

CYTOGEOGRAPHY OF *SOLIDAGO MISSOURIENSIS* (ASTERACEAE: ASTEREAE) AND OBSERVATIONS ON VARIETIES

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ABSTRACT

Solidago missouriensis is a widely distributed species in North America with multiple varieties proposed. Sixty-one chromosome counts were previously published. Forty previously unpublished chromosome counts for *S. missouriensis* are presented. Varietal identifications for all vouchers were determined based on an assessment of differences in morphology for var. *missouriensis*, var. *extraria*, var. *fasciculata*, var. *tenuissima*, and var. *tolmieana*. Diploids occur in var. *missouriensis*, var. *fasciculata*, and var. *tenuissima*. Tetraploids occur in var. *missouriensis* and var. *extraria*. No chromosome numbers have been reported for the rare var. *tolmieana*. A key to varieties is presented.

Solidago missouriensis Nutt. (Asteraceae: Astereae) is a widely distributed species in North America and was recently placed in *S.* subg. *Pleiactila* Raf. sect. *Unilaterales* G. Don subsect. *Junceae* (Rydb.) Nesom by Semple and Beck (2021) based on DNA sequence data and following previous placement based on morphology in the same subsection by Nesom (1993) and by Semple and Cook (2006). The five varieties recognized here have all been recognized as separate species in older floras or in the protologues but have generally been ignored recently. Fernald (1950) recognized var. *fasciculata* Holz. as being taller and with a more leafy stem than the typical variety. Cronquist (1955) divided the species into varieties with four being present in the Pacific Northwest but later (Cronquist 1994) concluded that the varieties in the Great Basin flora graded into each other so much that he did not recognize varieties within the species. Semple and Cook (2006) discussed traits of five varieties and noted the detailed study of the species was needed; they did not include a key to the varieties noting Cronquist (1994). Formal nomenclature details are presented in Table 1.

Solidago missouriensis var. *missouriensis* (Figs. 1-2) is the race that morphologically grades into the other four varieties where the ranges are sympatric with it. As delimited here, it includes shorter stemmed plants with relatively few reduced upper stem leaves and few much-reduced branch leaves. Lower stem and basal rosette leaves are often present and these have lanceolate/oblanceolate blades. Inflorescences are relatively small and somewhat secund apically and lower inflorescence branches are short. Involucres are generally less than 4 mm high with most plants of var. *missouriensis* being diploid (Table 2). The variety occurs most commonly scattered at lower elevations in the Rocky Mts. from western Canada to northern Mexico and eastward onto the western high prairies. Shorter stemmed plants further east are either just short-stemmed individuals of var. *fasciculata* growing under less favorable conditions or plants of var. *missouriensis* in eastern disjunct populations.

Solidago missouriensis var. *extraria* A. Gray (Fig. 3) occurs in the mountains of western North America from western Alberta and British Columbia south to the Sierras in California and isolated mountains in Nevada, Utah and New Mexico. The inflorescence is club-shaped and not secund conical. Involucres are large for the species (4-5 mm), which is likely a consequence of the variety being tetraploid over its range (Table 2).

Solidago missouriensis var. *fasciculata* Holzinger (Fig. 4) is the eastern race of the species occurring in prairie habitats across the Great Plains from the Rocky Mountains east to prairie-like and glade habitats east of the Mississippi River and Great Lakes in Canada and the USA. The range extends westward to central Washington in the west and south into northeastern Mexico. The variety includes the tallest stems occurring in the species reaching to nearly a meter in height but often much shorter further west or under drier growing conditions. Lower stem leaves are usually absent or wilted by flowering. Upper stem leaves are narrowly lanceolate and taper to an acute apex with small linear leaves developing on very short lateral branches giving the upper stem a more leafy appearance than in the other varieties. Only diploids have been previously reported over much of the range including scattered disjunct populations in central Washington (Table 2).

Solidago missouriensis var. *tenuissima* (Woot. & Standl.) C. & J. Taylor (Fig. 5) is native to the Mogollon Rim and Sky Island mountains of southeastern Arizona and adjacent Mexico and extreme southwestern New Mexico. The variety usually has very narrow lower stem leaves although this may depend upon seasonal growing conditions. Two diploid counts have been reported and can be assigned to this variety (Table 2).

Solidago missouriensis var. *tolmieana* (A. Gray) Cronq. (Fig. 6) is a rare race of the species native to prairie habitats in western Washington and Oregon. Cronquist (1955) distinguished the race by it having larger involucre (4-5 mm) than the typical variety and having somewhat secund inflorescences. No chromosome numbers have been reported for the variety.

Table 1. Formal nomenclature of *Solidago missouriensis* and its varieties.

Solidago missouriensis Nutt., J. Acad. Nat. Sci. Phil. 7: 32. 1834. **SYNTYPE**: USA. "On the upper branches of the Missouri and Arkansas," "Sources of the Missouri", s.d., Nutt. from *Wyeth s.n.*, (holotype: PH!; Fig. 1A). "*S. tortifolia* ? Elliott but for inty?? non serratis, Aug 11 12" {on field label}, *Nuttall s.n.* or from *Wyeth s.n.* (isotype or syntype: BM!; Fig 1B-C).

Solidago missouriensis var. *extraria* A. Gray, Proc Amer. Acad. Arts & Sci. 17: 195. 1882. **SYNTYPES**: **Colorado**. Dry mountain sides at 7000 ft, Aug 1877, *E.L. Greene 1123* (lectotype designated by Cronquist, Intermountain. Fl. 1994: GH!); Near Colorado City, Glen Erie, 18 Jul 1872, *Porter s.n.* (GH!); From the headwaters of Clear Creek and the alpine ridges lying east of "Middle Park," 1861, *Parry 17* (GH!). **New Mexico**. Pinos Altos Mountains, 28 Jul 1880, *E.L. Greene 202* (GH!).

