

Colorado Plateau Chenopod Field Trip

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Abstract—The field trip was held on June 14, 2000, in warm, dry weather. It consisted of eleven stops and additional views from the busses. Many saltbush (*Atriplex*) species were observed and their genetical and ecological characteristics described. In addition other chenopod shrubs and annual chenopods were observed and characterized. The field trip is described so that it can be experienced by interested parties on subsequent trips.

Introduction

Much of the Colorado Plateau is occupied by plants in the family Chenopodiaceae. Almost no other kind of plants can tolerate the severe challenge of the salty, alkaline deserts that make up much of the terrain in the Colorado Plateau.

Within the family, the genus *Atriplex* is by far the most common, often occupying vast acreages containing nothing else. Hopefully this tour will serve to introduce a number of *Chenopod* species and to portray the ongoing evolutionary process that is conspicuous at some of the frontiers.

Stop #1: Carbonville, Carbon County, UT; *Atriplex cuneata* and *A. confertifolia*.

Along the railroad embankment are two of the most common species of *Atriplex* in the Colorado Plateau: *A. cuneata* and *A. confertifolia*.

1. *Atriplex cuneata* ("Castle Valley Clover") is found only in the Colorado Plateau. The common name of this species says a lot about its reputation. Its value as an important forage plant for livestock and other herbivores is derived partly from its high nutritive potential but probably more from its occurrence in landscapes that would be completely empty were it not present.

The distinctive morphological features that distinguish it from other species of *Atriplex* are its low, bushy habit, tap-root system, burry fruiting bracts, cuneate leaves and early flowering habit (May). It is mostly dioecious but a few monoecious plants are usually present in most populations. Genetically, it occurs at two chromosome levels: diploids ($2n = 18$) and tetraploids ($2n = 36$).

Tetraploid *A. cuneata* is widespread throughout the Colorado Plateau and is morphologically highly variable. Some of the variation may be due to phenotypic plasticity in response to variable environments but most of it appears to be genetic.

Some tetraploid forms appear to be direct autoploid derivatives from diploids, others appear to be stabilized segregants from hybrids, and others appear to be products of introgression. Some isolated populations may have acquired their uniqueness from new mutations. There are several distinct forms of diploid *cuneata* throughout the Colorado Plateau. Each is phenotypically distinct and each is restricted to a specific ecological niche.

2. *Atriplex confertifolia* (shadscale) is distinguished from all other saltbushes by its broad obtuse leaves, thorny branches, and two-lipped, unappendaged fruiting bracts. It is widespread throughout Western United States from northern Montana to northern Arizona and New Mexico and from central Colorado to south-central California. On the Colorado Plateau it occurs as diploids ($2n = 18$), tetraploids ($2n = 36$), and hexaploids ($2n = 54$). Elsewhere (Utah, Nevada, Oregon) there are octoploids ($2n = 72$) and decaploids ($2n = 90$).

Diploid shadscale, on the Colorado Plateau, is most common in rocky soils, often in association with Utah Juniper. It usually occurs in small, isolated populations in which between-plant variation is conspicuous. In contrast, tetraploid populations are usually much larger and show minimal between-plant variation, suggesting that the tetraploids are autopolyploid derivatives from single or few diploid progenitors.

Interspecific hybrids occur, occasionally, between *Atriplex confertifolia* and *A. canescens*, *A. corrugata*, *A. cuneata*, and *A. garrettii* but no successful product from any of them has yet been found.

The hybrids between *A. cuneata* and *A. confertifolia* as seen here are fairly common where ever these two species meet. Notice that the fruiting bracts of the hybrids have two entire apical lips like those of *A. confertifolia* and numerous basal appendages as in *A. cuneata*. Most hybrid plants are somewhat thorny, like *A. confertifolia*.

Stop #2: Wellington, Carbon County, UT; *Atriplex tridentata*, *A. utahensis*, *A. confertifolia*, *A. cuneata*, *A. powellii*, *A. corrugata*, occasional *Atriplex* hybrids, *Sarcobatus vermiculatus*, *Kochia scoparia*, and *Sueda torreyana*.

About 1 mile south of Wellington, a jumble of ecological sites brings together several species of *Atriplex*. In the wet, alkaline bottoms, there are extensive patches of *A. tridentata*, salt sage. In contrast to all other species of *Atriplex* on the Colorado Plateau, *A. tridentata* shows extensive root-sprouting. Some individual plants may extend, by root sprouts, to several meters. Because it is a dioecious species, the limits of individual plants are usually clearly discernable. Throughout its geographic range it is highly variable, probably because it hybridizes with most of the other *Atriplex* species that it contacts. Hybrids of *A. tridentata* with *A. canescens* are particularly common and, from

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these hybrids, have come several new taxa (*A. nuttallii*, *A. robusta*, *A. anomala*).

On the clay slopes above the populations of *A. tridentata* occurs a mixture of chenopods including *A. confertifolia*, *A. cuneata*, *A. corrugata*, *A. utahensis*, *A. powellii*, *Kochia scoparia*, *Sueda torreyana*, and *Halogeton glomeratus*.

