* palatable (Dayton 1960). The corms were reported as also being "greatly relished by sheep" (Dayton 1960). Grazing animals, including cattle, apparently can pull up and consume the corms when the soil is wet (Dayton 1960). The corms were an important source of food to indigenous Americans and early European settlers (Chesnut 1898/1899, Dayton 1960, Moerman 1998).

*Triteleia grandiflora* plants are unlikely to have high forage value in sites where they are scattered or rare (e.g., OR-46 in **Table 2**). However, where abundant they can provide significant forage, and Dayton (1960) reports that *T. grandiflora* was a "good" forage plant on ranges in the Colville National Forest, Region 6, in northeastern Washington. This is consistent with reports about other non-toxic members of the lily family. When these species are more abundant, they can attain a higher forage value, especially for sheep (USDA Forest Service 1988).

The relationships between arthropods and *Triteleia grandiflora* are not documented. *Triteleia grandiflora* might depend on specific arthropod pollinators for cross-pollination. The flower structure of *Triteleia* is very similar to that of *Brodiaea*, which attracts a relatively wide range of arthropods. Niehaus (1971) observed several arthropods visiting *Brodiaea* species, including bee flies (Family Bombyliidae, order Diptera), the skipper butterfly (Family Hesperiinae, order Lepidoptera), tumbling flower beetles (Family Mordellidae, order Coleoptera), and sweat bees (Halictidae, order Hymenoptera). However, not all these visitors were pollinators. Further investigation indicated that although bee flies and butterflies were frequent visitors, they carried no *Brodiaea* pollen (Niehaus 1971). Their tongues are apparently long enough to collect nectar without having to contact the anthers. In contrast, tumbling flower beetles and sweat bees crawled into the flowers and were responsible for successful cross-pollination (Niehaus 1971). Niehaus noted that whereas the sweat bees visited the flowers in

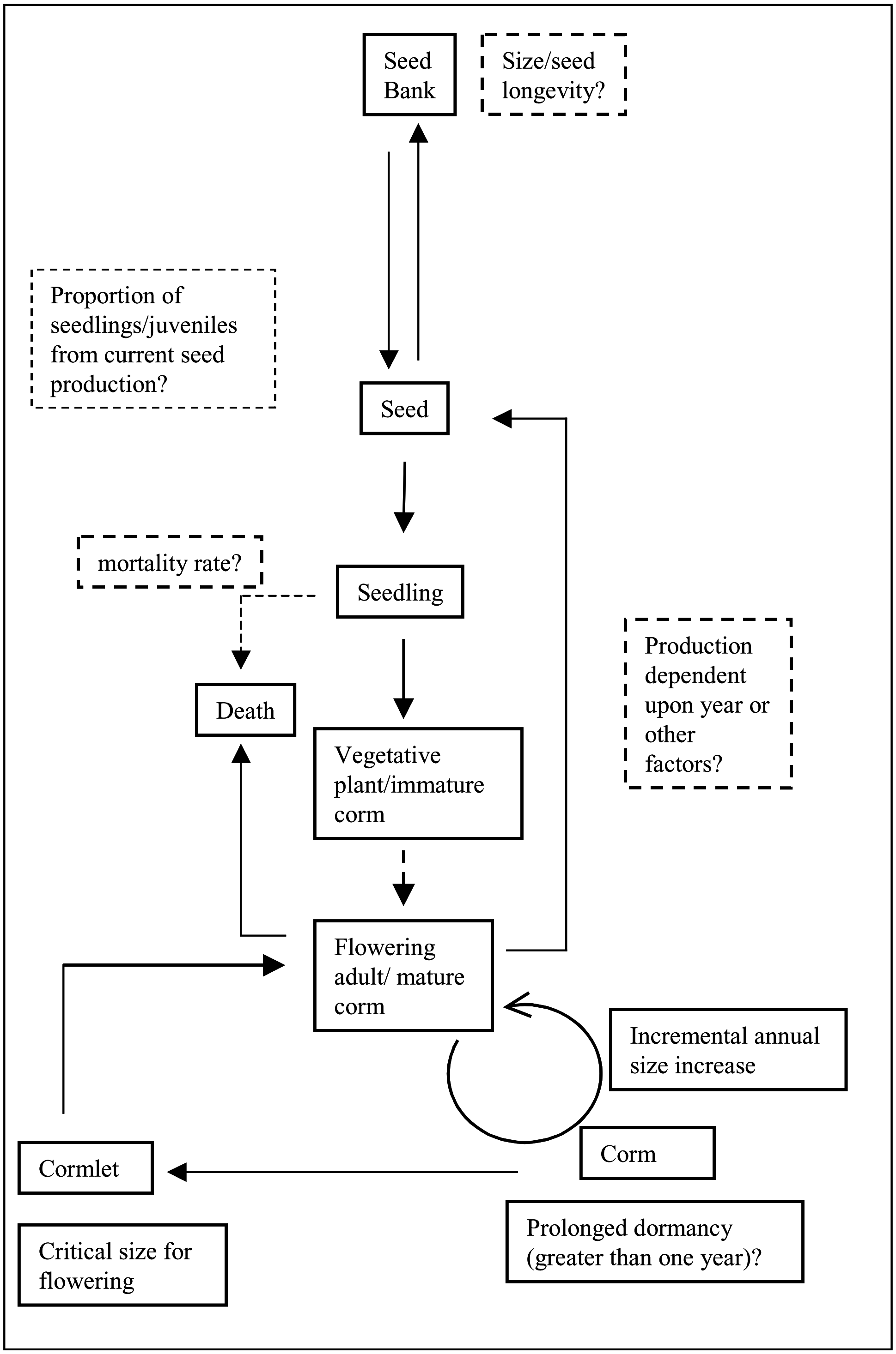



**Figure 6.** Life-cycle diagram for *Triteleia grandiflora*.

high winds, beetles did not because they were unable to fly in those conditions (Niehaus 1971).

The arthropods responsible for *Triteleia grandiflora* pollination are likely to be different from those of *Brodiaea*, but similar pollination behaviors may apply. Polylectic (pollen-generalist) bees, including *Bombus griseocollis vosnesenskii, Eucera cordleyi* (Apidae), *E. virgata, Halictus farinosus* (Halictidae), and *Osmia granulosa* (Megachildae) visited *T. laxa* in California (Griswold et al. 2005). Griswold et al. 2005 suggested some specificity in potential pollinators

**Table 5.** Summary of the types of *Triteleia grandiflora* habitat in Wyoming (see **Table 1** for more details of occurrences designated WY-2 through WY-16).

**In forests and woodlands:**

- Growing in partly shaded aspen-grass; surrounding area of sagebrush flats (WY-2)
- Aspen woods on rich, rocky soil (WY-5)
- Forest opening (WY-3)
- In *Populus angustifolia/Symphoricarpos albus, S. occidentalis, S. oreophilus* forest (WY-7)
- In timber (WY-8, sub-occurrence)
- Mixed open slope and coniferous forest dominated by species of *Pseudotsuga, Prunus, Populus*, and *Symphoricarpos* (WY-12)
- Coniferous forests and openings on slopes and bottoms of drainages (WY-13)
- Floodplain with *Populus angustifolia*, and species of *Carex* and *Elymus* (WY-6)

**In rich soils with no tree canopy:**

- Old alluvial, glacial bank with no aspen and rich sagebrush (*Artemisia tridentata* var. *vaseyana* and *Purshia tridentata*) (WY-6)

**On sites that are likely dry with no tree canopy:**

- On rocky, dry slope (WY-4)
- Steep roadside bank, rocky (WY-9)
- Frequent in drying soil on sagebrush hillside (WY-10)
- Level ground in loam soil in open sagebrush (WY-16)
- South-facing slope above aspen stand with *Helianthella uniflora, Balsamorhiza sagittata, Mahonia repens, Eriogonum umbellatum, Melica spectabilis*, and *Ceanothus velutinus* (WY-14, sub-occurrence)
- Southeast-facing slope with *Carex hoodii* and *Balsamorhiza sagittata*[1] (WY-14, sub-occurrence)

**In potentially disturbed or unusual conditions:**

- Open area adjacent to irrigation canal (WY-11)
- Thermally altered soil with some heat flow; not hot ground, but warmer than ambient (WY-15)
- Along road (WY-8, sub-occurrence)

[1] *Carex hoodii* is equally likely to occur in wetlands or non-wetlands (U.S. Fish & Wildlife Service 1997). Furthermore, *Balsamorhiza sagittata* is found on well-drained soils in open, fairly dry situations, including south-facing slopes (Stanton 1974)

since relative to plant species in the genera *Carduus, Centaurea, Holocarpha, Madia*, and *Silybum*, *T. laxa* did not attract many species of bees. For this reason, pollinators could be limiting in some circumstances. In addition to differences in potential pollinator species between *Triteleia* taxa, pollinators might vary between *T. grandiflora* plants with different colored flowers (Grant 1981). Polyploidy can also have a substantial influence on interactions with both pollinators and animal herbivores (Soltis et al. 2003).

Specific microbial associations with *Triteleia grandiflora* are not reported. However, interdependencies between species in the Liliaceae and symbiotic mycorrhizae species are well documented (Scagel and Linderman 2001). In fact, mycorrhizal associations can be essential to the survival of some members of the Liliaceae (Helgason et al. 2002). *Triteleia grandiflora* plants are likely associated with endomycorrhizae formed by glomalean fungi (Smith and Smith 1997). Mycorrhizal associations facilitate efficient mineral and water uptake (Allen 1990).

*Triteleia grandiflora* typically is found in open to partly shaded habitats (see Habitat section). Field conditions required for seed germination and seedling establishment are not documented. Some reports suggest that plants may grow preferentially in the shelter of shrubs. It is possible that under those circumstances, the shrubs served as refugia from large grazing animals. It appears likely that *T. grandiflora* is a mid-successional species that would be eliminated by dense forest canopies. Periodic fire is likely to have maintained *T. grandiflora* habitat. *Brodiaea coronaria* was reported to "invade certain burn areas" (Dayton 1960). It was not clear whether the burn reduced the aboveground matter so that the *Brodiaea* plants were more visible, whether the fire stimulated corms that existed prior to the fire to flower, or if seed from outside the burn site found suitable sites in which to germinate.

Many factors can alter the response of *Triteleia grandiflora* plants to fire. The intensity and frequency of the fire may be particularly important. High intensity fires are most likely to be detrimental to the buried corms (Whelan 1997). Although soil is typically a good insulator, drought may be advantageous to *T. grandiflora* because during a fire, moist soil can reach a higher peak temperature and reaches it more rapidly than does air-dry soil at a given depth (Whelan 1997). The depth at which the corms are growing may influence survival after fire; more deeply buried corms may be better protected than shallow corms. This suggests that polyploids may be able to withstand fire better than diploid corms. Other effects of fire include removing litter, eliminating or reducing competition from other species, and changing the soil nutrient and microbial environment (Oliver and Larson 1996, Whelan 1997). The consequences of these indirect effects of fire on *T. grandiflora* are unknown.

