

ASTRAGALUS ENDOPTERUS (FABACEAE), A SPECIES PURPORTED AS EXTINCT, FOUND IN NORTHERN ARIZONA, U.S.A.

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ABSTRACT

Astragalus endopterus (Barneby) Barneby, listed as an extinct species in a recent Conservation Biology paper (Knapp et al. 2021) was found in abundance after three hours of targeted searching. Continued searches revealed thousands of plants. Our work has doubled the known range of the species. *Astragalus endopterus* seems to mostly occur on sheetwash deposits composed of particles derived mostly from wind-blown sands along with a component of clay probably derived from the Chinle Formation. We have no indications that the species may have been in decline or was ever on the verge of extinction.

RESUMEN

Astragalus endopterus, catalogado como especie extinta en un artículo reciente de Conservation Biology (Knapp et al. 2021), se encontró en abundancia después de tres horas de búsqueda específica. Las búsquedas continuas revelaron miles de plantas. Nuestro trabajo ha duplicado el rango conocido de la especie. *Astragalus endopterus* parece ocurrir principalmente en depósitos de láminas compuestos de partículas derivadas principalmente de arenas arrastradas por el viento junto con un componente de arcilla probablemente derivado de la Formación Chinle. No tenemos evidencia que indique que pudo haber estado en declive o al borde de la extinción.

INTRODUCTION

Astragalus endopterus (Barneby) Barneby (sandbar milkvetch, Fabaceae), an annual edaphic endemic (AGFD 2020; Barneby 1964; Welsh 2023), caught the attention of Embrey (Rink & Embrey 2023) in a paper on North American plant extinctions (Knapp et al. 2021).

Prior to our work, *Astragalus endopterus* was known from six herbarium vouchers, as follows:

U.S.A. ARIZONA. Coconino Co.: Willow Spring, near Lees Ferry, Little Colorado, 11 Jun 1890, *Jones s.n.* (RSA); 12 mi below Tanner Crossing, Little Colorado, 25 May 1901, *Ward s.n.* (NY); sandy bed of the Little Colorado River, 5 Jun 1947, *Ripley & Barneby 8491* (RSA); sand dunes of the Little Colorado River, 5 Jun 1961, *Demaree 44420* (NY, RSA); 6 mi N of Cameron on Hwy. 89, 8 May 1972, *Beauchamp 3321* (SD); sand dunes along US 89, ca. 8 mi N of Cameron, 10 Jun 1978, *Phillips 78-563* (MNA)(SEINet).

That *Astragalus endopterus* was only known from six collection events and had not been noted by botanists in 45 years could lead an investigator to consider that it might be extinct. Historic collectors did not note how common the plant was, nor how they happened upon it. Ripley and Barneby, renowned *Astragalus* experts, probably sought *Astragalus endopterus* as part of a review of the genus and in an attempt to discern whether the plant warranted species status. It seems likely that, among historical collectors, Barneby and Ripley were the only botanists who ever specifically sought *Astragalus endopterus*. Barneby originally named *Astragalus endopterus* as a variety of *A. wootonii* (Barneby 1949), then raised it to species level 15 years later (Barneby 1964).

Astragalus endopterus has no ESA (Endangered Species Act) protections. It is ranked by NatureServe as GH (possibly extinct)(https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.145875/Astragalus_endopterus). It is not on the Navajo Nation Endangered species list (https://www.nndfw.org/nnhp/nnhp_nesl.pdf). The Arizona Natural Heritage Program (2020) maintains an abstract for *Astragalus endopterus*. *Astragalus endopterus* was not considered for the Arizona Rare Plant Field Guide (Arizona Rare Plant Committee nd). In a July 2, 2023 email to Rink, A. Laurenzi, who headed the Arizona Rare Plant Committee in 2014 (Laurenzi & Spence 2013), said, “that ASEN [*Astragalus endopterus*] was one of a handful of plants we were unable to rank and listed as Need More Data which would suggest no one thought that an extinct classification was

appropriate” (Jul 2, 2023 email to Rink). In a July 3, 2023 email to Rink he said, “With respect to HDMS [Heritage Data Management System] and NatureServe the lack of any recent records resulted in GH rank.”

Michael Barbour, HDMS Data Specialist at the Arizona Game and Fish Department, in an email to Rink on July 10, 2023, said,

With regard to the state rank for this plant, the SH rank was assigned in 2008 based on the 1978 collection as the last observed date. The note is “No known occurrence or collection info since 1978 collection.” So the last observation would have been 30 years prior at the time the rank was assigned. That is why it would have been given a rank of SH. The observation was too old to give it a rank of extant (generally our cutoff is 30 years for plants). This was reassessed at the 2012 Rare Plant Task Force ranking of all G1G2 in AZ. No new information was available and the rank was not changed. This species fell into their classification of need data so I assume this is why it was not included in the final sensitive plant list produced. Their note for it was “Only three records in AZ and last one from 1978. Plant may be extinct.” Our note in the distribution comments from this is “may be extirpated, but surveys need to be conducted.”