Atriplex "utahensis" is a distinct perennial diploid species endemic to the Colorado Plateau, mostly in east-central Utah. It is distinguished by its narrow leaves, upright habit, tap-root system, and prominent central beak on the copiously appendaged fruiting bracts.

Atriplex corrugata (mat saltbush) is tetraploid in this area but occurs as a diploid on vast acreages south of here (see Stops 8 and 9). *A. corrugata* occupies some of the most severe habitats found anywhere, often as near monocultures. When populations collapse, as they have been seen to do during severe extended droughts, no species other than *A. corrugata*, come into the vacant sites. Because of its low stature it is of minimal value as a forage plant for livestock but is of high value as a soil stabilizer and habitat for small animals. *A. corrugata* plants are easily distinguished by their small, compact habit, grey color, tiny (3 to 5 mm) linear to oblong leaves, and two-lipped bracts that are burry below.

Stop #3: East side of Wellington; *Sarcobatus vermiculatus*.

Sarcobatus vermiculatus (greasewood) is common in alkaline bottomlands in all of the Western States of North America. Although mostly octoploid ($2n = 72$) there is considerable between-population variability. Because nursery-grown plants maintain many of their differing, distinguishing features, much of the variation appears to be controlled genetically. Tetraploid populations of *S. vermiculatus* are confined to southern Alberta, southern Saskatchewan, northern Montana, northern California, northwestern Sonora, Mexico, and southern Arizona and may be relic ancestors to the more common, widespread octoploid populations. The genetic variation present among the octoploids may be an indication of polyphyletic origins or/and subsequent introgressive hybridization.

Stop #4: Southeast of Sunnyside, Carbon County, UT; *Atriplex canescens* var. "*cunescens*."

This stop is in a population of *Atriplex canescens* (fourwing saltbush) that appears to be introgressed with genes from *A. cuneata*.

Atriplex canescens (Pursh.) Nutt. is the most widespread species of perennial *Atriplex* in North America, distributed from southern San Luis Potosi, Mexico, to southern Alberta and Saskatchewan, Canada, and from the Pacific Coast of California and Baja California to Texas, Oklahoma, Nebraska, Kansas, and the Dakotas. Throughout its distributional range, *A. canescens* shows considerable between-population variation. Some of this variation may be due to phenotypic plasticity but most of it appears to be genetic. Mutations, polyploidy, introgressive hybridization, and segregation from interspecific hybrids all appear to have contributed to its extensive heritable variation. Polyploidy is unusually common with seven identified chromosome races ($2x$, $4x$, $6x$, $8x$, $10x$, $12x$, $20x$). *A. canescens* is also the most promiscuous of all species of *Atriplex* and natural hybrids have been found between it and almost all other perennial *Atriplex* species including *A. acanthocarpa*, *A. confertifolia*,

A. corrugata, *A. cuneata*, *A. falcata*, *A. gardneri*, *A. lentiformis*, *A. linearis*, *A. obovata*, *A. polycarpa*, and *A. tridentata*.

Many of the hybrids show some fertility and some appear to have been the source of new taxa. Seed from this tetraploid population has been valuable in reclamation efforts on BHP mine spoils in New Mexico.

Stop #5: Bottomlands south of the Carbon-Emery County line; *Atriplex tridentata* var. "*minutifolia*."

This extensive population of low-statured, small-leaved, *tridentata*-like plants appear to have been derived from hybrids between *A. tridentata* and *A. corrugata*. As with most other *tridentata* plants, these are hexaploid ($2n = 54$). The *corrugata* plants here are tetraploid ($2n = 36$).

As you travel south notice the extensive populations of this still unnamed species on both sides of the road.

Stop #6: Horse Canyon, Emery County, UT; diploid *A. confertifolia* (shadscale) and *Ceratoides lanata* (winterfat).

The *A. confertifolia* plants to the south of the exit road are diploid ($2n = 18$). The plants to the west are all tetraploid ($2n = 36$). Throughout the Intermountain West, most populations of *A. confertifolia* are tetraploid. Diploids are routinely on well-drained upland sites. Two hexaploid ($2n = 54$) populations have been found on the Colorado Plateau, one about 5 miles north of Green River, Utah, and one south of Cortez, Colorado. Both appear to be allopolyploids derived from hybridization between *A. confertifolia* and *A. corrugata*. Elsewhere, some *A. confertifolia* occurs as octoploids ($2n = 72$) and some as decaploids ($2n = 90$).

Ceratoides lanata (winterfat) appears to be diploid throughout its wide distribution and shows abundant variation between populations. Some populations consist of plants that are less than 6 inches (15 cm) tall. In other populations the plants grow to more than 1 m.

This species is highly prized for its forage value and in many areas has proven to be valuable in reclamation of disturbed lands.

Stop #7: Approximately 6 miles west of Green River, Emery County, UT.

