



A new species of stonecrop (*Sedum* section *Gormaniana*, Crassulaceae) from northern California

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Abstract

Sedum citrinum is described as a narrow endemic from three populations on ultramafic bedrock in the Klamath Mountains of southern Del Norte County, California, in the United States. It is distinguished from *Sedum obtusatum* subsp. *boreale* by its flattened inflorescence with elongate lower branches, as well as its deep yellow flowers and yellow anthers.

Key words: serpentine, succulent plants

Introduction

Sedum Linnaeus (1753: 430) sect. *Gormaniana* (Britton in Britton & Rose 1930: 29) R. T. Clausen (1942: 29) is a group of six perennial stonecrop species with stout flattened rosette leaves, paniculate inflorescences, and basally fused corollas. The section was summarized by Clausen (1975), Denton (1979a, 1979b, 1982, 1993), and more recently by Ohba (2007, 2009) and Denton and Boyd (2012). The species of *Sedum* sect. *Gormaniana* are distributed in California, western Nevada, and Oregon, and are restricted to western North America. Traditional herbarium-based research can be difficult with fragile dried plants such as stonecrops. Like many succulent genera, when handled, dried *Sedum* falls apart over time, important colors are rarely preserved in the lengthy drying process, seldom noted on labels, and the preserved flowers show few useful characters without special preparation. Taxonomic study is enriched by examining the fresh flowering plants in the field, and using color photographs to show such characters as the glaucous epidermis of sepals, corolla and stamen colors, as well as the aspect of the fresh foliage. Other useful morphological features are difficult to examine on dried specimens, such as nectary shape, petal fusion, width, or angle. When integrating these features, it is clear that sect. *Gormaniana* is in need of further research and revision.

Extensive field work on the perennial stonecrops of *Sedum* sect. *Gormaniana* of northern California was instigated by the United States Forest Service in the Shasta-Trinity National Forest, and involved more than a dozen botanists. It indirectly led to the discovery of a new stonecrop in the southern mountains of Del Norte County, California, described below.

Methods

Dried specimen preparation is challenging with *Sedum* because they store so much water in their foliage. The succulent tissue must be treated before drying in a press. Use of a microwave for the 2012 gatherings resulted in the quick wilting of the specimens, and they were easily, if slowly, dried over low heat. However, the resulting specimens were inadequate for DNA testing. Herbarium collections cited below from 2013 were frozen and then dried, to accommodate the possibility of subsequent molecular work. Some flowers and leaves were separated from the plants for photography, dried separately, and placed in fragment packets, where they can be easily sampled by

molecular biologists. Photographs of the fresh plants were printed and attached to selected herbarium sheets, or posted on-line with the collection number, to supplement notes on the herbarium labels.

Taxonomy

Sedum citrinum Zika, *sp. nov.* (Figs. 1–2, 3K–L, 4G–H, 5N–O, 6F–H).

Species nostra Sedo obtusato subsp. boreali affinis, a quo differt inflorescentia superne plana, floribus plus saturate flavis necnon antheris luteis.

Type:—UNITED STATES. California: Del Norte County, ridge 1.4 air km north of South Red Mountain, 1050 m, 9 June 2013, *P. F. Zika* 26185 (holotype: WTU!; isotypes: BH!, CAS!, GH!, MO!, OSC!, RSA!, UC!, US!).

Rhizomatous herbs, rhizomes and stolons 10–260 × 3–6 mm, often branched and terminating in numerous sterile leafy rosettes. Rosette leaves often loosely arranged with visible internodes, less commonly dense, slightly glaucous, at least when young, green, grey-green, orange to red, or purple, narrowly to broadly obovate, less commonly oblanceolate, cuneate, 10–31 × 6–22 mm, apices obtuse or notched. Stem leaves ascending, slightly glaucous, at least when young, and colored like the rosette leaves, 8–16 × 4–12.5 mm, truncate at base, often narrowly obovate, less commonly oblanceolate or obovate, apices usually obtuse, rarely notched. *Flowering stems* green to reddish, 5–27.5 cm tall, nodding or bent in bud, erect in flower and fruit. Inflorescences 1.5–12 × 2–9 cm, usually a flat-topped or slightly domed cymose panicle with narrow base and broad, flat or rounded summit, the proximal branches elongated and solitary at the nodes, ascending to spreading or recurving at tips. Inflorescence bracts resembling stem leaves, but smaller, 5–7 × 2–3 mm, oblanceolate, tips acute or blunt. *Flowers* 10–95 per inflorescence, fresh flower diameter 8–14 mm, flowers 5–merous (7–merous), erect, calyx green or reddish distally, slightly glaucous, at least when young, 2.2–4.5 × 2.7–3.9 mm, sepals fused basally 0.7–1.5 mm, free sepal tips 2–4.5 mm long, apex blunt or acute. Fresh petals 6–9 mm long, bright and deep yellow, midvein yellow or orange (especially in bud), apices or bases sometimes reddish, especially with age; fused at base 0.5–1.2 mm. Petal blade v-shaped in cross section, narrow, spreading or divaricate at 90 degrees to floral axis, apex usually apiculate with subterminal mucro 0.15–0.3 mm. Stamens 10, shorter than petals, filaments green or greenish-yellow, aging red, anthers oblong, 1.2–1.6 × 0.6–0.7 mm, yellow when fresh, after dehiscence aging brown to red, orange, or black. Nectaries nearly rectangular to shallowly crescent-shaped and slightly sunken in middle, dull yellow to white, aging red, 0.7–1.0 × 0.3–0.4 mm. Ovaries 4.9–6.5 mm, erect, fused basally 0.5–1.3 mm, maturing into 5 dark brown erect follicles, 5.2–6.5 mm, with erect to slightly curved style remnant forming a narrow beak 1.2–1.8 mm, follicles fused basally 1.7–2.5 mm, containing 12–16 seeds. *Seeds* mid-brown, lanceolate, shiny, striate, 1.2–1.5 × 0.4–0.5 mm, including stipe 0.1–0.3 mm.

