Staminate flowers each consist of 4 or 5 stamens and a 4- or 5-lobed perianth. They develop in clusters of 2 to 5 in bract axils (Goodrich and Neese 1986; Welsh and others 1987). Pistillate flowers are 1 to several in bract axils with each enveloped by 2 united bracts. The bracts are either dorsiventrally flattened and unequally 6-keeled with the seed horizontal (*Z. b*. var. *arizonica*) (figures 1 and 2) or obcompressed and thin-margined with the seed vertical (*Z. b.* var. *bradegei* and *Z. b.* var. *plummeri*) (Goodrich and Neese 1986; Welsh and others 1987) (figures 1 and 2). Plants of all varieties flower in late spring or summer and fruits ripen in mid to late summer or fall (Blauer and others 1976; Pendleton and others 1988) (table 1).

Protogynous plants generally produce more seeds, but protandrous plants may be equally productive in wet years or in years with low seed predation (Pendleton and others 2000). Fruits are dispersed slowly, with some usually remaining dormant on the plant through winter (Blauer and others 1976). Seeds are light yellowish brown at maturity (Hurd and Pendleton 1999) (figure 3). The outer layer of the seedcoat is elastic when imbibed. The embryo is well developed, with pale yellow cotyledons and an elongate, inferior radicle encircling the perisperm (figure 3). Seedling development is epigeal (figure 4).

**Collection of fruits and seed extraction and cleaning.** Fruits are collected by hand- stripping or beating and air-dried. Coarse debris may be removed with an air-screen machine or a seed blower, or by screening. Careful rubbing to remove bracts prevents radicle damage. The final product may consist of debracted utricles (Meyer and Pendleton 1990; Pendleton and Meyer 1990) or seeds (figure 3). Weight of bracted utricles and seeds and seed fill data are provided in table 2.

**Figure 1**—*Zuckia brandegei*, siltbush: bracted utricles.

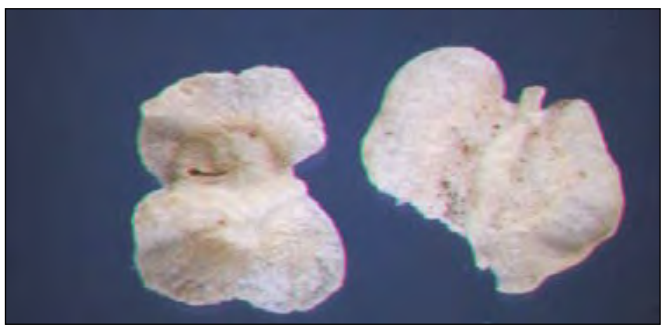


**Figure 2**—*Zuckia brandegei*, siltbush: utricle (**left**) and seed (**right**)

**Storage.** Germination of seeds incubated at 1 to 3 °C in constant darkness was 87% after 2 years of storage in cloth bags in a warehouse (Stevens and Jorgensen 1994; Stevens and others 1981). Germination from year 2 to year 4 was 88%, dropping to 57% by year 5, 13% by year 7, and 0% after 15 years. Viability of bracted utricles stored in paper bags at room temperature and debracted utricles from the same collection stored in a freezer at – 80 °C was 97% after 7 years as determined by tetrazolium chloride testing (Hurd and Pendleton 1994).