Solidago missouriensis var. *fasciculata* Holzinger, Contr. U.S. Nat. Herb. 1: 208. 1892. **SYNTYPES**: "Indian Territory". **Kansas**. [Cowley Co.: Cherokee Outlet {near Arkansas City; protologue}, Aug 1891, *M.A. Carlton 430* (holotype: US digital image!; Carlton's label includes "a form with linear fascicled leaves"). **Texas**. Hemphill Co.: Aug 1891, *M.A. Carlton 430* (MIN digital image! annotated as isotype in error by Cronquist in 1943, not from same location as the holotype). **Missouri**. *Blankenship s.n.* (not seen).

Solidago missouriensis var. *tenuissima* (Woot. & Standl.) C. & J. Taylor, Sida 10: 182. 1983. *Solidago tenuissima* Woot. & Standl., Contr. U.S. Nat. Herb. 16: 182. 1913. **TYPE**: **New Mexico**. Spring at head of Guadalupe Cañon, near Cloverdale, 15 Jul 1892, *Mearns 466* (holotype: US, digital image!; isotypes: GH!, NY!).

Solidago missouriensis var. *tolmieana* (A. Gray) Cronq., Vasc. Pl. Pacif. Northw. 5: 307. 1955. *Solidago tolmieana* A. Gray, Synop. Fl. N. Amer. 1, 2: 151. 1884. **SYNTYPES**: **Washington**. Fort Vancouver, *Tolmie s.n.* (lectotype designated by Cronquist 1955: GH!). "Idaho, Washington Territory and Oregon." **Oregon**. Clear Water, *Spaulding* (GH!).

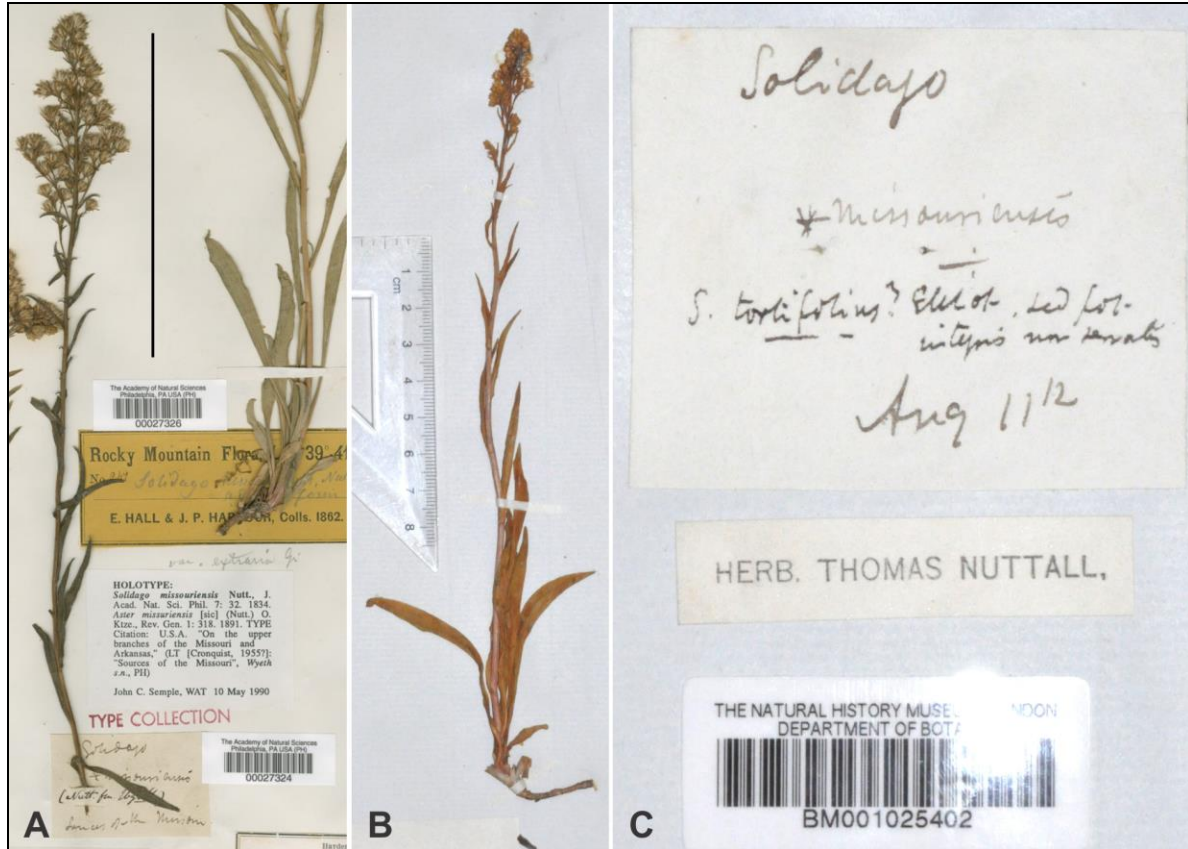


Figure 1. Type material of *Solidago missouriensis* Nutt. in PH (A) annotated as the holotype by J.C. Semple in 1990) and BM (B-C seen by J. Semple in 2014). The hand script on both field labels is that of T. Nuttall.

Chromosome numbers have been reported for *S. missouriensis* from scattered locations over much of its range previously (Table 2). Forty diploid counts ($2n=9\text{II}$ and $2n=18$) and 21 tetraploid counts ($2n=18\text{II}$ and $2n=36$) have been reported previously, mostly to species (Beaudry & Chabot 1959; Beaudry 1963; Solbrig et al. 1964; Anderson et al. 1974; Keil & Pinkava 1979; Semple et al. 1981; Keil & Pinkava 1981; Löve & Löve 1982; Mulligan 1984; Semple et al. 1984; Ward & Spellenberg 1986; Chinnappa & Chmielewski 1987; Semple & Chmielewski 1987; Keil et al. 1988; Semple et al. 1989; Semple et al. 1993; Semple et al. 2000; Morton et al. 2018; Semple et al. 2019). Only four of these included varietal level identifications: $2n=18$ for var. *fasciculata* from Manitoba (*Brother Bernard* 58-263 MT; Beaudry 1963) and from Tennessee (*Beaudry & DeSelm* 57-449 MT; Beaudry 1963) and $2n=18\text{II}$ for var. *extraria* from Wyoming (*Spellenberg* 5742 NMC; Ward & Spellenberg 1986). The fourth collection was originally identified as var. *fasciculata* from southwestern New Mexico which is identified here as var. *tenuissima* ($2n=9\text{II}$, Ward & Spellenberg 80-043 NMC; Ward & Spellenberg 1986).



