



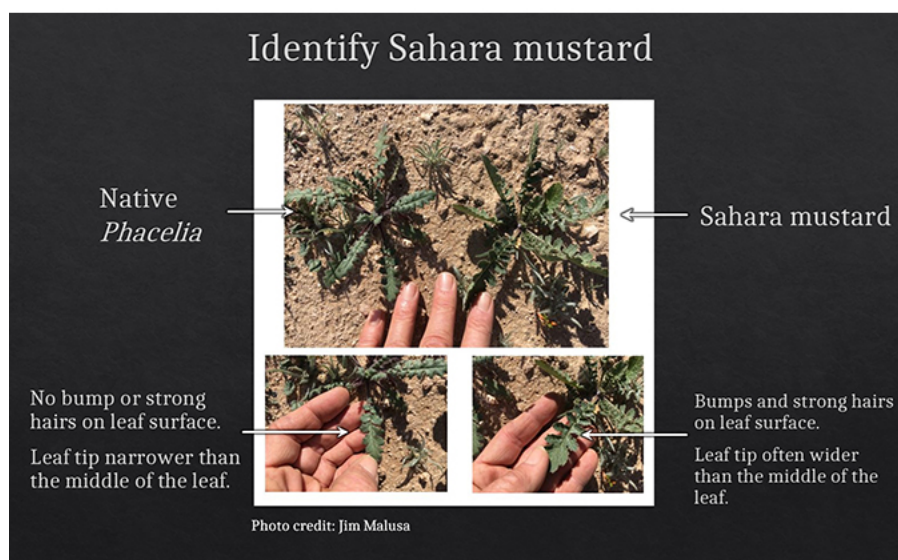
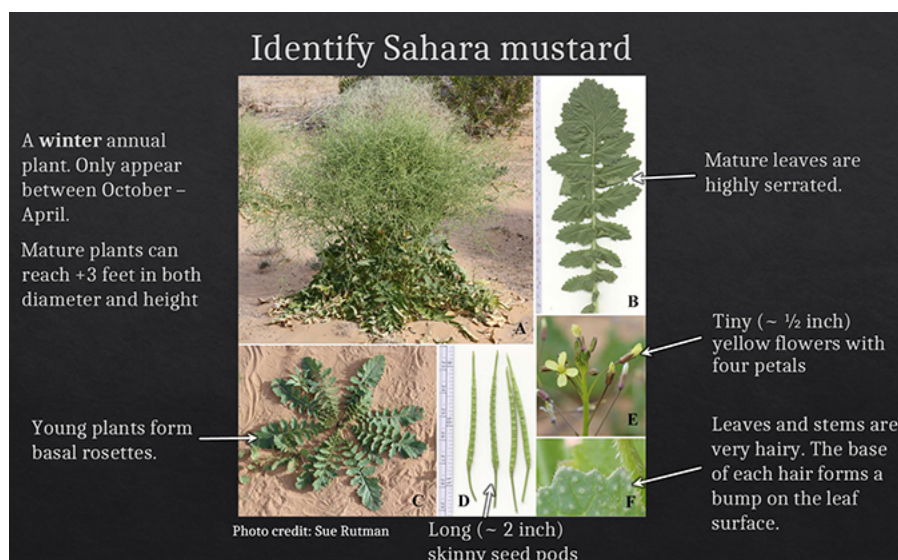
## Sonoran Desert Cooperative Weed Management Area

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### Sahara Mustard (*Brassica tournefortii*)

Sahara mustard (a.k.a African mustard, wild turnip, mostaza del Sahara, and several other names) is a fast-growing, drought-tolerant winter annual that prefers sandy soils, yet can invade a wide range of soil types [1,2]. Its native range covers most of the Mediterranean coast, middle east, and western central Asia [2]. Its distribution in North America ranges from California and Baja California coast to western Texas, and from southern Utah to southern Sonora (Fig. 2) [2]. The species normally form a basal rosette of divided hairy leaves, which can span more than three feet in wet years [3]. The nearly leafless flowering stems branch profusely and grow to a height of about two feet, creating the appearance of a shrub from a distance. The small light yellow flowers are self-pollinating [4], but out-crossing between individuals likely occurs [5]. Each of the thousands of flowers sets a seed pod. Large plants produce up to 16,000 seeds [6]. Dried plants break off at the base and tumble like Russian thistle (tumbleweed, *Salsola tragus*), spreading seeds rapidly across the landscape [1]. When wet, the seeds are sticky with mucilage and can be transported long distances by animals and vehicles [7].