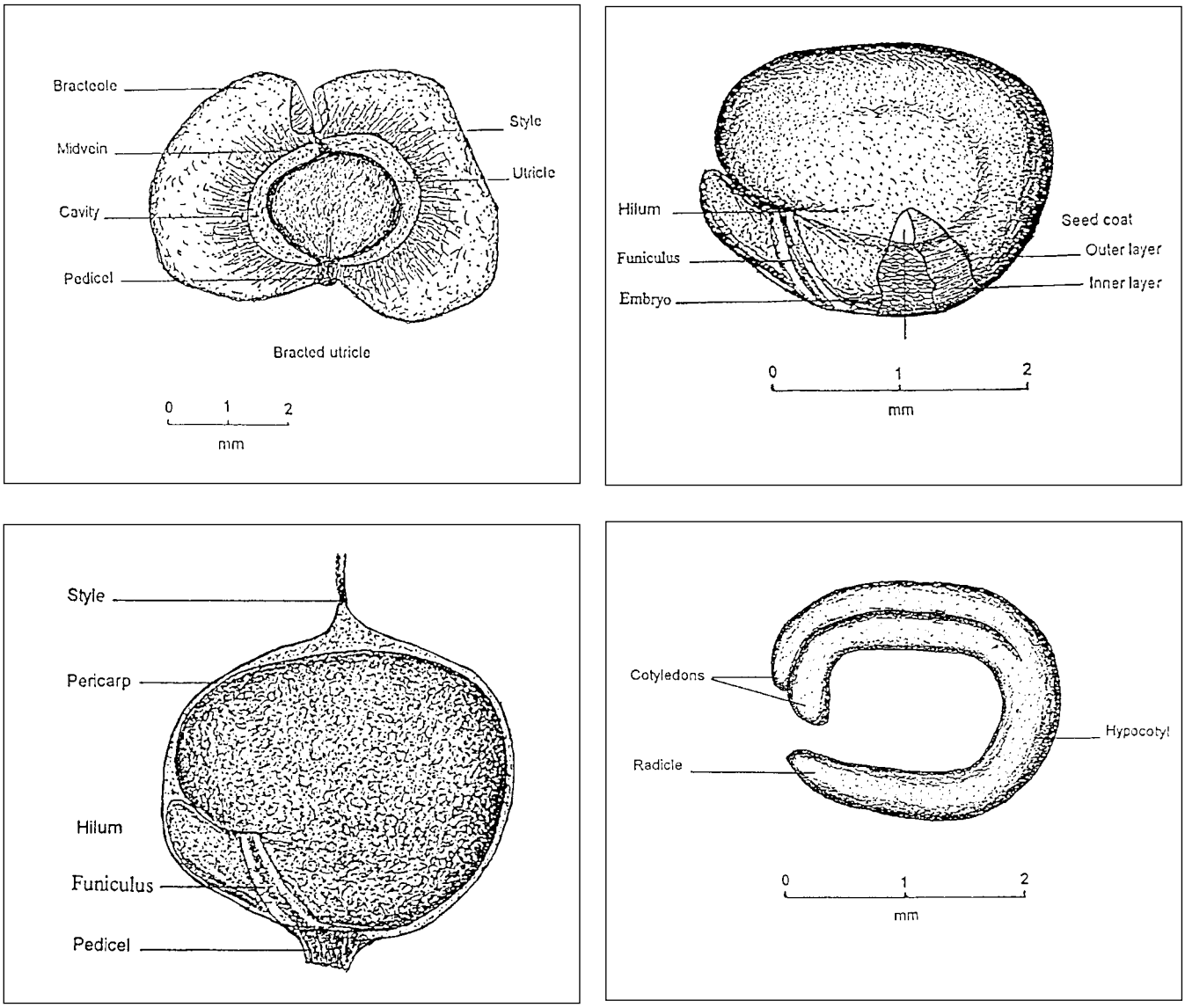
**Pregermination treatments**. Germination experiments have been conducted with seeds of *Z. b.* var. *brandegei* and *Z. b.* var. *plummeri*. Seeds of warm-winter populations may germinate opportunistically over a wide range of

**Table 1**—*Zuckia brandegei*, siltbush: phenology of flowering and fruiting

| Species | Location | Flowering | Fruit ripening | Seed dispersal |
|---|---|---|---|---|
| *Z. brandegei* | Central Utah | Mid-June–mid-Aug | Late Sept–early Oct | Jan or later |
| | Uinta Basin, Utah | May–June | Sept | — |
| | Sanpete Co., Utah | Mid-May–July | July–late Sept | — |
| | — | — | Sept 10–Dec 15 | — |

**Sources:** Blauer and others (1976), Goodrich and Neese (1986), Pendleton and others (1988), Plummer and others (1968).

**Figure 3**—*Zuckia brandegei*, siltbush: bracted utricle (**top left**), seed (**top right**), utricle (**bottom left**), and embryo (**bottom right**).




constant temperatures (15 to 30 °C) when water is available (Meyer and Pendleton 1990). Seeds of cold-winter populations are dormant at fall and winter temperatures, germinating in early spring following exposure to overwinter chilling. Germination generally increased with duration of wet prechilling at 1 °C for up to 8 weeks, dry after-ripening for up to 14 months, or removal of bracts (Meyer and Pendleton 1990; Pendleton and Meyer 1990).