Paratypes:—UNITED STATES. California: Del Norte County, ridge 1.6 air km NNW of South Red Mountain, 1210 m, 24 June 2012, *P. F. Zika* 25931 (HSC!, WTU!); same site, 9 June 2013, *Zika* 26193 (BH!, CAS!, OSC!, WTU!); ridge 1.4 air km N of South Red Mountain, 1050 m, 24 June 2012, *Zika* 25930 (CHSC!, JEPS!, OSC!, WTU!); gentle serpentine slope, 2.4 air km NW of South Red Mountain, 1235 m, 9 June 2013, *Zika* 26201 (CAS!, GH!, OSC!, RSA!, WTU!).

Relationships with other taxa:—*Sedum citrinum* is assigned to sect. *Gormaniana* (Denton 1982). The typical corollas of species in sect. *Gormaniana* fall into three general categories (Table 1). One is a pink-flowered corolla with elongate, erect, and narrow-tapering petal tips, displayed by *Sedum laxum* (Britton in Britton & Rose 1903: 29) A. Berger (1930: 451) subsp. *laxum*, *S. laxum* subsp. *heckneri* (M. Peck 1937: 121) R. T. Clausen (1942: 39), and *S. laxum* subsp. *latifolium* R. T. Clausen (1942: 38) (Fig. 3A–C). These subspecies have a distinctive flower shape and color, as well as a unique combination of dark red anthers and pink filaments. The corollas age to red or dark red. Although *S. moranii* R. T. Clausen (1942: 40) of southwestern Oregon has a similar corolla shape, the flowers are glandular and a different color. A second floral morphology consists of ascending to spreading-ascending and rather broad petals, usually pale yellow or white, but sometimes fading to pink with age. Examples of these are *S. albomarginatum* R. T. Clausen (1975: 424), *S. laxum* subsp. *flavidum* Denton (1978: 233), *S. obtusatum* A. Gray (1868: 342) subsp. *obtusatum*, *S. obtusatum* subsp. *paradisum* Denton (1978: 236), and *S. oregonense* (S. Watson 1882: 373) M. Peck (1941: 361) (Fig. 3D–J). Strikingly different in the field is a third floral morphology, displayed only by *S. obtusatum* subsp. *boreale* R. T. Clausen (1942: 32) and *S. citrinum*. The petals are relatively narrow and wide-spreading, with age they are sometimes slightly reflexed (Fig. 3K–R). The pale yellow petals and red (less commonly orange or yellow) anthers of *S. obtusatum* subsp. *boreale* differ from the deep yellow petals and uniformly yellow anthers of *S. citrinum*.



FIGURE 1. Holotype of *Sedum citrinum* (Zika 26185 WTU). Scale bar 10 cm.