Figure 2. *Solidago missouriensis* var. *missouriensis*: Semple & Xiang 10275 (WAT in MT), Owyhee Co., Idaho; scale bar = 10 cm.



Figure 3. *Solidago missouriensis* var. *fasciculata*: Semple & Brouillet 7314 (WAT) from Kansas.



Figure 4. *Solidago missouriensis* var. *extraria*: Semple & B. Semple 6605 (WAT), Boulder Co., Colorado.

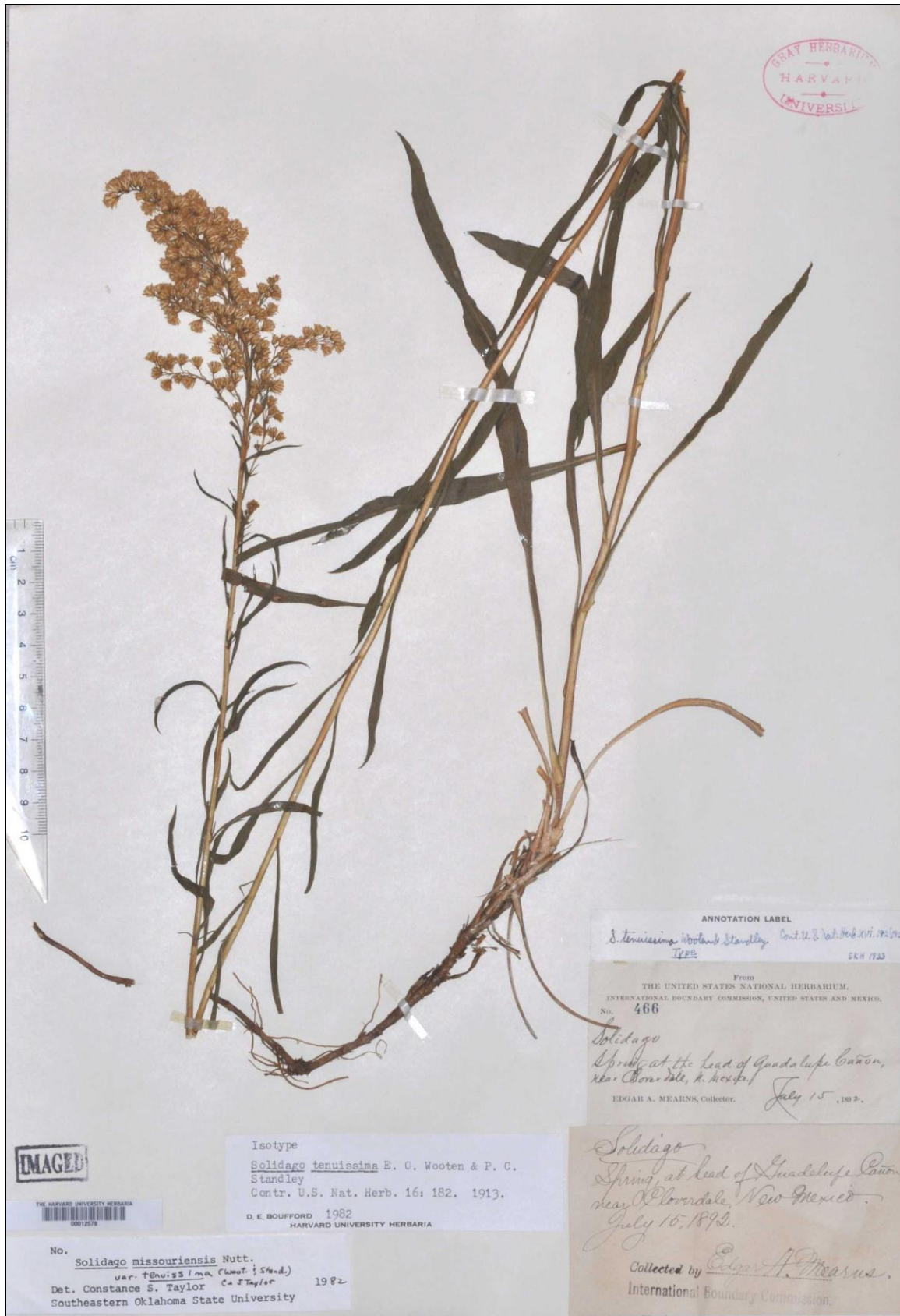


Figure 5. Isotype *Solidago missouriensis* var. *tenuissima*: Mearns 466 (GH), Cloverdale, New Mexico.