Techniques and criteria recommended for characterizing normal seedlings, excising embryos, and testing viability are as described for spiny hopsage (Shaw 1992):

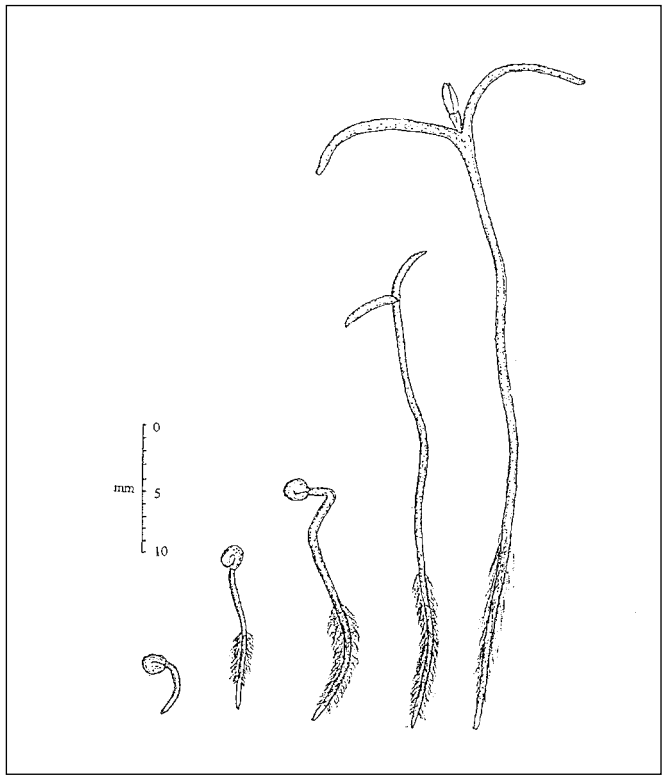
- Normal seedling—Epigeal, with thin, 10- to 15-mm-long hypocotyls; small, narrow cotyledons; short epicotyl; and well-developed root hairs (figure 4).
- Excised embryo—Seeds soaked in water at 28 °C for 12 hours and then drained can have their embryos excised with sharp needles; these embryos germinate rapidly at 15/5 or 15 °C and should be evaluated for presence of normal seedlings.
- Viability—Seeds soaked in water at 28 °C for 12 hours, and then drained can be pierced through the perisperm with a sharp probe or needle, then they are

**Table 2**—*Zuckia brandegei*, siltbush: fruit and seed characteristics

| Species | Bracted utricles (x1,000)/weight | | | | Seeds (x1,000)/weight | | | | Filled seed % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Average | | Range | | Average | | | |
| | /kg | /lb | /kg | /lb | /kg | /lb | /kg | /lb | Range | Average |
| *Z. brandegei* | 263–312 | 119–142 | 284 | 129 | 555–769 | 252–349 | — | — | 5–27 | 16 |
| *Z. brandegei* var. *arizonica* | 372–1,061 | 169–481 | 732 | 332 | 420–794 | 191–360 | 418–561 | 190 – 254 | 7–21 | 15 |

**Sources:** Pendleton and others (1988), Plummer and others (1968), Smith (1974).

**Figure 4**—*Zuckia brandegei*, siltbush: seedling development.




soaked in a 1% 2,3,5-triphenyl tetrazolium chloride solution for 4 to 8 hours at 28 °C; the seedcoat is translucent after soaking, making excision unnecessary for evaluation of staining.

**Nursery culture and direct seeding.** Because few data are available, recommendations for spiny hopsage (see Grayia, page 567) may be used as guidelines for establishing siltbush from seed. Based on studies conducted in south-central Utah, Monsen (1996) found that siltbush seedlings develop more rapidly than those of spiny hopsage. Root systems of bareroot stock are much more extensive after 1 growing season. Palatability is low to moderate (Monsen 1996; Stutz 1995). Plants may attract rodents, other small animals, and occasionally deer.

## References

Blauer AC, Plummer AP, McArthur ED, Stevens R, Giunta BC. 1976. Characteristics and hybridization of important Intermountain shrubs: 2. Chenopod family. Res. Pap. INT-177. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 42 p.

Dorn RD. 1988. Vascular plants of Wyoming. Cheyenne, WY: Mountain West Publishing. 340 p.