The potential for interaction among fire and herbivory effects has not been examined for *Triteleia grandiflora*. In a woodland community in Australia, Leigh and Holgate (1979) found the mortality rate for palatable species on sites that experienced both burning and post-fire grazing was double the mortality rate for sites that experienced either factor alone. In addition, mortality on burned-only or grazed-only plots was similar to mortality on control plots. Part of the reason for this might be that herbivores tend to congregate on patches where vegetation has burned (Whelan 1997). Increased herbivory may be an indirect consequence of fire that would negatively affect a palatable species such as *T. grandiflora*.

An envirogram is a graphic representation of the components that influence the condition of a species and reflects its chances for reproduction and survival. Envirograms have been used to describe the conditions of animals (Andrewartha and Birch 1984), but they may also be applied to describe the condition of plant species. Those components that directly affect *Triteleia grandiflora* make up the centrum, and the indirectly acting components constitute the web (**Figure 7**). Much of the information needed to make a comprehensive envirogram for *T. grandiflora* is unavailable. The envirogram in **Figure 7** is constructed to outline some of the resource components that might affect the species. At the current time, many of the elements outlined are rather speculative, but they can be tested in the field by observation or by management manipulation. The lack of direct studies of this species leads to forming opinions from inference rather than fact. Inferences are subject to error and need to be used cautiously in predicting responses to management decisions.

In **Figure 7**, the resources for *Triteleia grandiflora* include soils that provide a suitable edaphic environment. The non-vascular members of the soil community may be important to the vigor of *T. grandiflora* plants. Pollinators may be important for reproduction as agents for cross-fertilization. Water, wind, arthropods, and rodents may facilitate seed dispersal. All components of climate, especially temperature and precipitation, influence the populations of both plants, and pollinators and are likely to be important to the persistence of *T. grandiflora* occurrences.

# Conservation

## *Threats*

Habitat loss, fragmentation, and degradation caused by human recreation, livestock grazing, resource development, and invasive non-native plant species are potential threats to the long-term persistence of *Triteleia grandiflora* occurrences throughout its range, including Region 2. Threats from habitat loss and degradation are likely to increase in the foreseeable future as the human population increases. Soil disturbance from all sources is a potential threat to occurrence viability. *Triteleia grandiflora* occurrences are also vulnerable to the direct effects of herbivory, especially in areas where pressures from livestock grazing may be additive to those from wildlife. If *T. grandiflora* relies on cross-pollination to produce seed, then a change in the assemblage of pollinator species or a decline in their abundance is a potential threat.

The role of fire in the life history of *Triteleia grandiflora* is unknown. Although the species may occur in forested areas, it is typically found in areas with low or no tree canopy. Therefore, past fire suppression policies may have reduced the amount of habitat available. Fires intense enough to kill buried corms are a potential threat. As for all species, environmental stochasticity and global climate change pose potential threats to *T. grandiflora*. Elements of genetic and demographic stochasticity are also potential threats, especially to small and isolated occurrences. *Triteleia grandiflora* corms can be transplanted, so it may be possible to move an occurrence if destruction of the occurrence site is unavoidable. However, there are inherent risks in the process of translocation (Given 1994). Each potential threat is briefly addressed in the following paragraphs. Details of imminent threats specific to known occurrences are largely unavailable.

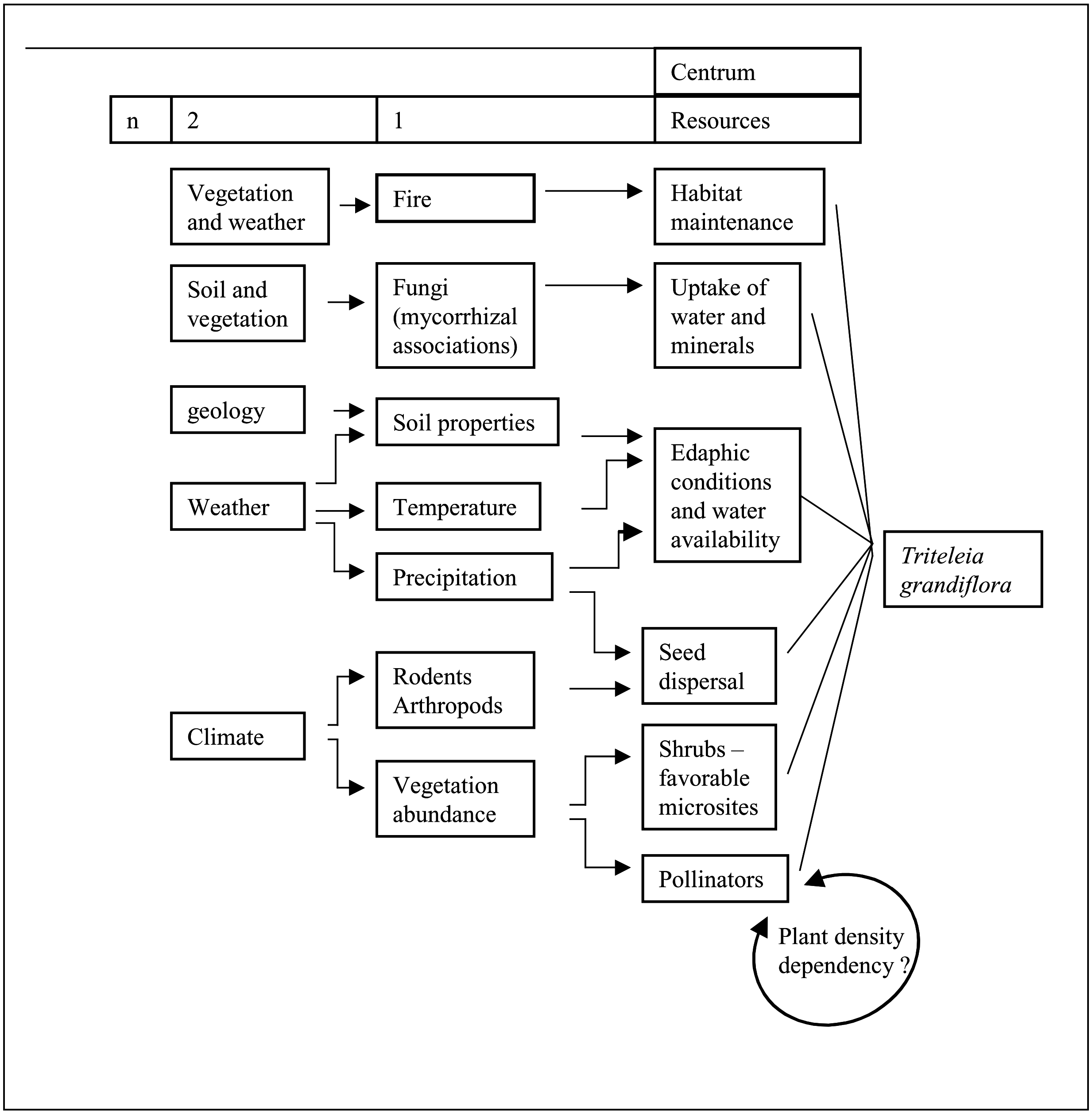



**Figure 7.** Resources envirogram for *Triteleia grandiflora*.

Urbanization also leads to habitat loss, fragmentation, and degradation and this continues to be a threat to occurrences outside of Region 2 (see Population trend section). Urbanization is not discussed in this section since it is highly unlikely to affect the only *Triteleia grandiflora* occurrence known to be extant in Region 2.

## Recreation

Development projects associated with recreation may threaten *Triteleia grandiflora* occurrences on National Forest System land throughout the species' range. The area in which *T. grandiflora* was reported to occur on the Medicine Bow National Forest (WY-1 in **Table 1**) has been developed for recreation with hiking trails, drinking water facilities, restrooms, and areas designated for camping and fishing (USDA Forest Service 2001, USDI Bureau of Land Management 2001). Human use of recreation sites can affect the area as much as the development of the site itself (Hammitt and Cole 1998, Leung and Marion 2000). Informal (social) trails and picnic areas tend to proliferate near campgrounds and fishing sites. Horseback riding, which combines disturbance and incidental herbivory, may be another potential threat to some occurrences.

Recreational travel away from managed trails by motorized off-highway vehicles (OHVs) may threaten existing *Triteleia grandiflora* occurrences and habitat. All forms of motorized recreation can severely disturb vegetation, cause accelerated soil erosion, increase soil compaction, and add to pollution (Ryerson et al. 1977, Keddy et al. 1979, Aasheim 1980, Fahey and Wardle 1998, Belnap 2002, Misak et al. 2002, Gelbard and Harrison 2003, Durbin et al. 2004). The potential for snow compaction, as well as for altered soil properties by wintertime recreational activities, especially snowmobiling, is another cause for concern. Snow compaction can cause considerable below-surface vegetation damage (Neumann and Merriam 1972). Significant reductions in soil temperatures, which retard soil microbial activity and seed germination, may also result from snow compaction (Keddy et al. 1979, Aasheim 1980).

The relationship between the number of motor vehicles and their negative effects is not directly proportional. Several passes by a motor vehicle will have negative impacts that are greater than a simple linear summation of single pass impacts (Payne et al. 1983). However, even a single vehicle pass can destroy or disrupt microbiotic crusts and damage many types of plants and soils (Payne et al. 1983, Webb 1983, Wilshire 1983). In addition, a single pass of one snowmobile causes significant snow compaction, which adversely affects snow permeability, soil properties beneath the snow, and snowmelt properties (Keddy et al. 1979, Fahey and Wardle 1998). All of these properties can be important to a taxon like *Triteleia grandiflora* that requires a long-lived underground corm for longevity.

In recognition of the significant degradation caused by motorized vehicles, the USFS has proposed a nationally consistent approach for managing motorized OHVs that will require each forest and grassland to designate a system of roads, trails, and areas for motor vehicle use, and if appropriate, to restrict their use to certain times of year (USDA Forest Service 2005b). When the designation process is complete, OHV use will be confined to designated routes and areas, and cross-country travel will be prohibited (USDA Forest Service 2005b). Strict enforcement of the policies will be needed for this program to be effective. In 2006, the San Juan Public Lands, which are composed of the San Juan National Forest and lands managed by the BLM San Juan Field Office, have begun the travel planning process in accordance with the Travel Management Rule of 2005 (USDA Forest Service 2006). The current level of recreational activities within the area of the San Juan National Forest occurrence (CO-1 in **Table 1**) appears to be relatively low. At this level, OHV impacts are unlikely to be a serious threat to this occurrence (Stewart personal communication 2005).