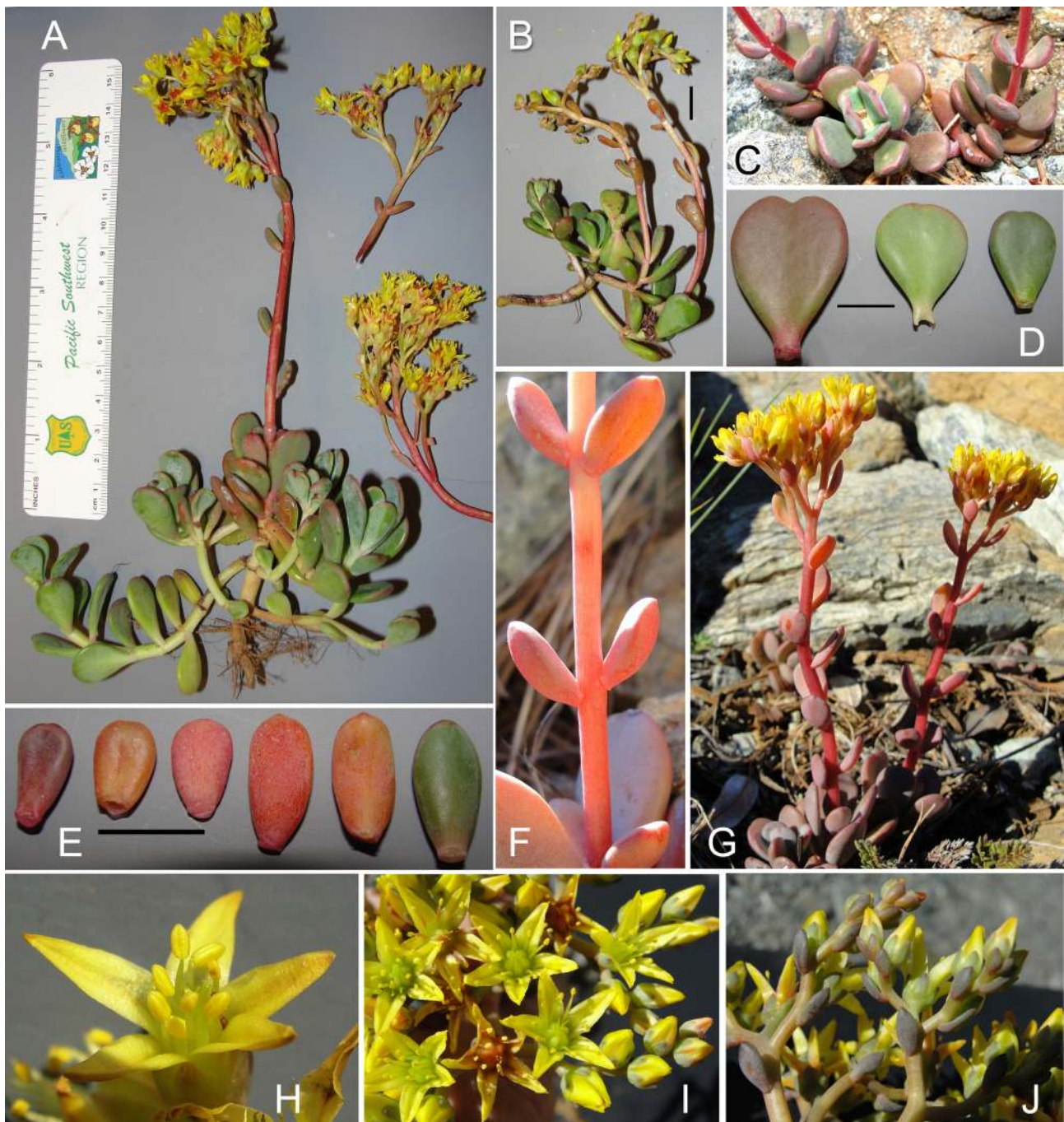


FIGURE 2. *Sedum citrinum* A. Habit and inflorescences, vegetative shoots with elongate distal internodes; B. Bent young inflorescence, pre-anthesis; C. Transition from rosette to stem leaves; D. Rosette leaves; E–F. Stem leaves, showing truncate bases; G. Flat-topped erect inflorescences at full anthesis; H. Narrow spreading petals, deep yellow anthers and petals (Zika 25930); I. Presentation of flowers at anthesis; J. Inflorescence bracts, slightly glaucous, acute-tipped, flower buds deep yellow. (From Zika 26185, except H). Scale bars 1 cm, except A, 15 cm.

Another useful character on fresh plants is the type of growth on the vigorous vegetative offsets, although this can require a bit of experience to interpret correctly. Most species, in sunny situations, display condensed vegetative offsets, with inconspicuous distal internodes, crowded and difficult to see between the leaf bases of the terminal rosette. Examples include *Sedum laxum* subsp. *flavidum*, *S. laxum* subsp. *heckneri*, *S. oblancheolatum* R. T. Clausen (1975: 404), and *S. obtusatum* subsp. *obtusatum* (Fig. 4A–F). However, any species in a protected or shaded location, such as between two sheltering rocks on a talus slope, seems to suffer less water stress and can infrequently produce elongate vegetative shoot tips. None-the-less, in sunny and exposed situations a few members of sect. *Gormaniana* characteristically produce numerous vigorous vegetative shoots, with loose foliage and easily visible distal internodes. These are *S. citrinum*, *S. obtusatum* subsp. *boreale*, and *S. oregonense* (Fig. 4G–N). In the

most exposed and xeric localities, even these taxa can produce relatively dense vegetative shoots, but in general most plants of most populations have well-spaced leaves on the shoot tips. *Sedum citrinum* can be separated from vegetatively similar plants of *S. obtusatum* subsp. *boreale*, and *S. oregonense* by floral characters, as discussed above and illustrated in Fig. 3.