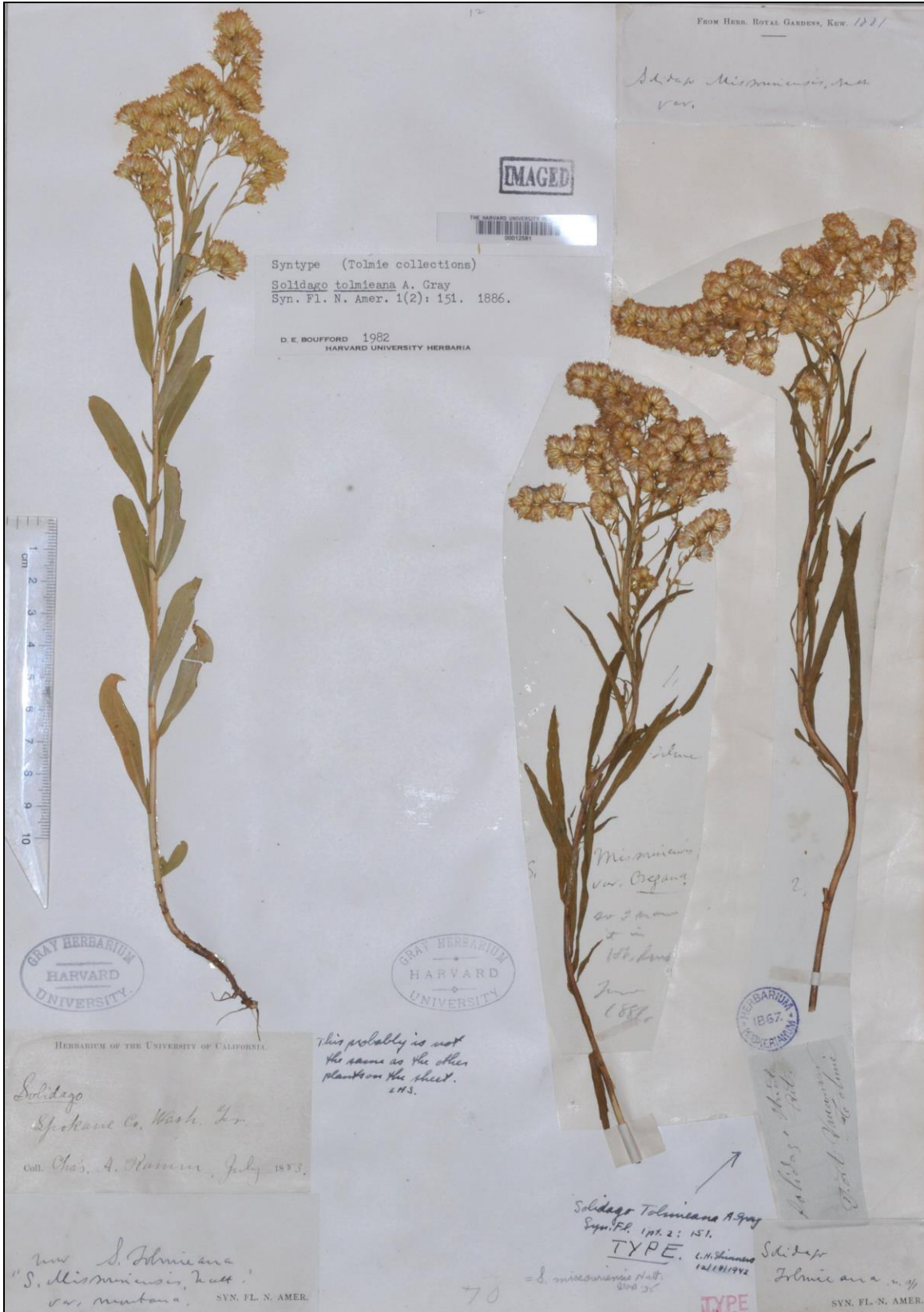


Figure 6. Type of *Solidago missouriensis* var. *tolmieana*: Tolmie s.n. (GH; specimen on right), Fort Vancouver, Washington.

Table 2. Previously published chromosome counts for *Solidago missouriensis* with varieties determined in this study. All vouchers seen unless otherwise indicate.

Variety not determined (voucher not seen or not seen recently)

2n=9_{II} U.S.A. **Arizona**: Cochise Co.; side canyon of Huachuca Canyon, *Schmierer & Reeves R876* (ASU; Keil & Pinkava 1979; Gila Co., *Reeves 519A* (ASU; Keil & Pinkava 1981).

2n=18 CANADA. **Manitoba**: Löve & Löve 5937 (voucher not located; Löve & Löve 1982). U.S.A. **Wyoming**: Albany Co., *Keil K10906* (OBI; Keil et al. 1988).

***Solidago missouriensis* Nutt. var. *extraria* A. Gray**

2n=18_{II} U.S.A. **Colorado**: La Plata Co., *Semple et al. 5517* (WAT; Semple 1985). **Wyoming**: Park Co., *Spellenberg & Soreng 5742* (NMC; Ward & Spellenberg 1986). **California**: San Bernadino Co., *Morton & Venn NA15836* (TRT; Morton et al. 2018).

2n=36 U.S.A. **Colorado**: Jefferson Co., *Semple & Brammall 2710* (WAT; Semple et al. 1981), *Semple & Brammall 2706* (WAT; Semple et al. 1981). **Montana**: Broadwater Co., *Semple 10316* (WAT; Semple et al. 2000); Carbon Co., *Semple & Xiang 10233* (WAT; Semple et al. 2000); Glacier Co., *Semple & B. Semple 11390* (WAT; Semple et al., 2019). **Nevada**: Elko Co., *Semple et al. 9280* (WAT; Semple et al. 2001), *Semple, Suropto & Ahmed 9279* (WAT; Semple et al. 2001), *Semple et al. 9277* (WAT; Semple et al. 2001). **Wyoming**: Carbon Co., *Semple et al. 9204* (WAT; Semple et al. 2001); Fremont Co.; *Morton & Venn NA15712* (TRT; Morton et al. 2018); Johnson Co., *Semple & Xiang 10205* (WAT; Semple et al. 2000).

***Solidago missouriensis* Nutt. var. *fasciculata* Holzinger**

2n=9_{II} CANADA. **Manitoba**: River Valley *Semple & Brammall 2669* (WAT; Semple et al. 1981). Saskatchewan: E of Viscount, *MacLeod 175* (Mulligan 1984). U.S.A. **Kansas**: Riley Co.; NW of Manhattan, *G. Morton 72-9, 72-10, 72-11* (not these numbers but NY has cytovouchers 4961 and 4961A; Semple et al. 1984), *Morton 5112* (NY; Semple et al. 1984). **Missouri**: Madison Co., *Semple & Brammall 2757* (WAT; Semple et al. 1981). **Nebraska**: Dawes Co.; *Keil K12855* (OBI; Keil et al. 1988). **North Dakota**: Grand Forks Co., 3.9 km E of Niagara *Semple & Brammall 2682* (Semple et al. 1981); Sargent Co., *Semple & Brammall 2688* (WAT; Semple et al. 1981). **New Mexico**: Catron Co., *Todsen 2-038* (NMC; Ward and Spellenberg 1986). **South Dakota**: Custer Co. *Solbrig 3113* (UC; Solbrig et al. 1964). **Washington**: Yakima Co., *G. Morton 5058* (NY; Semple et al. 1984).