Another common recreational activity within the range of *Triteleia grandiflora* is snow skiing. For example, occurrence WY-9 in **Table 1** is at the base of a run, and ID-45 in **Table 2** is near the Kelly Canyon Ski Area. Ski areas require development of facilities and ski trails, on which there will be direct snow compaction in the winter. Some areas also encourage summer visitors by running the lifts to areas that otherwise would not receive casual recreational use. There are no ski areas near the occurrences in Region 2. The nearest ski area to the occurrence on the San Juan Forest is approximately 6 miles away and has been abandoned since the early 1980s (Blair et al. 1996).

### Livestock grazing

The effects of wildlife and livestock grazing on *Triteleia grandiflora* are not documented, but elk, deer, and livestock are all likely to use the taxon to some extent (see Community ecology section). The effect of grazing on the long-term survival of a particular plant species is likely to depend upon the combination of animal species browsing the site (Mack and Thomson 1982). Different species of animals with complementary plant species preferences at any given site will have far less impact on the individual plant species than combinations of animals with additive preferences (Mack and Thomson 1982). The effects of past grazing on *T. grandiflora* occurrences (e.g., ID-56, ID-120, ID-122, and OR-46 in **Table 2**) are unknown.

The *Triteleia grandiflora* occurrence on the San Juan National Forest (CO-1 in **Table 1**) is in a cattle allotment that is grazed from late June through late July every year (Stewart personal communication 2005). Since the flowers and fruits of *T. grandiflora* are borne on the top of a tall stem, they are vulnerable to browsing and grazing animals, and mid- to late-season herbivory has the potential to reduce seed production.

### Resource development – timber

Logging is an economic activity throughout much of the range of *Triteleia grandiflora*, including in Region 2. A sawmill is located within approximately 1 mile of the occurrence on the San Juan Forest in Colorado. All of the known *T. grandiflora* sub-occurrences in the San Juan National Forest are in areas subject to timber sales (Stewart 1998). Timber was cut in the early 1900s and most recently in the 1940s in the area in which *T. grandiflora* is found (Stewart 1998). Logging and firewood cutting *per se* may not harmful to this taxon because they may open up potential habitat for *T. grandiflora*. However, the ground disturbance associated with these activities may have deleterious consequences, and the benefits of canopy reduction must be weighed against the substantial ground disturbance, soil compaction, and the potential for soil erosion caused by timber harvesting.

### Resource development – minerals and energy

Habitat loss from direct resource extraction activities is a threat to *Triteleia grandiflora*. Mining and oil and gas development are prevalent throughout its range. Mines have been reported near known occurrences. For example, ID-24, ID-32, and ID-64 (**Table 2**) are near mines, WA-10 (**Table 2**) is near a gravel pit, and WA-53 (**Table 2**) is near an asphalt site.

Other development projects involving areas supporting *Triteleia grandiflora* occurrences may also be potential threats. Some sub-occurrences on the San Juan National Forest in Region 2 may have been adversely affected during the construction of a power transmission line that traverses two of the sections in which *T. grandiflora* has been found. Areas with pipelines and transmission lines are subject to periodic post-construction disturbance during maintenance activities. An abandoned railroad near the San Juan National Forest occurrence may have affected *T. grandiflora* in the past but does not represent a current threat. Pipeline construction is a threat to *T. grandiflora* occurrences in California (California Native Plant Society 2005).

### Soil disturbance

Protecting *Triteleia grandiflora* corms is likely to be the most important factor in ensuring the long-term viability of occurrences. If this is true, any activities that disturb the soil and/or contribute to soil erosion are likely to be particularly detrimental to an occurrence. Activities that are particularly detrimental to soil structure and increase soil erosion include OHV traffic, moderate to heavy livestock grazing, and development projects such as road expansion and resource development. Even moderate disturbance, such as social trails, can lead to localized extirpation of *T. grandiflora* occurrences (Whipple personal communication 2005).

*Triteleia grandiflora* occurrences on slopes are particularly susceptible to soil disturbance. Polyploid populations have been reported to grow on steep hillsides, road banks, and other sites where the soil is unstable, whereas diploid populations tend to occupy rather flat areas or areas where there is a higher density of other plants (Barkworth 1977a). This observation raises the possibility that disturbances that extirpate slope populations rather than those on level ground may change the proportion of diploid to polyploid sub-occurrences in occurrences where individuals with different ploidy levels are mixed. The consequences of this change might influence the genetic diversity within this type of occurrence. The genetic composition of the *T. grandiflora* population in Region 2 is unknown, so both homogenous and heterogeneous ploidy states need to be considered when designing management plans.

### Fire and fire suppression

The effects of fire on *Triteleia grandiflora* are unknown. Some *T. grandiflora* plants grow in areas with relatively dense vegetation, which suggests that the species evolved in habitats that can carry a fire. The potential threat from fire is primarily determined by the temperature and frequency of the burn (Whelan 1997). Recovery after fire depends upon the depth and heat sensitivity of the corms, size of the seed bank, longevity of the seed, and seed dispersal efficiency from adults in adjacent unburned areas (see Community ecology section).

*Triteleia grandiflora* habitat is probably naturally maintained by fire (see Community ecology section). Long-term fire suppression may be as significant a threat as exposure to too hot or too frequent fire. *Triteleia grandiflora* appears to be a mid-successional species and intolerant of dense canopy closure. In some areas, conifer encroachment due to fire suppression may threaten the woodland and grassland habitat of *T. grandiflora* (Thilenius 1968, Knight 1994, Douglas and Penny 2003). It may be inappropriate to consider tree thinning and timber harvest as a substitute for fire. Fire affects many characteristics of the environment including removing litter, eliminating or reducing competition from other species, modifying soil albedo, and changing the soil nutrient and microbial composition (Oliver and Larson 1996, Whelan 1997).

### Introduced non-native plant species

The abundance and diversity of introduced non-native invasive plant species (i.e., weeds) are increasing throughout the range of *Triteleia grandiflora*, and weed infestation may be a substantial threat to *T. grandiflora* occurrences (Douglas and Penny 2003, Whipple personal communication 2005). Invasive weed species are likely to be the direct reason for the extirpation of an occurrence in Yellowstone National Park (WY-15 in **Table 1**) (Whipple personal communication 2005; see Population trend section).

Livestock, recreationists, and motorized and non-motorized vehicles contribute to the spread of invasive weeds (Sheley and Petroff 1999). Although *Triteleia grandiflora* often grows in communities where competition is low, it also grows in diverse communities with high grass, forb, and shrub cover (see Habitat section). Diploids in particular tend to occupy areas where there is a relatively high density of other plants (Barkworth 1977a). Because of this, some occurrences may be able to persist in weedy environments. However, more study is necessary before the competitive ability of *T. grandiflora* can be determined.

The ability of *Triteleia grandiflora* to tolerate weeds likely depends on the weed species. Even if *T. grandiflora* is competitive, some factors associated with weed invasions make persistence very unlikely. For example, some non-native invasive species (e.g., diffuse knapweed [*Centaurea diffusa*]) secrete allelopathic chemicals into the soil (Sheley and Petroff 1999, Callaway and Aschehoug 2000). These chemicals contribute to habitat loss, and their effects on native species may be more subtle than providing direct competition (Sheley and Petroff 1999, Callaway and Aschehoug 2000).

Invasion of non-native plants affects habitat of *Triteleia grandiflora* indirectly as well. For example, invasion by annual grasses can substantially alter soil properties and the fire regime, which is likely to be detrimental to native species while favoring the invader (D'Antonio and Vitousek 1992). It is of potential concern that the occurrence in Region 2 includes cheatgrass (*Bromus tectorum*), which is particularly invasive and when established tends to encourage more frequent fires (Daubenmire 1970).

Other non-native grasses at the Region 2 site include smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*; Stewart personal communication 2005). The potential threat from these two species is difficult to evaluate and depends on management, existing community health, and climate. Smooth brome can be an aggressive colonizer on mesic sites and may crowd out native species. It is adaptable and frequently persists in many of the habitats where it was planted to increase forage production (Howard 1996). However, it may have little chance of harming the Region 2 occurrence. Howard (1996) reported that smooth brome planted in low-fertility *Pinus ponderosa* forest soils in Colorado declined under even light-intensity cattle grazing. Kentucky bluegrass is a shallowly rooted, sod-forming, rhizomatous perennial grass that typically competes with native species, reducing species diversity and altering the natural floristic composition (Sather 1996). These characteristics indicate that Kentucky bluegrass may be a particular cause for concern at the Region 2 occurrence (Grime 2001). Musk thistle (*Carduus nutans*), a potentially aggressive forb, has been observed near the *Triteleia grandiflora* occurrence on the San Juan National Forest (San Juan National Forest 1999).

The Plant Protection Act of 2000 defines a noxious weed as a weed that could bring harm to agriculture, the public health, navigation, irrigation, natural resources, or the environment. Individual states list non-native plant species as noxious weeds when they are considered to have the potential to affect the economy or the environment substantially. Weed laws and protection measures vary by state. Under the Colorado Noxious Weed Act, Title 35, Article 5.5, state and local (county and city) authorities are responsible for noxious weed management. These authorities are tasked to prevent the introduction of new invasive plant species, eradicate invasive species with isolated or limited populations, and contain and manage those invasive species that are well established and widespread in Colorado (Colorado Environmental Pesticide Education Program 2006). These are similar to the objectives of the USFS national strategy and implementation plan for invasive species management (USDA Forest Service 2004). These directives are designed to eliminate the potential for competition between invasive species and native plants such as *Triteleia grandiflora* and to maintain native species' habitat. However, the law only requires the control of plant species listed as noxious. Of the invasive plant species near the Region 2 occurrence, only musk thistle and cheatgrass are listed as noxious in Colorado (Colorado Environmental Pesticide Education Program 2006).

Some invasive weed control methods may present threats as well. The palatability of *Triteleia grandiflora* increases its susceptibility to inadvertent damage if livestock are used as a biological control (Sheley and Petroff 1999). Some herbicides that are applied to control weeds may directly affect *Triteleia* species as well as the target plants. Although broad-leaved weeds (dicots) are frequently the targets for herbicide treatment, care needs to be taken to ensure that the herbicide used will not also affect *Triteleia* species. Some herbicides intended to kill broadleaf species may also affect certain members of the Liliaceae. For example, thifensulfuron and tribenuron are sulphonylurea herbicides used to control various broadleaf weeds. These chemicals generally do not harm monocots, but they are particularly effective against *Allium vineale* (wild garlic), a member of the Liliaceae (McGlamery and Hager 1999).