Just before arriving at highway I-70, turn right (west) on a well-improved road. Continue west for about 1 mile where there is an extensive mixed population of *Atriplex cuneata* and *A. corrugata*. Interspecific hybridization between them appears to be common here and many odd-ball segregants are produced. These species often hybridize in such ecologically "hybrid" habitats and may be responsible for some of the variation seen in both species.

Stop #8: Green River, Carbon County, UT; annual *Atriplex* species: *Atriplex minuticarpa*, *A. powellii*, and *A. rydbergii*.

Most annual species of *Atriplex* have narrowly limited distributions, occupy severely restricted ecological sites and are, within species, morphologically highly uniform. *Atriplex powellii* is the principal exception. It is widely distributed, occupies many different sites, and is morphologically variable, both within and between populations. The reason for this significant difference appears to be due to its sexuality. It is the only native annual *Atriplex*, that is dioecious; all

others are monoecious. Because of its dioecy it is obliged to outcross whereas monoecious annuals are perpetually inbred, leading quickly to genetic homozygosity.

A. powellii plants are easily distinguished from those of all other annual *Atriplex* species. In addition to being dioecious, the leaves are prominently three-veined and the fruiting bracts have crown-shaped, two-lipped apices and numerous basal appendages.

Atriplex minuticarpa, a recently, newly described annual species is found only on Tununck shale in eastern Utah. It has previously been confused with *A. powellii* but here, where they grow together, they are clearly distinct. *A. minuticarpa* is monoecious, *A. powellii* is dioecious; leaves of *minuticarpa* are single-veined, those of *powellii* are prominently three-veined, and *A. minuticarpa* is smaller statured with divaricate branching. The severe restriction of *A. minuticarpa* to a single, small, geologic formation suggests an ancient origin.

A. rydbergii is restricted in distribution to eastern Utah, northern New Mexico, and northern Arizona. It usually occurs in small isolated populations but in some places in Industrial Valley and near Bluff, San Juan, County, UT, there are several extensive populations.

Stop #9: 3 miles east of Green River, Grand County, UT; diploid *A. corrugata*.

All of these small plants that cover these hills are diploid ($2n = 18$) *A. corrugata*. They differ in phenotype from the tetraploids in being smaller and more erect. Following severe drought years it looks like every plant has died. Subsequently nothing comes back into the vacated acreage except more diploid *A. corrugata*. What appears to be an occasional tetraploid *A. corrugata* plant is present in the draws but on the more severe slopes only the diploids survive.

Stop (pause) #10: 10 miles west of Green River on both sides of I-70; more diploid *A. corrugata*.

There is no place to stop here but as we drive along the freeway, observe the vast populations of diploid *A. corrugata* on both sides of the highway. They extend for miles and miles and miles. What a forest this would be if they could grow up to be trees.

Stop #11: Hanksville exit from I-70; *Zuckia arizonica* and *Atriplex saccaria*.

Turn north on the dirt road for about mile. *Zuckia arizonica* and *Atriplex cuneata* are common here. *Zuckia arizonica* occurs periodically throughout eastern Utah and is very abundant in northern Arizona, particularly in the Painted Desert area south and west of Tuba City, Coconino County. It is a very distinctive species with yellow-green leaves, brittle branches, non-Kranz leaf anatomy, and six-pointed fruiting bracts enclosing a horizontally positioned embryo.

Also, here is a distinctive *Atriplex* annual, *A. saccaria*. Its broad, yellow-green leaves are covered with glistening

persistent trichomes that gives the leaf surface a sand-paper appearance. This and *A. asterocarpa* and *A. graciliflora* are the only species with such trichomes. Most of the fruiting bracts are covered with flattened appendages, a few are small, wedge-shaped, without appendages.

As we return to Provo, watch for the vast populations of the chenopod species that you now know. This is truly Chenopod Country! Where there are alkaline, clay slopes devoid of vegetation, "only" chenopods are encroaching at these evolutionary frontiers. If and when new species occupy these empty sites, they will almost certainly be chenopods.

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Contrasts in Utah's Great Basin and Colorado Plateau Salt-Desert Vegetation

Western Salt Desert (Great Basin)	Eastern Salt Desert (Colorado River Drainage)
1. Many polyploids	Few
2. Few diploids	Many
3. Low predictability of species by ecological site	High
4. Low predictability of ecological site by inhabitant species	High
5. Few well-defined endemics	Many
6. Few families, genera, species	Many
7. Mostly shrubs	Many herbaceous
8. Extensive hybrid swarms	Rare
9. Minimal plant succession	Conspicuous
10. Vast areas of sudden die back	Rare
11. Most species wind pollinated	Many other
12. High within-plant plasticity	Low
13. High within-population diversity	Low
14. Many extensive monocultures	Few
15. Few endemic annuals	Many

Perennial Chenopods in Western North America

Genus	Number of species
<i>Atriplex</i>	30 +
<i>Ceratoides</i>	1
<i>Grayia</i>	1
<i>Kochia</i>	1
<i>Sarcobatus</i>	2
<i>Suaeda</i>	2
<i>Zuckia</i>	2