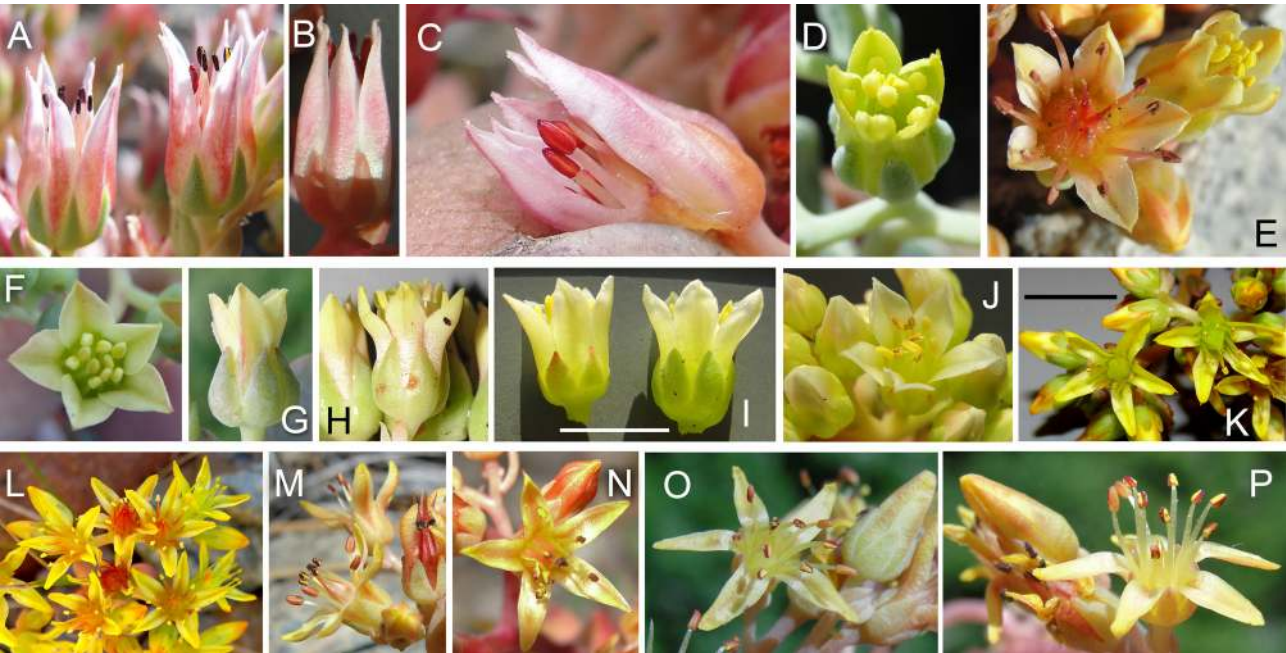


FIGURE 3. *Sedum* sect. *Gormaniana* corollas. A–C. *S. laxum*, pink (or white-tipped), elongate, tips erect and gradually tapered, anthers red, filaments pink; A. Subsp. *laxum* (Zika 25655, Josephine Co., Oregon); B. Subsp. *latifolium* (Zika 25927, Del Norte Co., California); C. Subsp. *heckneri* (Zika 25641, Siskiyou Co., California, type locality). D–J. Corollas with ascending to spreading-ascending and rather broad petals; D. *Sedum albomarginatum* (Plumas Co., California); E–H. *S. obtusatum*; E–G. Subsp. *obtusatum* (Zika 26271, Nevada Co., California); H. Subsp. *paradisum* (Zika 25920, Trinity Co., California); I–J. *S. oregonense* (Zika 25964, Clackamas Co., Oregon). K–R. Corollas with wide-spreading relatively narrow petals. K–L. *Sedum citrinum*, showing deep yellow petals, yellow anthers (Zika 26185); M–P. *S. obtusatum* subsp. *boreale*, with pale yellow petals, red anthers; M. Zika 25905, Siskiyou Co.; N. Zika 26289, Siskiyou Co.; O–P. Zika 26294, Trinity Co. Scale bars 1 cm.

TABLE 1. Comparison of *Sedum citrinum* and related taxa in sect. *Gormaniana* in southern Oregon and northern California.