2n=18 CANADA. **Alberta**: Fort Saskatchewan, *Beaudry 55-278-1, 55-278-2, 55-278-3* (MT; Beaudry and Chabot 1959). **Manitoba**: N of Otterburne, *Bro. Bernard 58-263* (MT; Beaudry 1963). U.S.A. **Arkansas**: Boone Co., *Semple & Heard 8312* (WAT; Semple and Chmielewski 1987); Fulton Co., *Semple & Heard 8320* (WAT; Semple and Chmielewski 1987). **Indiana**: La Porte Co., *Morton & Venn NA16036* (TRT; Morton et al. 2018). **Nebraska**: Gosper Co., *Morton & Venn NA15982* (TRT; Morton et al. 2018); Lincoln Co., *Semple et al. 9195* (WAT; Semple et al. 1993). **Tennessee**: Rutherford Co., *Beaudry & DeSelm 57-447, Beaudry & DeSelm 57-449* (MT; Beaudry 1963).

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2n=9_{II} U.S.A. **South Dakota**: Minnehaha Co., *Semple & Xiang 10182* (WAT; Semple et al. 1993).

2n=18 U.S.A. **Kansas**: Sheridan Co., *Morton & Venn NA15971* (TRT; Morton et al. 2018).

Solidago missouriensis* Nutt. var. *missouriensis

2n=9_{II} U.S.A. **Washington**: Okanogan Co., *G. Morton & Anderson 5063* (NY; Anderson et al. 1974)

2n=18 CANADA. **Saskatchewan**: W of Moosomin *J.K. Morton NA1800* (Morton 1981). U.S.A. **Idaho**: Fremont Co., *Semple 11353* (Semple et al. 2019); Owyhee Co., *Semple & Xiang 10257* (WAT; Semple et al. 2001). **Nevada**: Elko Co.; Ruby Mts., E of NV-227, Soldier Creek Trail, *Semple et al. 9272* (Semple et al. 2001); Humboldt Co., *Semple et al. 9290* (Semple et al. 2001). **Wyoming**: Albany Co., *Semple & Chmielewski 8861* (Semple et al. 1989); Crook Co., *Semple & Xiang 10187* (Semple et al. 2001); Park Co., *Semple & Zhang 10430* (WAT; Semple et al. 2001)

2n=18+1-2 supers. U.S.A. **Colorado**: Jefferson Co., *G. Morton & L. Anderson 4992* (NY; Semple et al. 1984).

2n=18_{II} CANADA. **British Columbia**: E of Osovoos, *G. Morton 5065* (NY; Semple et al. 1984).

2n=36 CANADA. **Alberta**: Banff, Bowfalls, *J.K. Morton NA3412* (TRT; Morton 1981); Medicine Hat *J.K. Morton NA3431, J.K. Morton NA3433* (TRT; Morton et al. 2018); Rosedale, *Chinnappa Lab CC 663*

(Chinnappa and Chmielewski 1987). U.S.A. Wyoming: Johnson Co., *Semple & Xiang 10195* (WAT; Semple et al. 2001)

Solidago missouriensis Nutt. var. *tenuissima*

$2n=9_{II}$ U.S.A. **New Mexico:** Grant Co., *Ward & Spellenberg 80-043* (NMC: Ward and Spellenberg 1986; published as var. *fasciculata*).

Solidago missouriensis Nutt. var. aff. *tenuissima*

$2n=18$ U.S.A. ARIZONA: Navajo Co., *J.K. Morton & J. Venn NA15891* (TRT; Morton et al. 2018); the field collected voucher is closer to var. *missouriensis* in lower leaf shape, but the transplanted cultivated voucher has much narrower lower stem leaves fitting var. *tenuissima*).

MATERIALS AND METHODS

The ranges of distribution of the varieties of *Solidago missouriensis* were determined by mapping field locations of more than 1000 herbarium specimens of *Solidago missouriensis* that were seen via SERNEC (Data Portal 2021), SEInet (Data Portal 2021), Rocky Mountain Herbarium (<http://rmh.uwyo.edu/data/search.php>), UNAM (<https://datosabiertos.unam.mx/biodiversidad/>) and specimens examined by JCS during herbarium visits or received in loans at WAT: ALAM, ALBC, ANHC, APSC, ARIZ, ASC, ASU, AUA, BHO, BHSC, BRIT, BRU, BRY, BUT, CALVIN, CHIC, CIBO, COCO, COLO, DES, EIU, EKY, EMC, EVE, F, FSU, GA, GH, HUDC, ID, ILL, IND, KDH, LEA, LL, LSU, MESA, MEXU, MICH, MISS, MOR, MSC, MT, NCSC, NCU, ND, NO, NY, OKL, PSM, RENO, RM, RSA, SAT, TENN, TEX, UNCC, USAM, USCH, URV, UT, UTCH, UWM, UWSP, VSC, WAT in MT, WIS, WTC, and WTU (Thiers, continuously updated). The majority of specimens could be tentatively assigned to one of the five varieties, some were assigned with the “aff.” prefix indicating that this was the likely identity. For example, most specimens collected east of the Rocky Mts were assigned to var. *fasciculata* being either tall and/or with well developed upper stem nodal clusters of linear leaves. Some shorter collections lacking such well developed clusters were tentatively assigned to either var. *fasciculata* or var. *missouriensis* with the latter being increasing more frequent on the prairies in states and provinces that included the Rocky Mountains.

