Endangered Santa Cruz Tarplant's (Holocarpha macradenia - Asteraceae) exceptional variations in genetic diversity, observed in nursery-grown seedlings spring 2021, planted in a "Common Garden" of the Arana Gulch, Santa Cruz, California - USFWS Critical Habitat Unit population.

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Common gardens have been used for over 100 years, to compare fixed physical and genetic traits between plant populations, and determine genetic variations. The common garden is done--by planting seedlings at the same time, in the same place, and in the same soil, with the same nutrients, water and light conditions, and make observations as they grow and develop.

Whenever populations are more or less genetically uniform, the common garden plants will all grow and develop in the same manner and time.

The differences that produce genetically fixed differences within the same species, are physically visible in the common garden study--the plant's height, rate of development, shape, when it flowers and so on.   The purpose of the common garden is to cancel out all of the environmental variations and influences that could influence a plant's grow--like nutrients and water--then the genetic differences if present, pop out.

The genetically-fixed differences are called "ecotypes" and Gote Turesson coined that term 1925-1931, after conducting common garden studies and finding that different environmental conditions produced genetically-fixed ecotypes, that he sorted by the environments that created them:

1.) Typical local lowlands populations, that all other ecotypes were compared = typical.
2.) Limestone or other rock formations = afar.
3.) Shifting dune populations (prostrate, fast growing to avoid being buried by sand) = arenarius.
4.) Coastal bluffs or stationary dune with fast drying soils = campestris
5.) Elevational ecotype varieties a.) Subalpine = subalpinus, b.) Alpine = alpinus
6.) Latitudinal ecotype variation.
7.) Edges of the species range (i.e. the extreme northern and southern portions of the range of distribution).
8.) Saline soils (fleshy leaves) = salinus. (Dremann).

Variations can be expressed by species, when seedlings are planted in a common garden, very common when the seed samples have been collected from very different and extreme environmental areas.

Often, the among-population variations have been ignored, because usually the differences are usually very slight. (Colautti, 2009).

CONCLUSIONS - The massive amount of genetic variation in this single populations, could be due to at least three different influences:

1.) Built-in genetic diversity, from the constantly changing environment in the past.
In the distant past, the habitat where the tarplants grow at Arana Gulch, was an environmental extreme and was constantly changing, from shifting dunes to stable dunes, so a wide genetic variation may have been needed by this species, to survive in the widest range of conditions as possible.

2.) Clausen, Keck and Hiesey's work on the Santa Cruz tarplant genetics may hold a clue. The Santa Cruz tarplant evolved recently, only a few thousand years ago when *Holocarpha virgata* invaded the coastal region during an usually warm period in the last 10,000 years (Baldwin, 2009), so could still be undergoing real-time evolution currently.

3.) Evolution in Real-Time could be happening, due to human-induced environmental changes -- The tarplant's human contact over the last 200 years, has been a complete disaster for the species in general, and for this Arana Gulch population in particular--when the population went from 100,000 plants in the 1980s, to zero plants in three of the last six years.

The introduction of exotic plants and domesticated grazing animals to the Arana Gulch Coastal Prairie habitat, eradicated the tarplant populations along that biome, until only 1% of the Coastal Prairie remains.

Therefore, what the tarplants may be expressing as many of their epigenetic variations as possible, and modifying itself in as many ways during this real-time evolution, to produce at least a few variations that could survive under these new and extremely severe environment conditions.

REFERENCES

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Arana Gulch Area A in June 2021 -- Yellow flowers in foreground are Cats Ears.

Tarplant seedling plot with some cat's ears, and redwood bark mulch 3-4 inches deep, June 2021.

Another planted plot, a total of 14 plots with about 200 seedlings survived in June 2021

The various forms seen, June 2021 - The UCSC nursery-grown seedlings in plots in Area A.

1.) Less than 12 main branches, flat to the ground, single flowers at the ends of branches.

2.) Less than 12 main branches, flat to the ground and ends of branches upright with small clusters of flowers at the ends of branches.

3.) Numerous, widespread branches arranged spoke-like at a 45 degree angle, and flowers at the ends of branches all flowering at the same time.

4.) Numerous widespread branches, more vase-like and flowers are flowering at different times.

5.) Numerous branches, with upright and trailing branches on the same plant.

6.) Compact round plant, early flowering all at same time, small 8 inches wide and 6 inches tall.

7.) Compact round form, with short stems where flowers appear.

8.) Compact round form, with longer straight branches at a 45-degree angle, and middle branch flowering first.

9.) Compact round form, similar to Type 8.

10.) Compact very large plant, compact base and spreading out to 2-3 feet wide.

11.) Large, compact upright form with the most flower per branch on straight branches.

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12.) Huge v-shaped form, about 3 feet by 3 feet, few flowers, and numerous leaves.