### Decline in abundance or change in the assemblage of pollinators

The breeding system of *Triteleia grandiflora* and the species' dependence on pollinators need to be determined. Although *T. grandiflora* may be able to self-pollinate, some level of cross-pollination is probably required in diploid and probably in some polyploid populations (see Reproductive biology and autecology section). If sexual reproduction or pseudogamy is important to *T. grandiflora*, the species may be vulnerable to changes in pollinator assemblage or declines in pollinator populations. Arthropods, primarily bees and beetles, are the likely pollinators of *T. grandiflora* (see Community ecology section). These arthropods are vulnerable to livestock grazing (Sugden 1985), pesticides (Kevan 1975), changes in plant community composition, and habitat fragmentation (Bond 1995, Kearns et al. 1998).

Pesticide applications for management of tree pathogens may negatively affect pollinator assemblages and abundance (Kevan 1975, Kearns et al. 1998). Even if land on which *Triteleia grandiflora* grows experiences no pesticide use, pollinator populations might be affected if nearby lands are managed using chemical controls. Small occurrences of *T. grandiflora*, which appear to be very common, may be at a particular disadvantage if bees are the primary pollinators. Bees are density-dependent foragers and will avoid populations where the reward is potentially low (Heinrich 1976, Thomson 1982, Geer and Tepedino 1993). Therefore, the number of flowers in a patch may influence the frequency with which cross-pollination occurs. Bumblebees (*Bombus* spp.) preferentially visited large, rather than small, clumps of *Astragalus canadensis* in an Iowa prairie (Platt et al. 1974). Another potentially serious consequence of high densities of weedy plants is the possible reduction in potential pollinator visits to native plants. In a California study, non-native invasive plants received more bee visits in May and June than native plants, even though in any given month there were more species of native plants that bees could visit (Griswold et al. 2005).

### Environmental stochasticity and natural catastrophe

Environmental stochasticity and natural catastrophes threaten *Triteleia grandiflora* occurrences. Environmental stochasticity includes random unpredictable changes in weather patterns or in the biotic members of the community, whereas wildfire or landslides are examples of natural catastrophes (Frankel et al. 1995). The latter may be influenced by human activity but are generally considered separately from anthropogenic threats. Specific environmental stochasticities that can affect survival and reproductive success of *T. grandiflora* include unfavorable variations in precipitation, increases in forces that cause soil erosion, and variable populations of arthropods (pollinators) and wildlife, especially rodents (see Community ecology section). With the exception of wildfire, there do not appear to be any foreseeable natural catastrophes that would impact the *T. grandiflora* occurrence in Region 2 (CO-1 in **Table 1**).

### Global climate change

Temperatures and patterns of precipitation within the range of *Triteleia grandiflora* have changed over the last century. In this period, the average temperature has increased by approximately 0.6 °C in Washington and by approximately 2.3 °C in Colorado (U.S. Environmental Protection Agency 1997a, 1997c). In Colorado, Wyoming, and Montana, precipitation has declined by as much as 20 percent in some areas. On the other hand, precipitation has increased in parts of Utah and Washington by a similar amount (U.S. Environmental Protection Agency 1997a, 1997b, 1997c, 1998c, 1998d). There are no consistent trends for precipitation within Idaho and Oregon, which have experienced increases of up to 20 percent in some areas but declines of the same magnitude in others (U.S. Environmental Protection Agency 1998a, 1998b).

The Intergovernmental Panel on Climate Change and results from United Kingdom Hadley Centre's climate model (HadCM2) have projected that by 2100, temperatures in all the states within the range of *Triteleia grandiflora* are likely to increase by 2.8 to 3.4 °C in summer and winter and 1.7 to 2.3 °C in spring and fall. The HadCM2 model also predicts changes in precipitation patterns and amounts. Within the range of *T. grandiflora*, decreases in precipitation in general are predicted during summer and sometimes during spring, while increases are predicted in winter and fall (U.S. Environmental Protection Agency 1997a, 1997b, 1997c, 1998a, 1998b, 1998c, 1998d). The consequences of these potential changes on *T. grandiflora* are very difficult to predict, but if prolonged droughts are more common, they will affect the species' potential for long-term persistence.

Climate change may have indirect effects on *Triteleia grandiflora*, such as interrupting the synchrony of pollinator activity and peak flowering period. In studies of *Brodiaea*, Niehaus (1971) observed that beetles were scarce at the start of flowering, but by peak bloom, ten or more beetles were seen on a single flower. The precise triggers of this phenomenon are unknown, but climate (e.g., temperature, precipitation, or perhaps even humidity) may be a factor. If the climate changes, pollinator and/or plant species may respond inappropriately to these triggers and lose their synchrony (Price and Waser 1998). Another indirect effect of global climate change may be an increase in episodes of abnormally high numbers of rodents (Epstein 1997). Prolonged droughts interrupted by heavy rains favor population explosions of both rodents and some species of arthropods (Epstein 1997). *Triteleia grandiflora* occurrences may be severely affected if rodent abundance and corm consumption increase beyond levels experienced periodically during the evolution of the species. Global climate change may also provide the conditions that encourage non-native plant species to invade intact plant communities, which would reduce available habitat and provide further competition for limited resources.

Diploid populations of *Triteleia grandiflora* may fare differently than some of the derived polyploid populations under changing climate conditions. The long-term evolutionary significance of polyploid formations for adapting to changing climate conditions has been subject to speculation (Soltis and Soltis 2000). However, it is not known if polyploid *T. grandiflora* plants of different origins will have distinct evolutionary potentials or if recurrent polyploid formation will lead to locally adapted genotypes that will survive into the future (Soltis and Soltis 2000). An optimistic view is that some of the polyploid forms of *T. grandiflora* will be more robust and have the potential to adapt to the changing climate conditions.

Although there is relatively little that can be done locally to avoid the consequences of global climate change, limiting other factors that contribute to the stress and decline of *Triteleia grandiflora* plants may alleviate the effects in the short term. In addition, maintaining as many *T. grandiflora* occurrences as possible will increase the probability of preserving populations that possess the appropriate genetic combinations to adapt to a changing environment.

### Demographic stochasticity and genetic stochasticity

Intrinsic or biological stochasticities may also contribute to the vulnerability of *Triteleia grandiflora*. These intrinsic stochasticities, which are typically addressed in population viability analysis, include elements of demographic stochasticity and genetic stochasticity (Shaffer 1981). Population viability analyses have not been conducted for *T. grandiflora*.

Demographic stochasticity relates to the random variation in survival and fecundity of individuals within a fixed population. This process may pose a significant threat to *Triteleia grandiflora* (Kendall and Fox 2003). Where occurrences are small, chance events independent of the environment may affect the reproductive success and survival of individuals, which can have an important effect on the persistence of the whole population (Pollard 1966, Keiding 1975). Few comments can be made on the influence of demographic stochasticity on individual *T. grandiflora* occurrences because there is no information on the survival probability of individuals at any life-stage or age. However, many *T. grandiflora* occurrences appear to be small, and the fate of any one individual is probably important to those occurrences.

Genetic stochasticities are associated with random changes in the genetic structure of populations, including inbreeding and founder effects. Small populations of outcrossing plants are at the highest risk of inbreeding depression, genetic drift, and subsequent loss of fitness (Primack 1998, Douglas and Penny 2003, Frankham 2003). The potential for inbreeding depression in *Triteleia grandiflora* occurrences is not known. Polyploidy in angiosperms is frequently associated with increased self-compatibility (Galloway et al. 2003). However, under extreme environmental conditions many self-incompatible species display a capacity to set seeds by selfing (de Nettancourt 1977). Lande and Schemcke (1985) proposed that the process of inbreeding maintains deleterious or lethal recessive alleles at low frequencies by exposing them to selection in homozygotes. Inbred (exclusively self-pollinated) populations may have a reduced potential for inbreeding depression because the lethal and severely deleterious alleles have already been selected against. Conversely, many plant species that normally reproduce by sib-mating or self-fertilization exhibit considerable heterosis upon outcrossing, which indicates that appreciable inbreeding depression exists within the inbred population (Lande 1988). Studies have largely focused on diploids, and relatively few empirical studies have been made to explore the extent of inbreeding depression in polyploids (Soltis and Soltis 2000). Theoretical models predict reduced inbreeding depression and higher levels of heterozygosity in polyploids as compared to their diploid parents because the extra genomes mask deleterious alleles (Stebbins 1971, Barrett and Shore 1989, Soltis and Soltis 2000). Confirmation of this generalization requires more research (Butruille and Boiteux 2000, Galloway et al. 2003).

The number of individuals needed to provide sufficient genetic diversity to maintain a population is much debated. There is usually a difference between effective population size and number of individuals *per se*. From a genetics perspective, natural populations often behave as if they were smaller than a direct count of individuals would suggest (Barrett and Kohn 1991). The minimum viable effective population size of a species will vary significantly according to differences in inherent species characteristics, demographic constraints, and the evolutionary history of a population's structure (Frankham 1999). Considering several different representative species, a minimum effective population size has been estimated to be between 500 and 5,000 individuals (Franklin 1980, Lande and Barrowclough 1987, Lande 1995, Franklin and Frankham 1998). Considering the obvious potential for clonal propagation, it is conceivable that, genetically, a patch of *Triteleia grandiflora* individuals can actually be clones of one genotype. Another possibility is that a *T. grandiflora* occurrence is composed of both diploid and polyploid individuals. This circumstance may reduce the effective population size and restrict the potential for cross-pollination between only a few individuals in any given year.

Many rare species that have evolved in isolated small populations do not exhibit the inbreeding depression experienced by some fragmented populations of naturally abundant species (Barrett and Kohn 1991). While inbreeding may result in deleterious genes being purged (Byers and Waller 1999), it more often compromises the fitness of a species that suffers substantial declines in the number or size of populations (Soulé 1980). The potential for inbreeding depression in *Triteleia grandiflora* populations appears to be most likely if it is primarily an outcrossing species and if its occurrences experience (or have experienced) significant long-term declines in size and/or number due to habitat loss, direct destruction, or attrition due to poor reproductive output (Soulé 1987).

The variation in *Triteleia grandiflora* habitat conditions throughout its range suggests that distinct ecotypes of the taxon might occur in different regions. This potential for local adaptation indicates that seed from one occurrence may not be suitable for use in restoration efforts in other regions. Some of the issues associated with using non-local seed in restoration efforts, including the potential for outbreeding depression, have been discussed by Lesica and Allendorf (1999) and Hufford and Mazer (2003). Outbreeding depression can result when local adaptations are disrupted after non-local genotypes are introduced (Waser and Price 1989, Lesica and Allendorf 1999, Hufford and Mazer 2003).

The degrees of threat to *Triteleia grandiflora* from loss of genetic integrity by hybridization cannot be estimated without more information on the species' breeding system and on the frequency and consequences of hybridization (see Reproductive biology and autecology section). There are no known reports of hybridization between *T. grandiflora* and other species. A *T. howellii* x *T. multiflora* hybrid was reported from the French Flat Area of Critical Environmental Concern, BLM Medford District in Oregon (Kaye and Blakely-Smith 2002). The nature of these plants is not clear. *Triteleia multiflora* does not appear to be a valid name (Pires 2002). *Brodiaea multiflora* is a synonym for *Dichelostemma multiflora*. The French Flat report can probably be ascribed to the natural morphological variability observed within *T. howellii*.