<i>Sedum</i> taxa	Petal angle	Petal shape	Fresh petal color	Fresh anther color	Sterile shoot leaf spacing	Stem leaf shape	Inflorescence shape on well-developed plants
<i>S. citrinum</i>	divergent, rarely reflexed	narrowly oblong	bright yellow	yellow	loose	longer than wide, base truncate	cymose panicle with narrow base and broad, flat or rounded summit
<i>S. laxum</i> subsp. <i>laxum</i>	erect	narrow, gradually tapered to tips	pink, fading to red	red	usually dense	longer than wide, base often decurrent	cymose panicle with narrow base and broad, flat or rounded summit
<i>S. laxum</i> subsp. <i>heckneri</i>	erect	narrow, gradually tapered to tips	pink, fading to red	red	dense	suborbicular, base notched	cymose panicle with narrow base and broad, flat or rounded summit
<i>S. obtusatum</i> subsp. <i>boreale</i>	divergent, rarely reflexed	narrowly oblong	pale yellow	red, orange, or yellow	loose	longer than wide, base truncate	cylindrical
<i>S. obtusatum</i> subsp. <i>obtusatum</i>	ascending	broad, abruptly tapered to tips	pale yellow	yellow	dense	longer than wide, base truncate	cylindrical to capitate
<i>S. oregonense</i>	ascending	broad, abruptly tapered to tips	white, rarely pale yellow	yellow	loose	longer than wide, base truncate; less commonly suborbicular, base notched	cylindrical



FIGURE 4. *Sedum* sect. *Gormania* vegetative shoots. A–F. Dense rosettes with abbreviated distal internodes in sunny locations; A–B. *S. laxum* subsp. *flavidum*, forming a dense, compact clone (Zika 25922, Trinity Co.); C. *S. laxum* subsp. *heckneri* (Zika 25640, Siskiyou Co.); D. *S. oblanceolatum* (Zika 25636, Jackson Co., Oregon, type locality); E–F. *S. obtusatum* subsp. *obtusatum*; E. Zika 26024 & Brainerd, El Dorado Co., California; F. Zika 26267, Sierra Co., California. G–N. Loose rosettes with well-spaced distal internodes in sunny locations. G–H. *Sedum citrinum* (Zika 26185); I. *S. obtusatum* subsp. *boreale* (Zika 26289, Siskiyou Co.); J–N. *S. oregonense*; J. Typical highly branched vegetative shoots, well-spaced and forming a loose clone (Zika 25647, Siskiyou Co.); K. Zika 25647; L. Zika 25666, Jackson Co., Oregon; M. Zika 25956, Linn Co., Oregon; N. Zika 25959, Linn Co. Scale bars 1 cm.

When working with living material, early in the flowering season, the stem leaves can provide useful taxonomic information when distinctive morphologies are present. However, the stem leaf shape can vary, and some shapes are common among different taxa. The stem leaves on blooming shoots seem to serve as water storage for the flowering effort. They tend to shrivel, then drop off as the flowers age, and are seldom present on herbarium specimens. The most distinctive stem leaves in sect. *Gormania* have decurrent bases, uniquely found on *Sedum laxum* subsp. *laxum* (Fig. 5A–B). Two species have oblanceolate and elongate stem leaves, much like their oblanceolate and elongate rosette leaves; these are *S. albomarginatum* and *S. oblanceolatum* (Fig. 5C–E). A few taxa have suborbicular stem leaves with clasping bases, most notably including *S. laxum* subsp. *flavidum*, *S. laxum* subsp. *heckneri*, and some populations of both *S. obtusatum* subsp. *retusum* (Rose, in Britton & Rose 1903: 31) R. T. Clausen (1975: 375), and *S. oregonense* (Fig. 5F–M). The remaining taxa in sect. *Gormania* tend to have stem leaves longer than wide, and truncate at the base instead of clasping. This includes *S. citrinum*, *S. laxum* subsp.

latifolium, *S. obtusatum* subsp. *boreale*, *S. obtusatum* subsp. *obtusatum*, and most plants of both *S. obtusatum* subsp. *retusum* and *S. oregonense* (Fig. 5N–T).



FIGURE 5. *Sedum* sect. *Gormaniana* foliage, stem leaves arrayed above rosette leaves, except E; A–B. *S. laxum* subsp. *laxum*, stem leaves with decurrent bases (Zika 25655, Josephine Co.); C–D. *S. albomarginatum* (Plumas Co.); C. Oblanceolate waxy stem leaves on fertile shoot; D. Stem leaves very similar in outline to rosette leaves; E. *S. oblanceolatum* rosette leaves on left, very similar in outline to stem leaves on right (Zika 25650, Siskiyou Co.); F–G. *S. laxum* subsp. *flavidum*; F. Suborbicular stem leaves, showing clasping base (Zika 25922, Trinity Co.); G. Stem leaves of upper row showing variation in outline (Zika 25928, Del Norte Co.); H–J. *S. laxum* subsp. *heckneri* (Zika 25652, Jackson Co., Oregon, except I); H. Cliff plants showing fertile stems densely packed with suborbicular leaves; I. Clasping bases of stem leaves, variations from sub-orbicular outlines (Zika 25641, Siskiyou Co., type locality); J. Zika 25652, Jackson Co., Oregon; K–M. *S. oregonense* (Zika 25959, Linn Co., except K); K. Suborbicular stem leaves, and variations (Zika 25964, Clackamas Co., Oregon); L. Strongly clasping stem leaf; M. Variation in stem leaf shape and clasping base (upper row); N–T. Stem leaves longer than wide and truncate at base; N–O. *S. citrinum* stem leaves, ascending (Zika 26185); P–Q. *S. laxum* subsp. *latifolium*, ascending stem leaves, plump rosette leaves (Zika 25927, Del Norte Co.); R. *S. obtusatum* subsp. *boreale* (Zika 26289, Siskiyou Co.); S. *S. obtusatum* subsp. *obtusatum* (Zika 26267, Sierra Co.); T. *S. oregonense* (Zika 25647, Siskiyou Co.). Scale bars 1 cm.