To determine whether a taxon was extinct or not, Knapp et al. (2021) claim to have used NatureServe methods as described in Faber-Langendoen et al. (2012), however they did not describe how they scored *Astragalus endopterus* within the NatureServe ranking system.

For “simplicity,” Knapp et al., categorized 65 plants as extinct, stating that,

NatureServe assessment categories are presumed extinct (GX for species; TX for infraspecies) and possibly extinct (GH for species; TH for infraspecies), whereas IUCN uses extinct (EX) and critically endangered (possibly extinct) (CR[PE]).

Due to the high degree of uncertainty surrounding modern extinctions, we use the term extinct for simplicity when discussing both categories.

Rink and Embrey (2023) thought there was a good chance that *Astragalus endopterus* was not extinct, but knew the only way to find out was the old-fashioned way, go into the field and look for it.

GOALS

First, we wanted to satisfy ourselves that *Astragalus endopterus* is taxonomically unique at the species level. This required looking at both curated specimens and plants in the field. Then, if we found *Astragalus endopterus* in the field, we wanted to learn as much as we could about its range and habitat.

METHODS

Rink reviewed the only specimen of *Astragalus endopterus* available at an Arizona herbarium (Museum of Northern Arizona (MNA), *Phillips 78-563*).

All six previous collections of *Astragalus endopterus* were made prior to global positioning system technology, so we depended on label information to discern target areas for our search. The type location is the sandy bed of the Little Colorado River near Cameron, AZ. Other collections were made 10–37 km N of Cameron. We searched Google Earth imagery for appropriate sandy substrate and made waypoints for these locations, which we then transferred to our handheld GPS units. These areas included six sandy areas 6 to 42 km to the SE of Cameron, areas where *Astragalus endopterus* had not been previously documented. We also targeted sandy areas along Highway 89 and Hamblin Wash from Cameron N to The Gap and beyond. This included all of the area where historical collections were made, except the one made “Twelve miles below Tanner’s Crossing, Little Colorado” (*Ward s.n.*).

We had hoped that any work Knapp et al. had done in seeking *Astragalus endopterus* might help us to find the plants. In the Discussion section of Knapp et al. (2021), they indicated, “Each taxon reported on here has been sought in the field, but not rediscovered.” However, Knapp et al. did not cite *Astragalus endopterus* field work. Upon questioning, they were unable to produce any evidence that anyone had ever sought the species in the field.

The collections N of Cameron seemed to have been made next to the main travel route at the time. In Jones’s and Ward’s time, much of this route would have been to the E of present Highway 89. The old route

crossed the Little Colorado River at Tanner's Crossing, about 3 km upstream (E) of Cameron. The historic route veered NE toward present day Tuba City, from about 7 km S of the present turnoff from Highway 89 onto Highway 160 to Tuba City. Highway 89 was built in the years 1926/27, then later improved to its present alignment, not far from the 1927 alignment, which is still visible on Google Earth images, and in some places, is still drivable. The Beaucamp and Phillips' collections were almost certainly made next to the present-day alignment of Highway 89. The historical plant collecting information allowed us to focus on areas from the bed of the Little Colorado River near Cameron to Moenave/Willow Springs. The only other information we had was that past collections were taken from sandy habitats.

Since the entire known range of *Astragalus endopterus* is within Navajo Nation lands in Coconino County, AZ, Rink applied for and was granted a Navajo Nation research permit effective Jan 31–Dec 31, 2023. The bulk of our field work was conducted by Rink and Embrey during Jun 3–9, 2023, at a time of the season when we expected *Astragalus endopterus* to be most noticeable and identifiable due to its flowering phenology. Three other highly qualified botanists joined us at various times, for a total effort of 17 person-days.

RESULTS

Phillips 78-563 has small, nearly white flowers; the leaflets are fewer than typical for *A. wootonii*. The species specific funicular flange is on the inside of the pod, so not visible in this herbarium specimen without dissection (Fig. 1). In the field, we noted the “funicular flange” of the pods, flanges that were up to 4 mm wide. These characters easily separate *Astragalus endopterus* from *A. wootonii* at the species level (Barneby 1964; Welsh 2023).