#### Why is it a threat?

This winter annual species grows very fast and large when soil moisture is abundant, smothering native herbaceous plants and potentially competing with large shrubs (e.g., creosote bushes) for light and soil moisture. Both native annual plants and arthropods declined following population increase of Sahara mustard in Coachella Valley, CA [8,9]. The famous wildflower fields of the sandy valleys of Lower Colorado River Valley can be in danger if Sahara mustard outcompete native species over the long run [3].

In arid regions with regular summer rainfall (e.g. southern Arizona), seed banks of Sahara mustard can be weak because of the combination of high fractions of seed germination and low seed survival [10]. Weak seed banks can create boom-and-bust cycles in local populations of Sahara mustard

following consecutive years of wet or dry growing seasons [11]. For example, Sahara mustard population on the Mohawk Dunes in southwestern Arizona boomed after a wet winter-spring in 2005, but crashed after three dry winters (2010-2012) [10], and had not recovered as in spring 2019.

## Control

Sahara mustard seeds can reach near 100% germination in saturated soil [10,12]. Its tendency of aggressive germination creates excellent opportunities for controlling this invasive annual in years with wet winter and spring. Removing germinated individuals in wet years can remove almost the entire local population of Sahara mustard. On the contrary, some exotic winter annual species (e.g., the Mediterranean grasses (*Schismus* species)) germinate conservatively, forming persistent seed banks similar to most of the native desert annual species [10], and thus making population control difficult.

Short-lived seed banks of Sahara mustard can lead to boom-and-bust cycles of its local populations. This pattern provides opportunities for large-scale containment of its invasion. Controlling effort should focus on locations with reliable water availability that can support high abundance of Sahara mustard even in relatively dry winter-spring seasons [11]. Examples of these locations include roadsides (where water draining off the road concentrates), sand dunes (where water seeps deep into the sandy soil), and washes (where water concentrates from the local watershed). Removal of persistent populations in these areas reduces the chances for these source populations to re-invade areas where Sahara mustard abundance has declined due to dry winters [11,13]. Removing Sahara mustard along roadsides also cuts dispersal corridors that facilitate large-scale invasion of this species [13,14].

In Arizona, large-scale control of Sahara mustard has been implemented on the Barry M. Goldwater Range West and Cabeza Prieta National Wildlife Refuge, two adjacent federal lands with a combined size of 1.5 million acres. The U.S. Marine Corps Air Station, Yuma and the U.S. Fish and Wildlife Service implemented an early detection and rapid response program, which has seen success in containing some of the local populations of Sahara mustard [14,15].

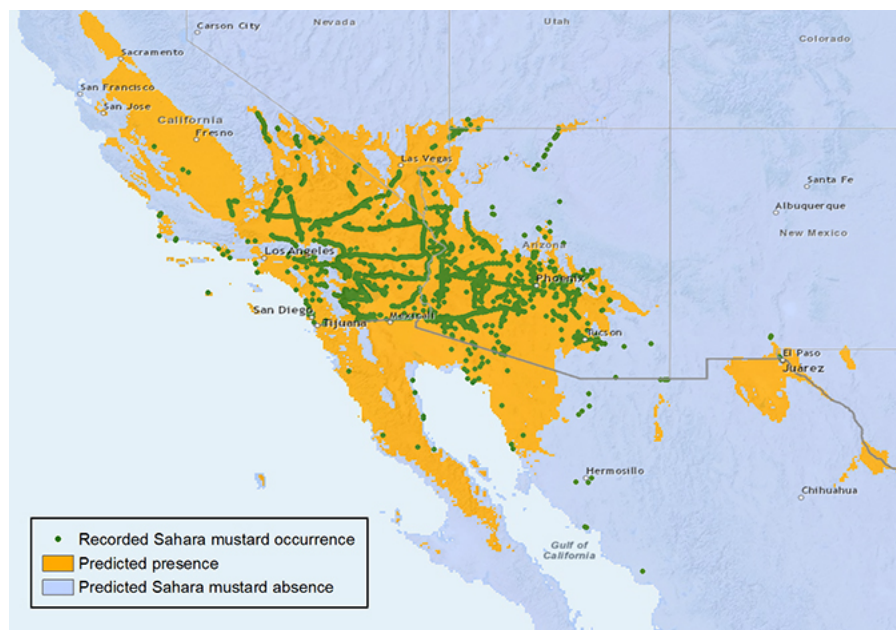
Herbicide treatment is the most effective method of controlling Sahara mustard [16,17]. Because Sahara mustard germinates and grows faster than most of the native desert winter annuals, herbicide application soon after Sahara mustard germination can effectively remove this species while minimizing the negative impact on native species [16]. When collateral damage is less of a concern (e.g., selective backpack spraying), herbicide treatment can be applied as late as seedpods of Sahara mustard remain green [17]. 2% Roundup Pro (Glyphosate as the main ingredient) or a cocktail of 1% Roundup Pro and 1% Weedar 64 (2,4-Dichlorophenoxyacetic acid as the main ingredient) can effectively kill developing seeds [18].