The inflorescences can provide useful characters for distinguishing species. Some taxa in sect. *Gormaniana* have cylindrical inflorescences, with the proximal branches suppressed and short. This includes *Sedum obtusatum* subsp. *boreale* (Fig. 6A–E), which typically has an inflorescence 1.5–5 cm wide, with up to 54 flowers. In marked contrast, *S. citrinum* has a flat-topped inflorescence (Fig. 6F–H), with elongated lower branches. The inflorescence of *S. citrinum* is usually 2–9 cm wide, and can contain up to 95 flowers. Also noteworthy is the uncommon tendency of some plants of *S. citrinum* to produce more than one fertile shoot from a single rosette, which is less frequently seen in other members of sect. *Gormaniana* (Figs. 1, 6G–H). *Sedum obtusatum* subsp. *boreale* does not seem to commonly branch at the base of the fertile shoots (Fig. 6I).

In summary, *Sedum citrinum* is most similar morphologically to *S. obtusatum* subsp. *boreale* (Table 1). They both display widely spaced leaves on their sterile shoots (Fig. 4), and elongate, truncate-based stem leaves (Fig. 5). In critical floral features, both exhibit narrow divergent petals not seen in any other taxa in the section *Gormaniana*.

(Fig. 3). The two are separable by inflorescence shape and width (Fig. 6), as well as by the intensity of the yellow pigment of the corolla and anther color variation (Figs. 2–3). Anthesis ends for *S. citrinum* in late June as it is starting for *S. obtusatum* subsp. *boreale*. In addition, *S. citrinum* is restricted to ultramafic exposures (Fig. 7), while *S. obtusatum* subsp. *boreale* is found on a wide variety of bedrock, including volcanics, metamorphics, and ultramafics. Finally, the distribution of *S. citrinum* is restricted to a tiny portion of Del Norte County, discussed below. The distribution of *S. obtusatum* subsp. *boreale* is allopatric, and covers a much larger area to the south and east, in Siskiyou and Trinity counties, over a broader range of elevations. When compared to other members of the group, both *S. citrinum* and *S. obtusatum* subsp. *boreale* differ strongly enough in floral characters to be considered separate species. Related taxa, like *S. oregonense* to the north, and *S. obtusatum* subsp. *obtusatum* to the southeast, have quite different corollas and distributions. (Fig. 3, Table 1).