### Transplantation (Translocation)

*Triteleia grandiflora* corms can be successfully transplanted (Barkworth 1977a, Skinner 2005), which is positive when planning how to mitigate the impacts of planned disturbance. Corms in Region 2 are often buried more than 15 cm below the soil surface and can be difficult to locate. However, if an existing population of *T. grandiflora* is to be destroyed by development, then it may be possible that at least some of the plants can be moved to another site (Skinner 2005). The corms can also be stored in pots for later replanting if necessary (Skinner 2005). However, translocation is not the preferred method of conserving *T. grandiflora* occurrences since transplanting is far riskier and less desirable than conserving the species *in situ* (Given 1994). Since there is not a clear understanding of optimum or suitable habitat, identifying where to relocate the occurrence is problematic. Difficulties in successful establishment and transmission of pests and disease acquired while away from the wild sites are among the threats to translocated *T. grandiflora* plants (Given 1994). In addition, predation may be higher in recently moved plants (Louda 1988).

Genetic diversity may be reduced and chromosomal aberrations may increase within translocated occurrences (Young and Murray 2000). Some of the genetic implications of re-establishing or transplanting populations were illustrated in a study of a self-incompatible grassland species, *Rutidosis leptorrhynchoides* (Asteraceae; Young and Murray 2000). These researchers compared allozyme and chromosomal variation between five small re-established *R. leptorrhynchoides* populations and the two large, wild tetraploid populations from which they were derived. Diploid populations of *R. leptorrhynchoides* were also near the re-established populations. Mean allelic richness at five allozyme loci was lower in re-established populations than in their progenitors, and re-established populations had a greater range of cytotypes than the wild populations (Young and Murray 2000). Some of this increased cytological diversity may have been attributable to inbreeding effects in small populations. However, other cytological observations suggested that immigration also influenced the chromosomal architecture of the new populations (Young and Murray 2000). The two measures of genetic variation (allelic richness and range in cytotypes) showed apparently different responses to re-establishment in this study. However, both of the observed changes are likely to affect population viability negatively: (1) If losses in allozyme diversity are paralleled by a loss of mating types in a self-incompatible taxon, there is the potential for significant effects on population demography (Imrie et al 1972, Barrett and Kohn 1991, Young and Murray 2000); and (2) Increased frequencies of chromosomal abnormalities, which are often associated with lowered fertility, will also reduce individual fitness (Young and Murray 2000). These results emphasize the importance of understanding components of the genetic system as well as the ecology of a species before being confident in the outcome of translocating or re-establishing occurrences.

### Malentities envirogram

**Figure 8** is a simple envirogram constructed to illustrate the threats and malentities to *Triteleia grandiflora*. Threats and malentities tend to be interrelated, so it was difficult to include the relationships between many of the threats in the envirogram (**Figure 8**; see Community ecology section). Extrinsic factors such as certain recreational activities, weed infestations, road improvements, and grazing, all contribute to habitat loss, but they can often interact at some level. Logging has been included as a potential threat, but the information available suggests that it is the accompanying ground disturbance, as noted in the envirogram, and not the loss of canopy that poses the threat. The consequences of inbreeding may become significant threats if populations experience significant declines in size and number. Populations on National Forest System land in Region 2 are likely to be most vulnerable to invasive weeds encroaching on their habitat, activities associated with recreation, and livestock grazing.

## *Conservation Status of Triteleia grandiflora in Region 2*

*Triteleia grandiflora* is a sensitive species (USDA Forest Service 2003a, 2005a). Sensitive species status is very valuable since it draws attention to a taxon, encourages amateur and professional botanists to obtain information about the abundance and range of that taxon, and provides a basis for initiating appropriate protective measures.

Within Region 2, *Triteleia grandiflora* is known from only two locations (**Table 1**; see Distribution section). The one extant occurrence is in the San Juan National Forest in Colorado. This occurrence was found in 1998 and consists of several patches of plants distributed across approximately 11 ha (Colorado Natural Heritage Program 2004). Since 1998, surveys have been conducted in similar habitat on the San Juan Forest, but no new occurrences have been located (Gildar personal communication 2005, 2006). This *T. grandiflora* occurrence is not formally monitored but has been visited by USFS personnel at least every other year since 1998 (Gildar personal communication 2005, Stewart personal communication 2005). A visit to the site in June 2005 confirmed the presence of a healthy population (Gildar personal communication 2005).

The only other occurrence reported from National Forest System land in Region 2 was documented in 1929 on the Medicine Bow National Forest in Wyoming (**Table 1**). The status of this occurrence is unknown, and no surveys for *Triteleia grandiflora* have been conducted on that National Forest (Proctor personal communication 2005).

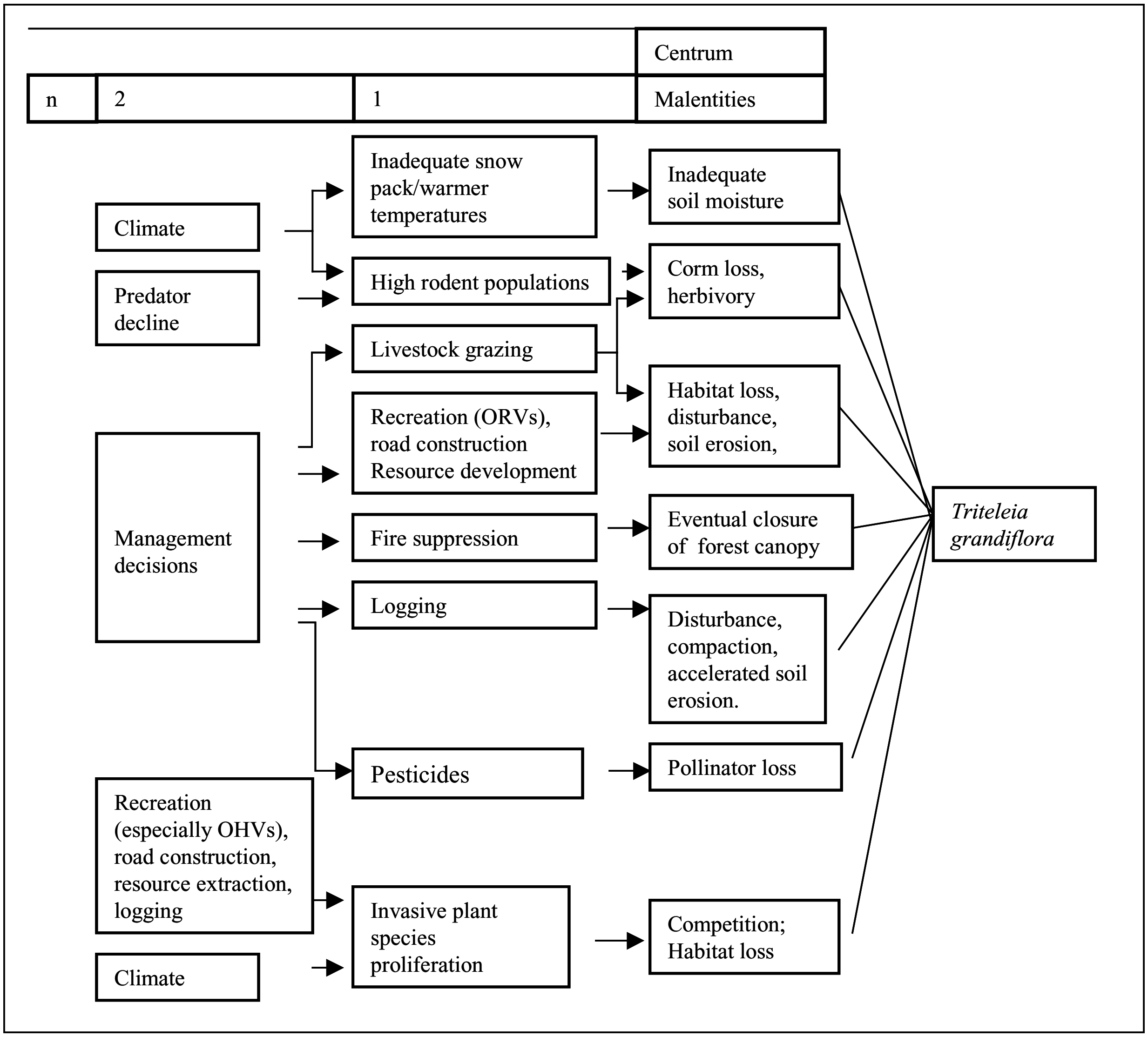



**Figure 8.** Malentities envirogram for *Triteleia grandiflora*.

Actions were taken recently to conserve the *Triteleia grandiflora* occurrence on the San Juan National Forest. In 2004, a timber sale unit was excluded from the project because of the potential for negative effects on resident *T. grandiflora* (Stewart personal communication 2005). The area containing the occurrence has burned, but the age of the Gambel oaks indicates that the sites where the plants are growing experienced only low intensity fire (Stewart 1998). The area could be scheduled for a prescribed burn in the future (Stewart personal communication 2005). The current level of threats does not appear to be substantially affecting the viability of *T. grandiflora* on the San Juan National Forest. However, an increase in the area of impact or intensity of the threats could have negative consequences for *T. grandiflora* in the future.

## *Management of* ***Triteleia grandiflora*** *in Region 2*

### Implications and potential conservation elements

There are at least five main conservation elements of the *Triteleia grandiflora* occurrence in Region 2 to consider:

- the likelihood of genetic uniqueness and enhanced evolutionary potential of disjunct populations, such as in Colorado

- the species' response in different life cycle stages (particularly corm sustainability and seed production) to management practices

- the potential for inbreeding depression and pollinator dependency, especially for diploid individuals

- the genetic variability among populations and the potential for outbreeding depression

- the existence of diploid and polyploid forms, which may have different morphology and physiology.

*Triteleia grandiflora* exists on National Forest System land in Region 2 as a single, isolated, and peripheral population. This occurrence has a relatively high conservation value because populations at the edge of a taxon's range may represent distinct genotypes. These genotypes may be important for the long-term survival and evolution of a species. Isolated populations, independent of ploidy level, present an opportunity for speciation (Coyne and Orr 1998). The possibility that the Colorado *T. grandiflora* occurrence is composed, wholly or partly, of polyploid individuals suggests that there is the potential for speciation to occur.