Three hours into our first day of searching, we found dozens of *Astragalus endopterus* plants. Soon we found hundreds. During our second day we found thousands more. We found more thousands of plants during the ensuing eight days of searching. In some locations, we took the time to waypoint each plant, counting 3067 plants. In five areas, the plants were so abundant that we determined that counting each plant was less important than putting our efforts towards exploring the species' range limitations. In two of those areas we estimated thousands of plants. Our estimates at three others were 500+, 300+, and 400–500. We never had the sense that we had seen every plant in the locations where we looked. And there were many more areas to look than we actually did look. Our survey timing during early June was appropriate. We found plants in vegetative condition, flowering, flowering and fruiting, fruiting, as well as disarticulating and blowing away in the wind.

We found *Astragalus endopterus* at all of the locations where it was previously vouchered, except along the Little Colorado River (Fig. 2). We explored and found six *Astragalus endopterus* locations as much as 42 km S and E of Cameron in areas where it was not previously known. We believe we have identified the range of *Astragalus endopterus* within a narrow 75 km long N-S band near the Chinle Formation. Willow Spring, about 37 km N of Cameron, seems to be the N limit. Whitewater Wash about 42 km SE of Cameron seems to be the SE limit. Most of this range is within the W portion of the Painted Desert, formed by the Chinle Formation. We did not find *Astragalus endopterus* N of Willow Springs, where the Chinle is expressed as a much narrower band, nor S of Whitewater Wash, where the Chinle is highly eroded, expressed over a wide expanse such that it is largely unnoticeable due to a lack of high escarpments. Our vouchers (deposited primarily at the Navajo Nation Herbarium (NAVA), the Deaver Herbarium, both on the campus of Northern Arizona University (ASC), and various other herbaria as duplicates were available) for *Astragalus endopterus* are: Rink 17426, 17447, 17450-17453, 17465, 17466, 17484-17486, 17488-17490, 17595, 17600, 17601.

We believe we have identified the specialized habitat requirements of *Astragalus endopterus*, which was critical to being able to reliably find the plants. When we began our survey all we knew was to look on sand. After several days of finding *Astragalus endopterus* we realized the species' habitat was more specialized than that. We noticed we always found *Astragalus endopterus* on sand in association with the Chinle Formation. The Chinle largely consists of fine-grained lacustrine, palustrine and eolian clay deposits with varied colors due to minerals in the deposits (Stewart et al 1972). Also, we noticed the deposits on which we found

Astragalus endopterus, though largely composed of wind-transported sand grains, were not strictly eolian deposits. Eolian deposits would have had crossbedding and little to no clay content. Instead, we found *Astragalus endopterus* on sediments that exhibited bedding parallel with the ground surface, with enough clay content cementing the grains together that we needed a steel tool to dig into those deposits. Typically, these deposits were situated below or near escarpments of Chinle. We interpreted this specialized substrate as having been deposited during precipitation events that caused sheetwash to carry both sand and clay, depositing it across open slopes, generally below the Chinle Formation.

Using this habitat model, we were able to find six previously undocumented *Astragalus endopterus* locations E and S of Cameron, allowing us to extend the known range of the species 42 km E and S of the previously known SE-most locations near Cameron.

DISCUSSION

Knapp has congratulated us on our “amazing” find and suggested collecting seed for seed banking, an approach used for plants that are thought to be on the verge of extinction (Dau et al. 2018; Walters & Pence 2021). No data exist which support the interpretation that *Astragalus endopterus* was ever in decline or is nearly extinct.

As far as we know, *Astragalus endopterus* is the only Arizona endemic plant that has been thought to be extinct. Prior to our work, there had been no documentation of its existence, since 1978. This is the only indication we could discern that could lead one to think it might be extinct. When considering the lack of collections in the last 45 years, one should

consider that this plant is known from places that are hot and inhospitable during late May and June, the period of the year when they are most detectable and discernable. The likelihood that a botanist would explore that Navajo Nation terrain during late May and early June looking for plants is low, especially considering this plant has no status and that research on the Navajo Nation requires permitting. It should be no surprise it was not documented in 45 years without targeted surveys.

Due to above normal precipitation in the West during 2023, botanists have thought this would be a good year to find annuals in the desert Southwest (email of Knapp to Rink June 14, 2023), and that was the reason we were able to find *Astragalus endopterus*. We have found good conditions for finding plants in 2023 in some areas and not in others. Wupatki National Monument has the closest weather station to the areas where *Astragalus endopterus* occurs. Winter and spring precipitation records for the last 11 years at Wupatki (<https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caazca>) show this was not a high precipitation year for the area. Five years during this period had less precipitation, as little as half of that in 2023, while six years had as much as twice to nearly five times as much precipitation as during 2023. Low precipitation and lack of germination probably



FIG. 1. Funicular flange on the inside of the pod (*Astragalus endopterus*). Photos by Teague Embrey.