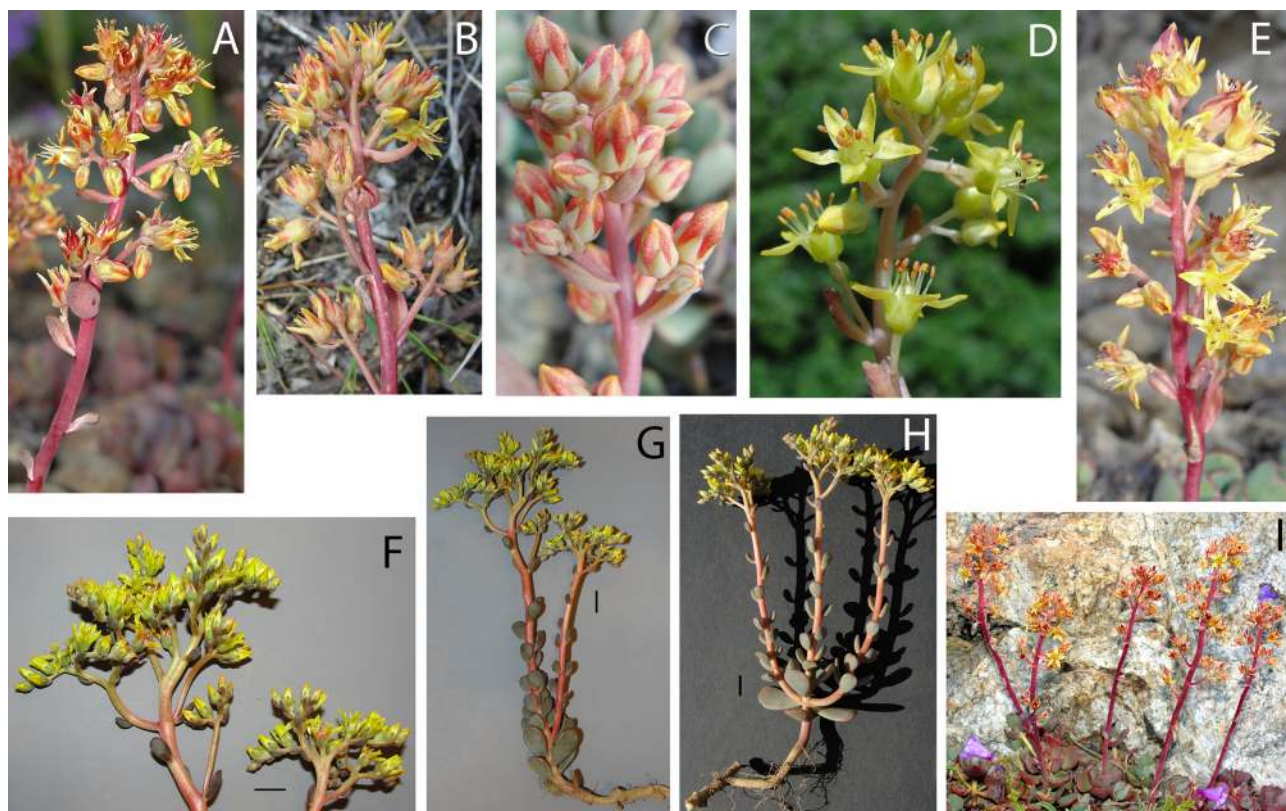


FIGURE 6. Inflorescence shape. A–E. *Sedum obtusatum* subsp. *boreale* cylindrical flowering shoots, with lower branches suppressed; A–B. Zika 26289, Siskiyou Co.; C. Zika 25687, Trinity Co.; D–E. Zika 26294, Shasta Co., California; F–H. *S. citrinum* (Zika 26185); F. Flat-topped flowering shoots, with well-developed lower branches; G–H. Plants with 2–3 fertile shoots from one rosette; I. *S. obtusatum* subsp. *boreale* several fertile shoots, typically unbranched at base (Zika 26289). Scale bars 1 cm.

Etymology:—The epithet *citrinum* reflects the color of the petals, which are a bright lemon yellow. A proposed common name is Blue Creek stonecrop, as all known records are from within this drainage.

Distribution and conservation:—Blue Creek stonecrop is restricted to the ridges between Red Mountain and South Red Mountain, in southern Del Norte County, California, over a linear distance of less than 4 km, and within an area of roughly 4 square km. The slopes are drained by tributaries of Blue Creek, in the lower Klamath River basin, part of the Klamath Ranges subregion of the California Floristic Province (Baldwin *et al.* 2012). Geologically the substrate is part of the extensive Josephine Peridotite exposures, which extend for 130 km from Josephine County, Oregon south to Humboldt County, California (Evans 1984).

More field work is needed to determine if there are additional colonies in the immediate area. At present fewer than 2000 plants are known, restricted to three populations in a small zone, suggesting some conservation efforts may be appropriate. More than 20 regional endemics, restricted to serpentine, are listed as rare in the Klamath Ranges by Nakamura and Nelson (2001, Table 3b). Using IUCN criteria (2013), *S. citrinum* would be vulnerable. It faces some risks in its remote stony habitats, including road-widening, road maintenance and off-road vehicles.

Phenology and ecology:—*Sedum citrinum* flowers have been recorded from 9–24 June. The habitat is characterized by sunny dry thin soils of serpentinite (ultramafic) exposures, on talus or scree, in crevices or between boulders, on flats or ground gently sloping east or west, and on adjacent roadcuts, at elevations of 1050–1235 m (Fig. 7). Common or noteworthy associates include: *Adiantum aleuticum* (Ruprecht 1845: 49) C. A. Paris (1991: 112), *Arctostaphylos nevadensis* A. Gray (1878: 27), *Aspidotis densa* (Brackenridge 1854: 120, pl. 13) Lellinger (1968: 141), *Berberis aquifolium* Pursh (1813: 219, pl. 4), *Calochortus tolmiei* Hooker & Arnott (1840: 398), *Carex serpenticola* Zika (*et al.* 1998: 261), *Ceanothus pumilus* Greene (1893: 149), *Elymus glaucus* Buckley (1862: 99), *Horkelia sericata* S. Watson (1885: 364), *Iris thompsonii* R.C. Foster (1936: 199), *Juniperus communis* Linnaeus (1753: 1040), *Montia parvifolia* (Moc. ex de Candolle 1828: 361) Greene (1891: 181), *Phlox diffusa* Benth (1849: 325), *Pinus attenuata* Lemmon (1892: 65), *P. contorta* Douglas ex Loudon (1838: 2292, f. 2210, 2211), *Pinus monticola* Douglas ex D. Don (in Lambert 1832: unnumbered page following Tab. 80), *Polystichum imbricans* (D.C. Eaton 1878: 188, pl. 25, f. 3) D.H. Wagner (1979: 50), *Quercus vaccinifolia* Kellogg (1870: 52), *Senecio integerrimus* Nuttall (1818: 165), *Stipa lemmonii* (Vasey 1892: 55) Scribner (1901: 3), *Viola lobata* Benth (1849: 298) and *Whipplea modesta* Torrey (1857: 90).