Weber and Wittmann (2001) suggested that Native Americans introduced *Triteleia grandiflora* to what is now the San Juan National Forest. Stewart (personal communication 2005) noted that there is a known historic Ute campsite near the occurrence (see Distribution and abundance section). An equally valid alternate hypothesis is that the occurrences in Colorado and Wyoming are remnants of a more continuous distribution (Daubenmire 1978). The Medicine Bow occurrence may be extirpated, and the occurrences in Yellowstone National Park are in danger of extirpation, if they have not already been destroyed (see Population trend section). Occurrences have been extirpated in the far northwestern (Vancouver Island, British Columbia) and southwestern (California) parts of the species' range (see Population trend section). Despite the perception that *T. grandiflora* is apparently secure (NatureServe 2005), it is possible that its range is contracting (see Distribution and abundance section). A phylogeographic study of *T. grandiflora*, incorporating molecular and biochemical analyses, might shed light on the relationship between the occurrence in Colorado and occurrences elsewhere.

Corms of *Triteleia grandiflora* individuals in the Colorado population appear to be buried particularly deeply (Stewart personal communication 2005; see Reproductive biology and autecology section). This suggests that they might be polyploid individuals (see Reproductive biology and autecology section). Corm depth may affect the response of the population to factors such as fire, grazing, and timber harvest. Corm depth may not matter in cases of intense soil compaction, but a deeply buried corm might be better protected from disturbance than a shallowly buried corm. Logging, firewood cutting, and thinning may have little effect on polyploid occurrences as long as there is no significant soil disturbance, and these activities may encourage *T. grandiflora* by opening the canopy. However, much more information is required before forest thinning can be recommended as a beneficial practice. Although there is the potential for significant adverse effects from snow compaction, limiting logging to the winter months in order to minimize soil disturbance might be an option to consider if timber harvest is deemed essential to local forest management.

The ploidy level(s) of the Colorado *Triteleia grandiflora* occurrence will have implications regarding its reproductive system and robustness. If the plants are diploid and cross-pollination for sexual reproduction is essential, then maintaining an abundant, healthy, and appropriate assemblage of pollinators will be important in maintaining a viable *T. grandiflora* population (see Reproductive biology and autecology and Demography sections). A decline in abundance and/or a change in the assemblage of arthropod pollinators may lead to inbreeding. Plants that self-fertilize or become inbred may exhibit significant differences in genetic variation between populations because different alleles become fixed during inbreeding (Crawford 1983, Barrett and Shore 1989). The relatively small population on the San Juan National Forest may be genetically depauperate due to inbreeding or founder effects (Menges 1991). The apparent isolation of the Colorado occurrence suggests that there is no opportunity for gene exchange with other populations. However, it is important not to underestimate the value of small, disjunct populations. Alleles that are absent in larger populations may only be found in small populations (Karron et al. 1988). Any reduction in population size may exacerbate the potential for inbreeding depression. This is a serious consideration when evaluating the effect of activities that would decrease the number of individuals within a population or reduce the available habitat around an existing population. Polyploidy in the Colorado *T. grandiflora* population may reduce the potential for inbreeding depression and diminish the absolute requirement for cross-pollinations since vigorous vegetative reproduction obviates the need for annual seed production (see Reproductive biology and autecology section).

Translocation of the existing *Triteleia grandiflora* occurrence in Region 2 cannot be recommended because of the risks involved (Given 1994; see Threats section). Any introductions of *T. grandiflora* corms or seed from other areas to the Region 2 population may lead to problems associated with outbreeding depression (Hufford and Mazer 2003).

### Tools and practices

Carefully planned, executed, and documented inventory and monitoring programs are needed to clarify the status, distribution, and vulnerability of this species, especially in southern Wyoming on the Medicine Bow National Forest (see historic record WY-1 in **Table 1**).

#### *Species inventory*

Inventories are needed to clarify the range and abundance of *Triteleia grandiflora*, especially since it is at the edge of its range in Region 2. Field survey forms for endangered, threatened, or sensitive plant species used by the Colorado Natural Heritage Program (no date) and Wyoming Natural Diversity Database (no date) are available on the Internet (see **References** section for Internet addresses). The San Juan National Forest uses a modified version of these forms (Stewart personal communication 2005). The number of individuals, the area they occupy, their distribution within the habitat, and the apparent potential habitat are important facts to record for comparing occurrences and determining trends in the future. The easiest way to describe the abundance of plants when they are distributed over a large area may be to count patches, make note of their extent, and estimate or count the numbers of individuals within each patch. Quantitative estimates (e.g., "approximately 10" or "100 to 200" individuals) or direct counts are more useful than subjective observations of abundance such as "many" or "few." One source of inaccuracy in estimating occurrence size is due to the inability to assess the number of dormant corms below ground. This is not only a source of possible underestimation of an occurrence's size, but whole occurrences may be missed in any given year when an inventory survey is carried out.

Geological and vegetation maps are typically used for planning where to search for a target species. The advent of easy to use geographic information systems (GIS) has simplified the combination of different coverages (essentially maps) to identify areas a combination of likely factors. Detailed digital vegetation maps have been prepared for most of the national forests and grasslands in Region 2 (USDA Forest Service Rocky Mountain Region 2003). In the case of *Triteleia grandiflora* on the San Juan National Forest, sites where the cover of *Pinus ponderosa* provides 30 percent canopy cover or less, the soils are derived from volcanic or sandstone parent material, and the potential for disturbance is low (areas away from roads and trails) may be promising places to search. Additional insight regarding the appropriate areas to survey for *T. grandiflora* may be gleaned from the descriptions of habitat conditions at occurrences throughout its range (**Table 1**, **Table 2**). For Region 2, the descriptions of habitat conditions of *T. grandiflora* occurrences in Wyoming may be more relevant than those from the Pacific Northwest (**Table 5**; see Community ecology section).

Collecting information on the distribution of plants of different sizes and reproductive status (i.e., flowering plants versus vegetative plants versus those with one leaf) is also valuable in assessing the vigor and reproductive potential of a population. Observations of habitat and associated plant species are also customarily recorded during inventories. The most appropriate time to make an inventory of *Triteleia grandiflora* is when the plants are flowering. This will depend somewhat upon the elevation and latitude, but mid- to late June appears to be an appropriate time in Colorado and Wyoming.

#### *Habitat inventory*

Data associated with the occurrences in Colorado and Wyoming (**Table 1**) suggest that *Triteleia grandiflora* grows in a variety of habitats within the montane zone. The sub-occurrences on the San Juan National Forest are in open to partially shaded areas in a *Pinus ponderosa/Quercus gambelii* community on soils derived from sandstone (see Habitat section). However, there is an insufficient understanding of all the features that constitute "potential" habitat to be able to make a rigorous inventory of areas that are likely to be colonized. More than 445 ha of apparently suitable habitat on the San Juan National Forest were surveyed for *T. grandiflora*, and no additional occurrences were found (Gildar personal communication 2006). One consideration is that the microhabitats occupied by *T. grandiflora* plants may depend upon their ploidy level (Barkworth 1977a; see Habitat and Community ecology sections).

#### *Population monitoring*

No formal monitoring studies have been reported for *Triteleia grandiflora* in Region 2. Informal surveys of the occurrence in the San Juan National Forest have been conducted every year or two since 1998. The observed abundance of *T. grandiflora* fluctuates between years, apparently due to variations in environmental conditions (Colorado Natural Heritage Program 2005b, Lyon personal communication 2005, Stewart personal communication 2005). As well as documenting the abundance of *T. grandiflora*, monitoring studies can provide information for assessing factors such as potential threats from invasive non-native species and the effects of management decisions. Using appropriate controls, monitoring populations in areas before and after management practices have been implemented is one way to determine quantitatively the consequences of the changes (Goldsmith 1991, Elzinga et al. 2001). To be statistically valid under conditions of normal variability, monitoring programs should be considered as long-term efforts. Responses to management changes are sometimes not observed in either vegetation structure or in individual plant behavior for several years or even decades, especially in semi-arid and arid environments (Vasek et al. 1975a, Vasek et al. 1975b, Kaye 2002, Guo 2004).

The use of permanent monitoring plots with photo-points is very useful for identifying potential threats and determining population trends. The monitoring scheme needs to address the patchy and possibly dynamic nature of *Triteleia grandiflora* occurrences. Problems associated with spatial auto-correlation can occur when using permanent plots to monitor a dynamic population (Goldsmith 1991). If the plot is too small or the establishment of new plots is not part of the original design, then when plants die and no replacement occurs, it is impossible to know the significance of the change without studying a very large number of similar plots. Elzinga et al. (1998, 2001), Goldsmith (1991), and Lesica (1987) describe protocols appropriate for monitoring species with spatially aggregated or patchy distributions.

The potential for shifts in *Triteleia grandiflora* patch locations due to a series of local colonizations and extirpations needs to be differentiated from the natural temporal variations in the aboveground evidence of a population due to the variable length of corm dormancy. If a *T. grandiflora* plant appears in an area, it is not clear whether it represents the colonization of a new patch or whether the plant is from a dormant corm of a pre-existing patch. Species occurring in drought-prone habitats may have relatively large proportions of dormant plants, and the dormant periods may be longer than two years (Lesica and Steele 1994). Lesica and Steele (1994) have discussed the challenges of monitoring taxa with organs that undergo periods of prolonged dormancy. The appropriate monitoring frequency and overall monitoring duration should be sufficient to identify trends in the presence of normal year-to-year variability. Since *T. grandiflora* is sensitive to its environment and has corms that can undergo prolonged dormancy, annual monitoring is probably most appropriate until a statistically valid assessment of normal temporal variability can be made. Three years of annual monitoring may be sufficient to achieve a useful short-term sample, but it is unlikely to allow for critical evaluation of a population's stability, long-term trends, or response to management (Lesica and Steele 1994). Lesica and Steele (1994) reported that, "when dealing with plants that have prolonged dormancy, it will be necessary to conduct a study for seven years to obtain five years of accurate data."

An attempt to measure the age of *Triteleia grandiflora* individuals is likely to be destructive and very difficult since the corms would need to be excavated. Size of the aerial parts of a plant has been suggested as a means of evaluating a population during monitoring (Gross 1981). This might not work well for *T. grandiflora* since an individual's size may be influenced by many factors, including ploidy level and environmental conditions. However, describing individuals by the number of leaves (one or two) and whether they are flowering or fruiting would be useful information to collect when monitoring a *T. grandiflora* occurrence.

The number of plots or transects, the area covered, and the level of detail in the monitoring data collected for *Triteleia grandiflora* and its habitat will depend upon the study's goals and the resources available. The protocol design needs to be sufficiently straightforward and robust so that field staff with all levels of expertise can collect data consistently and accurately. Appropriate statistical analyses need to be established prior to the first year of monitoring and, as far as possible, take into account budget-imposed circumstances such as varying search intensity, numbers of (sub)-occurrences that can be visited in any given year, and the total area covered. A minimum number of transects or plots and necessary information can be determined at the beginning of the monitoring project. For example, an ideal monitoring protocol might specify recording the number of flowering, fruiting, one-leaved vegetative, and two-leaved vegetative individuals on four transects in three locations (12 transects total). The protocol will also recognize that it may not be possible to obtain this level of data every year. The minimum data set required by the protocol consists of one transect in each of the three locations and a count of all plants regardless of stage. This minimum amount of information can be collected consistently according to the protocol to obtain statistically valid data.