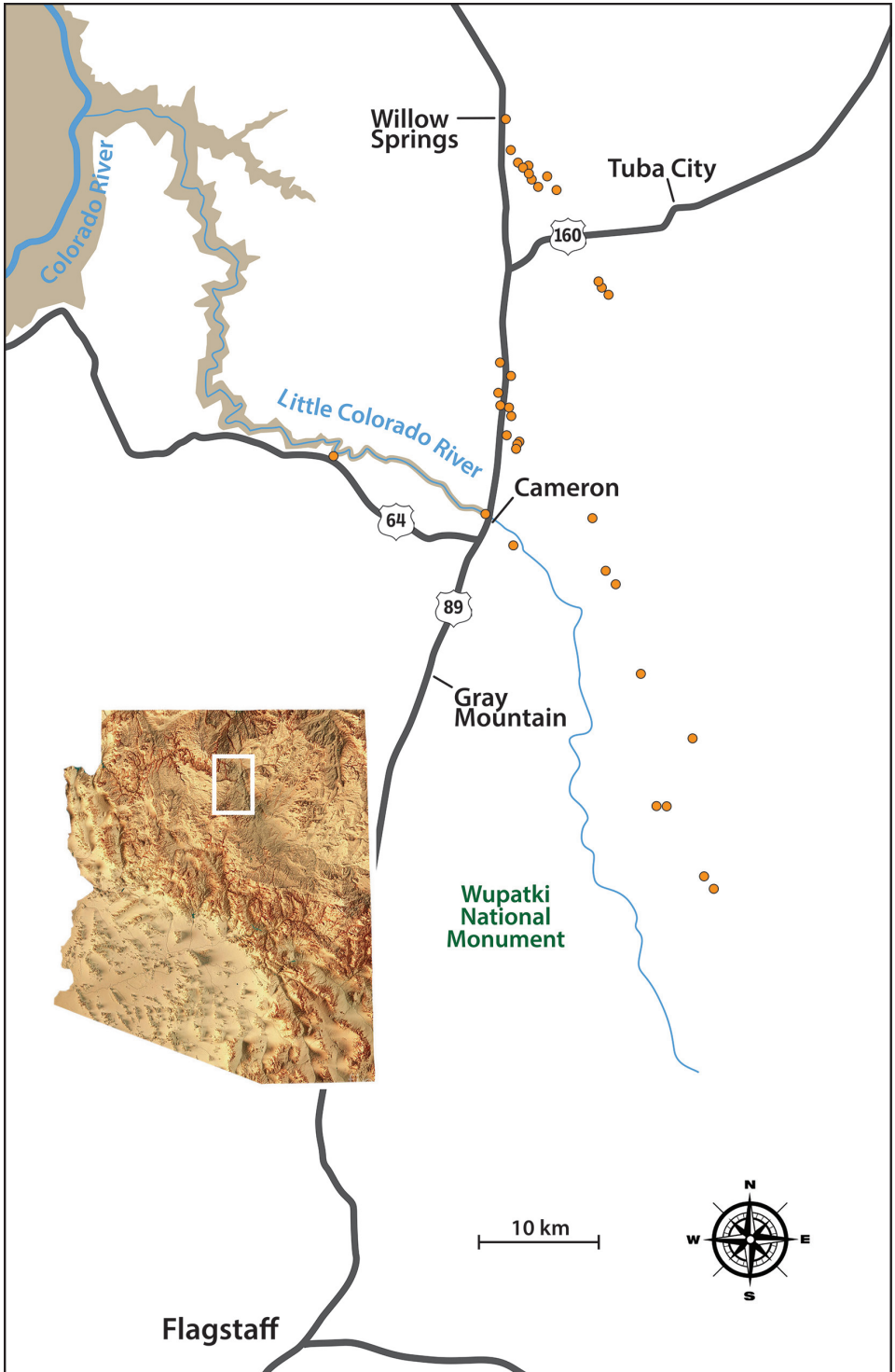


FIG. 2. Map of known *Astragalus endoapterus* (gold dots) locations in N Arizona.

do not account for the lack of *Astragalus endopterus* collections in the last 45 years. Instead, we suspect this lack is due to a lack of effort to document it.

Had we not found *Astragalus endopterus* during this work, we would not have been prepared to concede that it was extinct. As an annual, *Astragalus endopterus* surveys may have required repetition over a period of several years.

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