Chromosome numbers were determined in one of several ways. Meiotic counts were made from pollen mother cells (PMCs) dissected from buds fixed in the field in either Modified Carnoy's Fixative (4:3:1 chloroform: ethanol EtOH: glacial acetic acid) or Acetic Alcohol Fixative (3:1 ethanol EtOH:glacial acetic acid) for a minimum of 24 hours under refrigeration and subsequently stored under refrigeration in 70% EtOH. Mitotic counts were made from root tip cells taken from transplanted wild rootstocks or from seedlings grown from fruits collected in the wild. Root tips were pretreated in 0.01% colchicine or saturated paradichlorobenzene for 2–3 h, fixed in either Modified Carnoy's Fixative (4:3:1 chloroform:EtOH:glacial acetic acid) or Acetic Alcohol Fixative (3:1 EtOH:glacial acetic acid) for a minimum of 24 hours under refrigeration and hydrolyzed in 1N HCl for 30 min at 60 °C before squashing. Anther sacs containing PMCs and meristematic root tips were squashed in 1% acetic orcein, and counts of chromosomes were made from freshly prepared material. Fixation and pretreatment methods changed over the multiple decades that field work was conducted (1975-2006).

Vouchers for all Semple collections (including with other collectors) were deposited at WAT in MT as part of the transfer of the WAT herbarium to MT in 2012 (acronyms follow Thiers 2018) and should be cited as WAT. A few collections have yet to be deposited as these were set aside for additional studies and will be deposited in WAT in MT. Many collections included duplicates that were distributed to multiple other herbaria.

RESULTS

Forty previously unpublished chromosome number determinations for specimens of *Solidago missouriensis* are listed by variety in Table 3. Twelve tetraploid counts ($2n=18_{II}$, $2n=36$) for var. *extraria* are reported from collections made in British Columbia, Colorado, Idaho, Montana, Nevada, and Wyoming. One triploid ($2n=3x=27$) is reported for a putative var. *extraria* × var. *fasciculata* hybrid from Montana. Twenty-two diploid counts ($2n=9_{II}$, $2n=18$) are reported for collections of var. *fasciculata* from Canada (Ontario, Saskatchewan) and the US (Arkansas, Colorado, Kansas, Minnesota, Montana, North Dakota, Nebraska, Oklahoma, South Dakota, Wisconsin, and Wyoming). Four diploid counts ($2n=18$) are reported for collections of var. *missouriensis* from New Mexico, Nevada, and Utah. One diploid count ($2n=18$) is reported for a collection of var. aff. *tenuissima* from Arizona.

Table 3. Previously unpublished chromosome counts for *Solidago missouriensis*. All voucher collections in WAT in MT unless otherwise indicated. A = T. Ahmed; Bt = L. Brouillet; S = J.C. Semple; Su = B.A. Suropto.

***Solidago missouriensis* Nutt. var. *extraria* A. Gray**

$2n=36$ CANADA. British Columbia: BC-95, 2 km N of Edgemount, 12 km N of Radium *Chmielewski & Chmielewski CC4900*. U.S.A. **Colorado:** Boulder Co.; CO-119 3.9 mi E of Nederland Dam, *S & B. Semple 6541*; El Paso Co.; Manitou Springs, entrance to Garden of the Gods, *S & Bt 7278*; Teller Co.; Co.Rd-42 (Twin Rocks Rd.) 0.1 mi W of US-24, *S & Bt 7252*. **Idaho:** Custer Co.; Challis National Forest, O'Brien campground, ID-75, 2.4 miles E of Sunbeam, *S & Bt 7049*; Idaho Co.; E of Kooskia by Middle Fork R., *S & Bt 4402*; Lehmi Co.; Solmon Nat'l Forest, log road S of Stormy Peak Rd., *S & B 7035*. **Montana:** Broadwater Co.; US-12, Helena National Forest, Deep Creek picnic area, 16.5 miles E of Townsend (junction US-287) *S & Bt 7011*; Carbon Co.; S of Red Lodge *S & Bt 4431*. **Nevada:** Elko Co.; Ruby Mts, Humboldt N.F. E of NV-227, Soldier Creek Trail area, *S Su & A 9280*. **Wyoming:** Teton Co.; WY-22 by Coal Creek, ca 3 mi E of state line *S & Bt 7206*.

Solidago missouriensis* Nutt. var. aff. *extraria* approaching var. *fasciculata

$2n=36$ U.S.A. **US. Montana:** Musselshell Co.; US-12, 1.7 miles E of Musselshell, *S & Bt 6989*.

Solidago missouriensis* Nutt. var. *extraria* × var. *missouriensis

$2n=3x=27$ U.S.A. **Idaho:** Lehmi Co.; Salmon Nat'l Forest, Twin Creek Campground Rd. at junct. US-93, 5.2 mi N of Gribbonsville, *S & Bt 7029*.

***Solidago missouriensis* Nutt. var. *fasciculata* Holzinger**

$2n=9_{II}$ U.S.A. **Colorado:** Yuma Co.; US-385 20.8 km S of county line *S & Heard 7699*.