When herbicide treatment is not an option, this species can be eradicated by pulling plants before their seeds mature. Green seedpods on pulled plants can continue develop and produce viable seeds [17]. Therefore, bag the pulled plants if seedpods are visible. Alternatively, remove green seedpods from the large taproot [17]. Doing so reduces the available nutrients that support seed development after the plants are pulled.

Finding an acceptable biological control agent will be a challenge because many important crop plants are in the genus *Brassica* [7]. There are also numerous native mustards that might be threatened by a biological agent unless it is extremely host-specific. Preliminary studies suggest some native fungi can specifically kill Sahara mustard seeds, but only over the summer rainy season [19]. This pathogenic effect on seeds may explain low survival rate of Sahara mustard seeds observed in southwestern Arizona [10]. Since summer rain is essential for activating fungi to kill seeds, regions with low summer rainfall (e.g., the Colorado and Mojave Deserts of California) may host Sahara mustard populations that have more persistent seed banks. It may take a long and arduous research journey to develop a technique of using host-specific seed pathogen to control Sahara mustard.

## Distribution

Sahara mustard has a relatively broad climatic niche within the warm arid and semi-arid lands in western North America. It is capable of occupying all three major southwestern deserts: the Mojave, Sonoran, and Chichuchan Deserts. Its presence in the Chichuchan Desert, nevertheless, is quite limited. Genetic variation between its interior populations is low, suggesting the same origin of these widely distributed populations, and reflecting the plant's self-pollinating nature, which tends to limit genetic variation [20]. Its population on the coastal dunes of southern California appears to be genetically distinct from the rest of its populations, suggesting a different native origin [20].



Within its suitable climate, Sahara mustard can occupy a wide range of soil types (sand, sandy loam soil, rocky hillside, etc.), yet grow most aggressively on loose sandy soils [1,2,13], likely because its deep taproot can develop fully through loose sand to tap into deep moisture. Nevertheless, not all sandy soils are equally favorable to Sahara mustard. Subtle differences in physical environment, which often are more faithfully reflected by the association of dominant native vegetation, can affect greatly the possibility of Sahara mustard invasion. Linking classification of vegetation associations

with Sahara mustard survey is a great way to predict habitat suitability of Sahara mustard on a large scale, as what has been done on the Barry M. Goldwater Range [13].

## History

1920s through 1970s: This recent invader probably arrived in North America as a contaminant in date palm seeds. The first record is from California's Coachella Valley in 1927. It was first discovered in Arizona-Sonora in 1955 near Palm Canyon in the KOFA Mountains. By the 1970s it was widespread in the low deserts in Arizona, California, Baja California, and Sonora [21].

According to herbarium records, Sahara mustard experienced the fastest interstate expansion in the 1960s and the 1970s [2]. It was first discovered in Tucson, Arizona in 1968. The 1970s saw the species reaching El Paso, Texas, St. George, Utah, and California coast south of San Luis Obispo (which might be a different introduction from one of its native populations [20]). These locations remain as its range boundary in North America till this day. In the 1980s, its continental range boundary expanded further south in Sonora, while its distribution within this boundary also expanded rapidly [2,11].

Anecdotally, in the 1990s, it began rapidly spreading into undisturbed desert habitats, and became a dominant in large areas of the lower elevations of the Sonoran and Mohave deserts. It invaded the Great Basin in Owens Valley, California. Only in the 1990s did botanists and land managers become alarmed about Sahara mustard, but their concern subsided during intervening dry years when it did not appear in numbers.

Since the 2000s, the expansion of its continental range boundary has stopped, indicating Sahara mustard has reached the limit of its climatic niche in North America [2,11]. Nevertheless, rapid invasion over suitable habitat continues within this climatic envelope, causing serious management concerns [2,11].

## Links

Information page of Sahara mustard by California Invasive Plant Council: <https://www.cal-ipc.org/plants/profile/brassica-tournefortii-profile/>

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