Drobnick R, Plummer AP. 1966. Progress in browse hybridization in Utah. Proceedings of the Conference of Western State Game and Fish Commissioners 46: 211–213.

Goodrich S, Neese E. 1986. Uinta Basin flora. Ogden, UT: USDA Forest Service, Intermountain Region, Ashley National Forest and USDI Bureau of Land Management, Vernal District. 320 p.

Gray A. 1876. *Grayia brandegei*. Proceedings of the American Academy of Arts and Sciences 11: 101–103.
Hurd EG, Pendleton RL. 1994. Unpublished data (1987–1994). Boise, ID: USDA Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory.
Hurd EG, Pendleton RL. 1999. Unpublished data. Boise, ID: USDA Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory.
Meyer SE, Pendleton RL. 1990. Seed germination biology of spineless hopsage: between population differences in dormancy and response to temperature. In: McArthur ED, Romney EM, Smith SC, Tueller PT, comps. Proceedings, Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management; 1989 April 5–7; Las Vegas, NV. Gen. Tech. Rep. INT-276. Ogden, UT: USDA Forest Service, Intermountain Research Station: 187–292.
Monsen SB. 1996. Unpublished data. Ephraim: Utah Division of Wildlife Resources.
Pendleton RL, Meyer SE. 1990. Seed germination biology of spineless hopsage: inhibition by bract leachate. In: McArthur ED, Romney EM, Smith SD, Tueller PT, comps. Proceedings, Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management; 1989 April 5–7; Las Vegas, NV. Gen. Tech. Rep. INT-276. Ogden, UT: USDA Forest Service, Intermountain Research Station: 181–186.
Pendleton RL, McArthur ED, Freeman DC, Blauer AC. 1988. Heterodichogamy in *Grayia brandegei* (Chenopodiaceae): report from a new family. American Journal of Botany 75: 267–274.
Pendleton RL, Nelson SD, Rodriguez, RL. 1996. Do soil factors determine the distribution of spineless hopsage (*Grayia brandegei*)? In: Barrow JR, McArthur ED, Sosebee RE, Tausch RJ, comps. Proceedings, Symposium on Shrubland Ecosystem Dynamics in a Changing Climate; 1995 May 23–25; Las Cruces, NM. Gen. Tech. Rep. INT-GTR-338. Ogden, UT: USDA Forest Service, Intermountain Research Station: 205–209.
Pendleton RL, Freeman DC, McArthur ED, Sanderson SC. 2000. Gender specialization in heterodichogamous *Grayia brandegei*. American Journal of Botany 87: 508–516.
Plummer AP, Christensen DR, Monsen SB. 1968. Restoring big-game range in Utah. Pub. 68-3. Salt Lake City: Utah Division of Fish and Game. 183 p.
Sanderson SC. 2000. Personal communication. Provo, UT: USDA Forest Service, Rocky Mountain Research Station, Shrub Sciences Laboratory.
Shaw NL. 1992. Germination and seedling establishment of spiny hopsage (*Grayia spinosa* [Hook.] Moq.) [PhD dissertation]. Corvallis: Oregon State University [Dissertation Abstracts 9229768].
Smith JG. 1974. *Grayia* Hook. & Arn., hopsage. In: Shopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 434–436.
Stevens R, Jorgensen KR. 1994. Rangeland species germination through 25 and up to 40 years of warehouse storage. In: Monsen SB, Kitchen SG, comps. Proceedings, Ecology and Management of Annual Rangelands; 1992 May 18–22; Boise, ID. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: USDA Forest Service, Intermountain Research Station: 257–265.
Stevens R, Davis JN, Jorgensen KR. 1981. Viability of seed from thirty-two shrub and forb species through fifteen years of warehouse storage. Great Basin Naturalist 41(3): 274–277.
Stutz HC. 1995. Personal communication. Provo, UT: Brigham Young University.
Stutz HC, Sanderson SC, McArthur ED, Chu G. 1987. Chromosome races of *Grayia brandegei* (Chenopodiaceae). Madroño 34: 142–149.
Welsh SL. 1984. Chenopodiaceae. Great Basin Naturalist 44: 183–209.
Welsh SL, Atwood ND, Goodrich S, Higgins LC, eds. 1987. A Utah flora. Great Basin Naturalist Memoirs 9: 1–894.