$2n=18$ CANADA. **Ontario:** Kenora Dist.; Ingolf, *S et al. 6715*. **Saskatchewan:** W of Kandahar, dirt road off SASK-16 near S end of Big Quill Lake, *S & Bt 4231*; Springside, *S & Bt 4217*. U.S.A. **Arkansas:** Fulton Co.; US-62 E of Agnos, *S & Heard 8320*. **Kansas:** Ford Co.; US-50 0.5 mi E of county line, *S & Bt 7303*. **Minnesota:** Sherburne Co.; SE of Orrock, Sand Dunes St. For., Ann Lake Campground access road by county road, *S 11849*. **North Dakota:** Barnes Co.; Valley City, W exit to I-94, *S & Bt 6983*; Emmons Co.; 1 mile N of Linton on US-83, *S & B. Semple 6671*; Morton Co.; I-94, Sweet Briar Lake rest area {E of New Salem}, *S & Bt 6964*; Stark Co.; I-94 rest area E of Gladstone, near Green River, *S & Bt 6973*. **Nebraska:** Cherry Co.; US-20 E of Gordon, 2.2 mi E of co. line, *S & Bt 4482*; Lincoln Co.; S of North Platte, US-83 at crest of ridge, *S 6520*; : Seward Co.; SW of Seward, I-80 at exit Utica and Cordova, *Semple & B. Semple 6516*; Thayer Co.; US-136 2.4 mi W of US-81 {W of Hebron}, *S & Bt 7343*. **Oklahoma:** Murray Co.; OK-7 E of Sulphur, at junct of OK-12, *S & Heard 8253*. **South Dakota:** Campbell Co.; US-83 2.6 mi S of Mound City, *S & B. Semple 6661*. **Wisconsin:** Adams Co.; Co.Rd-B 5.9 km N of WI-82, SW of Brooks, *S & Jeff Semple 8844*; Jackson Co.; SE of Millston, I-94 rest area, *S & Bt 6939*; Weston Co.; US-16 3.1 mi SE of Upton (WY-116), *S & Bt 4459*.

***Solidago missouriensis* Nutt. aff. var. *fasciculata* Holzinger**

$2n=18$ U.S.A. **Montana:** Custer Co.; US-10 (I-94), at mile 150, 8.6 miles E of Miles City (junction US-12), *S & Bt 6982*.

Solidago missouriensis* Nutt var. *missouriensis

$2n=18$ U.S.A. **New Mexico:** Cibolla Co.; N of Grant, Mt. Taylor, For.Rd-453 (La Mosca L.Q. Rd.) 2.9 km S of For.Rd-239 (San Mateo Rd.), *S*, *Su* & *A* 9381; Mckinley Co.; SE of San Mateo, N of Grant, San Mateo Springs Canyon, *S*, *Su* & *A* 9375. **Nevada:** Humboldt Co.; NV-140 31 mi SE of Denio, flats N of Jackson Mts, *S*, *Su* & *A* 9289. **Utah:** Cache Co.; US-89 below Pass Summit, just E of county line, *S*, *Su* & *A* 9263.

***Solidago missouriensis* Nutt. aff. *missouriensis* approaching var. *fasciculata* Holzinger**

$2n=18$ CANADA. **Saskatchewan:** North Battleford, *S* & *Bt* 4252.

***Solidago missouriensis* Nutt var. *tenuissima* (Woot. & Standl.) C. & J. Taylor**

$2n=18$ U.S.A. **Arizona:** Gila Co.; AZ-260 40 km E of Payson, *S* & *Chmielewski* 9020.

A previously published report of a diploid count for *Solidago sparsiflora* A. Gray (Semple and Chmielewski 1987; $2n=18$. **Colorado:** Gunnison Co., *Semple & Heard* 7780 WAT) was determined to be for *Solidago missouriensis* \times *S. lepida* DC. The specimen looks like robust montane *S. missouriensis*, but the inflorescence is densely glandular.

DISCUSSION

The previously published cytological data and the new counts included in the results demonstrate that *Solidago missouriensis* is predominantly diploid over a large portion of its range in North America (Fig. 7). Tetraploids occur in western prairie and some montane populations of var. *missouriensis* with diploids occurring over much of the range of the typical variety. All counts for var. *extraria* were tetraploid with samples coming from much of the montane range of the variety. All counts for var. *fasciculata* were diploid over its entire range from prairie and prairie-like habitats in Indiana and Tennessee to Alberta and Oklahoma including a disjunct population in steppe habitat in Washington between the Rocky Mts. and the Cascades. The range of var. *tenuissima* is restricted to the southwestern portion of the range of the species with three diploid counts from populations across the central portion of the range. No chromosome counts have been reported for the narrowly distributed western most var. *tolmieana* that occurs in scattered populations in western Washington and Oregon.

Generally, varieties have not been recognized in *Solidago missouriensis* for multiple decades and this was accepted in the treatment of the species in relatively recent floras (e.g., Cronquist 1994; Semple & Cook 2006; Semple 2020). While it was a long-term plan to publish a paper on the cytogeography of *S. missouriensis* in the Semple Astereae Lab, only in the last year was it decided to add varietal names to all of the cytovoucher collections if this could be done utilizing the ever increasing numbers of digital images of herbarium specimens now available on line. This also applied to WAT cytovoucher collections which were transferred to MT in Montréal, PQ in August 2012. Ten years ago, this could not have been done and collections that were not available on line even five years ago are now readily viewed. Also, travel to herbarium to complete the project in much of 2020 and the first half of 2021 was severely restricted due to the covid 19 pandemic. Nearly all cytovouchers for *S. missouriensis* can now be examined via digital images accessed mostly via SERNEC and SEInet. Of the 101 cytovouchers (Tables 1 and 2), only a few could not be found and examined via the internet; e.g., the herbarium location of *Löve & Löve* 5937 (herbarium unknown) cytovoucher for a collection from southeastern Manitoba has not been seen by the first author, but was assumed to be for var. *fasciculata*. A few of the cytovoucher collections were seen by the first author on visits to herbaria many years ago but the identity was only confirmed to species level at the time and images of those collections have not been found via internet searches. Thus, while nearly all collections were seen at least digitally at the time of writing this paper, a few remain identified to species level only with variety identity being inferred by location (e.g., var. *fasciculata*) or ploidy level (e.g., var. *extraria*). The relative cost of doing herbarium botany via the internet is a strong