### *Habitat monitoring*

The relative lack of information on the habitat requirements of *Triteleia grandiflora* makes it premature to consider that monitoring unoccupied habitat can be an effective conservation strategy for this taxon. Monitoring occupied habitat needs to be associated with population monitoring protocols. Descriptions of habitat recorded during population monitoring activities will permit the analysis of the relationship between environmental conditions and abundance over the long term. Current management prescriptions and evidence of land use activities (e.g., hiking, biking, livestock grazing) are important to include with the monitoring data. Monitoring non-native plant species in an area is useful for weed management purposes, but would also help to assess the suitability of the area as potential habitat. Careful monitoring and management of non-native plant species in and around *T. grandiflora* occurrences is likely to be an effective approach to maintaining viable habitat for the existing occurrence.

### *Population or habitat management approaches*

There have been no systematic monitoring programs for *Triteleia grandiflora* and no documented attempts of active management, except for the exclusion of the San Juan National Forest occurrence from a recent timber sale (Gildar personal communication 2005, Stewart personal communication 2005). Considering the importance of the corm, minimizing soil compaction and soil disturbance is prudent. Some management practices to limit disturbance, such as restricting recreational vehicle traffic and routing hikers to designated trails, have been implemented in many national forests and would likely benefit *T. grandiflora* occurrences. Specific logging and grazing prescriptions can be adopted to minimize potential damage to occurrences (see Threats and Implications and potential conservation elements sections).

Methods to conserve rare taxa include the designation of occupied sites as protected areas (e.g., special interest areas, wilderness areas or research natural areas). The Region 2 *Triteleia grandiflora* occurrence is in a part of the San Juan National Forest that is managed for multiple purposes, including logging, utility right of ways, and transportation, and the area does not have any special protection. There are no formal plans to create a protected area for the *T. grandiflora* occurrence on the San Juan National Forest (Stewart personal communication 2005). However, in the near future, the San Juan National Forest will be exploring a proposal to create an old growth *Pinus ponderosa* Special Interest Area that may include at least part of the *T. grandiflora* occurrence (Redders personal communication 2006). The establishment of this area may require thinning or burning to restore some of the natural ecological processes that have been interrupted due to past fire suppression (Redders personal communication 2006). Thinning and burning have the potential to disturb *T. grandiflora* corms but also may contribute to the maintenance of suitable habitat for *T. grandiflora* if soil disturbance is minimized and if the burns are of low intensity (see Community ecology and Threats sections). Livestock grazing would probably continue in this proposed Special Interest Area, but no new trails and roads would be permitted, and some existing roads may be closed (Redders personal communication 2006).

The Colorado Natural Heritage Program has delineated an area around the *Triteleia grandiflora* occurrence in the San Juan National Forest as the House Creek Potential Conservation Area (Lyon 2005). A Potential Conservation Area (PCA) is designated "to identify a land area that can provide the habitat and ecological processes upon which a particular element occurrence…depends for its continued existence" (Doyle et al. 2005). The boundaries given to a PCA are established for conservation planning purposes and have no legal status. A PCA identified by the Colorado Natural Heritage Program has no relationship to a Conservation Area as defined in the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1702(e)). The Colorado Natural Heritage Program ranks each PCA for its significance with respect to biodiversity (Biodiversity Rank), need for protection (Protection Urgency Rank), and need for active management intervention (Management Urgency Rank) (Doyle et al. 2005). The House Creek PCA has a Biodiversity Rank of B4 indicating that it has moderate biodiversity significance since it has an excellent occurrence of a plant that is globally secure but disjunct and very rare in Colorado (Lyon 2005). The House Creek PCA has a Protection Urgency Rank of P4 indicating low urgency with no protection actions needed in the foreseeable future (Lyon 2005). The House Creek PCA has a Management Urgency Rank of M3 indicating moderate urgency because new management actions may be needed within 5 years to maintain the current quality of the element occurrences in the PCA (Lyon 2005). Control of exotic species along roads and the power line was noted as being a potential benefit to the *T. grandiflora* occurrence (Lyon 2005). The San Juan National Forest currently considers this PCA in their planning process (Anderson personal communication 2006).

Common methods of defending sensitive areas from anthropogenic threats without formally designating protected areas include erecting fences, establishing barriers to ATV traffic, and/or posting signs indicating that the areas are closed. However, the success of signage and barriers in protecting areas vulnerable to disturbance is variable and depends upon the site characteristics and the users' compliance. Federal acquisition and protection of private land that contains populations of a sensitive species is a mechanism to provide federal oversight of known occurrences. This approach does not appear to be a conservation option for *Triteleia grandiflora* in Region 2 at the present time.

Seed banks have been established to preserve seeds of commercially, ecologically, and/or socially important plant species in case restoration efforts are needed in the future (e.g., Royal Botanic Gardens at Kew undated, Global Crop Diversity Trust 2004, Center for Plant Conservation undated). However, seed banking may have limited value for restoring taxa whose ecology is not well understood. If microhabitat requirements are not known, the conditions to maintain an occurrence may not be met even if germination and seedling establishment can be achieved. Therefore, re-establishing occurrences that have been extirpated may be a very difficult task. The Center for Plant Conservation (CPC) is dedicated to preventing the extinction of native plants in the United States and maintains many taxa as seed, rooted cuttings, or mature plants, depending upon the taxon's requirements. Seeds or corms of *Triteleia grandiflora* do not appear to have been preserved at any plant species bank. The taxon is not included in the current CPC National Collection (Center for Plant Conservation no date).

## *Information Needs*

Completing a comprehensive inventory of *Triteleia grandiflora* would aid in determining its status in Region 2. Inventory surveys in Platte County, Wyoming would be useful in confirming the presence or extirpation of the occurrence last reported in 1929.

The effects of human population growth and land management decisions on the range and abundance of *Triteleia grandiflora* are unknown. Observations suggest that the taxon is vulnerable to habitat loss and degradation from a variety of sources, but the long-term consequences need to be clarified. Additional information on how this species responds to invasive non-native species is especially important because they are a substantial problem throughout its range, including Colorado and Wyoming (Colorado Department of Agriculture no date, Markin 1995, Sheley and Petroff 1999).

More information is needed on the life history and population dynamics of *Triteleia grandiflora*. The relative importance of existing corms, the seed bank, and seed dispersal to long-term sustainability needs to be clarified. The reproductive strategy of *T. grandiflora* also needs to be clarified. Information on the importance of asexual reproduction, the frequency with which cross-pollination occurs or is necessary, and the degree to which inbreeding depression is likely would help in assessing the vulnerability of this species. These factors also influence its sensitivity to a decline in either population size or population number (see Threats section). Where out-crossing occurs, specific information on the pollinator species and their behavior would assist in assessing the vulnerability of *T. grandiflora* to declines in pollinator abundance or changes to pollinator species composition. As many of the above issues vary according to ploidy, the population makeup of the Region 2 occurrence(s) needs to be determined.

There is little information on population structure or persistence of either *Triteleia grandiflora* individuals or populations. The factors that limit population size and abundance are not known. It would be useful to know whether seed from diploid plants is more robust than that of polyploid individuals since this may influence the longevity and viability of occurrences. The rate of colonization and how the availability of appropriate habitat influences population recovery after significant disturbance are also unknown. Habitat requirements, including possible relationships with non-vascular species, need to be more rigorously defined. Monitoring known occurrences is essential in order to understand the implications of existing and new management practices. Where management practices are likely to change, inventory that collects baseline data can be compared to the results gathered during periodic monitoring conducted after the new policy is implemented. Research needs to be carried out before artificially establishing new populations or including this species in vegetation restoration projects.

A study of the genetic structure of the Colorado *Triteleia grandiflora* population and comparing it with other populations may elucidate the origin of the Colorado population. This research would also help to determine the degree of genetic diversity within *T. grandiflora*.

In conclusion, answers to several questions would assist in appreciating the vulnerability of *Triteleia grandiflora*. Primary information needs for this species can be summarized as follows:

- ❖ clarify the range and abundance of *T. grandiflora*, especially within Colorado and Wyoming
- ❖ determine the impact of human activities on populations of *T. grandiflora* in order to promote steps towards threat mitigation
- ❖ determine the effects of current land management practices on National Forest System lands, which could be achieved by long-term monitoring of known sites of *T. grandiflora* and determining the long-term fates of individuals and the dynamics of the occurrence
- ❖ understand the genetic diversity and reproductive biology of *T. grandiflora*, especially as they relate to the potential for inbreeding, pollinator dependency, and limitations caused by vegetative reproduction
- ❖ define the habitat requirements of *T. grandiflora* and reasons that limit occurrence expansion
- ❖ determine the relationships between the *T. grandiflora* occurrence in southwestern Colorado and those elsewhere in its range; this can be achieved by an appropriate phylogeographic study.

# Definitions

**Allele –** a form of a given gene (Allaby 1992).

**Allelopathy –** "The release into the environment by an organism of a chemical substance that acts as a germination or growth inhibitor of another organism" (Allaby 1992).

**Apomixis (Apomictic) –** a type of asexual reproduction in plants (i.e., reproduction without fertilization or meiosis) (Allaby 1992).

**Autogamous or Autogamy –** self-fertilized, self-fertilization.

**Binomial –** derived from the binary nomenclature system in which the name of a species consists of a generic name (genus) and a specific epithet (species); trinomial refers to infraspecific taxa, that is, varieties or subspecies.

**Bulb –** underground storage organ comprising a short flattened stem with roots on the lower surface and above it fleshy leaves or leaf bases surrounded by protective scale leaves (Allaby 1992); compare with corm; for further discussion of bulbs and corms see Dahlgren and Clifford (1982).

**Cauline –** of, or pertaining to, the stem (Harrington and Durrell 1986).

**Clade –** a group of all the organisms that share a particular common ancestor and therefore have similar features; the members of a clade are closely related to each other.

**Corm –** underground storage organ formed from a swollen stem base, being adventitious roots and scale leaves (Allaby 1992); compare with bulb; for further discussion of bulbs and corms see Dahlgren and Clifford (1982).

**Habitat fragmentation –** continuous stretches of habitat become divided into separate fragments by land use practices such as agriculture, housing development, logging, and resource extraction; eventually, the separate fragments tend to become very small islands isolated from each other by areas that cannot support the original plant and animal communities and that cannot be easily traversed by animals (arthropods in this context).

**Heterosis –** hybrid vigor such that an F1 hybrid falls outside the range of the parents with respect to some character or characters; usually applied to size, rate of growth, or general thriftiness (Allard 1960).