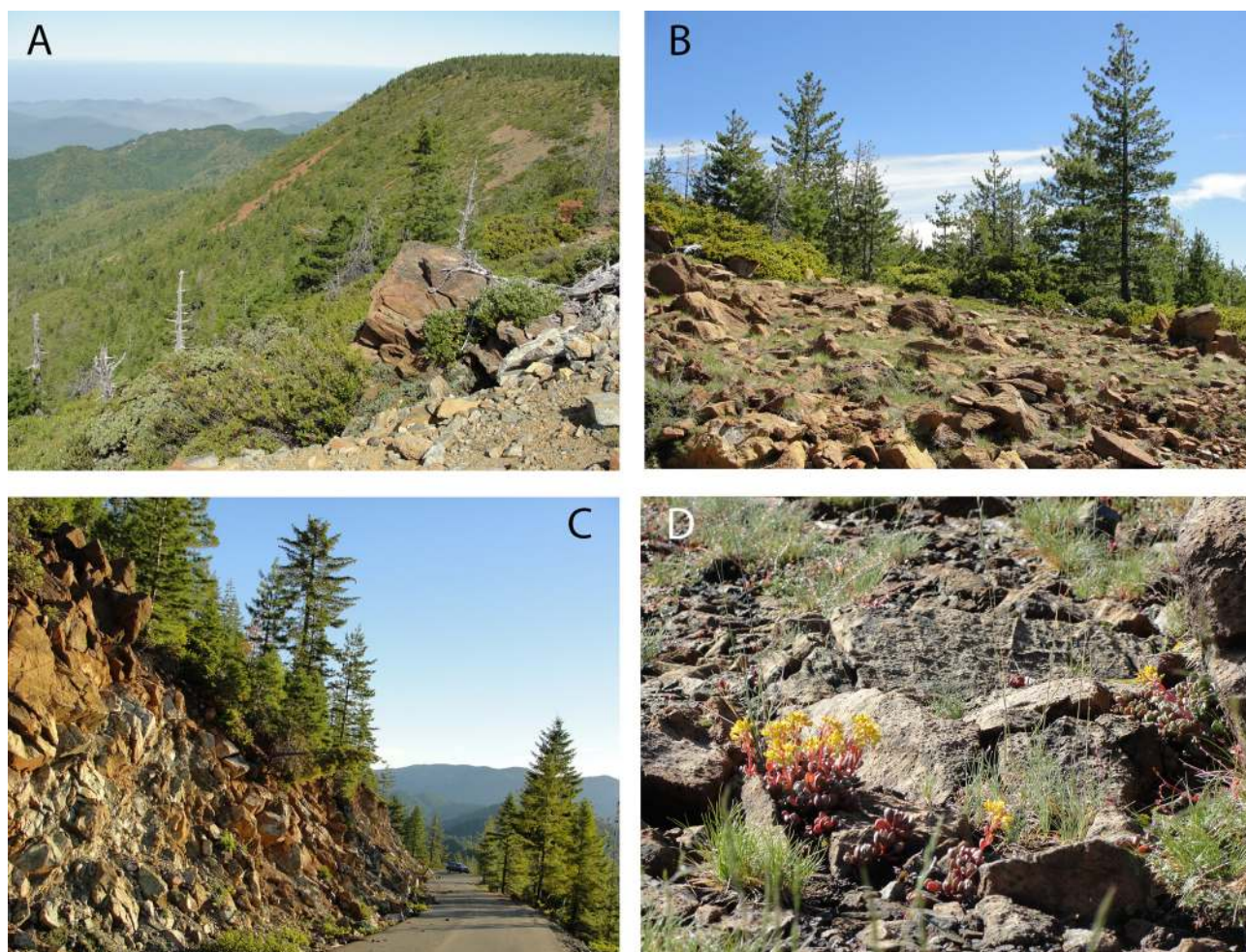


FIGURE 7. *Sedum citrinum* habitat, showing ultramafic exposures and surrounding forest at the three localities. A–B. Zika 26201; C. Zika 26185; D. Zika 25931.

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