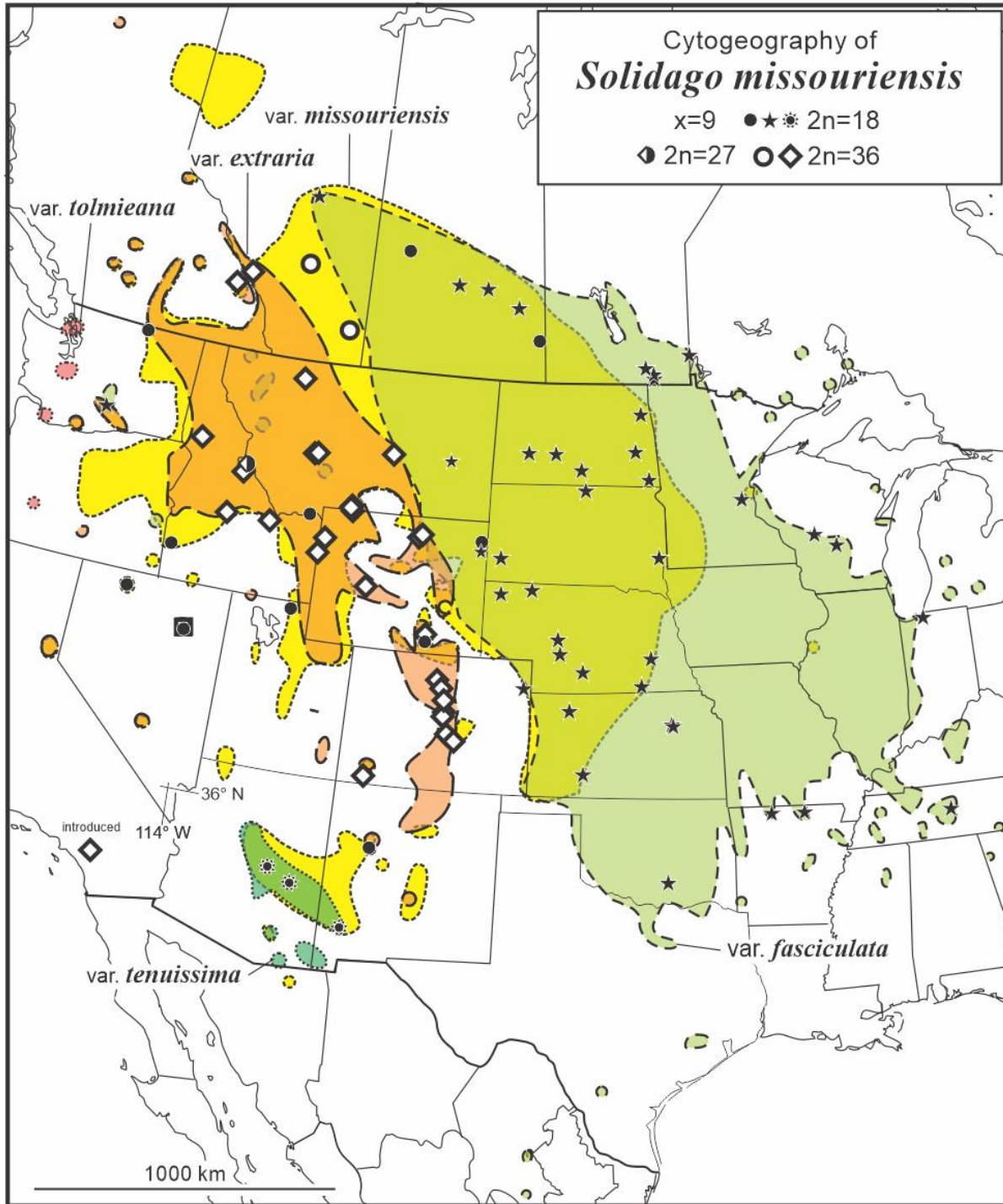


Figure 7. Cytogeography of *Solidago missouriensis* in North America: *var. extraria* (diamonds), *var. fasciculata* (black stars), *var. missouriensis* (dots, circles), *var. tenuissima* (sunbursts).

argument in favor of the methodology, although it only can be considered valid if critical key traits can be assessed from whole specimen images. In this study, stem height, leaf shape and size, and inflorescence shape could be determined without concern for image resolution and the majority of specimens were assigned to variety with high confidence. Identity of short-stemmed specimens were more problematic. Involucre height was less reliably assessed and particularly so on the lower resolution images posted online by some herbaria. Lastly, chromosome numbers cannot be

determined from online herbarium images or from having a specimen visible under a dissecting scope. Ploidy level may be determined from DNA sequence data in some cases, but not to 100% accuracy and only if a large sample of specimens with known ploidy level determined by traditional methods is available for comparison (Martino et al. 2020). Thus, it is concluded that counting chromosome numbers of large numbers of plants is still a useful practice that should still be encouraged. A single count for a taxon is not sufficient as it might be incorrect or the individual might be atypical, e.g. an aberrant aneuploid. Only large numbers of counts can generate a cytogeography distribution map such as shown in Figure 7.

Key to the varieties of *Solidago missouriensis*

(some individuals of all varieties can be difficult to distinguish from var. *missouriensis*)

1. Plants tending to be tall and rather leafy stemmed often with multiple narrow acute leaves in upper stem nodal clusters, usually 4-9 dm; inflorescence evidently secund, Great Plains and prairie-like habitats further east, occasionally to Grand Coulee, Washington var. **fasciculata**
1. Plants generally shorter seldom > 5 dm, lower leaves gen persistent, middle and upper ones relatively few with limited lateral branch leaves present in mid to upper nodes of main stem
 2. Heads relatively large (4-5 mm), somewhat secund inflorescence; rare on prairies W of Cascades Mts. var. **tolmieana**
 2. Plants E of the Cascade Mt. with either non-secund inflorescences or involucre smaller
 3. Heads relatively large, involucre usually 4-5 mm; inflorescence seldom at all secund, mountains var. **extraria**
 3. Heads generally smaller, the involucre 3-4 mm (rarely more), inflorescences secund, branches sometimes broadly ascending to spreading.
 4. Lower leaves linear-lanceolate, petioles sometimes longer than blades; Mogollon Rim and Sky Island mountains of Arizona and SW New Mexico var. **tenuissima**
 4. Lower leaves lanceolate; western prairies near mountains and in mountains from Alberta to New Mexico and Arizona var. **missouriensis**

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