**Heterozygote –** a diploid or polyploid individual that has different alleles at least one locus.

**Homologous –** in the context of chromosomes, homologous chromosomes contain identical linear genetic sequences that pair during meiosis.

**Homozygous –** "the presence of identical alleles at one or more loci in homologous chromosomal segments" (Allaby 1992).

**Iteroparous –** experiencing several reproductive periods, usually one each year for a number of years, before it dies.

**Malentity –** an environmental or biological factor that is capable of having an adverse affect on that organism with no adverse consequence to itself; a malentity can influence the subject organism accidentally (e.g., rain causing a flash flood) or intentionally (e.g., an herbicide).

**Monophyletic –** applied to a group of species that share a common ancestry being derived for a single interbreeding population (Allaby 1992).

**Noxious weeds –** those plant species of foreign origin that are new to or not widely prevalent in the United States, and can directly or indirectly injure useful plants, interests of agriculture, fish and wildlife resources or the public health of the United States (from United State Code as of: 01/26/1998; Title 7-Agriculture, Chapter 61, Sec. 2802).

**Phylogenetic systematics –** "the study of biological organisms and their grouping for purposes of classification, based on their evoluntionary descent" (Allaby 1992).

**Phylogeography –** phylogenetic study of the historical processes that have influenced geographic distributions in multiple, co-distributed taxa.

**Polyploidy –** a "condition in which an individual possesses one or more sets of homologous chromosomes in excess of the normal two sets found in diploid organisms." (Allaby 1992).

**Polymorphic (polymorphism) –** having several different forms.

**Pseudogamy –** development of ovum into a new individual as a result of stimulation by a male gamete, whose nucleus does not fuse with that of the ovum and contributes nothing to the hereditary constitution of the embryo (Abercrombie et al. 1973).

**Outcross –** a cross, usually natural, to a plant of different genotype (Allard 1960).

**Rank –** NatureServe (2005) and the Heritage Programs Ranking system, see Internet site: http://www.natureserve.org/explorer/granks.htm.

> G4 - indicates a taxon is "Apparently Secure—Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.
>
> S1 "critically imperiled—Critically imperiled in the subnation [state or province] because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the subnation. Typically 5 or fewer occurrences or very few individuals (<1,000).
>
> S2 "imperiled—Imperiled in the subnation [state or province] because of rarity or because of some factor(s) making it very vulnerable to extirpation from the nation or subnation. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).
>
> S3 "vulnerable—Vulnerable in the nation or subnation USFS Region 4 Payette National Forest either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals."
>
> S4 "apparently secure—Uncommon but not rare, and usually widespread in the subnation [state or province]. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals."

**Semelparous –** (semelparity) as opposed to iteroparous - reproducing once and then dying.

**Stochasticity –** uncertainty (Frankel et al. 1995).

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# Appendix

## *Details of observations of <u>Triteleia grandiflora</u> <u>ssp. howellii</u> and <u>T. grandiflora ssp. grandiflora</u> outside of Region 2*

### Taxonomic notes on *Triteleia grandiflora* ssp. *howellii* and *T. grandiflora* ssp. *grandiflora*

Some authorities recognize two subspecies of *Triteleia grandiflora*, ssp. *howellii* and ssp. *grandiflora* (Integrated Taxonomic Information System 2005, USDA Natural Resources Conservation Service 2005, NatureServe 2005). Subspecies *howellii* is distinguished from ssp. *grandiflora* by its flat filaments that are not strongly keeled and that are attached at the same level on the perianth tube. The filaments of ssp. *grandiflora* are not flat, are strongly keeled and are attached at two levels on the perianth tube (Hitchcock and Cronquist 2001, Pojar 2001, Pires 2002). The petals of the two species also differ. Those of ssp. *howellii* are all similar, not strongly ruffled, and the outer petals arising at nearly the same level as the inner ones, all flaring together (Hitchcock and Cronquist 2001). The two series of petals in ssp. *grandiflora* differ; the outer series are not ruffled whereas the inner ones are broader, strongly ruffled, and flared at approximately 2 to 3 mm higher than the outer series (Hitchcock and Cronquist 2001). In a taxonomic study, Barkworth (1977b) detected a total of 32 pigments in the two subspecies. Ten were restricted to ssp. *grandiflora*, seven to ssp. *howellii* and 15 common to both. Flower color was not a significant contributor to the differences observed since pigments in extracts from white and blue populations of ssp. *grandiflora* were not significantly different from each other (Barkworth 1977b). Pigments from three other *Triteleia* species were also analyzed and compared to the T. *grandiflora* subspecies. The pigment profiles of the two T. *grandiflora* subspecies were more similar to each other than were the profiles of any of the other three species (Barkworth 1977b). Variability for filament morphology apparently exists and some individuals that may represent intergrades have been found (Hoover 1955, Pires 2002). These observations have led Pires (2002) to suggest that infraspecific divisions are not warranted. *Brodiaea howellii* S. Watson is a synonym for T. *grandiflora* var. *howellii* (S. Watson) Hoover.

### Additional details of the abundance and distribution of *Triteleia grandiflora* ssp. *howellii* and *T. grandiflora* ssp. *grandiflora*

*Triteleia grandiflora* ssp. *grandiflora* is most abundant in western Oregon, Washington and Idaho. On National Forest System lands, occurrences have been reported from the Gallatin, Deerlodge, Nez Perce, and Idaho Panhandle national forests in Region 1, the Wasatch-Cache, Bridger-Teton, Payette, and Caribou-Targhee national forests in Region 4, the Modoc and Klamath national forests in Region 5, and the Colville, Umpqua, Ochoco, Wallowa-Whitman, Wenatchee, and Umatilla national forests in Region 6. It is fairly frequently encountered on the Payette and Targhee national forests in Region 4 (Hanson personal communication 2005, Lehman personal communication 2005). The highest number of occurrences was reported from the Payette National Forest in Region 4 where approximately 40 occurrences were reported in 1999 and 2000. Twenty-one (21) occurrences were reported in the early 1990s on the Targhee National Forest.

*Triteleia grandiflora* ssp. *howellii* is known from the Modoc and Klamath national forests in Region 5 (California). *Triteleia grandiflora* ssp. *howellii* is designated sensitive by the California Native Plant Society (2005), but it is not included on the Region 5 Regional Forester's sensitive species list (USDA Forest Service, Pacific Southwest Region 2003b). *Triteleia grandiflora* ssp. *howellii* was included in a discussion of the general sensitive plant species management policies of Sierra Pacific Industries, a timber harvesting company (James 2003). During analysis of sensitive plant species that may be encountered during Sierra Pacific Industries' timber harvests, T. *grandiflora* ssp. *howellii* was estimated to be a medium risk species since the taxon was determined to be "generally susceptible only to indirect effects of timber harvest activity" or "to occur in habitats or locations in which direct impacts from Sierra Pacific Industries' timber operations are infrequent" (James 2003). Pires (2002) reports that *T. howellii* may be already extirpated from California.

In British Columbia, Canada, *Triteleia grandiflora* is regarded as apparently secure (S4), but ssp. *howellii* is critically imperiled (S1) (NatureServe 2005). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recognizes the full species, *T.*

*howellii*, and lists it as Endangered (Committee on the Status of Endangered Wildlife in Canada 2003). The nine extant populations of *T. howellii* in British Columbia occur in regional and municipal parks, and on private properties (Douglas and Penny 2003). British Columbia does not have specific legislation in place for the protection of vascular plants at risk but on the federal level the Canadian Species at Risk Act protects COSEWIC-listed plants on federal lands (Committee on the Status of Endangered Wildlife in Canada 2003). If the laws of a province are deemed to be ineffective in protecting a species, the federal minister also has the option of recommending a federal Cabinet Order that would provide for protection of COSEWIC species on provincial lands (Committee on the Status of Endangered Wildlife in Canada 2003).

### Habitat and vulnerability of *Triteleia grandiflora* ssp. *howellii* and *T. grandiflora* ssp. *grandiflora* in areas outside of Region 2

In historical descriptions, *Triteleia grandiflora* ssp. *howellii* and T. *grandiflora* ssp. *grandiflora* were reported as being sympatric but not sharing the same habitat (Piper 1906, Hoover 1941). In British Columbia, occurrences of ssp. *howellii* are conspicuously restricted to southeastern Vancouver Island in remnants of the *Quercus garryana* (Garry oak) habitat type (Douglas and Penny 2003). *Quercus garryana* habitat type is unique in Canada and is at its northern limit, being more common south of the Canadian border (Douglas and Penny 2003). This habitat type thrives in a Mediterranean climate with warm, dry summers and mild, wet winters (Douglas and Penny 2003). Occurrences are in *Q. garryana* woodlands, specifically the *Q. garryana/Dactylis glomerata* (orchard grass) and the *Q. garryana-Arbutus menziesii* (Arbutus) plant communities (Douglas and Penny 2003). The *Q. garryana/Dactylis glomerata* (orchard grass) plant community is on deep, dark soils up to a meter in depth and the *Q. garryana-Arbutus menziesii* stands are at the base of rock outcrops (Douglas and Penny 2003). Occurrences are also known from highly disturbed, weedy sites in private yards and on roadsides but the current status of several of these occurrences is not known (Douglas and Penny 2003).

Ploidy level is unlikely to be related to any habitat differences between the two subspecies since diploids, triploids, and tetraploids were found in both subspecies (reported as *Brodiaea douglasii* and *B. howellii*, Barkworth 1977b). Intergrading forms between T. *grandiflora* ssp. *grandiflora* and ssp. *howellii* have been found at the western edge of the range of T. *grandiflora* ssp. *grandiflora*.

Many of the *Triteleia grandiflora* occurrences assigned to ssp. *howellii* have already been extirpated in California, Oregon, Washington, and British Columbia (see Population trend section in body of assessment). The Vancouver Island *Quercus garryana* communities that have ssp. *howellii* occurrences have been heavily urbanized or converted to agricultural land (Douglas and Penny 2003). These *Q. garryana* communities likely represent remnants of a formerly widespread community type (Douglas and Penny 2003). Other historic occurrences of both T. *grandiflora* subspecies are now located in areas that have since become urbanized and their current status is unknown (see Population trend section in body of report). The significance of these extirpations to the overall fitness of the species is unknown. The degree to which either subspecies of T. *grandiflora* disperses into new sites is also unknown but may be very limited (Douglas and Penny 2003).

As well as anthropogenic factors such as urbanization, *Triteleia grandiflora* occurrences in the Pacific Northwest may be vulnerable to the effects of global climate change. One model that was developed to determine ecosystem responses to climate change and carbon dioxide ($CO_2$) doubling made predictions for Washington where, if temperatures increased by 5.6 °C and precipitation increased by 13 percent, grass-, shrub-, and woodland acreage would decline and Sitka spruce and hemlock forests would become more dense (Vegetation/Ecosystem Modeling and Analysis Project 1995). These conditions would reduce potential habitat for T. *grandiflora*.